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# ТЕМАТИЧЕСКИЙ РЕФЕРАТИВНЫЙ СБОРНИК № 32-2

## “Radar Target Recognition”
## («Распознавание РЛ целей»)

Публикации в трудах конференций

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# ТЕМАТИЧЕСКИЙ РЕФЕРАТИВНЫЙ СБОРНИК № 32-2

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### "Detection Algorithm of Laser Radar Target Based on Wavelet Transform"

Given the different transmission characteristics under the wavelet transform (WT) domain and the different distribution characteristics of frequency domain of the signal and noise, a novel approach for detecting laser radar target based on wavelet transform has been proposed. Usually, wavelet decomposition has been used to de-noise a digital signal corrupted by noise. In our approach, we applied the wavelet decomposition and modulus maximum detect the locations of laser radar echo signal. Simulations show that the proposed algorithms are more efficient than only utilizing wavelet decomposition in a big clutter background. [C1]

### "SAR Automatic Target Recognition Based on Classifiers Fusion"

Synthetic aperture radar automatic target recognition (SAR ATR) remains a challenging problem in military and civil field. Much work has been done to improve the performance of SAR ATR systems, both in feature extraction and classifier designing. This paper designs a multiple classifier system to solve the target classification problem in the area of SAR ATR. The proposed multiple classifier system trains three classifiers on different feature sets using three leaning algorithms. The outputs of the three classifiers are combined through evidence combination rule and discounting operation of Dempster-Shafer theory of evidence. Experiments on MSTAR public data set demonstrate that the proposed multiple classifier system significantly outperforms single classifiers and also excels adaptive boosting with RBF network as base learner. [C2]

### "Three-dimensional micro-doppler signature extraction in MIMO radar"

In traditional monostatic radar, only the micromotion signatures projected in line-of-sight (LOS) could be extracted from the target's echoes, which are insufficient for accurate target recognition due to the target-aspect sensitivity. In this paper, we propose an algorithm for the three-dimensional micro-Doppler signature extraction using the multi-input multi-output (MIMO) radar technique. The micro-Doppler effect in MIMO radar induced by rotation is analyzed. Profited from the multi-view of MIMO radar, the three-dimensional micro-motion features, which are not sensitive to the target's aspect anymore, are obtained by solving nonlinear multivariable equation systems. Simulations are given to validate the effectiveness of the proposed algorithm. [C3]

### "Automatic classification of metallic targets using pattern recognition of GPR reflection: a study in the IAG-USP Test Site, Sao Paulo (Brazil)"

In this work, a methodology to automatically classify of metal targets using pattern recognition techniques on GPR reflection data is presented. The methodology consists of designing a multilayer perceptron (MLP) classifier based on features extracted from the targets in the subsoil, and then using it to classify hyperbolas diffraction indicating their position and depth. The classification of reflections allows a high resolution reconstruction of the subsurface with reduced computing time. The system was developed in MATLAB and applied to GPR data obtained at IAG-USP test site, located in the city of Sao Paulo, Brazil, where metallic drums were studied under controlled field conditions. This site contains different targets of variable sizes buried under different depths and it served as a model for the computational experiment. The results indicate that the automatic classification of the metallic targets in the subsoil is efficient, contributing for the reduction of the ambiguities in the geophysical data interpretation, besides having application on the subsoil mapping of utilities. [C4]

### "Inverse synthetic aperture 3-D imaging laser radar"

Three-dimensional (3-D) Image can represent target's physical characteristic well and improve target recognition capability, however, conventional optical imaging radar which is limited by the array units or scan system cannot realize the high resolution imaging for moving targets. This paper combines the inverse synthetic aperture technology, laser signal and interferometric technique to suggest a new radar system which is called Inverse Synthetic Aperture 3-D Imaging Laser Radar, describes initial design project of this radar system, analyzes the imaging theory and implement method, and finishes the imaging simulation. The simulation shows the feasibility

of this radar system and advantages of the image obtained from this radar. [C5]

## "Cover page"

The following topics are dealt with: kinematics, compressive sensing radar imaging, discrete Hilbert transform, feature extraction, nondestructive testing, dynamic programming, STAP algorithm, spread spectrum communication systems, face detection, wireless sensor networks, signal denoising, anti-jamming, information fusion, game theory, shipborne radar echo, ad hoc networks, wavelet transform, Hough transform, wind farm power, acoustic echo cancellation, speed estimation, image enhancement, curve fitting, perceptron neural nets, statistic decoding algorithm, LDPC codes, diffraction tomography, video watermarking, pulse compression technique, image analysis, cognitive OFDM, analog signal, fault diagnosis, target recognition, adaptive beamforming, nonlinearity correction imaging, computer vision, image segmentation, mobile networks, synthetic aperture radar, Kalman filtering, hidden Markov model, support vector machine, network intrusion detection, network congestion control, mobile VoIP, intertial navigation, edge detection, image resolution, image reconstruction, power control, cognitive radio, speech processing, attibute reduction, routing protocol, and incremental learning. [C6]

## "Performance evaluation of subsurface target recognition based on ultrawideband short-pulse excitation"

Automated Target Recognition (ATR) based on Natural Resonance Frequencies (NRFs) embedded in Ultra Wideband (UWB) transient electromagnetic signatures have been extensively studied. To our knowledge, most studies concerning ATR using the E-Pulse technique are about radar targets in free space. Recent attempts have been made to apply the E-Pulse technique for subsurface target detection. In this paper, performance evaluation of a recently proposed subsurface target recognition technique based on the E-Pulse and Baum's transform under different signal-to-noise ratios (SNR) is considered. Examples of target recognition of three different perfect electric conductor (PEC) targets sited below a frequency-dependent lossy halfspace are presented. [C7]

## "Three-dimensional through wall imaging using an UWB SAR"

A 3-D UWB SAR has been designed to detect the positions of the targets behind the wall and identify them as well. The beam scanning is based on the mechanical movement of the wideband Tx/Rx Vivaldi array. The system transceiver and 3-D microwave beamforming algorithm are introduced in details. An experiment is performed to recover the 3-D images of a human mock-up. The demonstrated 3-D imaging results have indicated the capability of accurately locating, tracking and identifying human beings behind the wall. [C8]

## "Analysis of micro-doppler effect in SIMO radar"

SIMO (Single Input Multiple Output) radar system capitalizes on the receiving diversity, so it can obtain more information about the target and highly improve the target recognition capability of radar. In this paper, the micro-Doppler effect induced by rotation and vibration parts of target in SIMO radar system which transmitting single frequency signal are deduced respectively. Both the micro-Doppler effect induced by rotation and vibration are sinusoidal curves, but their amplitude vary with the selection of different receiving radar. In addition, the translation of the target's body will lead some horizontal shifts to the micro-Doppler curves with different value according to the selected receiving radar. Simulations are presented to validate the theoretic conclusions. [C9]

## "Low velocity small radar target detection in maritime environment"

Researches on target detection are mainly focus on the amplitude characteristics nowadays. Sometimes the only use of amplitude characteristics is not enough to describe the signal, so that the target detection performance is usually poor. In this essay a method to make use of the information "hidden" in the signal phase is put forward, the theory is based on polynomial fitting of the signal phase train structure. At last, the method is validated using actual data. [C10]

## "Microwave visualization of layered dielectric half-space using range profiling of phase"

A novel method of subsurface radar data processing based on independent determination and representation of amplitude and phase profiles is described. As the phase of the reflected signal depends on dielectric properties of buried target, the proposed technique is suitable for target discrimination. The amplitude and phase information is merged in the common image by governing intensity and color of the image. The amplitude profile of the reflected signal is obtained using a standard inverse Fourier transform of the frequency domain data whereas the phase profile associated with the reflection act at the given depth is derived using a special data

processing technique. Some numerical and experimental examples illustrating the method performance are presented. [C11]

## "Object recognition in ground surveillance doppler radar by using bispectrum-based time-frequency distributions"

Performance estimation and comparative study of different kinds of time-frequency distributions (TFDs), especially Wigner-Ville distribution (WVD), as well as bispectrum-based distributions: Wigner-bispecrum (WBD), parametric (PBD) and non-parametric (NPBD) obtained by real non-stationary echosignal measuring in ground surveillance Doppler radar are considered for solving moving object recognition and classification problems. Automatic target recognition (ATR) performance has been examined by using information features contained both in the TFDs and cepstral coefficients. Experimental results performed by ground surveillance radar operating in millimeter wavelength for walking human, group of walking humans, bicyclist, vehicles and vegetation clutter show that bispectrum-based approach seems to be attractive tool for ATR systems comparing to the conventional energy-based approaches. [C12]

## "Fusion of SAR and optical images as a method for improving target recognition on the earth surface"

The paper presents the real-life data results of SAR and optical images data fusion. The fusion has been carried out for SAR images obtained in classical SAR, multilook SAR and multilook color mapping SAR modes. The aim of the presented images fusion was to enhance the target recognition capabilities on the Earth surface for a simple single-channel SAR receiver. [C13]

## "Analysis of ATR features for non-cooperative ground-based classification of ships"

Measurements were taken at 17 GHz of a ship that was first approaching the coast-based radar and then followed a circular course between 6km and 7km distance. It is demonstrated how the high range resolution profile of the ship and consequently any ATR (automatic target recognition) classification features derived therefrom are modified by multipath as a function of range and aspect angle. For comparison, the TERPEM software is used to simulate the effect and analyse it in a more controlled way. [C14]

## "Applying the decision trees to radar targets recognition"

Electronic Support Measure (ESM) systems have been used to passively detect electromagnetic emission from airborne, shipborne, and landborne platforms. The paper describes a method of an automatic radar target recognition based on following principal stages: digital signal processing, feature extraction and selection and applying a combination of decision tree, minimum distance classifier and knowledge base. [C15]

## "Target vehicle selection based on multi features fusion method"

A target selection method based on multi features fusion is proposed to improve the accuracy of target vehicle selection. The parameters consisting of the longitudinal distance, lateral distance, relative speed between objects and the host vehicle, the in-lane probability of objects are regarded as the features of individual vehicles. Firstly, some pre-processes of features data are carried out including Distance Compensation Factor (DCF) correcting and Kalman filtering, which are used to correct the in-lane probability data provided by lidar, track and predict the relative distance and speed of objects to lower the missing rate of vehicle detection respectively. Furthermore a two-layer BP neural network is designed to train the sample data and obtain the importance weight of feature variables; the training output is finally utilized as the index for target recognition. The selection method utilizes the valid information collected by sensors through the fusion of multi vehicle features. Experiments show that the vehicle detection results can be improved and the target selection and tracking accurately can be fulfilled through the proposed method. Even under cut-in conditions, the target can also be switched to the cut-in vehicle in time. [C16]

## "GPR as an imaging device: Some problems & potential solutions"

Ground Penetrating Radar (GPR) is an invaluable tool in a wide range of applications. In each sphere of activity to which the technology is applied, however, there is a tension between gaining meaningful information and the time and resources committed to data collection, processing and interpretation. In the light of the current world economic crisis, this is not likely to ease. [C17]

## "Methods of target recognition for UWB radar"

With the growth of embedded components (GPS, radar, cameras...), road vehicle becomes more and more intelligent and reassuring. The concept of the intelligent vehicle is to make it able to analyze, individually and independently, the external data before transmitting them to the driver. In recent years, ideas for studies and research programs on this concept have proliferated in different environments. The cars now have tools to control speed, manage traffic and ensure the avoidance collision task. A radar, that allows to detect obstacles in the road environment and to alert the driver, is one of the very powerful devices, even essential to ensure the safety of road users. This device has the advantage of being effective anytime (fog, rain...). The arrival of Ultra Wide Band (UWB) technology for radar application allows the development of compact and relatively cheap sensors. Dedicated to military applications, radar devices using UWB are now a good tool of detecting obstacles for many applications in life everyday. These sensors could be used to measure distances and positions with greater resolution than existing radar devices or to obtain images of objects buried underground or placed behind surfaces. This paper is focused on the study of UWB radar signatures to identify the type of obstacles. [C18]

## "A fusion method of data association and virtual detection for minimizing track loss and false track"

In this paper, we present a method to track multiple moving vehicles using the global nearest neighborhood (GNN) data association (DA) based on 2D global position and virtual detection based on motion tracking. Unlikely the single target tracking, multiple target tracking needs to associate observation-to-track pairs. DA is a process to determine which measurements are used to update each track. We use the GNN data association not to lost track and not to connect incorrect measurements. GNN is a simple, robust, and optimal technique for intelligent vehicle applications with a stereo vision system that can reliably estimates the position of a vehicle. However, an incomplete detection and recognition technique bring low track maintenance due to missed detections and false alarms. A complementary virtual detection method adds to GNN method. Virtual detection is used to recover the missed detection by motion tracking when the track maintains for some periods. Motion tracking estimates virtual region of interest (ROI) of the missed detection using a pyramidal Lukas-Kanade feature tracker. Next, GNN associates the lost tracks and virtual measurements if the measurement exists in the validation gate. Our experimental results show that our tracking method works well in a stereo vision system with incomplete detection and recognition ability. [C19]

## "Cross Entropy Optimization of the Random Set Framework for Multiple Instance Learning"

Multiple instance learning (MIL) is a recently researched technique used for learning a target concept in the presence of noise. Previously, a random set framework for multiple instance learning (RSF-MIL) was proposed; however, the proposed optimization strategy did not permit the harmonious optimization of model parameters. A cross entropy, based optimization strategy is proposed. Experimental results on synthetic examples, benchmark and landmine data sets illustrate the benefits of the proposed optimization strategy. [C20]

## "Evaluation Method of Jamming Effect on ISAR Based on the Similarity of Features"

By weighing the similarity of features before and after jamming, a novel evaluation method of jamming effect on ISAR based on the similarity of features is presented in the paper. This method can reflect the impact on the target features caused by jamming, consequently, the jamming effect can be evaluated by the similarity of features. It can not only be computed easily, but also has the merit of unitary. Furthermore, Two typical noise barrage jamming modes, radio frequency (RF) noise jamming and noise frequency modulation (FM) jamming are employed in computer simulation of interference with ISAR, The results indicate the validity and feasibility of the proposed method. [C21]

## "Vehicle Tracking Using Particle Filter in Wi-Fi Network"

Location tracking for vehicle plays a key role in increasing road safety and transportation efficiency. In this paper, a Wi-Fi based real-time tracking system which can work in both indoor and outdoor environments is presented. The proposed system estimates the location of vehicle using the Received Signal Strength (RSS) fingerprints of transmitted Wi-Fi Access Points (APs) and Particle Filter (PF). A simple, effective approach based on Inverse Distance Weighting (IDW) is designed to build fingerprints database effectively. Outdoor experiments have been carried out to investigate the usefulness of IDW and PF. Experiment results show that a tracking system based on Wi-Fi signals is able to give a position estimate of moving vehicle in real time, and that it can be significantly enhanced by PF compared with by Kalman Filter (KF). [C22]

## "Adaptive Enhancement with Speckle Reduction for SAR Images Using Mirror-Extended Curvelet and PSO"

Speckle and low contrast can cause image degradation, which reduces the detectability of targets and impedes

further investigation of synthetic aperture radar (SAR) images. This paper presents an adaptive enhancement method with speckle reduction for SAR images using mirror-extended curve let (ME-curve let) transform and particle swarm optimization (PSO). First, an improved enhancement function is proposed to nonlinearly shrink and stretch the curve let coefficients. Then, a novel objective evaluation criterion is introduced to adaptively obtain the optimal parameters in the enhancement function. Finally, a PSO algorithm with two improvements is used as a global search strategy for the best enhanced image. Experimental results indicate that the proposed method can reduce the speckle and enhance the edge features and the contrast of SAR images better with comparison to the wavelet-based and curve let-based non-adaptive enhancement methods. [C23]

## "Forereaching motion generation of mobile robots for pedestrian face identification"

This paper describes the generation of forereaching motion using mobile robots for pedestrian face identification. The motion generation system estimates the positions and velocity of the pedestrians and generates a path that enables the robot to forereach the target pedestrian while avoiding the other pedestrians. In this paper, the pedestrian motion estimation method, forereaching path planning method, and experiment results are described. [C24]

## "Range Instantaneous Doppler ISAR imaging based on FRFT"

Very high resolution inverse synthetic aperture radar (ISAR) imaging of maneuvering targets is a complicated task. Due to the phase error caused by target's non-cooperative motion, we can't use conventional Fourier transform in ISAR imaging reconstruction. Therefore, the method of Range Instantaneous Doppler (RID) technique based on Fractional Fourier Transform (FRFT) is presented. First, we define a model of the ISAR received signal that is valid for maneuvering targets. In order to eliminate phase error caused by translational motion components, the strong scatter signal that backscattering from the target is used for phase compensation, which can be extracted from the echoes using FRFT. Finally, RID is proposed to reconstruct ISAR image. After time-frequency transform named SPWVD, we get the instantaneous Doppler frequency. Even without exact motion compensation, a clear image of the target, such as aircraft, is obtained, which avoids the insufficiency of conventional Fourier-based image algorithm. The theoretical analysis is validated by presenting and discussing the simulation results. [C25]

## "Specific Emitter Identification Based on Intrinsic Time-Scale Decomposition"

Practical signals such as communication and radar signals turn out to be non-stationary and nonlinear time series, and estimating instantaneous parameters of such signals in time domain will benefit detecting and identifying specific emitters, such as radio stations and aerospace targets. However, conventional methods such as Wavelet and Wigner-Ville distribution (WVD) methods are difficult to deal with these transient signals when the signal is not stationary. To provide more efficient approach for estimating instantaneous parameters of non-stationary and identifying specific emitter with high accuracy, a novel method based on intrinsic time-scale decomposition (ITD) for analytic signal is proposed in this paper. The simulation results are presented to demonstrate the power and effectiveness of this novel method. [C26]

## "SAR image target recognition based on NMF feature extraction and Bayesian decision fusion"

In this paper, a new approach of synthetic aperture radar (SAR) image target recognition based on non-negative matrix factorization (NMF) feature extraction and Bayesian decision fusion is presented for recognizing ground vehicles in MSTAR database. First, feature vectors are extracted from image chips by NMF algorithm. Support vector machine (SVM) is used to classify the feature vectors. After multiple views of the same vehicle collected at different aspects are classified by SVM, the outputs are fused by Bayesian decision fusion algorithm and then the final classification decision is generated. We evaluate NMF algorithm and the Bayesian decision fusion approach. Experimental results indicate that there are significant target recognition performance benefits in the probability of correct classification when NMF algorithm is applied and three or more views are used for Bayesian decision fusion. [C27]

## "Waveform diversity and advanced signaling strategies for the Hybrid MIMO Phased Array Radar"

The Hybrid MIMO Phased Array Radar, or HMPAR, is a notional concept for a multisensor radar architecture that combines elements of traditional phased-array radar with the emerging technology of Multiple-Input Multiple Output (MIMO) radar. A HMPAR comprises a large number, MP, of T/R elements, organized into M subarrays of P elements each. Within each subarray, passive elementlevel phase shifting is used to steer transmit and receive beams in some desired fashion. Each of the M subarrays are in turn driven by independently amplified phase-coded signals. This paper proposes new transmit signal selection strategies based on the observation that some MIMO signal sets, such as those proposed by us previously, cause a very rapid sequential or raster

scan across some field of view. Exploiting this property allows one to create and process multiple beams simultaneously. Furthermore, there exists a range-angle coupling in the transmit and receive signals that may lead to high-resolution target localization. [C28]

## "An improved particle filter based on 4D discontinuous measurements"

During the target detection of the airborne pulse Doppler (PD) radar, a 4D measurement comprised of range, azimuth, elevation and radial velocity can be obtained to track the target exactly. But the factors including the Doppler blind zone (DBZ) would result in discontinuous measurements which breaks the continuity of the target track. To be consistent with the practice, we constitute the 3D relative motion model between the airborne radar and the target based on moving platform, and deduce the character of the relative radial velocity in DBZ. According to this, an improved particle filter with relative maneuver detection is proposed. This algorithm is able to adjust the moving direction of the particles according to the type of maneuver, and maintain the tracking by predicting the possible region where the target reappear from the DBZ. The simulation results indicate the validity and feasibility of this method. [C29]

## "A target selection method for ASM based on ICP algorithm"

It's a hard task for anti-ship missile (ASM) to select the target ship from multi-objects acquired by terminal guidance radar. In this paper, a method to select the target in a ship formation is presented based on iterated closet point (ICP) algorithm. The principle of this method is described as follows: (1) a ship formation is independently detected by fire-control radar and terminal guidance radar, and the detected ships by each sensor are separately described with two point sets in a plane; (2) the target selection is realized by matching this two point sets based on ICP algorithm, i.e. finding the correspondences of points in the two point sets; (3) the correspondence of the designated ship in the point set detected by fire-control radar is the target ship to be selected. Compared with former MPR (mutual Position Relationship) method, the performance of the method in this paper is hardly influenced while the ship formation changes the course during the self-control phase of ASM. This superiority is validated by simulation results. [C30]

## "A novel method for limiting the amplitude of SAR images with the principal axis detection"

Amplitude limiting of SAR target is one important preprocessing procedure in SAR target recognition. Traditional amplitude limiting adopted simple threshold value and is usually sensitive to noise. In this paper, a novel method for limiting amplitude is proposed, which is based on the priori knowledge that normally the strong scatter points are nearby target's principal axis. First, target's principal axis and its center is detected with the strong scatter points, then the target area is estimated and the strong scatter points' amplitude are limited by a simple smooth process. Experiments on SAR image show that the proposed method can limit the amplitude of the strong scatter points and enlarge that of the weak scattering points well. [C31]

## "Application of fuzzy pattern recognition in burden surface identification"

A kind of pattern recognition method with Fuzzy clustering is applied to identify the burden surface of blast furnace. According to the information of burden surface distribution, the target clustering analysis is used to set up a standard model database. Based on the character of distribution, each target burden surface is matched into different standard model database by using fuzzy pattern recognition method. Maximal minimal similarity method is adapted in the course of fuzzy pattern recognition. The simulation results show the effectiveness of the proposed method. [C32]

## "Target recognition for marine search and rescue radar"

The key point of marine search and rescue is to find out and recognize the distress objects. At present, the visual search method is usually adopted to detect the ships in distress, and this method can only be used at good sea condition and visibility. In this paper, a new target detection and recognition system is proposed. The parameters of radar transmitter and echo graphics and the invariant moments of radar images are extracted as the system's recognition features, and the system's target classifier is based on BP neural networks. The developed recognition classifier has been tested using three kinds of target images, the target's features are used as the inputs of trained BP neural networks and the outputs of networks are target classification. Sea experimental results show that the proposed method is well-clustering and with high classified accuracy. [C33]

## "A fuzzy pattern recognition method of radar signal based on neural network"

Radar signal recognition is an important step of radar countermeasure processing. The classical recognition method is called weight distance, in which the feature parameter weights are obtained by expert and then the

weight distance of unknown radar signal and signal template in database is computed. For it existing subjectivity in setting of feature parameter weights with classical recognition method, and the computing method of recognition is too simple, all of which make recognition result can't reflect the true fact objectively. Considering this point, a fuzzy pattern recognition method based on neural network getting weights to radar signal recognition is studied in this paper, the feature parameter weights in this method are fixed on by neural network and then the unknown radar signal is recognized by fuzzy pattern recognition method. Simulation experiment and its result show the method in this paper is practicable and more reliable compared with classical method. [C34]

## "SAR Target Recognition with Data Fusion"

This paper presents an approach for synthetic aperture radar (SAR) target recognition with data fusion. The data of multi-aspect images of a target are fused by principal component analysis (PCA) or discrete wavelet transform (DWT) after preprocessing. Wavelet domain PCA is used to extract feature vectors from the fused data. Support vector machine (SVM) is applied to classify the extracted feature vectors. Experiments are implemented with three military targets in MSTAR database for analyzing the effects on recognition rate of targets caused by different number of images and aspect intervals in different fusion algorithms. The experimental results demonstrate the higher recognition rate of the proposed method than that of the method without data fusion. Therefore, the proposed method can be applied in SAR image target recognition effectively and advance recognition rate of targets significantly. [C35]

## "Research on the Recognition Method of Bridge Target in SAR Image"

An algorithm for SAR images based on knowledge of bridge over water is proposed. According to the positional relationship between bridge and river, it is pivotal for recognition to extract river correctly. First, pretreatment for SAR images is necessary, including noise reduction and image enhancement. Second, region-based threshold segmentation, region growing and mathematical morphology are used to extract water areas. Third, the water contours are extracted and traced. Fourth, potential bridge points are searched among water contours and fitted into lines which form two edge lines of potential bridge. Finally, feature extraction of potential bridges is implemented and certain rules are set to determine whether potential bridge is genuine target. The experiments show that the algorithm presented by this paper is effective. [C36]

## "Topology of high-contrast patches in SAR images"

With continuing growth in sensor capabilities and database complexity, the analysis and understanding of large data sets becomes increasingly important. Numerous researchers have recently explored the geometry and topology of high contrast patches in natural images in an attempt to understand the underlying manifold of the data. The results show that the majority of natural image patches are best represented by corners and edges, as one would expect from visual inspection. In this paper, we extend this analysis to log-magnitude SAR images from the MSTAR database. Our results show that the most representative high contrast patches in SAR images lie among the clutter however methods extracting target patches only show results more similar to that obtained for natural imagery. Contrary to their natural image counterparts however, high contrast patches in SAR imagery lack a significant geometric structure. [C37]

## "Novel side-view imaging of ships at sea for airborne ISAR"

For airborne ISAR imaging of ship targets at sea, both ship's three-dimensional rotation driven by waves in the sea surface and the relative tangential translational motion between the platform and the ship contribute to the imaging. At high sea-state and in long-range and low-altitude observation, the rotation component produced by the relative tangential motion between the radar and the ship is negligible. A well-focused side-view image of a ship formed by utilizing the ship's dominant roll and pitch is always available via a suitable imaging time selection scheme. However, the effect of the rotation due to the platform tangential motion with respect to the ship, which provides much top-view information of the ship, has to be taken into account in some cases, such as when the ship is observed in a relatively close range. In these cases, the resulting image presents a mixture of the ship side-view and top-view that is less valuable than a pure side-view image for further classification. We present a ship side-view imaging method in this paper to solve this issue. The Doppler frequency derivative of each scatterer is shown to approximately only contain the height information and is estimated and utilized for the side-view image formation, with the use of 'CLEAN' technique and a concentration measure that is introduced to increase the estimation accuracy of the Doppler frequency derivative. For a short imaging interval, the Doppler frequency derivative is approximate to a constant chirp rate. The corresponding estimation reduces to a chirp rate estimation. The proposed method is verified by experiments on simulated data. [C38]

## "Performance prediction for a coherent X-band radar in a maritime environment with K-distributed

## sea clutter"

In this paper, theory is developed for the prediction of the false alarm (PFA) and detection (PD) performance of surface targets in K-distributed sea clutter detected by means of Doppler processing techniques. Vital to this analysis is the inclusion of the correlation properties of the sea clutter between all the pulses within a burst of pulses. The resultant technique allows for the prediction of PFAand PDfor each of the bins in the output of the Doppler processing stage of a fixed-threshold detector. The technique provides the ability to specify different thresholds for each of the Doppler bins. The analysis is extended to include Swerling type 1 and 2 targets for the calculation of PD. The performance of a noncoherent detector is provided for comparison. Results that demonstrate the application of the developed theory are also presented. [C39]

## "A spatiotemporal model for radar HRRP sequence recognition"

A temporal factor analysis (TFA) model which can describe both the spatial structure and temporal dependency of high range resolution profiles (HRRP) has been proposed for radar HRRP sequence recognition. Variational Bayes method and Bayesian classifier are adopted for model learning and classification task, respectively. The favorable results based on measured data show the effectiveness of this model. [C40]

## "Radon transform and the modified envelope correlation method for ISAR imaging of multi-target"

In multi-target ISAR imaging, if the returned signals are range non-separable and the relative radial velocity is large. We can neither resolve them in range domain nor the Doppler frequency domain. In order to solve this problem, the use of the Radon transform and a modified envelope correlation method for multi-target ISAR imaging is presented. The radon transform is used to align the range profiles coarsely. For more accuracy alignment, a modified envelope correlation method is proposed. After range alignment, phase compensation is fulfilled by Discrete chirp-Fourier transform (DCFT). The simulation results show that the method proposed in this paper is effective. [C41]

## "Ultra-wideband forward scatter radar fence for maritime surveillance-Initial experimental results"

The work described in this paper is a continuation of previous analytical work that has progressed to an experimental phase. The paper discusses the development of an ultra-wideband (UWB), forward-scatter radar (FSR) system for the detection and (ultimately) automatic recognition of low reflectivity maritime targets. Here we present the concept, developed hardware and selected initial experimental results. A number of novel ideas have been developed to reduce cost, size, prime power requirement, complexity and utilise the advantages of FSR operation. System benefits include increased target cross section (over conventional bi/monostatic radar), increased target detection capability, robustness to stealth targets, decrease in sea clutter effects from synthesis of extremely narrow beams whilst using omni directional antennas and sub-Hertz Doppler frequency measurement capability. The experimental work investigates the use of an UWB FSR fence for security, UWB propagation measurements, UWB sea clutter measurements at very low grazing angles, UWB spectral coverage and the synthesis of narrow beamwidth antennas using forward scatter pulse transmission. [C42]

## "A target alignment algorithm for through-the-wall radar imagery classification"

Sensing through the wall using radar is a valuable capability. There is considerable work in generating radar images of the interior of a room by beamforming of the radar backscatter generated in a Synthetic Aperture Radar (SAR) configuration. However, high level interpretation of the scene is a more difficult task. In previous work a minimum distance classifier was successfully used to recognize various targets placed in the scene. The approach suffered from the dependency of target features on target location. This work presents a solution to this problem by bringing the target intensity profiles into alignment with the training data prior to classification. The alignment is performed by moving the intensity profiles between locations using an Autoregressive Moving Average (ARMA) model. The classification results before and after alignment show a marked improvement. [C43]

## "Moving target detection and characterization with circular SAR"

In this work, we examine ground target detection and characterization from radar data, which incorporates a modelbased optimization method called dynamic logic (DL). We apply our methodology to a prototype airborne radar platform called Gotcha, developed by the Air Force Research Laboratory/Sensors Directorate/Automatic Target Recognition Division in recent years. The aircraft traces out a circular path around an area of interest, and the onboard, side-looking radar transmits and receives energy at a constant pulse repetition frequency, while the main beam direction is maintained at a fixed aim point on the ground. Data collected during any appropriate length arc of the flight path can be used to create synthetic aperture radar (SAR) images of the

ground. The data can also be used for ground moving target indication (GMTI) and provide Doppler/Range imagery of the same ground area. Our approach combines the computation of Range-Doppler surfaces and a variable target velocity backprojection SAR method. Potential targets are detected using multiple backprojection images and features are extracted using adaptive mixture models. We demonstrate the feasibility of our approach using target truth information provided with the Gotcha dataset. We outline the steps toward implementing a comprehensive automatic target tracking solution based on presented methodology. [C44]

## "Pedestrian detection procedure integrated into an 24 GHz automotive radar"

Driving a car is a dangerous task! There are about 5000 fatalities on German streets every year, which is absolutely too much. Human beings have strong limitations in the ability to measure precisely the distance and the speed difference between cars which is the reason for several accidents. Therefore some individual assistance is needed. A radar sensor measures the target range and radial velocity very accurate and with high resolution even in multiple target situations and there is tremendous progress in 24 GHz radar sensor development. The objective of this paper is to protect vulnerable road users by a target recognition scheme. Therefore, a pedestrian detection procedure is additionally integrated into the 24 GHz automotive radar sensor. [C45]

## "Scattering Centers Extraction of Radar Target Using Biquaternions"

Scattering centers estimation results are significant for radar target recognition in high frequency section. This paper introduces biquaternion theory into full-polarization scattering centers extraction of radar target. Firstly, we define full-polarization scattering centers as a biquaternion model. It makes a close connection between polarization parameters. Then, we propose Bihan's BQ-MUSIC thought to extract scattering centers' position parameters. Simulations illustrate that our theory gets better estimation results compared to polarization MUSIC algorithm of complex model. [C46]

## "Sparse representations for automatic target classification in SAR images"

We propose a sparse representation approach for classifying different targets in Synthetic Aperture Radar (SAR) images. Unlike the other feature based approaches, the proposed method does not require explicit pose estimation or any preprocessing. The dictionary used in this setup is the collection of the normalized training vectors itself. Computing a sparse representation for the test data using this dictionary corresponds to finding a locally linear approximation with respect to the underlying class manifold. SAR images obtained from the Moving and Stationary Target Acquisition and Recognition (MSTAR) public database were used in the classification setup. Results show that the performance of the algorithm is superior to using a support vector machines based approach with similar assumptions. Significant complexity reduction is obtained by reducing the dimensions of the data using random projections for only a small loss in performance. [C47]

## "Analysis of induced surface currents on high velocity target using a relativistic approach"

Radar is an electromagnetic system used for the detection and location of objects based on reflection. It operates by radiating energy into space and detecting the echo signal reflected from an object or target. This work analyzes how currents are induced on targets by the electromagnetic waveforms radiated by an antenna when the object is moving at high velocity. It is assumed that the target is a perfect electric conductor moving at high velocity. This work analyzes how the amplitude, the frequency and the duration of these currents are affected by the target velocity. The transmitted electromagnetic waveforms can then be calculated using vector potentials and by using the Lorentz transformation, the electromagnetic waveform is transformed from the stationary reference frame to a moving reference frame. Currents induced on the object can be modeled by using the transformed waveform and the equivalence principle. The object radiates an electromagnetic waveform as a consequence of the induced currents. The radiated waveform is calculated using the vector potentials and once more the reflected waveform is transformed from the moving reference frame to the stationary reference frame using the Lorentz transformation. Finally the equivalence principle was used to calculate currents induced in the antenna by the reflected electromagnetic waveforms. The relationship of the induced current on the antenna as a function of the target velocity is analyzed. [C48]

## "A radar target recognition method based on wavelet power spectrum and power offset"

Radar high resolution range profile (HRRP) is sensitive to the target aspect and highly overlapped in feature space between different targets, thereby hybrid features are suitable for representing the target's property. In this paper, the quadratic spline wavelet with compact support properties was used to extract the energy spectrum features of HRRP by multi-resolution decomposition, and the power offset was defined to characterize the Structural characteristics of aircraft under different target-aspect. Then the joint features which combine the

energy spectrum features and the power offset of HRRP were selected in the kernel space. The simulation results based on support vector machine (SVM) classifier show that the proposed method is effective. [C49]

## "A novel approach to synthesize the range profile via predesigned stepped-frequency waveforms"

In stepped-frequency radar systems, the phase error due to target motion in each burst make range profiles blur. Conventional technology, such as motion compensation, requires velocity estimation to eliminate the distortion of the synthetic range profile. However, it suffers a major drawback, namely that it is difficult to achieve real-time accurate estimation of the velocity of the target. A novel technology is presented to achieve a focused target range profile via predesigned stepped-frequency waveforms. By applying a new stepped frequency waveform, HRRP of the target can be obtained by the Fourier transform without any other process. The simulation results demonstrate the effectiveness of the proposed technology. [C50]

## "Feature matching and result feedback in radar and infrared fusion"

Based on difference of target azimuth sensitivity between radar feature and infrared(IR) feature, this paper presents a new algorithm for fusion recognition. By estimating the target azimuth through the infrared feature matching, the search domain of radar feature base and calculation of feature training are reduced. Through introducing a new conflict ratio of fusion, recognize feedback is used to avoid mistake. The results have shown the availability of this method through simulated the algorithm. [C51]

## "Modified combination rule of D-S evidence theory"

For solving information fusion problem of inequality important information in integrated target recognition the concept of evidence weight is introduced based on D-S reasoning. For transformation of each evidence according to its weight difference the evidence synthesis is completed using tradition method in integrated target recognition of different grade using this method the problem of target recognition of only same grade sensor using tradition evidence theory can be solved. An identification example using this method indicates that the precision and effectiveness of target recognition are raised. [C52]

## "Automatic target recognition of SAR images based on the fuzzy neural networks"

ATR (automatic target recognition), based on SAR (synthetic aperture radar) image, is crucial to the success of battlefield awareness and has become a very hot research topic. But many problems, which are caused by a great deal of missing, polluting, and superimposing of the signals, still generally exist in practical application, such as the low recognizing rate. How to recognize the useful signals from badly polluted images has become a difficult point in remote sensing image process. Thus, this paper will provide a way to recognize radar signal automatically by using the fuzzy neural networks. [C53]

## "A target polarization recognition method for radar echoes"

This paper distinguishes ship target from chaff by their difference in depolarization characteristics using fully polarized dual-channel radar which transmits vertical and horizontal polarization wave alternately and receives co-polarization and cross-polarization components simultaneously with two channels. It recognize the target by taking advantage of the difference of the vertical and horizontal depolarization characteristic parameters of the target and chaff in radar echoes, after enlarging the difference between the cross-polarization component and co-polarization component of the radar echoes involving both target and chaff. furthermore, non-linear polarization transformation is adopted to increase the chaff and targets separability and to improve the recognition rate in result. In the end, the recognition result is proved to be more desirable by processing information in polarization domain than in time and frequency domain. [C54]

## "Detection of human targets using ultra-wide band through-the-wall radar"

In this paper, an ultra-wide band (UWB) through-the-wall radar (TWR) prototype is described, and experiments are performed on detecting human targets behind wall. An adaptive background subtraction method is applied to signal processing to reduce clutter and antenna couplings. Range-time histories of an adult male person behind wall are presented for different locomotion states such as standing, marking time, and walking along cross-range direction. [C55]

## "Slow-time multi-frequency radar for target detection in multipath scenarios"

We propose a method to detect a target in the presence of multipath reflections, employing sequential transmission of multiple frequencies in a slow-time (pulse-to-pulse) approach. First, we develop a parametric

measurement model that accounts for the multipath components at multiple frequencies as well as Doppler shifts. Then, we develop a statistical detection test and analytically evaluate its performance characteristics. Based on the performance analysis, we propose an adaptive algorithm to select the best combination from a subset of frequencies that maximizes the detection performance. Our numerical examples show that the sequential approach requires more coherent pulses to match the performance of the simultaneous usage of multiple carriers in OFDM format. We also study the extent of performance degradation due to employing a subset of available frequencies. [C56]

## "A spectral space-variant approach for structure indexing in Spotlight TerraSAR-X data"

Modern space missions equipped with SAR instruments provide high spatial resolution data. In such data features of urban objects, man-made structures, as well as natural targets can be identified. We propose a descriptive model based on the frequency spectra of the complex signal, that integrates the radiometric, geometric, and texture features, for scene and target indexing, to cope with the problem of large database queries and information retrieval. Considering the properties of the Spotlight imaging mode in particular, a phase correction algorithm is applied to the data, prior to feature extraction. The assignation of a particular scene to a certain class is done using a Bayesian Support Vector Machine classifier. The method allowed for the recognition of more than thirty targets and structures in the scenes. [C57]

## "Facial expression invariant head pose normalization using Gaussian Process Regression"

We present a regression-based scheme for facial-expression-invariant head pose normalization. We address the problem by mapping the locations of 2D facial points (e.g. mouth corners) from non-frontal poses to the frontal pose. This is done in two steps. First, we propose a head pose estimator that maps the input 2D facial point locations into a head-pose space defined by a low dimensional manifold attained by means of multi-class LDA. Then, to learn the mappings between a discrete set of non-frontal head poses and the frontal pose, we propose using a Gaussian Process Regression (GPR) model for each pair of target poses (i.e. a non-frontal and the frontal pose). During testing, the head pose estimator is used to activate the most relevant GPR model which is later applied to project the locations of 2D facial landmarks from an arbitrary pose (that does not have to be one of the training poses) to the frontal pose. In our experiments we show that the proposed scheme (i) performs accurately for continuous head pose in the range from 0° to 45° pan rotation and from 0° to 30° tilt rotation despite the fact that the training was conducted only on a set of discrete poses, (ii) handles successfully both expressive and expressionless faces (even in cases when some of the expression categories were missing in certain poses during the training), and (iii) outperforms both 3D Point Distribution Model (3D-PDM) and Linear Regression (LR) model that are used as baseline methods for pose normalization. The proposed method is experimentally evaluated on data from the BU-3DFE facial expression database. [C58]

## "Ocean-land segmentation based on active contour model for SAR imagery"

Ocean-land segmentation is a basis for oceanic targets detection for SAR imagery. The traditional manual segmentation method can acquire a fairly good result, while it is unable to achieve a satisfying efficiency. Thus the manual method is unsuitable for batch processing. Ocean map based land masking method requires a priori information, which restricts its application. This paper presents an automatic active contour model based ocean-land segmentation method for SAR imagery. This method forces the active contour to the real coastline by variation level set. Under the restriction of minimizing a given energy function, the method obtains the final segmentation result when the active contour is overlapped on the coastline. In addition, an optimizing method is proposed to improve its computation efficiency, which makes our segmentation method more applicable. [C59]

## "FDTD analysis of three-dimensional target covered with inhomogeneous unmagnetized plasma"

A normalized RC-FDTD algorithm is applied to study both the bistatic and monostatic radar scattering of perfectly conducting sphere covered with inhomogeneous unmagnetized plasma. The effects of electron density distributions and plasma collision frequencies on the radar cross section (RCS) are discussed respectively. The simulations confirm that plasma cladding can be successfully used to reduce the RCS of a conducting sphere at almost all scattering angles, although the RCS could increase at some other angles. And the back scattering results indicate that plasma cladding can reduce the RCS of the conducting sphere in a very wide frequency range. Reasonable selection of the plasma parameters can enhance the effectiveness of plasma stealth. [C60]

## "A probabilistic framework for joint segmentation and tracking"

Most tracking algorithms implicitly apply a coarse segmentation of each target object using a simple mask such as a rectangle or an ellipse. Although convenient, such coarse segmentation results in several problems in tracking-drift, switching of targets, poor target localization, to name a few-since it inherently includes extra non-

target pixels if the mask is larger than the target or excludes some portion of target pixels if the mask is smaller than the target. In this paper, we propose a novel probabilistic framework for jointly solving segmentation and tracking. Starting from a joint Gaussian distribution over all the pixels, candidate target locations are evaluated by first computing a pixel-level segmentation and then explicitly including this segmentation in the probability model. The segmentation is also used to incrementally update the probability model based on a modified probabilistic principal component analysis (PPCA). Our experimental results show that the proposed method of explicitly considering pixel-level segmentation as a part of solving the tracking problem significantly improves the robustness and performance of tracking compared to other state-of-the-art trackers, particularly for tracking multiple overlapping targets. [C61]

## "Feature extraction and optimization of representative-slice in ambiguity function for moving radar emitter recognition"

Radar emitter recognition is an important and challenging subject in radar signal analysis and processing. In this work, an ambiguity function (AF) representative-slice based feature extraction and optimization algorithm is presented for unintentional modulation recognition of moving radar emitters. It considers near-zero slices of AF as representative feature set of radar emitters, which not only coincides with the characteristics of real radar signals, but also mitigates the computation problem and avoids undesired cross terms in existing AF based method. Direct Discriminant Ratio (DDR) criterion is further utilized to preserve the most discriminant features and boost recognition accuracy, by ranking the kernel points along the representative-slice. Experimental results validate the practical usefulness and high stability of the proposed approach on real data of moving radar emitters, as well as synthetic radar data from U.S. Naval Research Laboratory. [C62]

## "Development of a tree structured hierarchical wavelet representation of synthetic database to NCTR"

In this paper, problem of efficient representation of large database of target radar cross section is investigated in order to minimize memory requirements and recognition search time, using a tree structured hierarchical wavelet representation. Synthetic RCS of large aircrafts, in the HF-VHF bands, are used as experimental data. Hierarchical trees are built using wavelet multiresolution representation and K-means clustering algorithm. Criteria used to define these hierarchical trees are described and the obtained performances are presented. [C63]

## "3D feature estimation for sparse, nonlinear bistatic SAR apertures"

We present an algorithm for extracting 3D canonical scattering features observed over sparse, bistatic SAR apertures. The input to the algorithm is a collection of noisy bistatic measurements which are, in general, collected over nonlinear flight paths. The output of the algorithm is a set of canonical scattering features that describe the 3D scene geometry. The algorithm employs a pragmatic approach to initializing feature estimates by first forming a 3D reflectivity reconstruction using sparsity-regularized least squares methods. Regions of high energy are detected in the reconstructions to obtain initial feature estimates. A single canonical feature, corresponding to a geometric shape primitive, is fit to each region via nonlinear optimization of fit error between the complex phase history data and parametric scattering models using a modification of the CLEAN method. Feature extraction results are presented for sparsely-sampled, nonlinear, 3D bistatic scattering prediction data of a simple scene. [C64]

## "Automatic recognition of multiple targets with varying velocities using quadratic correlation filters and Kalman filters"

Automatic target recognition (ATR) systems require detection, recognition, and tracking algorithms. The classical approach is to treat these three stages separately. In this paper, we investigate a correlation filter (CF)-based approach that combines these tasks for enhanced ATR. We present a Kalman filter framework to combine information from successive correlation outputs in a probabilistic way. Our contribution is a framework that is able to locate multiple targets with different velocities at unknown positions providing enhanced ATR with only a marginal increase in computation over other CF ATR algorithms. [C65]

## "Characteristics of ships in harbour investigated in simultaneous images from TerraSAR-X and PicoSAR"

An experiment has been carried out with simultaneous Synthetic Aperture Radar (SAR) imaging of ships in harbour from the satellite-based system TerraSAR-X and the small helicopter-based radar PicoSAR. The targets are two large passenger vessels. The data sets are well suited for studying the results of different radar

parameters and imaging geometries, in particular different resolution, azimuth angle and elevation angle. The imaging geometry plays an important role for the appearance of the ships in the SAR images. In satellite images from a high elevation angle the layover makes the silhouettes of the ships visible. The silhouette can be used as a feature for target recognition and be compared with a reference set of silhouettes produced from 3D models. Experimental results demonstrate a potential for ship recognition from TerraSAR-X images following this approach. With low elevation angle typical for an airborne system, top-view projections of the targets appear in the images, and the silhouette can not be used as a feature. Analysis of the high-resolution PicoSAR images reveals the importance of relatively small structures in the radar signatures. An example is the poles in the railings, which give a significant contribution to the total backscattering. It is therefore natural to assume that a reference set for target recognition based on scatterer positions should include the scattering from such structures. [C66]

## "Robust automatic target recognition using extra-trees"

In this paper, we describe a new automatic target recognition algorithm for classifying SAR images based on the PiXiT image classifier. It uses randomized sub-windows extraction and extremely randomized trees (extra-trees). This approach requires very little pre-processing of the images, thereby limiting the computational load. It was successfully tested on an extended version of the public standard MSTAR database, that includes targets of interest, false targets, and background clutter. A misclassification rate of about three percent has been achieved. In this paper, we describe a new automatic target recognition algorithm for classifying SAR images based on the PiXiT image classifier. It uses randomized sub-windows extraction and extremely randomized trees (extra-trees). This approach requires very little pre-processing of the images, thereby limiting the computational load. It was successfully tested on an extended version of the public standard MSTAR database, that includes targets of interest, false targets, and background clutter. A misclassification rate of about three percent has been achieved. [C67]

## "Radar HRRP statistical recognition with Local Factor Analysis by automatic Bayesian Ying Yang harmony learning"

Radar high-resolution range profiles (HRRPs) are typical high-dimensional non-Gaussian and inter-dimensional dependently distributed data, the statistical modelling of which is a challenging task for HRRP based target recognition. Considering the inter-dimensional dependence, a recent work applied Factor Analysis (FA) to model radar HRRP data and showed promising recognition results, which however still restricts to Gaussian distribution. This paper aims to simultaneously consider the inter-dimensional dependence and the non-Gaussian distribution, by using Local Factor Analysis (LFA) model. For not only learning parameters but also appropriately selecting the component number and local hidden dimensionalities, we adopt the automatic Bayesian Ying-Yang (BYY) harmony learning, in order to relieve the extensive computation and inaccurate evaluation encountered in the conventional two-phase implementation. Moreover, a heuristic aspect-frame partition is implemented based on the BYY harmony criterion rather than AIC or BIC in the previous work, to tackle the radar HRRP's target-aspect sensitivity. Experiments show improved recognition performances over on the same measured HRRP dataset, i.e., for both equal interval and heuristic aspect-frame partitions, LFA automatically learned by BYY always outperforms FA selected by a two-phase procedure with either AIC or BIC. [C68]

## "Automatic through the wall detection of moving targets using low-frequency ultra-wideband radar"

This paper presents a time-domain, Moving Target Indication (MTI) processing formulation for detecting slow-moving personnel behind walls. The proposed time-domain MTI processing formulation consists of change detection and automatic target recognition algorithms. We demonstrate the effectiveness of the MTI processing formulation using data collected by an impulse-based, low-frequency, ultra-wideband radar. In this paper, we describe our radar system and algorithms used for the automatic detection of moving personnel. We also analyze the false alarm and detection rate of four operational scenarios of personnel walking inside wood and cinderblock buildings. [C69]

## "Bat-inspired ultrasound tomography in air"

Classification of targets is of great interest to the radar and sonar community. The development of modern systems has resulted in a drive to improve automatic target recognition in order to be able to identify targets under all weather and clutter conditions. Echolocating mammals, such as bats, have an imperative to identify the targets they depend on for their survival and have evolved an excellent ability to detect, select, and attack prey even in the most challenging environments. They acquire multi perspective information as to construct an image of the target in the way a typical tomographic image is developed. In this paper ultrasound high range resolution profiles of a real scaled target are processed to exploit tomographic images at ultrasound frequencies in air.

Results are discussed and related to the radar case. [C70]

## "A TBD algorithm based on dynamic-programming for dim radar target detection"

When the received echo signal energy reflected from a target is quite small, the target cannot be detected reliably with traditional accumulation and detection method. In this paper, based on the stable factor, an improved method is proposed, which utilizes the difference of correlation characteristics between clutter and target to suppress clutter spike. Then the track-before-detect algorithm based on dynamic-programming is applied to dim radar target detection. Compared with the combination method of coherent and non-coherent integration, the predominance of the algorithm is obtained on dim radar target detection. [C71]

## "SAR image target extraction based on 2-D leapfrog filtering"

This paper reveals that the classical R-D imaging algorithm can not remove the strong noise and extract the objects in R-D imaging image by their range and azimuth matching filters. Though 2-D DCT-DWT or 2-D DFT-DWT can be a 2-D filtering for the issue, while the algorithms need huge computation amount, they can not process SAR image real time. To solve the problem, this paper develops a new 2-D filtering algorithm based on 2-D leapfrog filter, which is good at extracting the SAR image target clearly. The 2-D recursive filter is of few multiplications for SAR image each pixel to realize fast and real-time image filtering. Practical experiments of SAR image processing have shown that the approach and algorithm are correct, effective and pragmatical. [C72]

## "Radar track-before-detect algorithm of dim target based on track test"

This paper proposes a track test-based track-before-detect algorithm for radar target detection. Track test is used to estimate the target motion model. The implementation of this scheme on the search tracks and the detection strategy on the energy accumulation values of tested tracks are presented. Simulation results show the proposed algorithm have better detection performance and tracking performance, compared with the dynamic programming-based track-before-detect algorithm. [C73]

## "Parameters estimation of target with precession based on combined feature"

It is beneficial for the recognition and classification of targets to obtain geometrical and motional parameters simultaneously. This paper proposes a new method to estimate parameters of target with precession based on combined feature, which is generated by Doppler feature and high range resolution feature of target from a new radar-OFDM radar. Expanded Hough transform (EHT) is employed to establish the combined feature with range and motion information of scatterers. The paper mainly presents the principle to establish the combined feature and the estimation of precession angle, target posture and target length. Finally, the results from simulations and anechoic chamber data prove the validity of the method. [C74]

## "Influence and compensation of target motion on monopulse estimation in PD radar"

Pulse Doppler (PD) radar system with monopulse estimation can effectively acquire the location information of weak target, since it combines the advantages of coherent integration and monopulse technique. However, as it takes some time to realize the coherent integration, target motion will result in the decline of integration efficiency, thus affects the angle measurement precision. This paper investigates the principle of monopulse estimation in PD radar and the influence of target motion on angle measurement. A modified expression for angle measured value is presented when target has tangential motion, which can be interpreted as the midpoint angle of target motion track. Moreover, the target radial motion can be compensated by envelope interpolation method in time domain with the prior information of velocity, or by Keystone transform method in frequency domain without velocity information. Finally, the availability of the modification and compensation is verified by simulation. [C75]

## "Ballistic missile precession frequency extraction by homomorphic filtering"

In order to extract the precession frequency, which is an important feature parameter in ballistic missile target recognition, we first establish the dynamic Radar Cross Section (RCS) signal model for a conical ballistic missile warhead with precession motion. A homomorphic filter is designed to remove the scintillation effect in the RCS signal. Simulations show the practical usefulness of the proposed method in extracting an estimate of the precession frequency. [C76]

## "Micro-Doppler effect analysis based on inverse synthetic aperture imaging LADAR"

Although the micro-Doppler (m-D) effect can provide additional information for target recognition, the microwave

radar cannot afford enough resolution to detect the m-D effect of small targets and long distance targets. To obtain high range resolution for the extraction of the fine m-D signatures, inverse synthetic aperture imaging LADAR (ISAIL) is used here. Because of the frequency modulation continuous wave (FMCW) laser signal is used in ISAIL, the m-D effect of ISAIL is different from the microwave radar. In this paper, the m-D effect of ISAIL is analyzed and compared with that in X-band radar. The experiment results show that ISAIL can offer sufficient information of micro-motions when the feature of motions is tiny. [C77]

## "Radar angular superresolution algorithm based on Bayesian approach"

Angular resolution is the key parameter of radar. Conventional means of increasing angular resolution are dependent on the size of the antenna aperture. In framework of maximum likelihood, this paper presents an iterative algorithm to restore the target location information and then to obtain angular superresolution. Theoretical analyses indicate that algorithm accelerates convergence speed and achieves angular superresolution efficiently, and computational burden is relatively small. Simulation results show that the algorithm can efficiently attenuate the effect of antenna pattern convolution and highly enhance angular resolution; test data results show an order of improvement in angular resolution over real aperture image, also confirm that the method could obtain angular superresolution. [C78]

## "Relationship of target identification performance and waveform parameters"

In this paper, we established rigorous relationship between target recognition performance and the parameters of a fixed waveform via Kullback-Leibler information number of single observation (KLINs). The method we proposed takes advantage of the methodology of sequential hypothesis test. It depicts the target recognition efficiency of certain radar waveform parameter in the metric of average number of necessary signal (ANS) transmission. Compared with the traditional simulation methods in literature, it is a more efficient and valuable one to find the optimum values of a certain waveform parameter. Simulation results about the parameters of LFM signal show the validity of the method. [C79]

## "Automatic target recognition based on neutral networks"

Several researches published about artificial neural networks are connected with military problems. This research put forward ideas connected with the processing of military information to search and identify targets-automatic target recognition (ATR). A main-purpose automatic target recognition system did not exist. The research put forward here was demonstrated on military data, however it could only be considered as a proof of principle until systems were fielded and proven "under-fire". A TR data could be in the form of non-imaging one-dimensional sensor returns, such as ultra-high range resolution radar returns for air-to-air automatic target recognition and vibration signatures from laser radar for recognition of ground targets. The ATR data could be two-dimensional images. The most common ATR images were infrared, but current systems might also deal with synthetic aperture radar images. Finally, the data could be three-dimensional, such as sequences of multiple exposures taken over time from a no stationary world. [C80]

## "Target decomposition for fully polarimetric wideband radar system"

For fully polarimetric wideband radar system, a novel method of radar target recognition using polarimetric feature is proposed. First, polarimetric scattering matrix is obtained from fully polarimetric high resolution range profiles(HRRPs). Then, two different kinds of polarimetric features are extracted by polarimetric target decomposition theorem. At last, K-Nearest Neighbors(KNN) classifier is applied to verify the recognition performance of these two features. The simulation experiments indicate target recognition via polarimetric features can reach a higher recognition performance in different experimental scenarios. [C81]

## "Roll invariant target detection based on PolSAR clutter models"

Based on the Kennaugh-Huynen decomposition, the Target Scattering Vector Model (TSVM) allows to extract four roll-invariant parameters. Those parameters are necessary for an unambiguous description of the target scattering mechanism. The proposed method consists in applying the TSVM prior to the GLRT-LQ detector for the detection of any oriented target. [C82]

## "Study on emitter signal recognition based on rough sets and grey association theory"

Recognition degree of unknown radar emitter signal can be describe by upper and lower approximation sets of Rough Sets. From the uncertain degree measure by multi-sensors, pessimistic and non-pessimistic distances of every object to sensors and grey association matrix can be calculated by grey association theory. According α,β and grey association matrix, grey association degree and fusion result can gain. The simulation results show the

method of combining Rough Sets and Grey Association theory is effective, and it can be applied on radar emitter signal recognition, especially in decreasing the uncertain degree introduced by multi-sensors. [C83]

## "A novel STAP method for the detection of fast dim air moving targets"

Space-time adaptive processing (STAP) is an effective method for moving target detection in airborne radar. In this paper, a novel STAP method for fast dim air moving target detection is proposed. The new method suppress clutter in the received data firstly, and then apply Keystone formatting (KF) to compensate the target's range walk. Finally, target is accumulated by the conventional space-time beamforming. Effectiveness of the new method is verified via simulation examples. [C84]

## "The imaging research of the ground moving targets in forward scattering radar"

The present shadow inverse synthetic aperture radar (SISAR) imaging algorithm is derived based on some assumptions for air moving objects such as long baseline, large target size and so on. For the forward scattering radar (FSR) system to detect ground moving targets, the assumption conditions are often unsatisfied because of relatively small objects size, the strong ground clutter and the short baseline length. Furthermore, the assumptions will result in distorted imaging results for the extraction of profile median line and height difference using the present imaging algorithm. To obtain the accurate imaging results of ground moving target, the more accurate signal model for ground moving target is first time presented based on Fresnel-Kirchhoff diffraction formula and high order phase approximation methods, and the modified imaging algorithm is also proposed for the accurate profile reconstruction of ground moving target. Finally, the effectiveness is verified by simulation results. [C85]

## "A micro-motion feature deception jamming method to ISAR"

One of the main features of IS AR target recognition is the micro-motion feature. In order to jamming target recognition of IS AR, a micro-motion feature deception jamming method to ISAR based on digital image synthesizer is presented in this paper. In this method, the constant Doppler frequency of the scatterer in the template of false-target is replaced by the time-varying micro-Doppler frequency that produced by micro-motion scatterer, and the intercepted radar signals are modulated by the modified template of false-target in the slow time. The research results shows that this method can add the micro-motion information to the echoes of rigid body targets, and realize the micro-motion feature deception jamming to ISAR, Furthermore, the validity of the jamming method is justified by simulation experiment. [C86]

## "Spread clutter mitigation via knowledge-aided STAP in miltiple-input single-output system"

In Multiple-Input Single-Output (MISO) HF surface wave radar system, the fact that bistatic operation and the movement of the receiver platform causes the nonstationarity and spreading of sea clutter, which will lead to the difficulty in detecting those immerged targets. The space-time distribution of sea clutter in different geometry is firstly investigated; and a knowledge-aided STAP scheme is proposed for mitigating the clutter. The weights of different range bins are acquired from both the clutter priori and the prefiltered training data by direct data domain (DDD) algorithm. Numerical simulation shows the proposed scheme effective. [C87]

## "Quantum Neural Network Algorithm Based on Multi-agent in Target Fusion Recognition System"

The paper presents the quantum neural network algorithm based on multi-agent in target fusion recognition system. Firstly, it discusses the distributed cooperation and solution synthesis in MAS and describes the design of target recognition system. In that, the key techniques of task cooperation, task distribution and solution synthesis based on information fusion are demonstrated. Then quantum neural network is introduced to the MAS, by synthesizing the infrared and radar features of target from the 2 heterogeneous recognition agents, the membership function value is calculated, and the fusion membership function value is gained by using multi-layer excitation function. According to the fusion data, the true target is found out. The experiment shows its satisfactory performance and effectiveness. So the solution presented by the authors is valuable for designing distributed fusion target recognition system under heterogeneous sensors and target characteristics being imitated each other. [C88]

## "Radar target discrimination using neural networks"

Time domain response based neural network and frequency domain response based neural network have been proposed for radar target recognition. In this paper, we propose a natural frequency based neural network for radar target recognition. Our scheme makes advantage of an aspect angle independence of a natural frequency. In the results, we show that, for the multiple aspect angles, natural frequency based neural network is superior to

time domain response based neural network. [C89]

## "Parameter selection of MIMO radar under the long time integration"

Long time integration is a common work mode for multiple-input multiple-output (MIMO) radar. In this mode, the accumulation effect is seriously affected by range migration. To solve this problem, we derive an expression, which describes how the accumulation output changes with the target velocity, bandwidth, and other factors, based on the MIMO radar moving target echo model. This expression quantifies the relation between the range migration and the influence factors. It can be used to determine the range of the target velocity in which the motion compensation is needed. Further, through appropriate parameter selection, such as choosing a proper transmission bandwidth etc., the influence of the range migration on accumulation output is minimized. The correctness of the theoretical results is verified by simulations. [C90]

## "Autonomous marine craft navigation: On the study of radar obstacle detection"

Technological advancements over the years have increased the use of Radar technology in the field of robotics, especially in marine robotics to aid obstacle detection algorithms. Obstacle detection comprises of an analytical process in which different algorithms are applied to the field of study to determine the range of objects that are within the reach of a robot. Radar signal analysis and target detection in conjunction with target tracking are attributes required for autonomous marine navigation. The paper presents a model which converts optimal estimates of radar range values for each range spectra into multiple targets down-range and also presents an approach for power range spectra (range bins) prediction using the radar range equation with adequate information of the signal-to-noise ratio (SNR) of the radar. Obstacle detection in the presence of noise raises certain probabilities of false alarms. Target characteristics are simulated and these are fluctuating targets and non fluctuating targets. Analytical models, simulations and techniques of obstacle detection for autonomous marine craft navigation using a continuous wave radar system were points of discussion in the paper. [C91]

## "On the polarization response using resonances for target recognition"

In most studies concerning resonance based target recognition, targets are usually excited and measured using a linear polarized basis and at the same time ignoring the cross polarization component. In this paper, the possibility of using circular polarization in this context is investigated. Numerical results of some simple wire targets demonstrate that it would be easier to fully excite all of the important resonances using a circular polarization basis with due consideration of the co- and cross-polarized directions. [C92]

## "Net based waterside security applications: From small solutions to maritime security networks"

The protection of military harbours is a complex task. A force protection system integrates several sensors and databases for ashore and waterside surveillance: • passive sensors (acoustic, magnetic, CCTV, IR, FO fence) • active sensors (Radar, Diver Detection Sonar) • remote / autonomous vehicles for inspection and surveillance • chart database • information database Additionally a network-based waterside security application should integrate several additional sources and services e.g.: • WEB based Automatic Identification System (AIS) • Satellite based AIS • Access to online databases e.g. weather information, ship register data • C4I data e.g. MCCIS (NATO C4I system) or JoCIS (EADS export C4I system) Also, new technical possibilities of modern multi touch HMI approaches and aspects of user centric man machine interface design will be discussed. [C93]

## "Predicted radar/optical feature fusion gains for target identification"

Airborne tracking and identification (ID) of high value ground targets is a difficult task impacted by sensor, target, and environmental conditions. Layered sensing, using a combination of standoff and short-range sensors, maintains target track and identification in cluttered environments such as cities or densely vegetated areas through sensor diversity. Data, feature, decision, or information fusion is necessary for high confidence target classification to be achieved using multiple sensors and sensor modalities. Target identification performance is improved by exploiting the extra information gained from independent sensing modalities through information fusion for automatic target recognition (ATR). Increased target ID has been demonstrated using spatial-temporal multi-look sensor fusion and decision level fusion. To further enhance target ID performance and increase decision confidence, feature level fusion techniques are being investigated. A fusion performance model for feature level fusion was applied to a combination of sensor types and features to provide estimates of a fusion gain. This paper presents a fusion performance gain for Synthetic Aperture Radar (SAR), electro-optical (EO), and infrared (IR) video stationary target identification. [C94]

## "Discremination of adjacent radar targets via the E-pulse technique"

In all radar detection systems, the antenna system has resolution that is inversely proportional to the antenna beam-width. Even with a very narrow beam-width, the resolution decreases with the increase in the target height. The resolution is defined by the capability to discriminate between targets. In this paper, we propose the target identification scheme, the Extinction pulse "E-pulse", to discriminate between two targets that lie within the antenna main beam. In this paper, the discrimination procedure is tested using two adjacent cylinders illuminated by an incident plane wave with arbitrary incidence angle. The scattered field is calculated using the XFDTD software package. [C95]

## "Enhanced supervised neighborhood preserving embedding for radar target recognition"

Recently, the computer vision and pattern recognition community has witnessed the rapid growth of a new kind of dimensionality reduction method, namely manifold learning. Among them, neighborhood preserving embedding (NPE) is one of the most promising techniques, which can be performed in either unsupervised or supervised mode. In this paper, a new dimensionality reduction algorithm, called enhanced supervised neighborhood preserving embedding (ESNPE), is proposed. ESNPE can enhance the local within-class relations by taking into account class label information. Moreover, neighbors are found according to a new distance metric instead of Euclidean distance, aiming for better generalization. Experimental results on radar target recognition with range profiles indicate the superior performance of the proposed method, compared with PCA, NPE and supervised NPE (SNPE). [C96]

## "Extraction method of large-scale linear objects from SAR images"

Public safety concerns have been raised by potential safety problems due to deformation of infrastructures such as railways, highways and bridges. Monitoring the deformation of large-scale man-made linear objects (LMLO) by permanent scatters (PS) interferomerty would be critical to prevent this kind of disasters. However, the estimation of LMLO deformation is sensitive to the influence of those random PS from nearby natural objects. Thus, extraction of LMLO from PS images is the necessary condition for an accurate monitoring of LMLO deformation. In this paper, a new procedure of extraction LMLO from SAR images is proposed based on classification, morphological operations and line recognition methods. A preliminary step, merging optical image, would be identification of man-made objects regions from background. Image of permanent scatters (PS) points from PALSAR data will then be masked to remove unrelated PS points. Then a set of morphological operations and line feature extraction methods are performed to connect PS points continuously distributed along the linear target. This method is successfully applied to a PALSAR image to extract the Lantau Link highway (LLH), Hong Kong and the experiment result demonstrates its validity on comparison with the ground truth in optical image. [C97]

## "Stability criterion of angle tracking systems in real time under conditions of interference distorting direction finding characteristic"

The article considers stability of the automatic angle tracking systems under conditions of interference distorting direction finding characteristic. The automatic angle tracking is described in the system state. Since the estimation of the modulus of continuity in the theorem on continuous dependence of the characteristic roots on matrix elements accepts very significant roots change under small matrix perturbations of the such that these perturbations cannot be simulated by computer, hence, the stability criteria based on characteristic roots location analysis are not always convenient for practical applications. In this article a stability criterion is proposed which is determined by solving the differential equation system of the system. A computational procedure is obtained which allows us to determine the stability of automatic control system in real time. The solution is not sensitive to significant changes in the characteristic roots under small matrix perturbations of the system. Well-timed detection of the forthcoming loss of the automatic target tracking provides an opportunity to protect the system in automatic mode and therefore minimize jamming effects. [C98]

## "Intelligent Processing Research for Target Fusion Recognition System Based on Multi-Agents"

According to the target fusion recognition under dynamic and uncertain target information conditions, a distributed target fusion recognition model is presented based on multi-agents. As a distributed multi-agents target recognition system, the model includes several widely distributed agent workgroups. The model is mainly made up of the detection agent, the recognition agent and the decision-making agent. The detection agent mainly realizes characteristics matching and sensor conditions controlling, the recognition agent is composed of information fusion algorithms into the nesting agents, the decision-making agent carries out various decision-making and cooperation mechanism. Then, the intelligent fusion processing under dynamic and uncertain environment is realized through communication and cooperation of the three agents for the actual condition request. It combines MAS and information fusion technology in target recognition system, and incarnates the

advantages such as flexibility, reliability. Finally, by analyzing a ballistic target recognition experiment, the result is shown the model efficiency is advanced by the means. [C99]

## "Waveform Design and Optimization in Radar Sensor Network"

We investigate the use of information theory to design waveforms for the measurement of extended radar targets in radar sensor networks (RSN). The different channel gains for transmitting signals from different radar sensors are introduced to model the radar system channel. Given the transmitting signals, we optimized the estimation waveforms that maximize the mutual information between a target ensemble and the received signal within additive Gaussian noise given the transmitting signals so that characteristics of the target could be well recognized. We also study the maximum mutual information with the constraints of the number of radar sensors, waveform energy and duration, which could be taken into consideration when waveforms are designed for RSN. [C100]

## "Theory and simulation of statistical representation of the Stokes parameters in multilook fields based on polarization basis transformation"

A novel analytical representation of polarimetric Stokes parameters' distributions and their lower-order statistics are derived via the joint Wishart distribution of the covariance matrix of the stochastic multi-look speckle fields by using the polarization basis transformation. The last three Stokes parameters are expressed as a universal form by three parameters of the number samples, the degree of polarization and the polarization weight, which is an extension and generalization of R. Touzi and Y.Q. Jin by considering multiple look radar images, and can be used directly to describe the radiometric data in low resolution radar with polarimetric capabilities. The physical meanings of Stokes parameters via polarization basis transformation bring a short cut for solving the probability density function (PDF) of Stokes parameters. The simulated and experimental data are calculated to justify the expressions derived by us, which provide an excellent match with the novel representation. The conclusion can be useful to speckle reduced, classification and target recognition in complex environments or other applications. [C101]

## "Synthetical Generalized Discriminant Analysis for radar HRRP target recognition"

The prevalent applications of traditional statistical discriminant methods for radar High Range Resolution Profile (HRRP) target recognition are designed to obtain Common Discriminant Information (C-DI) among all classes at the expense of Individual Discriminant Information (I-DI) between them, so they may lose slight I-DI between close-set classes and result in a dissatisfied recognition performance. To overcome this weakness, we design a Distributed Generalized Discriminant Analysis (D-GDA) for I-DI extracting, and accordingly, a new variation called Synthetical Generalized Discriminant Analysis (S-GDA) is presented to deal with C-DI and I-DI equally. Experimental results for simulated data show that GDA and D-GDA are complementary in many facets and can be considered as a feature extraction method couple. Furthermore, compared with GDA and D-GDA, the proposed S-GDA not only achieves the best recognition performance, but also is more robust to many challenges, such as noise disturbance, aspect variation and Small Sample Size (SSS) problem. All these experimental facts confirm that C-DI and I-DI are different as two aspects of Discriminant Information (DI) but both are beneficial to target recognition. [C102]

## "Speckle noise reduction in SAR images using adaptive morphological filter"

Speckle noise is one of the most critical disturbances that alter the quality of Synthetic Aperture Radar (SAR) coherent images. Before using SAR images in automatic target detection and recognition, the first step is to reduce the effect of speckle noise. Several adaptive and non-adaptive filters are widely used for despeckling in SAR images. In this paper, an adaptive mathematical morphological filter is proposed to reduce the speckle noise in SAR images. The new filter performance is compared with a number of despeckling filters with different parameters. For performance measurements, several parameters were evaluated to test the filter ability to attenuate the speckle noise and keep target information. From experimental results, the new proposed morphological filter gives promising results for significantly suppressing speckle noise and preserving the potential targets. [C103]

## "Full polarimetric SAR classification based on Yamaguchi decomposition model and scattering parameters"

The full polarimetric information of the target from polarized Synthetic Aperture Radar (POLSAR) enables us to implement recognition and classification of remote sensing images more effectively. Based on the analysis of typical polarized target decomposition and classification, the issue proposes a new scheme for iterative

classification of polarimetric SAR image, which blends the outcomes of Yamaguchi decomposition and H/α decomposition. This technique extracts four decomposition coefficients of four scattering mechanism components through Yamaguchi decomposition, the scattering entropy and angle through H/α decomposition first; then the initial classification of the POLSAR images is done by the combination of the 6 parameters mentioned above. The final result is obtained by iterative classification due to coherence scattering matrix following wishart distribution. The effectiveness of this method plus less computation required is demonstrated by the experimental results of polarimetric SAR data. [C104]

## "A survey on feature extraction of SAR Images"

The feature extraction is one of the key steps for SAR ATR. It can greatly reduce the amount of information processing by SAR ATR, improve the identification efficiency, reduce the time of recognition and lower resources utilization by means of the feature extraction. In the beginning, the feature extraction methods are classified by target type and then various categories methods are summarized. Finally, some unsolved problems of feature extraction are probed. [C105]

## "A refuse-recognition method for radar HRRP target recognition based on mahalanobis distance"

In the radar automatic target recognition (RATR) system using high resolution range profile (HRRP), if a test sample has not been trained in training phase, it would lead to a full miss classification in test phase. In this paper, we design a classifier based on generalized confidence, which can efficiently refuse-recognize a new target. Firstly, principal component analysis (PCA) method is used to extract feature vector from every sample. Secondly, the classifier calculates each feature vector's generalized confidence on mahalanobis distance. Consequently, the distribution of confidence is used to define a refuse-recognition threshold for each training target. In test phase, for each trained-target in the database, we suppose that the test sample belongs to current target, calculate the generalized confidence, judge whether the test sample really belongs to the target or not via comparing the confidence with the target's refuse-recognition threshold. The final class is determined by vote. The experimental results demonstrate the effectiveness of the proposed algorithms. [C106]

## "Odd-Symmetry Template based three-step detector for IR-UWB radar"

The detection scheme for robust detection and target location in the presence of interference is presented. The problem of detecting the slow-moving target at noisy background is addressed in this paper. A novel kind of Odd-Symmetry Template Correlation (OSTC) process is developed as the first-step of the detector. The OSTC method has a better performance due to interference suppression than traditional ones. The Range-Extended Constraint and Threshold Feedback technique is proposed as the second-step for detecting range-extended target and controlling the false alarm rate. The Multi-Cycle Fusion method completes the third-step detection procedure, and improves the detection reliability by reducing false alarms. Experimental results are given to demonstrate the efficiency of this approach. Moreover, the effectiveness of this method allows for real-time execution. [C107]

## "Ramp response radar imaging: Analysis of frequency parameters"

Low frequency imaging in radar domain can have applications for stealthy or buried targets. Transient scattering response from a ramp waveform is related to the profile function of the target, namely its transverse cross-sectional area along the line-of-sight, and it thus provides information about the target size, orientation and geometrical shape. Indeed, such profile functions can be used for generating a 3-dimensional image of the target shape. However the required frequency band is very large and may involve difficulties for experiments as well as simulations. That is why, we propose to study the effect of these frequency parameters on targets profile functions and, consequently, on their reconstructed shape. [C108]

## "A New Method for Target Aspect Estimation in SAR Images"

The target aspect estimation is important to Synthetic Aperture Radar Automatic Target Recognition (SAR ATR). Due to the nature of SAR imaging, the front edges are comparatively distinct and stable features in target images, and are suitable for target aspect estimation. In this paper, a new method is proposed for target aspect estimation. A simple adaptive threshold processing is used to extract the strong scatters in target area. By analysis on the projection distribution in different directions of the strong scatters, the normal front edge response is defined and is used as basis of the aspect estimation. The 90-degree correction is carried out on several unreliable results in the last step. According to the results of experiments on the MSTAR public database, the proposed method can achieve the optimal performance compared with the major edge fitting method, while has simpler processing flow and higher computing efficiency. [C109]

## "A Novel Long-Distance Measurement Method Based on Secondary Radar"

In this paper we present a novel method for high precision long-distance measurement based on secondary radar. In this method, we employ two transceivers unit to work in an acknowledged mode as secondary radar system to achieve the round-trip time-of-flight (RTTOF), and introduce a system group delay (SGD) to estimate the time of the measurement signal through the system circuit. The real RTTOF related to the measured distance is acquired by deducting the SGD in the RTTOF. The prototype operates within the 433MHz ISM-Band. The results show the method has a good preference in long distance measurement at 1 km and the measurement principle is robust towards multi-path effect and target identification. [C110]

## "Micro-Doppler extraction from ballistic missile radar returns using time-frequency analysis"

The spinning motion of a ballistic missile (BM) induces periodic frequency modulations on the returned radar signal. This micro-Doppler modulation frequency is a stable and unique parameter in radar target recognition. This paper first establishes the radar signal model of the spinning missile during flight, and then extracts the micro-Doppler modulation frequency through analysis of the periodic structure of the resulting spectrogram (short time Fourier Transform (STFT))-i.e., the time-frequency distribution (TFD). In order to be used for BM target recognition we implemented a data-dependent optimal window length for the STFT. We treated the resultant TFD as an image and then used the 2-D DFT/FFT for feature extraction. Experimental results illustrate the validity of the proposed method. [C111]

## "Dynamic Template Preparing and Application on FLIR Target Recognition"

Template matching technology has been widely used in FLIR guiding. When using FLIR guiding weapon attack targets, the target imaging in the FLIR lens will be distorted by size and shape. In order to prepare the corresponding dynamic template, it proposes a new target dynamic template preparation method using the simulated 3-D scene of the target and the weapon flight track. Based on that method, an experiment of template preparation and IR real-time picture matching is completed. The results of the experiment show that the matching templates prepared using that method can realize relatively high successful-matching probability. Furthermore, that method can be widely applied for all types of targets; the reader can refer to and benefit from it when facing FLIR target recognition problems. [C112]

## "Algorithm research on ladar range image segmentation"

Image segmentation is the key factor for target recognition of ladar range images. Morphological watershed segmentation is a steady method, which can produce a closed curve. In this paper, a watershed segmentation based on markers is used to carry out emulational experiments on image segmentation of range images: simulated range image of coherent ladar, background-suppressed range image and range image processed by adaptive histogram filter. Experimental results show that applying the method of background-suppression and adaptive histogram filter, the segmentation of range image is satisfying. [C113]

## "On the design of integrated HF radar systems for Homeland Security applications"

In this paper, HCAC's research and development efforts on the development of integrated and low cost HF radar for coastal surveillance and other Homeland Security applications are summarized. The proposed design incorporates electrically small antenna for rapid deployment, supports operation on floating platforms by using enhanced DSP algorithms to mitigate clutter, incorporates improved propagation modeling to more accurately select optimum frequency channels based on atmospheric conditions and overcome the errors due to terrain effects, utilizes Genetic Programming for automatic target recognition and classification, and provides for passive radar operation utilizing existing broadcast transmitters to enable covert operation. [C114]

## "Automatic target recognition in SAR images using multilinear analysis"

In this paper, we investigate an approach based on multilinear analysis for synthetic aperture radar automatic target recognition (SAR/ATR). High resolution SAR images are the composite consequences of multiple factors: bearing angle, grazing angle, number of views and polarisation. Linear methods like principal component analysis (PCA) require to reshape images into a high dimensional vector. This vectorisation processing breaks natural structure and correlation in the original data set. Moreover the PCA, based on a matrix singular value decomposition (SVD), allows only one factor to vary in the image database. Multilinear analysis provides a powerful mathematical framework to analyse ensembles of images resulting from the interaction of underlying factors and preserves their original shapes. In this paper, we propose a method based on multilinear principal component analysis (MPCA) to classify unlabeled targets. We form a tensor with the images of the training set and use the higher order singular value decomposition (HOSVD) to reveal interesting patterns and dependencies

between images. HOSVD is also used to compress the data and remove all information belonging to the background. A multilinear projection algorithm projects the unknown target into multiple basis which characterize learned classes. Tests using real SAR images database show that the multilinear approach provides very good recognition performance with a very high compression rate. [C115]

## "Target automatic recognition based on ISAR image with wavelet transform and MBLBP"

A novel feature extraction algorithm of Inverse Synthetic Aperture Radar (ISAR) image based on wavelet transform (WT) and multi-scale block local binary pattern (MB-LBP) is proposed in this paper. Firstly, the mathematical morphology method is adopted to enhance ISAR image. Secondly, 2D wavelet transform is used to get the low frequency sub-band image from the enhancement ISAR image. Then, ISAR image is divided into small regions from which block local binary pattern (BLBP) with different weight histograms are extracted and concatenated into a feature vector to be used as an efficient ISAR descriptor. At last the classification is performed by using a nearest neighbor classifier with Chi square as a dissimilarity measure in the computed feature space. The experimental results on three kinds of aircraft targets show that the method performs very well. [C116]

## "A new method of radar target recognition based on time-frequency analysis"

In this paper, focused on three targets with simple structure, such as cone, sphere and cone, cylinder and cone, dynamic RCS echo signals is predicted with the improved Greco software. The Dynamic RCS echo signals of targets with micro-movement are preprocessed by using short time Fourier transform, and high-resolution time-frequency distribution images are obtained. A new radar target recognition method based on time-frequency distribution images is proposed. Pixel scan technique is adopted to extract the feature vector, and the nearest neighbor classifier is used for classification decision. Compared with the target recognition method based on singular value decomposition, the correction probability for recognition of the proposed method is higher. Simulation results verify the correctness and the effectiveness of the proposed method. [C117]

## "High range resolution DVB-T Passive Radar"

Passive Radar systems, also referred to as Passive Coherent Location systems (PCL), exploit reflections from illuminators of opportunity (IO) in order to detect and track objects. Digital waveforms like DVB-T and UMTS signals offer wide bandwidth channels which allow achieving good spatial resolution. Moreover, they have spectral properties which are nearly independent of the signal content. Such waveforms exhibit an ambiguity function with a thumb-tack shape and bandwidth that is constant in time. This paper focus on the usage of multiple channels of the same IO (e.g.: DVB-T or UMTS channels) in order to improve range resolution and make target recognition and radar imaging feasible. Specifically, two different architectures based on the exploitation of multiple DVB-T channels have been considered. A DVB-T transmission system has been simulated with a Simulink® model compliant to. Simulation results are presented and discussed in order to evaluate the system performance in terms of spatial resolution. [C118]

## "Coherent LADAR range image for target recognition using Back-propagation neural network"

Range, intensity and Doppler images can be obtained by using coherent LADAR (laser radar). Range image is closely relative to physical structure property of target surface, and it can reflect essential characteristics of targets. At present the research on automatic target recognition technology for LADAR is attention-getting. The Back-propagation neural network (BPNN) has been used in multi-layered feed-forward adaptive neural networks, deserving special attention. In this paper, BPNN is introduced to recognize Vehicles on the ground with different carrier to noise ratio (CNR) of clutters, different orientations of target, and different distances between the object and sensor. The results of simulation show that the BPNN is feasible and effective for the target recognition. [C119]

## "Estimation of efficiency of a tree structured hierarchical wavelet representation of synthetic database applied to Non-Cooperative Target Recognition"

In this paper, problem of efficient representation of large database of target radar cross section is investigated in order to minimize memory requirements and recognition search time, using a tree structured hierarchical wavelet representation. Synthetic RCS of large aircrafts, in the HF-VHF bands, are used as experimental data. Hierarchical trees are built using wavelet multiresolution representation and K-means clustering algorithm. Criteria used to define these hierarchical trees are described and the obtained performances are presented. [C120]

## "Optimal sensor placement for multi-bistatic ISAR imaging"

Inverse Synthetic Aperture Radar (ISAR) images are typically used for target recognition and identification purposes. The target projection on the ISAR image plane depends on the target's own motions and on the relative position of target and radar. Since targets of interest are often non-cooperative, the first condition is not under the radar's control. Nevertheless, the relative radar-target position can be somehow controlled or predicted in some cases. Moreover, the use of multiple receivers enhances the likelihood that a desired radar-target position occurs during radar measurements. In this paper, the theoretical aspects of optimal sensor positioning for obtaining desired ISAR image projections are detailed. A mathematical tool will be presented that is able to predict the optimal sensor positions for maximising the probability of obtaining a desired ISAR image. Real data will be used that demonstrate the effectiveness of the proposed tool. [C121]

## "Target Recognition Based on the Self-Correlation Function of HRRP"

The theoretical result shows that the self-correlation function not only has the time-shift invariant feature, but also largely reduces the computational work. To overcome the sensitivity of High-Resolution Range Profile(HRRP), this paper has extracted the self-correlation function of HRRP as a feature for target recognition. Templates and test data are created by using the measured data of sea targets. The results of comparison among the self-correlation function feature, the original range profiles and the amplitude spectrum feature show that the self-correlation function feature has higher recognition efficiency and better anti-noise performance. [C122]

## "Increasing airport security with the development of high accuracy location algorithms based on ray-tracing techniques over WLAN networks"

Airport security focuses on providing a cost effective and efficient operation to deliver high-quality and secure service to customers. For this, different technologies are deployed. For example, primary radar is used to detect airplanes during flight approach. Cameras, surface radar, and triangulation systems are deployed for ground surveillance. The ultimate goal of these systems is to improve the efficiency and safety of airport operations. However, airport areas where aircraft are parked, loaded, refueled, and boarded, present a high risk due to the large number of vehicles, goods and people involved in the aircraft handling activity. We propose different algorithms to improve location accuracy of vehicles and goods in critical airport areas where GPS satellite and radar coverage does not provide adequate target localization resolution. [C123]

## "Effect of the polarization on SISAR imaging and feature recognition in forward scattering radar"

In this paper, the effect of the polarization and the multipath on shadow inverse synthetic aperture radar (SISAR) imaging is analyzed respectively in forward scattering radar (FSR). The multi-polarization and the multipath imaging results of targets, based on SISAR, are discussed respectively. In addition, the target forward scattering (FS) RCS under multi-polarization conditions are also obtained using CST simulation software to research the effect of multi-polarization on moving target feature recognition in FSR. [C124]

## "GNSS illuminator based high range resolution algorithm in space-surface bistatic SAR"

Space-surface bistatic synthetic aperture radar (SS-BSAR) has gained more and more researcher's interests. In this paper, we focus on improving range resolutions of GNSS illuminator based SS-BSAR with the method of spectrum synthesis of ultra-wide-band (UWB). Narrow bandwidth signals, such as GPS P code, can be spliced into a wider signal. Simulation results show that it can effectively increase signal processing bandwidth, improve range resolution and target recognition capabilities. [C125]

## "Pose estimation for ISAR image classification"

This paper presents aircraft target recognition (ATR) system using Inverse Synthetic Aperture Radar (ISAR) images. Knowing the pose of the target can improve the ATR performance (recognition rate and computational complexity). So, we propose in this paper a new pose estimator from ISAR images, based on the axis of symmetry and the similarity measure. The method proposed is compared with several approaches proposed recently in the literature, such as 2-D Continuous wavelet Transform and Hough transform. Once the pose of target is estimated, the classification if finally performed by K-Nearest Angle (KNA) classifier which insert the pose information into image retrieval task. [C126]

## "An experiment for oil spill recognition using RADARSAT-2 image"

In this paper, an experiment that is oriented to discriminate between different oil slicks using polarimetric SAR

image was introduced. Dark patches which often appear in SAR images such as biogenic slicks, atmospheric front, and crude oil with different chemical composition were identified according to the result of Eigenvector-Eigenvalue based Incoherent Target Decomposition. The experiment demonstrated that polarimetric SAR can be of great help in classifying of oil spills. [C127]

## "NFIPO based technique for near-field angular glint calculation of radar targets"

Based on recently developed near-field iterative physical optics (NFIPO) and the Poynting vector method, near-field angular glint calculation formulations are derived and applied to perfect electric conducting (PEC) radar targets, which are of great importance for radar seeker applications. Numerical results are presented with new findings to demonstrate the usefulness of the proposed technique. [C128]

## "Log-polar and polar image for recognition targets"

We describe in this paper, data processing algorithms applied on radar image in order to extract feature descriptors and then to perform recognition task. Several kinds of descriptors can be used to acquire information about target characteristics from radar images such as ISAR (Inverse Synthetic Aperture Radar) images. This paper presents two types of vector descriptors extracted via two minds of transformed images so-called polar and log-polar images obtained respectively from the polar and log-polar mapping. In order to guarantee the invariance of some geometrical transformation, additional processing are proposed. In this paper, we present the polar and log-polar transformations and then the classification scheme adapted on correspondent polar and log-polar templates. In the classification step, log-polar and polar mapping results are compared using adapted classification scheme. [C129]

## "Generic object recognition in high resolution SAR images"

This paper presents a non-parametric modeling scheme for high resolution SAR data, based on Short Time Fourier Transform which is able to integrate the radiometrical and morphological properties of the data, for object recognition, scene and target indexing, addressing the problem of large data base queries and information retrieval.. The method is assessed by using a Bayesian Support Vector Machine image search engine based on a hierarchical learning model. The method allowed for the recognition of over 30 different classes, both homogeneous and heterogeneous urban objects with high levels of details. Qualitative and quantitative measures for evaluation are presented and discussed. [C130]

## "Navigation Satellite Passive Radar Moving Target Detection and SAR Imaging Based on FRFT"

Conventional radars have less invisibility, but the passive radars based on TV, FM signals also have some restrictions in SAR imaging by a range of issues such as ground electromagnetic environment and signal silence. This paper presents a new method of passive SAR imaging based on navigation satellite signal with single/multiple receive-only mode in FRFT domain. The received reflection of single multiple GPS signals from target is approximately linear FM signals which can be transformed by FRFT for signal frequency and Doppler frequency detection and estimation, especially for the target SAR imaging. Simulation results shown the effectiveness of the algorithm, and help to avoid the multi-target SAR imaging interference. [C131]

## "Detecting and Identifying Two Stationary-Human-Targets: A Technique Based on Bioradar"

Bioradar is a novel kind of radar combining the technology of radar and biomedical engineering. It can detect vital signals (such as breath, heartbeat, movement, etc.) in a certain distance through the nonmetal substances (such as brick walls, rubble, etc.) without using electrodes or sensors. However, multi-stationary-human-target identifying and locating has not been resolved yet. Based on the Ultra Wide-band (UWB) bioradar, we developed a method combining biomedical signal processing and space-frequency analysis to distinguish two stationary human subjects in different distances and to identify the location of each human subject. Experiments were done to evaluate the effectiveness of the proposed method. In 86 data sets the accuracy of distinguishing two stationary subjects reached 73%. This method may serve as a basis for further studies in developing appropriate 2-Dimension locating image reconstruction models via multi-antenna (static) UWB radar. [C132]

## "Extraction of Radar Target Length Based on High Resolution Range Profile"

In the identification of radar target based on high resolution range profile (HRRP), the target length is an important feature. It can be used not only for the rough sort to decrease the time of identification, but also for the interception of real target echo information from the raw data to reduce noise redundancy. In this paper, an adaptive difference operator for target length feature extraction from HRRP is proposed. It is used to deal with three airplane-measured data. Experimental results and analysis are provided to show that the proposed method

can effectively acquire the radial projection length of the target with high precision even in case of lower Signal-to-Noise Ratio (SNR). [C133]

## "The Research on RIC-ISAR Image of Ship Target Based on High-Order Match-Phase Transform"

Due to the constantly changing motion of a ship target, high order phase terms which cannot be neglected and results in bad azimuth focusing are generated. In this condition the RD algorithm is not a very effective way for ISAR imaging. In fact, the azimuth position of target scattering point can also be illustrated by the instantaneous chirp rate of received signal not just by the Doppler frequency. In this paper, a new approach is proposed, which is based on Product High-Order Matched-Phase Transform (PHMT) to estimate the value of the changing rate of chirp rate, chirp rate, central frequency and amplitude, thus the high quality range-instantaneous chirp rate (RIC) ISAR image of the object can be obtained. At last, the simulation results prove the effectiveness of the method proposed. [C134]

## "The database of radar echoes from various targets with spectral analysis"

In this paper we describe a database, noted as RadEch Database, containing radar echoes from various targets. The data has been collected in controlled test environments at the premises of Military Academy-Republic of Serbia. Our goal is to provide a balanced and comprehensive database to enable reproducible research results in the field of classification of ground moving targets (pattern recognition). A time-frequency analysis of radar echoes has been performed, in order to identify the main features of the various targets. The RadEch Database is freely available for download and we hope that our database provides researchers with a valuable tool to benchmark and improve the performance of classification algorithms. [C135]

## "CFAR and KPCA for SAR image target detection"

A SAR target detection model based on CFAR and KPCA is presented in this paper. This Detection is divided into a pre-screening and discrimination process. Within the large-scale and low-resolution SAR imagery, pre-screening adopts classic CFAR techniques, while the discrimination process adopts kernel principal component analysis to separate the target from clutter. Experimental results show that the detection performance of our algorithm appears to be superior to the classic CFAR methodology. The combination of both pre-screening and prior knowledge of targets can effectively enhance detection rate and inhibit false alarm at the same time. [C136]

## "Optimal sensor positioning for ISAR imaging"

ISAR imaging is a powerful signal processing that allows obtaining images of non-cooperative targets. Such images are often used as input to classification and recognition systems since they contain useful two-dimensional features. Nevertheless, the interpretation of ISAR images remains problematic since the image plane cannot be defined by the user but it depends on the target's own motions and on the relative position of it with respect to the radar. In this scenario, the only degree of freedom that is controlled by the user is the position of the sensor. In this paper, the problem of selecting an optimal position of the sensor to maximise the probability of obtaining a desired image projection plane is addressed. Moreover, mathematical tools are derived that may assist the user in deciding where to place an ISAR sensor given a priori knowledge of the scenario. [C137]

## "Target deteciton algorithm for spatial diversity MIMO radar with space partition"

For spatial diversity multiple input multiple output (MIMO) radar, target echo signals received by its widely separated antennas may be semi-correlated and different in SNR. According to the correlation and SNRs of received target echo signals, a space partition based target detection method is proposed, which partition the surveillance volume into two sections, one using the coherent accumulating detector and the other using the incoherent accumulating detector. The partition method is shown to achieve an improved detection performance at a low computation cost. [C138]

## "Multiresolution Target Detection in Wavelet Domain for SAR Imagery"

Multiresolution CFAR detection algorithm in wavelet domain using db4 wavelet is investigated in this paper, which can be incorporated into SAR image compression system. It is derived on a multiscale model of SAR imagery. Thanks to the structure of this model and detection in wavelet domain, calculation is much simpler than that of two parameter CFAR detection algorithm in image domain. Tests on simulated and collected image show that the proposed algorithm performs best. The algorithm is more suitable for the application in ROI-based image compression than two parameter CFAR detection algorithm in image domain. [C139]

## "Tracking and imaging algorithm of walking human bodies for ultra wideband radar"

The Ultra WideBand(UWB) Radar used for detecting human bodies is a promising technique in many fields such as urban-warfare, counter-terrorism and calamity rescue scenarios. Conventional UWB imaging algorithm can not meet the demand in the capability of targets recognition and calculation efficiency. The SEABED Algorithm based on the reversible Boundary Scattering Transform (BST) can be used to fast reconstruct target shape, but its application is restricted because antenna are scanned to collect data, which is impractical for systems of detecting moving targets. In this paper, walking motion was used to replace antenna scanning by assuming a system model, and a novel algorithm based on SEABED for UWB radar systems is proposed. Simulation results show that the proposed algorithm features simple hardware requirement, low calculation, and high imaging precision, and it can also estimate the velocity, image and track walking human bodies. [C140]

## "New approach of imagery generation and target recognition based on 3D LIDAR data"

Light Detection and Ranging (LIDAR) sensor is an advanced technology of 3D-measurement with high accuracy. The processing of 3D point cloud data collected via LIDAR sensor is of topical interest for 3D target recognition. In this paper, a new approach of imagery generation and target recognition based on 3D LIDAR data is presented. The raw 3D point cloud data are transformed and interpolated to be stored in 2D matrix. The target imagery is generated and visualized by means of height-gray mapping principle proposed in paper. For different poses of target, the affine invariable moments of target imagery are selected as features for recognition because of its invariance in rotation, scaling, translation and affine transformation. BP neural network algorithm and Support Vector Machine (SVM) algorithm are utilized as method of target classification and recognition. The recognition results by two algorithms are compared against and analyzed detailedly. The new method had been applied into target recognition in outdoor experiments. Different types of targets are classified and the rate of correct recognition is greater than 95%. Through outdoor experiments, it can be proven that this new method is applied to the field of 3D target recognition effectively and stability. [C141]

## "Doppler radar signatures analysis by using joint bispectrum-based time-frequency distributions"

Estimation of instantaneous frequency (IF) time-varying behavior of a non-stationary and multi-component signals embedded in additive Gaussian noise is considered for Wigner-Ville (WVD), Wigner bispectrum (WBD), parametric (PBBD) and non-parametric (NPBBD) bispectrum-based distributions. A performance comparative study between WVD, WBD, PBBD and NPBBD is carried out by computer simulations both for several non-stationary and multi-component test signals and real radar backscattered echo-signals measured by Doppler surveillance radar for a moving human. Analysis of time-frequency (TF) distributions shows that bispectrum-based approach permits to detect and extract phase coupling among pairs of Doppler IFs containing in non-stationary and multi-component wideband signals. Experimental radar micro-Doppler signatures derived from the returns measured for moving human demonstrate important information features about the object dynamics and kinematics. These information features can be useful in radar automatic target recognition systems. [C142]

## "Multiscale Orientation and Recognition for Permanent Scatterers"

How to effectively detect and identify permanent scatterers (PS) from SAR images is one of the crucial procedures in PS interferometric system. In this paper, a new method of PS detection is presented by using the wavelet multi-scale product and wavelet modulus maxima according to the PS targets' features and the characteristics of speckle noise in SAR image. This paper analyzed the theory of wavelet multi-scale product and wavelet modulus maxima and its suitability for identifying PS points respectively. Using 4 SAR images over Nanjin from satellites ENVISAT of European Space Agency, both of the methods have been validated for PS detection. The testing results show that both the two algorithm can identify PS from SAR images effectively and reliably. Of which the method using wavelet modulus maxima has stronger anti-noise ability. [C143]

## "A New Method for Estimating the Number of Targets from Radar Returns"

This paper introduced linear frequency modulation (LFM) waveforms and proposed a new method based on the Wigner transformation and Hough transformation, the new method was used to estimate the number of targets contained in the LFM radar returns. At last we got the simulation result through experiments. The simulation results show that as long as the waveforms meet the certain conditions, the number of targets contained in the LFM radar returns can be estimated exactly by the new method, whose algorithm is simple and easy to implement in works, so it has good technical expansibility, so it could not only be applied to the field of military, but also the field of civil. [C144]

## "Errors of target detecting using triangulation method in radar with phased antenna array"

In this paper a study of spatial beam pattern of electrically scanning antenna arrays in order to obtain the curve of a bearing error versus the height of bearing targets in the azimuthal plane in the cases of different ranges. [C145]

## "SAR Image Target Recognition Based on Hu Invariant Moments and SVM"

Target recognition is a key step in the application of SAR images, but because of the existing of speckles in SAR images, targets can not be recognized well by using traditional methods. According to the advantages of invariant moments extraction and support vector machine (SVM) classification, an efficient method of SAR image target recognition is proposed. First, image preprocessing is performed by using wavelet transform. Second, seven Hu moments, which have the properties of rotation invariability, translation invariability and scaling invariability, are extracted as feature vectors and are normalized. Then a SVM classifier is designed and trained by using normalized feature vectors. Finally, the testing sets of SAR images are recognized by trained SVM. In the experiments of recognizing planes and tanks, better results have been obtained with this new method. [C146]

## "Modified spin-image target recognition algorithm applied to laser radar range imagery"

We modify the spin-image matching algorithm to recognize targets in range images. It not only resolves the rotation-invariance problem existing in forward detection of laser radar (Ladar), but also meets a rapid target recognition requirement. [C147]

## "An application of DSmT in ontology-based fusion systems"

The aim of this paper is to propose an ontology framework for preselected sensors due to the sensor networks needs, regarding a specific task, such as the targets threat recognition. The problem will be solved methodologically, taking into account particularly non-deterministic nature of functions assigning the concept and the relation sets into the concept and relation lexicon sets respectively and vice versa. This may effectively enhance the efficiency of the information fusion performed in sensor networks. [C148]

## "Impact of HRR radar processing on moving target identification performance"

Airborne radar tracking in moving ground vehicle scenarios is impacted by sensor, target, and environmental dynamics. Moving targets can be assessed with 1-D High Range Resolution (HRR) Radar profiles with sufficient signal-to-noise (SNR) present which contain enough feature information to discern one target from another to help maintain track or to identify the vehicle. Typical radar clutter suppression algorithms developed for processing moving ground target data not only remove the surrounding clutter but also a portion of the target signature. Enhanced clutter suppression can be achieved using a multi-channel signal subspace (MSS) algorithm which preserves target features. In this paper, we (1) exploit extra information from enhanced clutter suppression for automatic target recognition (ATR), (2) present a gain comparison using displaced phase center antenna (DPCA) and MSS clutter suppressed HRR data; and (3) develop a confusion-matrix identity result for simultaneous tracking and identification (STID). The results show that more channels for MSS increase ID over DCPA, result in a slightly noisier clutter suppressed image, and preserve more target features after clutter cancellation. [C149]

## "Model-based integrated HRR object tracking and classification"

Radar target classification based on 2D stochastic object model matching is studied in this paper. A network of high range resolution (HRR) radars provides range measurements at multiple time steps, while the extended object is moving in the surveillance area. Alignment of the multi-aspect HRR data in a common 2D coordinate system is required. For this reason, tracking of the extended object is integrated in the classification algorithm. The novelty of this work is the estimation of the object state, conditioned on the object class, by applying the HRR data on a particle filter. A coarse-to-fine multi-resolution data processing scheme is introduced in the filter update step. The reason is the experienced filter degeneracy, when working with HRR data. The proposed processing scheme achieves accurate auto-alignment of the HRR data. The classification system successfully distinguishes between very similar objects, by applying 2D object model matching. [C150]

## "Target Detection Using Radar with Dynamic Programming Approach"

Dim point target from an image sequence has been merged into the clutter. So the image has a low SNR and the detection of the dim point target under the low conditions becomes the sticking point. We introduce a novel tracking system based on dynamic programming algorithm (DPA). This algorithm can detect the dim point targets under the condition of low SNR. The dynamic programming technique can detect the trace of the point target which is moving with straight line and reduce the calculation amount. With the result of simulation test, it can be

shown that the introduced algorithm can effectively detect moving point target trajectory in image sequences than previously developed algorithm. [C151]

## "Exploitation of track accuracy information in fusion technologies for radar target classification using Dempster-Shafer Rules"

The surveillance of the littoral is required by applications in the defence, protection and security area. One might think about anti asymmetric warfare, harbour and coastal surveillance or the prevention of smuggling, illegal fishing, illegal immigration or acts of piracy.To establish situation awareness ground, sea and air targets must be detected and tracked in the littoral simultaneously. Also the detailed classification of targets is of extraordinary importance, e.g. persons vs. vehicles, helicopters vs. planes or buoys vs. ships. This classification can be overtaken by an operator, who listens to the Doppler sound of a target. Unfortunately, obligated to the classification issue an operator gets distracted from the tactical surveillance task. Further, an operator is only able to classify a limited number of targets. Hence, automatic target recognition is an important issue for radar systems applied to the littoral surveillance. Finally, automatic target recognition offers also a synergy with the multi target tracking of such a radar system. In this paper 2 Dempster-Shafer (DS) based fusion methods will be described. Both use tracks and track accuracy information to fuse with Doppler based classified targets, in order to provide a robust classification technique for distinguishes between different kinds of targets. The first classification technique uses a hierarchical tree structured decision method, integrated in a track-based classifier. The second classification technique uses a non-hierarchical decision method also integrated in a track based classifier. In this paper both kinds of DS methods will be compared. The results will be discussed especially with respect to the following performance criteria: track accuracy, classification confusion matrix, targets hit rate, targets rejection probabilities, DS topology requirements, convergence reliability, training duration and generalization efficiency. [C152]

## "Space Target Recognition Based on Biomimetic Pattern Recognition"

Biomimetic Pattern Recognition is a new model of Pattern Recognition based on ldquomatter cognitionrdquo instead of ldquomatter classificationrdquo. This new model is much closer to the function of human being, than traditional statistical Pattern Recognition using ldquooptimal separatingrdquo as its main principle.But it has been investigated in 2D sample space, In this paper, we extend to space target Image sample space by Clifford Algebra, and study its property. The experiment result proves the efficiency of our theory. [C153]

## "High-performance pattern recognition system using an improved neural classification chain and decision fusion on multispectral information"

The performance level of pattern recognition (PR) systems can be improved using in a proper way new powerful artificial neural networks inside of its classification chains and respectively, decision fusion techniques on available multispectral information. Consequently, to increase the pattern recognition performances, an improved neural classification chain and respectively, an evolutive version of Sugeno's fuzzy integral based on high-resolution radar (HRR), video and thermal imagery use are described. To confirm the broached theoretical aspects, a real image database was used. [C154]

## "Multiple dictionaries-based radar target identification via a likelihood ratio test"

Target identification has been an active researching area in past decades. In this paper, we present an iteration procedure to optimize the size of the undercomplete dictionary when multiple undercomplete dictionaries are used to characterize the scattering signatures of a complex target. Furthermore, we extend the signature reconstruction and decision criterion with only single undercomplete dictionary to the case with multiple dictionaries for a more practical target identification application. The proposed approach is compared with the matching-score criterion-based approach and single dictionary-based approach using measured signatures of three aircraft models in an ultra wide-band chamber. Results show that the proposed approach can provide more promising identification accuracy due to a more effective representation to the complex scattering behaviors. [C155]

## "A radar ranging algorithm based on characteristic decomposition power spectrum estimation"

The linear frequency modulation (LFM) signal is the main signal form of the high resolution radar. By analysis for the principle of the LFM radar signal to realize the high range resolution profile and the impact of clutter and noise over target echo signal, we propose the method of using spectrum estimation based on the characteristic decomposition to estimate the frequency and realize the LFM signal range profile. The simulation results prove that this method to the goal 1D range profile is effective under low signal-to-noise ratio conditions. [C156]

## "Modeling of Complex Radar Target for High-Resolution Synthetic Aperture Radar Image Simulation Based on GRECO"

The electromagnetic scattering models of complex radar targets, e.g. aircrafts, vehicles etc, are of great significance to Automatic Target Recognition (ATR) of Synthetic Aperture Radar (SAR) imagery. Based on the Graphical Electromagnetic Computing (GRECO) technique, a novel implementation method of complex radar target modeling for the simulation of high-resolution SAR image is proposed. The three-dimensional (3-D) scattering modeling of the complex radar targets is founded on the basis of GRECO. Furthermore, high-resolution SAR image simulation is implemented through echo simulation and image formation procedure with the 3D scatting data generated by using GRECO. Computer simulation results of an aircraft target are provided, with high-resolution millimeter wave SAR system parameters, which illustrate the radar image characteristics such as foreshortening, layover as well as shadowing. The datasets of simulated SAR images with different elevation and azimuth angles are presented, verifying the effectiveness of the method of the paper. The simulated high-resolution SAR images could be applied in ATR research as the input source data. [C157]

## "Monitoring subsurface target changes based on cross-polarized wideband scattering"

In the context of resonance based radar target recognition, most work is done based on the co-polarized transient target signature excited by linearly polarized excitation. In this paper, the possibility of target recognition based on a cross-polarized wideband transient signature is investigated. Numerical examples of monitoring subsurface target-depth changes demonstrate that the cross-polarized transient target signature can also be applied to these applications. In addition, for the first time, the possibility of applying the e-pulse technique together with cross-polarized target signature for monitoring geometrical changes of subsurface target is also investigated. [C158]

## "Radar techniques for human gait automatic recognition"

In this paper we extend the investigation on the use of Doppler signatures for human motion detection. As it is well known, human movements generate additional Doppler frequencies on top of the main Doppler carrier. In recent times research has been trying to exploit this effect for dynamic feature extraction and, consequently, automatic target recognition. Here a simulation tool is developed and measurements are presented as a term of comparison. Several scenarios that model arbitrary trajectories and multiple targets are analyzed. Finally we provide an insight into the potential using more than one sensor. This may improve dramatically the performance of the system as it does in many other radar applications. [C159]

## "Passive short range X-band frequency doubling transponder"

Various radar methods exist to identify and distinguish stationary and moving objects. Well known methods include synthetic aperture radar (SAR), millimetre-wave real aperture radar (RAR) and interferometric synthetic aperture radar (IFSAR) systems. In specific cases, one is interested to recognize a unique signal from objects. For example, in search and rescue operation radars, unique signals are identified from the Search and Rescue Transponder (SART) that is attached to the object of interest. However, unwanted clutter echoes can severely limit the detectability of the target. Clutter can be caused by obstacles, rain and surface reflections, is unpredictable and it cannot be easily removed. This paper presents the development of a low-cost, passive X-band transponder using frequency doubling to eliminate the problem of clutter. The passive transponder comprises of two rectangular patch antennas, a bandpass filter and a passive frequency doubler. Theoretical calculations show that such a passive transponder is able to operate at a range of about 1 km away from the radar. [C160]

## "Performance analysis of resonance based radar target recognition with different excitation bandwidth using the E-Pulse technique"

Under different excitation bandwidth, the number of the resonant modes that will be excited from the radar target will be different. As a result, different numbers of resonant modes will be involved in the target recognition process and the performance of target recognition may also be affected. The objective of this paper is to study how the variations of the excitation bandwidth that may affect the performance of resonance based target recognition. In particular, the E-Pulse technique is chosen and numerical examples of two stick model aircrafts will be used to investigate this problem. [C161]

## "Rare Class Mining: Progress and Prospect"

Rare class problems exist extensively in real-world applications across a wide range of domains. The extreme

scarcity of the target class challenges traditional machine learning algorithms focusing on the overall classification accuracy. As a result, purposefully designed techniques are required for effectively solving the rare class mining problem. This paper presents a systematic review of the major representative approaches to rare class mining and related topics and gives a summary of the important research directions. [C162]

## "Underwater target detection from multi-platform sonar imagery using multi-channel coherence analysis"

This paper introduces a new target detection method for multiple disparate sonar platforms. The detection method is based upon multi-channel coherence analysis (MCA) framework which allows one to optimally decompose the multichannel data to analyze their linear dependence or coherence. This decomposition then allows one to extract MCA features which can be used to discriminate between two hypotheses, one corresponding to the presence of a target and one without, through the use of the log-likelihood ratio. Test results of the proposed detection system were applied to a data set of underwater side-scan sonar imagery provided by the Naval Surface Warfare Center (NSWC), Panama City. This database contains data from 4 disparate sonar systems, namely one high frequency (HF) sonar and three broadband (BB) sonars coregistered over the same area on the sea floor. Test results illustrate the effectiveness of the proposed multi-platform detection system in terms of probability of detection, false alarm rate, and receiver operating characteristic (ROC) curves. [C163]

## "Precession character study of space target in midcourse"

Characters analysis for space target is the basis of target modeling. Here I analyzed the precession characters of axis-symmetry and non-axis-symmetry targets in midcourse, gave some simple models and computational formulas on precession parameter for targets such as true warhead, bait with same profile, metallic air balloon, space fragment and mother cabin. It has more significance on modeling and simulation for characters of targets in midcourse. [C164]

## "Classifier Design via Projection Approximation"

In the viewpoint of inverse problem and function approximation theory, we set up a framework for pattern classifier design, wherein the classifier is assumed to be an element of a Reproducing Kernel Hilbert Space (RKHS) continuously defined on the pattern feature space. Based on the RKHS metrics, an orthogonal projection criterion is adopted for pattern feature representation so that optimal generalization capability is ensured for the classifier, with respect to minimum error norm. In addition, by orthogonally projecting the outputs of the target class samples onto the null space of an operator defined by the sample outputs of other classes, the target class is optimally discriminated from other classes, with respect to minimum mean output energy. Combination of the above two criteria yields a criterion for optimal representation and discrimination of pattern features, which yields another classifier wherein the balance between representation and discrimination may be controlled by a parameter. Some experimental results on handwritten digit classification, face recognition, and radar target recognition are given to show the feasibility of the presented classifiers. [C165]

## "3D building reconstruction from LiDAR data"

Airborne LiDAR data can be used to create 3D terrain models useful in augmented or virtual reality in which real-world landscapes are incorporated. Automatic generation of 3D models of man-made structures such as buildings is essential for creating these detailed models. We present a method that builds a 3D mesh, segments the triangles, and forms planar facets that correspond to a roof structure of a target building. We illustrate our method with real-world data sets. [C166]

## "Real-time software implementation of Passive Radar"

The paper presents a comparison of three different computing platforms for signal processing in Passive Coherent Location radar: general-purpose PC, Sony Play Station 3 and NVIDIA graphic card with CUDA technology. The radar under consideration was developed at Warsaw University of Technology, and it is called PaRaDe (Passive Radar Demonstrator). It utilizes commercial FM radio transmitters as illuminators of opportunity to detect and track airborne targets. In order to perform real-time processing, high computing power is needed. The aim of this paper was to investigate various solutions providing good performance at a reasonable price. [C167]

## "Recent advances in waveforms for radar, including those with communication capability"

New scalable and flexible waveforms offer a great number of new opportunities for object- or environment-

tailored signal processing. The paper will discuss two classes of such flexible waveforms, i.e. single carrier waveforms with orthogonal modulations and multiple carrier coded waveforms. These waveforms may for instance be used for the benefit of scalable resolution, fast unambiguous Doppler assessment, two-channel code-orthogonality supporting to measure the full back scatter matrix in radar polarimetry, and message transfer in a network by radar. [C168]

## "Feature Extraction of 2D Radar Profile via Double-Sides 2DPCA for Target Recognition"

Target recognition based on 2D radar profile is a rising application of radar technology, because 2D radar profile can offer more structural information about targets. But the methods of feature extraction based on 2D radar profile are very scarce. In this paper, a new approach double-sides 2DPCA is presented. It is performed by using original image matrices directly, while PCA always needs image matrices to be transformed into 1D vector. Besides, it can reduce the dimension of image from two sides and obtain a feature image with a much smaller size, while traditional 2DPCA, mainly used in the area of face recognition, can only reduce the size of image from one side. This approach has excellent dimension reduction property. The experimental results show that double-sides 2DPCA is effective on feature extraction of 2D radar profile and in much smaller dimension level, it has better recognition performance than traditional 2DPCA. [C169]

## "Forward scattering indicatrix of aircrafts and possibility of over-the-horizon surveillance"

The scattering indicatrixes of targets in L and S bands for bi-static angles of (180plusmn55) degrees and a method of an aircraft beyond-the-horizon detection and estimation of its range and the cross velocity, when the aircraft crosses a propagation path, are discussed in the paper. [C170]

## "Multi-frame data fusion techniques for ATR of ship targets from multiple ISAR images"

This paper deals with the topic of Automatic Target Recognition (ATR) of Non Cooperative Targets. Specifically the focus is on the ATR of ships from multiple ISAR images. An investigation on different techniques for the fusion of the information provided by multiple image frames is presented. The techniques exploit the principles of multi-feature based ATR and apply them to the case of availability of several images. The recognition process makes use of a wire-frame models library which undergoes a step of candidate models selection before feeding the target model declaration step. Both cases of centralized and decentralized data fusion techniques are considered. The performance of the proposed techniques is investigated in depth by means of simulated data. Moreover the paper provides a comparison of the results of the proposed techniques when applied to live ISAR images of ship targets. [C171]

## "Time frame selection for High PRF Pulsed Doppler radar ISAR image formation"

Inverse Synthetic Aperture Radar is a signal processing technique used to obtain high resolution images of targets. In ISAR imaging high cross-range resolution is obtained by exploiting the radar to target relative motion. The radar target kinematic affects the data grid spacing and shape in the Fourier domain (acquisition surface). When the grid is rectangular with equally spaced points, the ISAR image is focussed and it has predictable resolution properties. The object of this paper is to investigate the relationships between the acquisition surface and both the resolution and defocusing properties of the ISAR image given the radar-target kinematic. A distortion parameter that depends on the kinematic properties is defined and compared to image focus quality indicators. Simulation results are also shown considering a complex target model. [C172]

## "A statistical approach to assess randomly rough surfaces in imaging radars"

In this paper, a statistical approach to evaluate randomly rough surfaces (RRS) in an inverse scattering problem is presented. Whereas in these investigations the roughness criterions possess random variables, the use of deterministic techniques such as the target decomposition (TD) can not be useful by itself as a tool of analysis. In these conditions, a statistical approach is essentially required to evaluate the target parameters. The goal of this study is the estimation of the polarimetric signatures, such as the scattering mechanism a and the entropy H, via a novel approach including the combination of TD and a new statistical model. To validate our work, SAR data sets, provided by the European Space Agency (ESA), are analyzed and compared with the simulation results. [C173]

## "De-ghosting of tomographic images in a radar network with sparse angular sampling"

Taking into account sparsity of the reflectivity function of several radar targets of interest, efficient low-complexity automatic target recognition (ATR) systems can be designed. A low-dimensional 2D spatial model, where information on the radar target signature is compressed, can be estimated using high range resolution (HRR)

data from a sparse system of view angles. Incoherent tomographic processing of HRR data from a distributed surveillance system, made up of several radar nodes, is studied in this paper. A sparse angular sampling scheme is proposed, which exploits diversity due to both the distributed radar system and the target motion. The novelty is in the exploitation of this locally dense, but otherwise sparse set of viewing angles of the targets, obtained using a sparse network of radars. The de-ghosting efficiency of such a sampling scheme is demonstrated geometrically. This results in identification of minimal information resources for unambiguous estimation of a 2D target model, useful for radar target classification. [C174]

## "A class of Cramer-Rao optimal estimators for analysis of clutter"

Fisher information matrix can be seen as the metric of a Riemannian manifold, Fisher-Rao metric. As such it can be evolved through Ricci flow. For the case of the estimation of two parameters, the two dimensional manifold is also conformal. In this case we show that the Cramer-Rao bound is saturated as a scalar function always exists that is a also a solution of Liouville equation. This implies that in order to have an optimal estimation of parameters one have to solve this equation. This result can be extended in higher dimensions when the Fisher information matrix can be cast into a similar form as for the two-dimensional case and the estimator vector admits a potential field. Applications of this result are wide-ranging going from tracking to control theory and clutter analysis. We present an example for the analysis of sea clutter data. [C175]

## "A Radar Target Recognition Method Based on Circular Convolution Coefficients of High-Resolution Range Profiles"

In order to extract robust features for radar high-resolution range profile (HRRP) recognition, a feature extraction method using circular convolution coefficients of HRRP is proposed in this paper. The features extracted by the proposed method represent the HRRP structure information which is more robust compared with local details. Moreover, this feature can make up for the loss of HRRP local details caused by feature selection. Due to the high dimensionality and nonlinear separability of HRRP features, feature selection based on kernel class separability was also used. Experiment results on simulation HRRP data sets are analyzed to demonstrate the efficiency of our method. [C176]

## "Target detection in high clutter using passive bistatic WiFi radar"

The rapid rollout of wireless local area networks (WLANs) has provided a ubiquitous source of signal transmissions that may be exploited for surveillance applications using passive bistatic radar (PBR) and passive multistatic radar (PMR) systems. In this study, a series of experiments were conducted to examine the feasibility of using IEEE 802.11 wireless fidelity (WiFi) transmissions for detecting uncooperative targets in high clutter indoor environments. The range and Doppler characteristics of the system were also assessed theoretically from an ambiguity function analysis on WiFi signals having similar transmission parameters. Through-wall detections of personnel targets moving at differing velocities within an indoor environment are presented for the first time. The work demonstrates the feasibility for developing a low cost surveillance device that utilises WiFi networks as transmitters of opportunity. [C177]

## "Synthetic Aperture Radar moving target indication processing of along-track monopulse nonlinear gotcha data"

This paper is concerned with imaging and moving target detection using a synthetic aperture radar (SAR) platform that is known as Gotcha. The SAR platform can interrogate a scene using an imperfect circular trajectory; we refer to this as nonlinear SAR data collection. This collection can make monostatic and quasi-monostatic measurements in the along-track domain. We present subaperture-based wavefront reconstruction algorithms for motion compensation and imaging from this nonlinear SAR database. We also discuss adaptive filtering algorithms to construct MTI imagery from the two receiver channels of the system. Results will be provided. [C178]

## "Nonlinear classifier combination for a maritime target recognition task"

This research proposes a nonlinear combination of an ensemble of classifiers to improve pattern recognition performance. A maritime target recognition application is considered. A database of radar range profiles with six ship classes from various aspect angles were created. Five structurally based features are defined on the simulated range profiles. Three kinds of classifiers are used: neural network, Bayes, and nearest neighbor. The proposed nonlinear combination scheme utilizes a neural network combiner. The performance of this combiner is compared to individual classifiers as well as two other combination approaches. [C179]

## "A new approach for target localization of through-the-wall radar with unknown walls"

Based on imaging through assumed wall parameters, an approach of target localization for through-the-wall radar in the presence of wall ambiguities is proposed. The target location is estimated by finding the maximum pixel point in composite image which is composed by image sequences corresponding to different assumed wall parameters. The proposed approach is available for target localization with unknown wall parameters and robust to the target location behind the wall. [C180]

## "Ku-band retrodirective radar for ballistic projectile detection and tracking"

A Ku-band radar has been developed for detection and tracking of sniper rifle bullets and other ballistic projectiles. The radar utilizes a novel retrodirective architecture based on separate 8-element receive and transmit antenna arrays. A pseudorandom noise waveform provides for precise ranging and high processing gain. Digital filtering allows for discrimination of high-velocity bullets and small supersonic projectiles up to at least 1700 ft/s, as demonstrated experimentally in field tests. [C181]

## "UWB Radar for Railway Fall on Track Object Detection and Identification"

This paper presents a new system for detecting and identifying objects fallen onto railway tracks. The proposed solution is based on an ultra-wideband (UWB) radar technique combined with a long travelling wave radiating microwave transmission line. This line is maintained adequately all along the railway station platform. Scheduled steps for system realization are presented. A preliminary analysis of different transmission lines which could be used and their performance is provided. Automatic Target Recognition (ATR) application, which describes identification procedure, is discussed. An overview of extraction methods is provided and a procedure of selection of contributing poles is presented. Available target identification techniques based on UWB pulse are analyzed and compared to experimental results. [C182]

## "Hardware Design of Signal Processing System Based on DSP"

Millimeter wave short range combined detection technology refers to that combining millimeter wave radar with radiometer and taking full advantage of the active range measurement and passive radiation characteristics of target to realize target bearing decision and target recognition, which is the development trend of millimeter wave detection technology and greatly improves the performances of millimeter wave detector. This paper takes TMS320VC5410 DSP chip as the core and utilizes the high-speed signal processing ability, rich on-chip resources and flexible external interfaces of C5410 DSP chip to finish the hardware design of signal processing system, including the following modules, such as AD sampling, memory extension, system power and system clock, etc, finally debugs the system and sums up the debugging experience. [C183]

## "The use of wavelet transformation for detection and recognition of the small size and small contrast subsurface targets"

In this paper, possibilities of use of the wavelet analysis for detection and recognition of small size and small contrast subsurface targets are considered. For the test image the wavelet spectrum was performed and its analysis was carried out. [C184]

## "Research on Supervised Manifold Learning for SAR target classification"

Nonlinear manifold learning algorithms, mainly isometric feature mapping (Isomap) and local linear embedding (LLE), determine the low-dimensional embedding of the original high dimensional data by finding the geometric distances between samples. This paper proposed an approach to reduce the dimensions of SAR image targets based on supervised manifold learning algorithm. Three steps were done to reduce the dimensions of original data. Firstly take use of a priori information of the sample point to find the k-neighbors. Secondly to build the local reconstruction weight matrix W. Thirdly get the dimension reduction result based on W and the neighborhood of original data. Experiments were done to test the effect of dimensionality reduction to classification results. Three types of targets were used in the experiments. The implementation steps and parameter settings are discussed in details. The results show SLLE is more conducive to SAR image target classification than the traditional LLE. [C185]

## "Improved waveform design for target recognition with multiple transmissions"

This paper presents a matched waveform technique for target class identification, i.e., a multiple hypotheses testing (MHT) framework. This technique is shown to improve classification performance of SNR-based matched waveforms derived from a probability-weighted spectral variance (PWSV) approach. The technique, which allows

for real-time adaptive waveform transmission, is also shown to be computationally efficient. [C186]

## "Frequency agile stepped OFDM waveform for HRR"

High range resolution (HRR) is an important feature for radar, aiming at target classification. The range resolution is inversely proportional to the bandwidth of the transmitted signal. Pulse burst waveforms can achieve HRR at low expenses when the carrier frequency increases from one pulse to the next, stepping and synthesizing the wide bandwidth. In such a stepped frequency approach the resolution is determined by the bandwidth of the total pulse burst. With the orthogonal frequency division multiplexing (OFDM) waveform, the time/frequency pattern of the transmitted radar signal is fully flexible while the waveform can be generated easily by IFFT. The novelty of this paper is to demonstrate how the combination of frequency agility and HRR processing into one system can benefit from the OFDM flexibility. An elementary scenario with a single stationary or low speed point target is assumed. [C187]

## "Latency-Information Theory: A Novel Latency Theory Revealed as Time Dual of Information Theory"

This paper outlines a space-time duality study started in 2003 and leading to a latency-information theory (LIT) that unifies information theory with a novel latency theory revealed as time-dual. While information theory guides the design of communication systems, latency theory does the same for recognition systems. A unified recognition-communication system is an intelligence system and LIT illuminates its design. LIT naturally arose from the author's desire to systematically address the design of a real-world intelligence system for DARPA's knowledge-aided sensor signal processing expert reasoning (KASSPER) program. This work has led to practical intelligence system solutions that yield outstanding target detections under severely taxing environments, while also exhibiting several orders of magnitude savings in prior-knowledge storage-space, processing-time, and implementation complexity over standard schemes. Moreover, it has led to the discovery of a mathematical-physical duality guiding life system designs. [C188]

## "Hardware Design of Signal Processing System Based on DSP"

Millimeter wave short range combined detection technology refers to that combining millimeter wave radar with radiometer and taking full advantage of the active range measurement and passive radiation characteristics of target to realize target bearing decision and target recognition, which is the development trend of millimeter wave detection technology and greatly improves the performances of millimeter wave detector. This paper takes TMS320VC5410 DSP chip as the core and utilizes the high-speed signal processing ability, rich on-chip resources and flexible external interfaces of C5410 DSP chip to finish the hardware design of signal processing system, including the following modules, such as AD sampling, memory extension, system power and system clock, etc, finally debugs the system and sums up the debugging experience. [C189]

## "Passive Coherent Location as Cognitive Radar"

Cognitive radar describes a generic radar system that is capable of adapting its transmission waveforms and cooperation with other sensors in order to achieve superior detection, recognition and tracking of targets. For example, the sensors of a cognitive radar system might use the illumination signals to carry broadcast data, allowing the sharing of target information. In this paper we postulate that it would be possible to implement a cognitive version of passive coherent location (PCL) which has much in common with the broad cognitive radar concept, but adapts only to the waveforms it senses in the environment, and exploits those that are most useful to it for target detection. In addition, it would model the terrain to improve coverage and provide countermeasures against direct signal saturation. By its name, PCL does not transmit, but relies on emissions from other radiating systems, such as broadcast services, other radars, cellular radio, WiFi, and so on. It is clear that such a system, consisting of multiple, cooperating receivers, can achieve excellent performance in the presence of deliberate jamming, difficult terrain and attempts at target stealth. In the civilian radar domain, the technology offers opportunities for bandwidth conservation. [C190]

## "Reduced-complexity delay-Doppler correlator for time-frequency hopping signals"

The delay-Doppler correlator is most commonly used for target detection in a radar system. It is essentially a two-dimensional filter matched to the hypothesized delay and Doppler shifts of echoes reflected from the illuminating signal. More recently, it has been applied in communication to the detection of signature sequences generated from artificially introduced time-frequency shifts of a base sequence. In this paper, we derive a computationally efficient delay-Doppler correlator for a class of time-frequency hopping waveforms that can be represented by segments of equal-length sinusoids. These sequences can be found in applications such as continuous waveform radar and device identification in wireless communication. By applying sliding discrete

Fourier transform and exploiting the structure of the waveform, the number of multiplications required for evaluating the entire delay-Doppler range can be reduced by a factor equaling the length of the sequence. [C191]

## "Response of polar format algorithm to moving target with consideration of wavefront curvature"

The synthetic aperture radar (SAR) signatures of moving target are the basis of ground moving target detection and imaging (GMTI&Im). However, previous studies are mainly focused on the influence of target's motion on phase history; and little work has been done to investigate the signatures of moving target after the application of a particular SAR image formation algorithm. In this paper, we derive the image spectrum of moving target after polar format algorithm (PFA) processing. Based on this image spectrum, detailed analysis on the SAR signatures of moving target, including the geometric displacement, residual range migration, range and azimuth defocusing are performed. Simulation results validate the theoretical analysis. [C192]

## "Image distance based ship detection using SAR images"

A novel method is developed for ship detection in synthetic aperture radar (SRA) images, which is based on image distance computation techniques. Using a second-order hidden Markov mesh model to learn statistical models of images, one can obtain the distance of two images for the purpose of detecting ships. First, the features of an image can be extracted using a method that best matches its statistical model, which is related to dynamic programming. Second, given the state transition matrix and observation distributions within states, statistical distance between images based on the similarity of their statistical models can be estimated. Experimental results demonstrate that this ship detection algorithm can effectively enhance ship target as well as suppress speckle and has better detection precision and lower calculation complexity. [C193]

## "Robust target localization in moving radar platform through semidefinite relaxation"

Accurate target localization is an important task in various commercial and military applications. One way to achieve this goal is to use the time-of-arrival (TOA) or time-delay-of-arrival (TDOA) information observed at multiple distributed sensors. On the other hand, there is a great need to use moving sensors to form a radar platform with synthetic apertures. In this paper, we consider the problem of target localization based on the range information estimated from two-way time-of-flight (TW-TOF) at multiple synthetic array locations, where the position of these synthetic array locations is subject to certain random errors. The nonconvex estimation problem is approximated by a convex optimization problem using the semidefinite relaxation (SDR) approach. Simulation results show that the proposed estimator provides mean square position error performance close to the Cramer-Rao lower bound. [C194]

## "UWB LNAs for ground penetrating radar"

Two LNA topologies for use in UWB systems are examined and compared in this paper. Design specifications have been derived from a ground penetrating radar system which is the target application. Circuits have been designed to cover the frequency range from 3.1 GHz to 10.6 GHz. The SiGe:C technology SGB25V of IHP Microelectronics is applied to enable volume production at low prices. For measurement purposes, input and output are matched to 50 Omega. [C195]

## "Learning a Locality Preserving Subspace for ISAR Target Recognition"

Io order to overcome the instability of Inverse synthetic aperture radar (ISAR) image caused by shift, rotation and scale variation, a new approach based on Locality Preserving Projections (LPP) algorithm of manifold learning is proposed to feature analysis in ISAR target recognition. Firstly, the LPP algorithm is used to reduce the dimensionality of the ISAR image, and then the reduced feature is classified by k-nearest neighbor classification with rejection recognition capability. Experimental results on four kinds of aircraft target suggest that the LPP algorithm has the capability of finding the low- dimensional manifold structure embedded in the high-dimensional ISAR image space, which is controlled by few parameters, such as attitude angle, scale and position, etc., and the better classification performance is acquired with the low-dimensional feature. [C196]

## "New Velocity Dealiasing of Doppler Radar with the Interactive Method"

Doppler weather radar plays an important role for detecting and forecasting severe weather, it could probe atmosphere with high spatial and temporal resolutions. Because Doppler velocity ambiguity disturbs target recognition and data application, a lot of work focuses on velocity dealiasing. This research tries to study a new interactive method for unfolding the velocity ambiguity with the computer graphic function, which is quite different from the previous unfolding methods. The positive and negative areas of radial velocity are distinguished by zero

velocity line in the radial velocity field which is easy to do with human's experience, then unfold process has been made in the selected area. This method needs not any extrapolation and hypothesis, could deal with one and more times velocity ambiguity. The result shows this unfold method is convenient and fast, and corrected information accuracy is ensured. [C197]

## "Title Page i"

The following topics are dealt with: signal processing system; speech recognition; hidden Markov model; TDOA; DSP; Radon transform; iris recognition; wireless sensor network; watermarking; image registration; radar detection; genetic algorithm; routing protocol; OFDM; wireless channel; steganography; FPGA; adaptive filter; FIR filter; video surveillance; target tracking; data mining; image processing; rough set theory; TCP; fuzzy inference rule; RBF neural network; MIMO system; case-based reasoning; encryption; P2P network and image compression. [C198]

## "Jamming detection in providing for radar jamming immunity"

The article considers the objective of providing for radar jamming immunity by optimizing the radar structure, parameters or operating algorithms on the basis of correct recognition of jamming in progress. Procedure of recognition in the determined feature space is examined. Viability of this approach is demonstrated using the example of airborne radar operation against the source of polarization and blinking jamming. [C199]

## "ISAR Target 2D Images Pre-processing in ATR"

The recognition performance can be enhanced using the ISAR target 2D image pre-processed. The image consists of many scatters. The image with holes is disadvantageous for extracting features in automatic target recognition (ATR). An approach of ISAR target 2D image pre-processing is proposed. It contains suppressing the interferential stripes, connecting the scatters and normalizing the mass center. The smoothed image in the center of the picture is obtained. It is tested that the feature of low order moments has a favorable distinguishing. [C200]

## "Automatic Target Recognition Based on HRRP Using SKO-KPCA"

In this paper, an adaptive and data-dependent single kernel optimization (SKO) algorithm is developed to improve the performance of radar target feature extraction and recognition by optimizing the kernel function of iterative kernel principal component analysis (KPCA). Based on SKO-KPCA and support vector machine (SVM), a radar target high resolution range profile (HRRP) feature extraction and recognition approach is proposed, and ensures, while comparing with other approaches, the satisfactory performances which are illustrated through automatic target recognition (ATR) experiments of Su-27, F-16 and M2000. [C201]

## "Radar Target Scattering Center Extraction Based on the Full-Polarization GTD Model"

To accurately describe the high frequency electromagnetic scattering of the radar objects, the full-polarization GTD model is established based on the combination of the full-polarization information and the geometric theory of diffraction model. Meanwhile, A novel method, MUSIC based on polarization linear variation method (PL-MUSIC) is proposed. The estimation accuracy is improved and the computational load is greatly decreased compared with the method extracting the parameters from every polarization channel. Compared with the parallel polarization MUSIC method (PP-MUSIC), the proposed method decreases the computational complexity of the smoothing process and has the close accuracy. Moreover, the spatial spectrum estimation method based on eigenspace is utilized to establish the spectrum function. Simulations and computational load comparison show the validity of the full-polarization GTD model and the advantage of the MUSIC based on polarization linear variation method. [C202]

## "Radar target imaging using distributed radar networks"

Target images can be clearly reconstructed from the monostatic and bistatic range profiles generated by a DRN with enough radar sensors. Because the images are instantly formulated, no synthetic aperture processing or motion compensation is needed. From the generated image, various target features such as target sizes, speed and scattering center pattern can be extracted for target recognition. [C203]

## "Automatic Target Recognition Based on Rough Set-Support Vector Machine in SAR Images"

An automatic target recognition (ATR) system based on rough set-support vector machine (RS-SVM) for SAR targets is proposed in this paper. The system combines the strong feature selection ability of rough set (RS) with

the excellent classification ability of SVM together. The wavelet invariant moments firstly are extracted, then selected by using forward greedy numeral attribute reduction algorithm (FGNARA) as the optimal feature subset to indicate targets and fed to SVM for target recognition. Experiments with neural network (NN) and SVM on both original and selected feature set demonstrate the selection of optimal feature subset is meaningful and RS-SVM is efficient in ATR of SAR. [C204]

## "Research on target classification for SAR images based on C-Means and support vector machines"

Aim at multiplicative speckle noise and little difference among targets in synthetic aperture radar (SAR) images, a target classification algorithm is proposed based on C-Means and support vector machines (SVMs). Its front part adopts a C-Means clustering method to classify targets and suppress speckle noise in feature space, and its back part adopts an SVM classifier to improve classification accuracy in image space. Experimental results show that this algorithm can reduce the dimension of SVM and have a better classification performance using Ku-band SAR database. [C205]

## "Geometrical definition and computation methods of line target features"

Line target recognition in discrete space is a difficulty in the field of image processing. Line features in the scene include tracks, roads, rivers, bridges and field boundaries. Usually, target features include amplitude, histogram and statistics characterizations. However, these features are insufficient to describe a line target for a practical image. Utilizing the geometry of target, we present the definitions and computation methods of length, orientation angle, smoothness degree, roughness degree, and barycenter for line target in discrete space. Computational examples show that these new definitions can exactly character line target such that it can provide new theoretical and technical supports for image processing of line target in discrete space. [C206]

## "Ship classification by sound signature"

Nowadays, either for supervision or for defense purposes, the transportation is being controlled by RADAR (Radio Detecting and Ranging). RADAR helps us get information about objects of interest by transmitting electromagnetic radio waves to the target and analyzing the reflecting signals. We understand that in order to determine any given object's information (speed, distance etc) the first action is always taken by the control center. This also tells us that the moving object can also notice the electromagnetic radio waves and hence the control center can also be sensed. It is of great importance in the defense systems that the object under inspection should not notice being recognized. If we could get information about the target by controlling the waves sent by the target rather than sending any signals to it we could be on the advantageous side. In this study the vehicles were classified by the sounds they make while operating. Working units of the marine vehicles (engine, fan, the generator and etc) analyzed and the sounds they diffuse to the environment while operating were characterized. In the characteristics determination the MFCC (Mel Frequency Cepstral Coefficients) method used to determine the features of the vehicles and by the k-means method, the defined features degraded to a specific number, k-NN (k-Nearest Neighbor) method selected for the classification and recognition of the vehicles. [C207]

## "Automatic recognition of man-made objects in SAR images using support vector machines"

Over the past two decades the remote sensing technology is applied in a large scale in environmental research and policy, i.e. water pollution monitoring and conservation of soil, etc. The methods for recognition of man-made objects in remote sensing images are providing capabilities for mapping and monitoring crucial objects or sites in environmental management, i.e. hazardous chemicals storerooms, oil depots, etc. However, the task of recognizing key man-made objects from large images is time consuming and complex. In the paper we aim at developing an automatic and fast image processing method for the recognizing man-made objects in synthetic aperture radar (SAR) images, which is a supervised learning approach based on support vector machines. Firstly, a sample image data set which contains several classes of interested man-made objects is manually extracted from SAR images. Then we train the image data set by least squares support vector machines. After cross-validation and an exhaustive grid search, a model that can predict target label of data instances in the testing set is obtained. Finally we can implement classification in random image set using above prediction model and recognize the man-made objects. This approach needs no a priori knowledge, and only a set of train examples for the learning step is needed. [C208]

## "Improving high range resolution ATR performance with average absolute error metric"

As a complementary mode to synthetic aperture radar (SAR), high range resolution (HRR) is mainly developed to identify moving ground targets automatically. Previous studies have demonstrated many promising solutions in

HRR Automatic Target Recognition (ATR). Most of them popularly build on template-based approach and employ mean square error (MSE) metric in matching algorithm to measure the likelihood between test profiles and template profiles. However, discussion about whether MSE works as it is expected is inadequate. This paper represents a preliminary investigation into MSE metric used in matching algorithm. We firstly illustrate MSE metric theoretically, and then indicate its shortcomings such as random coefficients distorting the difference between profiles in mathematical calculation, excessive emphasis on large difference, and lack of reasonable interpretation in physical distance space. An alternative metric named average absolute error (AAE) is utilized to replace MSE. It is directly based on the distance between profiles and is able to provide a clear physical interpretation. The experiment results show that no matter estimated aspect angles are given or not during classification, AAE-based HRR ATR significantly outperforms the baseline MSE-based HRR ATR. [C209]

## "Multiresolution Framwork with Neural Network Approach for Automatic Target Recognition (ATR)"

Automatic Target Recognition (ATR) is an approach by which we identify one or a group of target-objects in a scene. It plays a pivotal role in the challenging fields of defense and civil. Most of the methods in this context are based on fix window-size technique. In this paper we propose a novel approach which gives scale, rotation and translation invariant results for automatic target recognition in high-resolution satellite images which in turn are able to recognize the multiple targets in a scene. We have developed a system which can predict the possible area of interest in a scene, where target may be present or not. Prediction of areas of interest is based on edge detection and similarity measure of wavelet co-occurrence features of segmented sub-blocks. Zernike moments, calculated for scale and translation normalized area of interest, is thereby used as the features of the concerned area. Zernike moments are rotation invariant. The extracted features are then fed to trained neural network for recognition. This approach is more suitable for the satellite images because resolution of image and idea about the target are two essential factors by which we can predict the minimum and maximum size of the target. The approach takes considerably less time compared to the fix window based approach because the predicted numbers of interest areas to be processed in a scene are very less. The proposed approach has successfully been tested on number of satellite images of different resolutions and their timing analysis has been compared with fix window based approach. [C210]

## "Ego-motion estimation and moving object tracking using multi-layer LIDAR"

This paper presents an approach for the robust recognition of a complex and dynamic driving environment, such as an urban area, using on-vehicle multilayer LIDAR. The multilayer LIDAR alleviates the consequences of occlusion by vertical scanning; it can detect objects with different heights simultaneously, and therefore the influence of occlusion can be curbed. The road environment recognition algorithm proposed in this paper consists of three procedures: ego-motion estimation, construction and updating of a 3-dimensional local grid map, and the detection and tracking of moving objects. The integration of these procedures enables us to estimate ego-motion accurately, along with the positions and states of moving objects, the free area where vehicles and pedestrians can move freely, and the dasiaunknownpsila area, which have never previously been observed in a road environment. [C211]

## "SAR ship target imaging by induced complementary movement"

In this work a generalized ISAR approach to solve the SAR problem for ship target image reconstruction and recognition is addressed. A new coordinate definition of the 3-D SAR scenario is suggested. An analytical geometrical approach to define apparent yaw, pitch and roll angle of the ship target at sea is implemented. Mathematical expressions to determine slant range distances to point scatterers are derived. The model of the SAR signal return is composed by a linear frequency modulated transmitted signal, geometry and reflectivity properties of point scatterers placed on the object. Image reconstruction procedure includes fast Fourier transform range compression and fast Fourier transform azimuth compression. To verify the new ISAR image reconstruction concept with respect to SAR problem a numerical experiment is carried out. [C212]

## "A GPS-based system design for the recognition and tracking of moving targets"

This study aimed to develop a software to enable recognition of moving objects and detection of their orbits by processing the images obtained through a camera. The secondary objective was to design a GPS-based mobile robot which tracks moving objects. [C213]

## "Target detection in MIMO radar using Golay complementary sequences in the presence of Doppler"

In this paper, we present a method for detecting a point target using multiple antennas when the relative motion

between the receivers and the target induces a non-negligible Doppler shift. As a key illustrative example, we consider a 4 ГѓВ— 4 system employing a unitary matrix waveform set, e.g., formed from Golay complementary sequences. When a non-negligible Doppler shift is induced by the target motion, the waveform matrix formed from the complementary sequences is no longer unitary, resulting in significantly degraded target range estimates. To solve this problem, we adopt a subspace based approach exploiting the observation that the receive matrix formed from matched filtering of the reflected waveforms has a (non-trivial) null-space. Through processing of the waveforms with the appropriate vector from the null-space, we can significantly improve the detection performance. We provide simulation results to confirm the theoretical analysis. [C214]

## "SAR target recognition based on sub-block statistical features extracted from the Gabor filtered image"

A method for SAR target recognition using low-frequency sub-band and Gabor filter sub-block statistical feature is proposed. The sub-band image extracted from the pre-processed SAR image is filtered by Gabor filter on different directions and scales. The each filtered sub-band image is divided into different sub-blocks and the statistical features derived from every sub-block of all filtered sub-band images are regarded as the target recognition feature, which can be used to recognize the targets with SVM. The proposed method is validated on MSTAR dataset for 3-type SAR target recognition. [C215]

## "Subsurface target recognition using an approximated method"

An approximate target recognition method based on the E-pulse technique is proposed and applied to subsurface target recognition. The proposed method is described in detail with numerical examples using wire scatterers. [C216]

## "Doppler-polarimetric radar system for recognition of distributed objects"

This paper considers Doppler-polarimetric radar methods in application to observing distributed targets. Examples of typical distributed targets are meteorological objects. For instance, among wide variety of meteorological objects, such targets as clouds with precipitation are considered. Developed mathematical models of Doppler-polarimetric reflections from distributed targets as rain and clouds are discussed. Phenomenological and mathematical aspects of the relationships between different Doppler-polarimetric measurable variables and parameters of the object under observation such as its microstructure and dynamic properties of scatterers inside the resolution volume are considered. Implementation of Doppler-polarimetric approach, which requires significant processing power, in reasonable devices is considered. [C217]

## "Automatic target recognition of aircraft models based on ISAR images"

In this paper, we present a system for aircraft automatic target recognition (ATR) using inverse synthetic aperture radar (ISAR) and based on knowledge discovery from data process adapted to radar domain. We propose a method for target shape extraction from ISAR images based on the combination of two methods, SUSAN modified and active deformable contours via level set. In the second part of this work, we propose to fuse two commonly used shape descriptors algorithms based on moments invariant and Fourier descriptors. We have investigated the impact of the information fusion on the recognition rate. The classification scheme is ensured using support vector machine (SVM) classifier. Several combination strategies are compared at score/decision/feature level. Experimental results of the proposed method are provided and discussed. [C218]

## "Resonance-region radar target identification using aspect sampling"

We investigate the performance of three target identification algorithms that rely on aspect samples of target features extracted from multifrequency resonance-region radar returns. The first algorithm uses only the amplitudes of radar returns, the second uses amplitudes in conjunction with feature-space trajectories, and the third uses complex radar returns and time-domain correlations. To test the algorithms, the Numerical Electromagnetic Code was used to generate radar returns of five test targets made of conducting wires. Simulation results show that very low identification error probabilities can be achieved with relatively large sampling intervals, few frequencies and low computing costs. [C219]

## "Investigation of 1D and 2D PCA for SAR ATR"

Principal component analysis (PCA) has been used in many applications ranging from social science to space science, for the purpose of data compression and feature extraction. Usage of PCA for synthetic aperture radar (SAR) image classification, have recently been exploited by the automatic target recognition (ATR) community. PCA can be used in one dimensional as well as two dimensional mode. These different modes have recently

been studied for face recognition. Following similar trends, 1D and 2D PCA has been exploited in the present paper for SAR ATR. 2D PCA based algorithm has been fine-tuned for the current usage. Contrary to the conclusions in face-recognition research, here it has been concluded that both 2D and 1D PCA perform equally well for SAR ATR. And both the algorithms outperform the conventional SAR ATR algorithms. [C220]

## "Microwave scattering behaviour analysis of typical targets with SAR image"

As the high resolution radar satellite's has been successfully launched, its ability of the typical target's recognition monitor enhances a lot. This article mainly does analysis based on the RADARSAT2 quad-polarimetric data, compared scattering properties of typical target feature with two temporal full polarized data, and used the measured data to drive MIMICS (Michigan Microwave Canopy Scattering model) model and carry on the multi-wave band full polarization backscattering simulation about the farmland and forest. Then we carried on the comparison between X, C band SAR image gain's actual scattering value and simulation value in order to infer the typical target feature' scattering properties rule of S band. With anticipation of HJ-1-C satellite soon launched by China and then we can carrry on the comparison with the fact. Along with the full polarized data's development, the typical target feature's scattering properties analysis will be more perfect. [C221]

## "Target identification performance improvement from enhanced HRR radar clutter suppression"

Airborne radar tracking in moving ground vehicle scenarios is impacted by sensor, target, and environmental dynamics. Moving targets can be assessed with 1-D High Range Resolution (HRR) Radar profiles with sufficient signal-to-noise (SNR) present which contain enough feature information to discern one target from another to help maintain track or to identify the vehicle. Typical radar clutter suppression algorithms developed for processing moving ground target data not only remove the surrounding clutter but also a portion of the target signature. Enhanced clutter suppression can be achieved using a multi-channel signal subspace (MSS) algorithm which preserves target features. In this paper, we exploit extra information from enhanced clutter suppression for automatic target recognition (ATR), present a gain comparison using displaced phase center antenna (DPCA) and MSS clutter suppressed HRR data, and generate confusion-matrix identification results. The results show that more channels for MSS increase ID over DCPA, result in a slightly noisier clutter suppressed image, and preserve more target features after clutter cancellation. [C222]

## "Performance comparison of target classification in SAR images based on PCA and 2D-PCA features"

Feature extraction is an important step for target classification in SAR images. Principal component analysis (PCA) is common in pattern recognition, and has been used widely for target classification in SAR images. In order to utilize PCA, two-dimensional image has to be arranged to an observation vector. However, two-dimensional PCA (2D-PCA), which is developed from PCA, can extract features from two-dimensional SAR image directly. Although 2D-PCA is consistent with PCA in theory essentially, which represents original data by extracting principal components with high variance values by linear transformation, they perform distinctly due to the difference of data processing methods. Based on the theoretical analysis and classification experiment using MSTAR data, this paper compares PCA and 2D-PCA systematically and roundly. [C223]

## "Radar target recognition based on combined features of high range resolution profiles"

This paper is focused on the feature extraction techniques of radar high range resolution profiles (HRRPs). In order to release the translational sensitivity of HRRPs, two translation invariant features, the central moments and distribution entropy, are extracted from the HRRPs and combined to form a new feature vector. Experiment on real data of three airplanes in flight is implemented to evaluate the recognition performance of the combined feature, using the nearest neighbour (NN) classifier and the support vector machine (SVM) classifier, respectively. Experimental results demonstrate that the combined feature can significantly enhance the separability of different targets and improve the average recognition rate of HRRP target recognition. [C224]

## "Study on SAR target recognition based on Support Vector Machine"

This paper studies MSTAR SAR target recognition with Support Vector Machine (SVM) classifier by using Principal Component Analysis (PCA) features, without consideration of errors in target aspect angle estimation. A good strategy is proposed to avoid errors in classifier selection for the errors in estimation of aspect angle. The experiments based on MSTAR data set show perfect results. [C225]

## "Application of assistant knowledge to detect and recognize target in SAR imagery"

Because of the characteristics of its imaging principle, strong speckle and impacted by background clutter, SAR

image is very difficult to be interpreted, especially for the complex military targets. An interactive recognition system framework is proposed in this article which using contextual information, geospatial information and multi-temporal images, etc, as assistant knowledge in the recognition workflow. It can help detecting and recognizing some target which is difficult to be detected and recognized through human vision or automatic target recognition technology alone. [C226]

## "Novel evaluation method of jamming effect on ISAR based on target detection"

Study on evaluation methods of ISAR jamming effect is to be an important research problem in electronic countermeasures (ECM). Up to now there is no generally accepted progress and objective criterion published. In this paper, on the basis of studying the image model of ISAR point target used the most classical range-Doppler(R-D) algorithm, equivalent jamming-to-signal ratio (EJSR) is utilized, and then the relation between image quality, jamming and jamming effect is built, and the evaluation index via recognition probability of point target is put forward. In the end, aiming to three kinds of typical blanket jamming modes, radio frequency(RF) noise jamming, frequency modulation(FM) jamming and amplitude modulation(AM) jamming, through simulation and analysis, the results indicate the validity and feasibility of the proposed method. [C227]

## "Power Delay Profile Matching for Vehicle Target Recognition"

Radar echo contains unwanted echoes called as clutter, which make it difficult to detect vehicle or obstacle. Especially short-range/wide-angle vehicle radar at 24 GHz suffers from heavy clutter unlike long-range radar at 77 GHz. It is therefore expect to improve the detection performance by suppressing the clutter using a pulse integration and CFAR (Constant False Alarm Rate). However the radar echo should include multiple vehicle targets as well as the clutter, thereby it is not easy to improve the performance. In this paper the target discrimination technique, let say, power delay profile matching scheme is proposed and the usefulness is investigated by conducting the measurement at 24 GHz where the clutter suppression scheme is also considered. As a result, a vehicle target is found to be recognized from multiple vehicles. We have also investigated the effect of bandwidth on the target discrimination capability. [C228]

## "Situation assessment via multi-target identification and classification in radar sensor networks"

DoD has defined three levels of data fusion for network centric warfare (NCW). Level 1 data fusion combines data from single or multiple sensors and sources to provide the best estimate of objects and events in the battlespace. Level 2 data fusion focuses on situation assessment. Level 3 data fusion is threat assessment. To facilitate situation assessment, we investigate the problem of jointly classifying and identifying multiple targets in radar sensor networks where the maximum number of categories and the maximum number of targets in each category are obtained a priori based on statistical data. However, the actual number of targets in each category and the actual number of target categories being present at any given time are assumed unknown. It is assumed that a given target belongs to one category and one identification number. The target signals are modeled as zero-mean complex Gaussian processes. We propose a joint multi-target identification and classification (JMIC) algorithm for radar surveillance using cognitive radars. The existing target categories are first classified and then the targets in each category are accordingly identified. Simulation results are presented to evaluate the feasibility and effectiveness of the proposed JMIC algorithm in a query surveillance region. [C229]

## "Doppler ambiguity resolving for SAR ground fast moving target indication"

This paper investigates the restrictions of Synthetic Aperture Radar (SAR) ground fast moving target indication based on the conventional clutter suppression method in image domain which ignores the problems of range cell migration (RCM) and azimuth defocus. A technique for fast moving target indication and motion parameter estimation is proposed based on Doppler ambiguity resolving. In range frequency and compressed azimuth time domain of tri-channel SAR/GMTI data, the clutter is suppressed with DPCA technique, and the Doppler ambiguity number can be estimated from the residual signal using Radon transform. This approach exploits the relation between the line slope and the Doppler ambiguity number of fast moving target. Azimuth focusing is carried out with the criterion of entropy-minimization after azimuth cell migration correction (ACMC), and at last the fast moving target is imaged after range compression. The feasibility of the approach is validated by the real airborne data. [C230]

## "Local cell-averaging fast CFAR for multi-target detection in high-resolution SAR images"

A local cell-averaging fast CFAR scheme is proposed for multi-target ship detection. The proposed algorithm is based on global censoring scheme to avoid multitarget situation in reference cell. Fast CFAR scheme is employed to reduce computational load. Local average in the vicinity of test cell can remove small sized false alarms so that additional binary clustering is not required for final decision. The test results using real SAR

images show good performance in multitarget situation and heterogeneous environment. [C231]

## "Effect of frequency diversity on SAR ATR"

Synthetic aperture radar (SAR) based automatic target recognition (ATR), has been one of the demanding usages of airborne radar systems. With the developments in the field of hardware, more complicated radar systems can be deployed on aerial platforms. This opens the possibility of using different advanced versions of radar systems, like multi-band radars, multi-polar radars and multi-static radars. In the current paper, we report the preliminary experiments studying the effect of frequency band on SAR ATR performance. In this pilot study we have used the well accepted MSTAR SAR database. The results show that even though bandwidth is kept the same, the ATR performance strongly depends on the central frequency. [C232]

## "A new pulse deinterleaving algorithm based on Multiple Hypothesis Tracking"

The main function of ESM is to receive, measure, deinterleave pulses and then identify alternative threaten emitters, among which pulse deinterleaving process is significantly difficult and important. Dense electromagnetic environments cause an ESM to receive a seemingly total random pulse stream with large noise. The traditional algorithms have behaved weak and unstable under the rather severe situation, so we propose a new pulse deinterleaving approach based on Multiple Hypothesis Tracking method in target tracking system. Simulation results have shown that the algorithm can perform PRI estimation and pulse recognition with high precision. Moreover, the algorithm is proved to be considerably robust and reliable even with large observation noise and PRI jitter at a missing rate up to 25%. [C233]

## "Multiple target Doppler estimation under possibly moving radar clutter"

Multi-target detection for pulsed Doppler radars under land/moving clutter characterized by antenna scanning modulation is analyzed using linear prediction based Tufts-Kumaresan's method. Comparison between this method and other line spectra estimation algorithms such as MUSIC and ESPRIT is performed. A technique to determine the model order required by the frequency estimation algorithms, which does not distinguish between targets and clutter, is presented. The clutter region concept is then introduced to identify targets from the clutter. [C234]

## "Bat-pollinated plants: feature extraction for target recognition in the natural world"

In recent years, with the development of high range resolution radars, the desire to be able to identify targets under all weather and clutter conditions has become of great importance. Bat-pollinated plants have evolved flowers to ease classification by nectar feeding bats even in a dense clutter environment. In this paper we analyze three real images of a Cobaea scandens corolla. These were collected by means of an acoustic radar capable of very high range resolution. The features of these flowers that allow high classification performance by bats are exploited. Results are discussed and related to the task of classification in radar systems. [C235]

## "New results on convoy tracking by airborne radar"

In this contribution the authors continue their work on convoy tracking supported by estimating the lateral width of the convoy. New results on the impact of the array size and the data sample size are presented. It is shown that the ML estimator is the most suitable tool for estimating the apparent target length. In a companion paper the tracking performance is analysed. [C236]

## "Generation of three dimensional photo-realistic models from Lidar and image data"

Light detection and ranging (Lidar) instruments collect high density and accurate three dimensional (3D) point clouds of scanned surfaces of objects. 3D building modelling from terrestrial Lidar requires the raw point cloud data to be processed. Through processing, noise and outliers are eliminated from the point cloud, and a 3D photo-realistic model is generated using image data. This effectively reduces redundant data and enhances the visual representation. This paper deals with point cloud processing and proposes methods to automate several of the processing procedures. Specifically, we implemented automatic 3D point cloud registration, automatic target recognition used for geo-referencing, automatic plane detection algorithm used for surface modelling, and texture mapping. The proposed approach leads to the generation of accurately geo-referenced three dimensional (3D) photo-realistic models from point clouds and digital imagery. [C237]

## "Exploiting correlation in target detection using MIMO radar with angular diversity"

Multiple-input multiple-output (MIMO) radars utilize multiple waveforms simultaneously to improve performance. A

MIMO radar in which angular diversity is achieved by using widely distributed antennas has been proposed before. This type of system is also known as the statistical MIMO radar. Typically, it has been assumed that the signals received by different antennas are either fully correlated or independent depending on the configuration. We make a more realistic assumption of partially correlated scattering from the target. In this paper, we show that taking the correlation of the scattered signals into account can improve the probability of detecting the target. It is shown that the scattering statistics do not need to be known, but can be estimated reliably from the received signal if a certain type of scattering model is assumed. In this paper, the GLRT using the maximum likelihood estimates of the unknown parameters is proposed for target detection. [C238]

## "A method of angle error extraction for monopulse radar with 3-subarray variable polarization antenna"

To improve the ability of radar's anti-jamming and target recognition, polarization technology is applied to monopulse angle measurement. 3-subarray millimetre wave variable polarization array antenna is also proposed and discussed in this paper. A novel method of angle error extraction in horizontal and vertical direction is given by analyzing polarization synthesis and electric field of the antenna, meanwhile, the difference between the new method and traditional one is discussed. Finally, according to the new method, simulation results of angle error extraction are presented. [C239]

## "Intelligent Target Recognition Based on Data Fusion"

In order to improve the performance and reliability of automatic target recognition system, an intelligent target recognition method based on the data fusion of radar and infrared sensor is proposed. For infrared sensor, the image target recognition algorithm based on wavelet moment and BP neural network is proposed; for radar sensor, the target recognition method based on fuzzy reasoning is proposed. Finally, Dempster-Shafer theory is used to combine the two basic probability assignment functions and achieve the data fusion of radar and infrared sensor. Simulation experiments indicate that the recognition results by data fusion of two sensors is better than that by single sensor. [C240]

## "Study on Ship Target Detection and Recognition in SAR imagery"

Analysis the characteristics of SAR ship target detection and identification. Summarize and divide the commonly used features into three categories: spatial features, transform features and the moving feature. The general ship detection and identification process is discussed in details. The development of SAR ship target detection and identification are surveyed and the mainstream approaches are listed. The main problems on ship detection and recognition process have been described as well. Finally a possible development direction of SAR ship target detection and recognition is given. It is expected that the researchers will obtain useful information from this paper, which will help for their future works and promote the SAR image target detection and recognition of ship development. [C241]

## "Aircraft Target Recognition: A novel approach for features extraction from ISAR images"

In this paper, we present a system for Automatic Target Recognition (ATR) based on ISAR images. The methodology used is based on knowledge discovery from data (KDD process) process adapted to radar field. The shape extraction is the most important step in recognition system. However, we propose a new approach for Target shape extraction based on combination of Smallest Univalue Segment Assimilating Nucleus (SUSAN) method and Variational Level Set (VLS). The feature vector is then represented by Fourier descriptors of each target shape. Finally, recognition scheme is achieved by both: Support Vectors Machine (SVM) and K Nearest Neighbors (KNN) classifiers. [C242]

## "Multi-platform distributed ISAR for surveillance and recognition"

In this paper we exploit the data acquired by multiple radar systems carried by multiple air platforms to increase the cross-range resolution of ISAR images. The distributed ISAR technique is devised for two different cases: (i) multistatic with a single platform carrying an active radar and the remaining platforms equipped with receiving only devices, (ii) MIMO with each platform carrying an active radar. The processing chain needed by the distributed ISAR is shown with the results obtained against simulated ISAR data for both multistatic and MIMO cases; the performance analysis shows that the proposed technique is able to provide an increase of the cross-range resolution up to the number of radar systems in the multistatic case or even higher in the MIMO case, if the platforms are properly located. The performance degradation arising from errors in the knowledge of both the target rotation motion and the acquisition geometry is also analyzed. Results obtained by processing the experimental data collected by a ground based radar operating together with a rotating platform are shown to validate the proposed approach. [C243]

## "An extra-trees-based automatic target recognition algorithm"

In this article, we describe a new automatic target recognition algorithm for classifying SAR images. It is based on the PiXiT image classifier, already used in several applications, which uses randomized sub-windows extraction and extremely randomized trees (extra-trees). This approach requires very little pre-processing of the images, thereby limiting the computational load. It was successfully tested on the public standard MSTAR database, achieving a misclassification rate of about one percent. [C244]

## "Detecting 3-D rotational motion and extracting target information from the principal component analysis of scatterer range histories"

ISAR imagery of ships are complicated by the 3-D motion of the target, which causes blurring in the imagery. A technique is proposed which could help detect such motion and prove useful to both analyse the 3-D motion as well as possibly help to estimate the 3-D position of scatterers as a by-product of the analysis. The technique is based on principal component analysis of accurate scatterer range histories and is shown only in simulation. Future research should focus on practical application. [C245]

## "Image enhancement and motion compensation of moving targets in ISAR using S-method"

For target recognition applications, a blurred ISAR image has to be refocused quickly so that it can be used for real-time target identification. In this paper, we present the S-method-based approach to real-time motion compensation, image formation and image enhancement of moving targets in ISAR. This approach performs better than the Fourier transform by drastically improving images of fast, maneuvering targets. The method is also computationally simple, requiring only slight modifications to the existing Fourier transform-based algorithm. [C246]

## "The insertion of ISAR targets into pre-existing SAR scenes"

For the training of automatic target recognition algorithms, and of scene understanding in image intelligence, it is important to have the largest possible data base. This can be achieved by inserting targets that were measured in a tower/turntable configuration, into pre-existing SAR scenes. The blending has to be performed in exactly that stage of the SAR processing chain that produces a result corresponding to that as if the target had been present in the scene during the SAR overflight. [C247]

## "Probability distribution mixture model for detection of targets in high-resolution SAR images"

In this paper, the detection of close targets in heterogeneous clutter in high-resolution SAR images is investigated. We adopt a probability distribution mixture model where each pixel intensity image is characterised by two probability density functions: one related to the targets and one related to the background clutter. A specific detection threshold, based on the estimates of the mixture parameters, is used. The statistical characterisation of SAR images modeling is a key issue for detection. The clutter is modelled using the K distribution that is a flexible tool over non-homogenous areas. We show that our method is able to detect close targets at constant false alarm ratio without making any assumptions about their size and their spatial configuration. [C248]

## "2D parametric target model estimation using HRR data from a radar network"

Estimation of a parametric 2D spatial target model is proposed in this paper, with ultimate goal to support radar target classification. Limited number of multi-aspect High Range Resolution (HRR) data from a radar network are used as source of information. Back-projection in 2D space and mixture model fitting is applied for the estimation. The ghosts are progressively resolved and unambiguous retrieval of the 2D target model is achievable using data at consecutive time steps, while the target is moving. [C249]

## "Application of the multiresolution wavelet representation to Non-Cooperative Target Recognition"

In this paper, the problem of efficient representation of large database of target radar cross section is investigated in order to minimize memory requirements and recognition search time, using wavelet representation. Synthetic RCS of large aircrafts, in the HF-VHF frequency bands, are used as experimental data. Many parameters are evaluated like mother wavelet, decomposition level, and classification parameters. Criteria used to determine the efficiency of multiresolution representations are compression scores, false identification rate and search time. [C250]

## "SAR target recognition based on Gabor filter and sub-block statistical feature"

A method for SAR target recognition based on low-frequency sub-band image, Gabor filter bank and sub-block statistical feature is presented in the paper. The sub-band image extracted from the pre-processed SAR image is filtered by Gabor filter bank on different directions and scales. The each filtered sub-band image is divided into different sub-blocks and the statistical features derived from every sub-block are regarded as the target recognition feature, which can be used to recognize the targets with SVM. The proposed method is tested and validated on MSTAR dataset for 3-type SAR target recognition. [C251]

## "Applications of kernel methods to polarization radar target recognition using polarizationscattering matrix"

In this paper, we propose novel methods of polarization radar target recognition based on kernel methods using polarization scattering matrix (PSM), in which feature extraction from PSM is avoided. Firstly two kinds of kernel function based on PSM are defined, then, they are employed to the kernel principal component analysis (KPCA) respectively. Finally the nearest neighbor (1NN) classifier and the support vector machine (SVM) classifier are used for classifying targets. Experimental results based on simulated data show that the proposed methods achieve good recognition performance. Several forms of kernel function are used to prove the generalization of the proposed kernel methods. In order to validate its effectiveness, radar target recognitions of high resolution radar profiles (HRRP) are done, and the results show that the proposed methods are feasible. [C252]

## "A method of waveform design based on multi- eigenvecor selection"

Cognitive radar is a newly proposed radar system, which may adaptively and intelligently interrogate a propagation channel using all available knowledge including previous measurements. Thanks to a great important role of the adaptive waveform design technique in cognitive radar, it receives much more attention in the near future. However, due to the existence of aspect uncertainty and sensitivity characteristic of the target's impulse response, it is difficult to adaptively design waveform for target recognition task, which also often leads to the available approaches ineffective. In order to solve the problem, a new method termed Multi- Eigenvector Selection is proposed in the presence of additive Gaussian coloured noise (AGCN) in this paper, which optimizes via selecting multi-eigenvector and tries to improve the separability effectively. Experimental results prove the efficiency of the proposed method compared to the existing methods. [C253]

## "Radar automatic targt recognition for alterable noise environment"

Noise level of radar target returned echoes is an essential issue for HRRP automatic target recognition, which will deteriorate recognition performance if test sample have different noise level compared with the training samples. Assuming that HRRP contains additive Gaussian white noise and HRRP signals of range cells are jointly Gaussian-distributed, this paper selects PPCA-subspace model to describe HRRP. The main contribution is a promising adaptive method to deal with alterable noise environment between training phase and test phase for HRRP statistical recognition. To make the algorithm more practical, an approximate algorithm is presented to accelerate the original one while keeping the sacrifice of recognition precision very small. Simulated recognition experiments based on measured data illustrate our proposed method's effectiveness. [C254]

## "SAR ATR based on Generalized Principal Component Analysis Integrating Class Information"

Generalized Principal Component Analysis Integrating Class Information (ICGPCA) is proposed for feature extraction in this paper. Firstly we compute wavelet coefficients of images using DB2 wavelet and extract the approximate sub-image of wavelet transformation, and then extract the feature of the sub-image using ICGPCA which maximizes the between-class scatter and minimizes the within-class scatter. Experimental results adopting Nearest Neighbour Classifier (NNC) and Support Vector Machine (SVM) Classifier show that the proposed method can extract effective features with lower dimensions, consequently enhance the correct probability of recognition and decrease the recognition computation effectively. The recognition rate without target azimuth information arrives at nearly 97%. [C255]

## "Ballistic missile micro-Doppler parameter estimation based on multi-section signals"

Spin motion of the ballistic missile (BM) with empennages caused micro-Doppler modulations in radar returns, which was quite an important characteristic in BM radar target recognition systems. Early-warning radar (EWR) sometimes had to observe targets in time segmented due to the demands of multi-object-tracking and multi-tasking. While there were many difficulties to extract feature parameters from the non-coherent multi-section signals. The paper modelled the multi-section radar signals of the spinning BM firstly. According to the characteristics of the multi-section signals, the method of Radon-pseudo-STFT was proposed to estimate the

radial acceleration using the multi-section signals. After the acceleration compensation, the micro-Doppler modulation period was extracted based on the method of complex envelops unbiased autocorrelation. [C256]

## "Combining wavelet invariant moments and relevance vector machine for SAR target recognition"

A new method to classify targets in SAR images is proposed in this paper. The method combines both the advantages of wavelet invariant moments and relevance vector machine (RVM). The wavelet invariant moments have the wavelet inherent property of multi-resolution analysis and moment invariants quality. We firstly extract wavelet invariant moments to indicate targets in SAR images, and then select the feature set with principal component analysis (PCA). Finally, the selected feature set is fed to RVM for training and classifying. The RVM can powerfully manage complex classification and regression problems basing on the concept of probabilistic Bayesian learning framework. We perform 2-class and 3-class classification experiments respectively. Test results show that wavelet invariant moments indicate the target effectively, and RVM performs better than K-nearest neighbourhood (K-NN), back propagation neural network (BPNN) and least square support vector machine (LSSVM). [C257]

## "Adaptive statistical model for radar HRRP recognition"

Radar automatic target recognition (RATR) should have a robust recognition performance in different noisy conditions. Most of the algorithms in RATR are based on high signal-to-noise (SNR) condition, not consider the recognition performance in low SNR. In this paper, based on the probabilistic principal component analysis (PPCA) model, we develop an adaptive statistical model for radar target recognition. This algorithm makes the parameters of PPCA model altered by different noisy conditions. Experimental results for measured data show that the average recognition performance of the proposed adaptive statistical model has an obvious improvement in low SNR. [C258]

## "A radar target recognition method based on auto-correlation wavelet SVM"

Radar high-resolution range profile (HRRP) provides potentially discriminative information on the geometry of target, which has been shown to be promising signatures for radar Automatic Recognition (ATR) application.In this paper, a radar target recognition method based on auto-correlation wavelet support vector machine (AWSVM) is proposed. As the kernel of AWSVM, the auto-correlation of a compactly supported wavelet satisfies the translation invariant property, which is very important for radar ATR with HRRP. The theoretical analysis and simulation results have shown that the new algorithm is effective, the average recognition rate of five airplanes is 97.6%, and the high recognition rate is comparatively steady when the wavelet scale factor is changed in a certainty range. [C259]

## "Application of MoM-PO hybrid technique in complex target high resolution imaging simulation"

Simulation and modeling of complex targets high resolution imaging by electromagnetic calculating method is very important for high resolution radar targets detection and automatic recognition. In the process of calculating the high resolution image of electrically large targets, high-frequency approximation method and low frequency numerical method have their respective superiorities and limitations, so it is a feasible method to combine the two methods to calculate. In this paper, the high resolution information in wideband frequency of the target with arbitrary shape and in arbitrary attitude is simulated by MoM-PO hybrid techniques for accurate and efficient analysis of scattering fields, and the high resolution range profile (HRRP) and two-dimensional images of the complex target is simulated with these wideband responses. The simulation results show that this hybrid method is effective and applied in high resolution imaging for complex real targets. [C260]

## "Target Intention Inference Model Based on Variable Structure Bayesian Network"

Target intention inference is an important aspect of situation assessment. The evidence system of targets' intention inference is discussed according to the independent relationship between targets' intention and input evidence. The targets' intention probability inference model is proposed based on static Bayesian network. In order to expand the application domain and predigest the parameter learning contents, the decomposition and mergence of network' structure are disposed. The process of parameter learning is simplified according to the condition independent relationships. Different network architecture and condition probability state space of their parameter learning method are carried on. The result shows that variable structure is a suitable method for reducing the state space of the network conditional probability. [C261]

## "Diagonal Clustering-based discriminant analysis for synthetic aperture radar Automatic Target Recognition"

A novel subspace analysis method called diagonal clustering-based discriminant analysis (DiaCDA) is proposed. Unlike principal component analysis (PCA), fisher linear discriminant (FLD) and clustering-based discriminant analysis (CDA), DiaCDA directly seeks the optimal projection vectors from 2-dimensional diagonal image matrices not from 1-dimensional original image vectors. Moreover, the advantage of DiaCDA over 2-dimensional PCA (2DPCA), 2-dimensional FLD (2DFLD) and 2-dimensional CDA (2DCDA) is that DiaCDA seeks the projection vectors by interlacing both row and column information of the original images, while 2DPCA, 2DFLD and 2DCDA seek the projection vectors by using only row information of the original images. Experimental results conducted on the moving and stationary target acquisition and recognition (MSTAR) public database show that DiaCDA has obtained higher recognition rates or at least the same ones as 2DPCA, 2DFLD, and 2DCDA. In addition, the recognition performances can be further improved and feature dimensions can be reduced sharply by combining DiaCDA with 2DCDA. [C262]

## "Recognition of SAR Image Based on SVM and New Invariant Moment Feature Extraction"

Support vector machine (SVM) is regarded as a good alternative of the traditional learning classification. Because of its excellent learning performance, it has become a research hot spot in the field of machine learning. This paper describes the new invariant moment feature extraction of SAR objectives based on shape feature, then classify and train the eigenvectors by using SVM. The excellent recognition rates achieved in experiments indicate that SVM is well suited for SAR image target recognition. [C263]

## "SAR Target Recognition with the Fusion of LDA and ICA"

In this paper, an approach for synthetic aperture radar (SAR) target recognition with fusion of linear discriminant analysis (LDA) and independent component analysis (ICA) features is presented. We first employ LDA and ICA to extract feature vectors from SAR images. The extracted LDA and ICA features are then imported to two support vector machine (SVM) classifiers respectively. Ranking based decision fusion algorithm is used to fuse the results of two SVM classifiers and the final classification decision is achieved. Finally, we apply the method for various ground vehicles in MSTAR database to evaluate the recognition performance. Experimental results show the higher target recognition performance compared with the methods using LDA or ICA feature. [C264]

## "Micro-Doppler analysis of high speed moving targets"

Micro-Doppler induced by mechanical vibrating or rotating of structures in a radar target is potentially useful for target detection, classification and recognition. While the Doppler frequencies induced by the target body scatterers are constants after motion compensation, the micro-Doppler due to vibrating or rotating structures of the target is a function of dwell time. Now the characteristic of micro-Doppler has been used in low speed moving targets' recognition widely, but high speed moving targets have different properties from the low speed moving targets. Due to the influence of high speed, the returned signal after stretch processing will appear range profile broadening and range migration. This paper analyzes the micro-Doppler signature of high speed moving targets, and computer simulations are given to prove the validity of the analysis. [C265]

## "Efficient compression of wavelet packet OFDM radar signals"

Wavelet packet based OFDM radar signals have been recently introduced to achieve high range resolution in radar systems. As in single carrier phase coded radars, the conventional method for compression of these signals is based on using matched filter or direct computation of the autocorrelation function. In this paper, we introduce a new method for compression of these signals based on Discrete Wavelet Packet Transform (DWPT) that is mathematically equivalent to the matched filtering. The proposed structure is efficient for use in dual mode radar/communication systems and also is the base for having a multi-resolution radar which is a new concept in radar systems. Also this structure facilitates the estimation of phase and amplitude of different subcarriers frequencies. These data can be used in radar systems in various scenarios, especially for target recognition and appropriate power management in the tracking mode or using adaptive waveform design concept in radar systems. [C266]

## "The performance of power transform in high resolution radar target identification"

Power transform is a nonlinear pretreatment method, which can improve the recognition rate of high resolution range profiles obviously[2]. This paper mainly analyses how we should decide the power transform coefficient in order to get good recognition results. We process the range profiles in different noise condition using different power transform coefficients, and then we classify them with radial basis function classifiers. According to the real data processing results, we know that we should decide power transform coefficients in accordance with the signal-to-noise ratio. [C267]

## "A novel method for ISAR imaging of ship target"

High resolution ISAR (inverse synthetic aperture radar) imaging and recognition of ship target is very important for many applications. Although the principle of ISAR imaging of ship target on the sea is the same as that of flying target in the sky, the former usually has more complex motion (fluctuation with the oceanic waves) than the latter, which makes the motion compensation very difficult. However, the change of phase chirp rate caused by the complex motion of ships will deteriorate the azimuth focusing quality. In this paper, we first model the complex motion of ship target with cubic phase terms (parameterized on chirp rate and its change rate), then a new ISAR imaging method, referred to as TCD-echirpClean, is proposed, which estimates the chirp rate and the change rate of chirp rate of all scatters in the time-chirp distribution plane. Both numerical and experimental results are provided to demonstrate the performance of the proposed method. [C268]

## "Adaptive single-tone waveform design for target recognition in Cognitive Radar"

Cognitive Radar is a recently proposed system concept, one of whose most important characteristics is the closed-loop operation. The feedback structure from the receiver to the transmitter enables the optimization of transmission waveforms based on the latest knowledge about targets and environments. In this paper, we propose an improved waveform design method for target recognition in cognitive radar by restricting the waveforms to be single-tone with constant envelope which are commonly used in practical transmitters. Comparing with a previously proposed method using arbitrary waveforms, our method provides almost the same performance with highly reduced computational cost in sequential transmissions. [C269]

## "CASpatch: A SAR image simulation code to support ATR applications"

In this paper, A SAR image simulation code of 3D complex targets named CASpatch is introduced. This code is based on the high frequency technique of shooting and bouncing rays (SBR). The original purpose to design the code is for SAR automatic target recognition (ATR) applications, but it can also be used for RCS prediction and high resolution range profile (HRRP) generation. A GB-SAR indoor experiment is used to validate the CASpatch system. The simulation results of complex targets show that high resolution, full polarimetry and wide bandwidth SAR images can be obtained via CASpatch, which means our code can support multiple SAR ATR applications. What's more, an improved PolSAR ATR algorithm is also proposed in this paper. The full PolSAR ATR experiment based on simulated data is firstly reported in this paper, and higher recognition rate is achieved comparing with the single PolSAR result. [C270]

## "Texture feature coding method for SAR automatic target recognition with adaptive boosting"

In this paper, the applicability of texture feature coding method (TFCM) to synthetic aperture radar (SAR) automatic target recognition (ATR) is studied. The TFCM cooccurrence matrix (CM) is used as an additional image feature for adaptive boosting (AdaBoost) algorithm which uses originally 2D-DFT coefficients as an image feature. The TFCM CM extracts the connected texture information from the image while 2D-DFT gives the value of the spatial frequency components. The TFCM CM is invariant under the rotation of images. With these characteristics, the TFCM CM can discriminate a confused target which is not classified properly using 2D-DFT. The TFCM CM is combined with 2D-DFT in fusion process of the AdaBoost algorithm. In experimental results, it is shown that the correct-classification probability of the proposed scheme is larger than that of the conventional scheme which uses only 2D-DFT and raw image as image features. [C271]

## "An iterative segmentation algorithm of SAR image based on support vector machine"

In this paper, an iterative algorithm, which is based on support vector machine (SVM), is proposed for synthetic aperture radar (SAR) image segmentation. The proposed method considers the SAR image segmentation as the pixel classification. The pixels of the previous segmented image are regarded as the training samples for SVM, which is used to re-segment the image. These iterations are repeated until the convergence, which is determined by checking the relative change of the entropy between two consecutive segmented images. Experimental results show that compared with, the proposed algorithm can achieve much better segmented results than the Markov random field (MRF) algorithm, and the proposed method dramatically reduces the influence of initial segmentation on the final result. [C272]

## "Time Allocation in Cognitive Radar for Multiple Target Detection"

For cognitive radar, it should have the basic function which is learning. The radar needs to manage its resources dynamically and interactively between the setting of radar parameters to optimize the tasks the setting of radar parameters to optimize the tasks to be carried out and perceive environment highlights the role in which knowledge and intelligence will be central in cognitive radar performance. The problem discussed here is the

time allocation of cognitive radars in a multitarget environment. Radars are used to detect, to locate and to identify target. In this paper, we develop the optimization criterion based on the detection probabilities. [C273]

## "Study of Data Fusion of AIS and Radar"

In this paper, the function and necessity of target data fusion of radar and automatic identification system (AIS) are discussed. The characteristic and difference of tracking performance, target data category and precision between radar and AIS are analyzed. We propose a fuzzy fusion extrapolation method for target tracking data fusion processing based on AIS and radar. The proposed method can improve the performance and stability of vessel traffic service by AIS. [C274]

## "Evaluation of jamming effectiveness on ISAR system"

After introducing the evaluation of jamming effectiveness on SAR and ISAR of recent articles, the difference of the evaluation indicators are proposed, thus SAR jamming effectiveness indicator can not be used in ISAR jamming effectiveness evaluation. Then a model of three layers ISAR jamming effectiveness evaluation based on analytic hierarchy process and fuzzy comprehensive are analyzed, in the view of target recognization. Track and Image are chosen as the indictors of the jamming side; while recognization capability and reaction time are used as the indictors of the victim side. Following this, membership functions of each indicator are set up according to the real operations. This evaluation of jamming effectiveness is a bridge and intergrade from equipment technique evaluation to macroscopical defence system evaluation. [C275]

## "Imaging and locating multiple ground moving targets based on keystone transform and FrFT for single channel SAR system"

Synthetic aperture radar (SAR) imaging techniques have been successfully developed for static ground targets, but if the moving target returns are processed in the conventional imaging way, the resulting SAR image of moving targets will appear blurred and be misplaced in azimuth direction. In this paper, we proposed a method which is based on keystone transform and fractional Fourier transform (FrFT) to solve these problems. Firstly, first order keystone transform is performed on range compression results to correct range walk, then estimates of Doppler Centroid and Doppler modulation rate are obtained by using fractional Fourier transform, finally focused image of multiple moving targets is achieved by making use of the Doppler estimates. It can ascertain initial positions of multiple moving targets; moreover, it can estimate azimuth velocity, radial velocity and radial acceleration for every moving target. The simulation results show that this method can image and locate multiple ground moving targets effectively. [C276]

## "Analysis of the polarimetric parameters of representative targets and its application to land use classification"

Polarimetric SAR (POLSAR) data contains both phase and amplitude information from radar returns transmitted in four different polarizations. Thus it is necessary that we place strong emphasis upon extracting physical information from the observed scattering of microwaves. In this paper, we studied the Freeman decomposition method as well as some feature parameters that can represent targets' characteristics. Further more, we made an in-depth investigation on applying these parameters to discriminate several representative terrain cover types. [C277]

## "A SVR-based SAR target azimuth fusion estimation"

In SAR ATR, target azimuth estimation is one of the important pre-processing steps. Accurate estimation will bring a higher recognition rate. This paper presents a novel target azimuth estimation algorithm based on SVR with feature fusion. First target imaging pose is estimated roughly by long-edge fitting (LF) and ridgelet transform (RT) respectively, then SVR estimators are trained by the above estimated results which are combined together as the sample features. With the SVR, SAR target azimuth can be estimated more accurately. Experimental results with Moving and Stationary Target Acquisition and Recognition (MSTAR) database show the proposed method is effective, and can give better estimation performance than that either by LF or RT. [C278]

## "Optimal projection space method for SAR target recognition"

Automatic target recognition technique, based on the projections in the samples range space, can be availably used in SAR target recognition. It requires that the relativity between the range spaces of different targets should be minimal. However, the relativity between the corresponding range spaces is very big if the different targets have similar appearance and structure, which will considerably reduce the recognition performance. So, it is essential to construct new projection spaces from the range spaces of similar targets, so as to enlarge projection

difference. In this paper, an efficient method for constructing the optimal projection space is proposed. The proposed method can effectively enlarge the difference between similar targets by the projections in the optimal projection space. Experimental results show that the optimal projection space can greatly increase the separability between different similar targets, and is superior to other classical methods in both recognition performance and efficiency. [C279]

## "A W-KNN classifier to improve radar outlier rejection performance"

Radar automatic target recognition (ATR) mainly corresponds to uncooperative targets, and the training database is usually incomplete. So in the test step, we should reject the targets with new class labels as outliers firstly, and then recognize the remaining targets (inners) in detail. Combining with engineering application, we proposed a reasonable method to artificially generate outliers and designed a weighted KNN (W-KNN) classifier to treat with the outlier rejection problem. Experiments conducted on high-resolution range profiles (HRRP) data show that the W-KNN classifier is a promisingly method to treat with the rejection problem. [C280]

## "The multi-path scattering characteristics in SAR image of cylinder cavity"

In this paper, the shooting and bouncing ray (SBR) technique is employed to calculate the scattering of the cylinder cavity and by combining with range Doppler algorithms (RDA), the SAR image of the cylinder cavity is accurately obtained. Furthermore, the results reveal the effects of multi-path scattering mechanisms happened in the cavity, and also we give a detail explanation of the interference of multi-path scattering mechanisms on SAR imagery. And we point out for the first time that the cloud phenomenon in the down range is corresponding to focus mechanisms, which is totally different from that in the across range. Our present quantitative investigation provides guidelines for the SAR target recognition. [C281]

## "ISAR target recognition based on manifold learning"

In this paper, the idea of manifold learning is introduced into inverse synthetic aperture radar (ISAR) target recognition, a new method based on Locality Preserving Projections (LPP) algorithm and k-nearest neighbour classification for ISAR target recognition is proposed. Firstly, the LPP algorithm is used to reduce the dimension of ISAR image, and then three kinds of aircraft target are classified by k-nearest neighbour classification in the low-dimensional subspace. The simulated experimental results suggest that the proposed method has the capability of finding the low-dimensional manifold structure embedded in the high-dimensional ISAR image space controlled by few parameters, such as attitude angle, scale and position, etc., and better classification performance is acquired comparing to PCA and LDA. [C282]

## "Research on micro-motion and micro-Doppler of ballistic targets"

The micro-motion characteristics and micro-Doppler of ballistic targets are becoming a research hotspot in target recognition domain. In this paper, micro-motions of ballistic targets are analyzed, and the methods of extracting micro-Doppler of narrowband and wideband signal are studied. The autocorrelation in time domain and cepstrum in frequency domain are introduced to extract the period of micro-Doppler variation. The experiment to extract the micro-Doppler of warhead in darkroom is carried out. The experimental result proves that the methods proposed above are valid. [C283]

## "Marker-controlled SAR image segmentation algorithm"

This paper presents an algorithm for automatic segmentation of SAR imagery into target, shadow, and background clutter regions, which is a key pre-processing step for SAR image based automatic target recognition. Power transformation is employed in this algorithm to transform SAR image data to nearly Gaussian distributed data, followed by which is a de-nosing processing by using partial differentiation equation. A marker-controlled based SAR image segmentation algorithm is used to segment the de-noised images. We introduce a new sliding window method to find extreme value in SAR image, which is used as marker for controlling segmentation region. Experiment results show that this algorithm can overcome the influence of impulse noise and the correlation and dependency of adjacent pixel in SAR imagery,and get trim borderline and good segmentation performance. [C284]

## "Efficient subspace-based recognition method for SAR targets with similar structure"

To identify target for the images obtained by synthetic aperture radar (SAR), those subspace-based methods for automatic target recognition (ATR) usually operate on the range subspace of the training samples. When some targets with similar structures need to be distinguished, the corresponding templates are poorly separable because their range subspaces of each other have a big intersection. A method is proposed for SAR target ATR

in this paper, which chooses the orthogonal subspace of the sample range subspace as the projection subspace. Consequently, the difference, between the projections of the different type targets on the projection subspace, is enlarged, which significantly improves the identification effect. Experimental results show that the proposed method is superior to the other similar methods. [C285]

## "Analysis of regularization based on lk norm in SAR complex-imagery domain"

Synthetic aperture radar (SAR) target recognition needs high quality image. This can be realized by the regularization method, which is beneficial to super-resolution and noise suppression by utilizing prior information. Via analyzing the iterative process of SAR complex imagery domain regularization based on lknorm, the inherent principles of super-resolution is revealed. On the basis of the process, the essential reason of inconsistent resolution of the original algorithm is exposed and a modified method based on weighted amplitude is presented. Experimental results on synthetic scene and real MSTAR data prove the validity of our approach. [C286]

## "Anti-vessel end-guidance radar ECCM against deception jamming of range gate pull off"

Electronic counter-countermeasures (ECCM) against range gate pull off (RGPO) are the key ability needed by anti-vessel end-guidance radars. An integrated means of jamming recognition is presented using automatic gain control (AGC) voltage, CFAR output, echo dimension and velocity of tracking gate, based on analyzing the modes of RGPO. A novel method of ECCM against RGPO using memory tracking and narrow gate monitoring is proposed. Interference of RGPO will be out of tracking gate earlier than target echo. This method can deal with all kinds of RGPO, and can apply to both coherent radars and non-coherent radars. [C287]

## "Using potential accuracy of object localisation with multilateration systems"

One of the most stringent requirements to a multilateration (MLAT) system is very high accuracy of target (emitter) localisation. In view of this, the potential accuracy of emitter localisation (PAEL) based on Cramer-Rao inequality is important to use. Its dependence on system geometry and time of arrival (TOA) measurement accuracy allows choosing reasonable system geometry and requirements for TOA measurements. PAEL for MLAT systems and wide area MLAT (WAM) systems with different geometry is considered including systems developed for the Marco Polo airport in Venice, Italy (as an example). The possibility of velocity determination using PAEL for landing and taking off aircrafts is also discussed. [C288]

## "Sound and dynamics of targets-Fusion technologies in radar target classification"

The challenge of modern sensor systems is besides the tracking of targets more and more their classification. The knowledge of the target class has significant influence on the identification, threat evaluation and weapon assignment process of large systems. Especially, considering new types of threats in anti asymmetric warfare the knowledge of a target class has an important drawback. Also the target class is used to optimize track and resource management of todaypsilas agile sensor systems. A technology is presented that fuses different classifiers to decide between persons, tracked vehicles, wheeled vehicles, helicopters, propeller aircrafts and clutter for a 2 dimensional, electronically scanned radar system. A first classifier analyses the Doppler sound of the target to decide its target class. Therefore, a cepstrum based feature extractor and a hidden Markov model (HMM) is applied. Similar to techniques that have been well proven in speech and image recognition, the time-varying nature of radar Doppler data is exploited. A second type of classifier extracts dynamic features of the target found by the underlying target tracking methodology. Through a fusion of these classifiers a highly reliable classification result is established. [C289]

## "Robust multi-look HRR ATR investigation through decision-level fusion evaluation"

Simultaneous tracking and identification (STID) is impacted by sensor and target dynamics especially in move-stop-move type scenarios. For most scenarios, both moving and stationary targets can be processed into 1D High-Range Resolution (HRR) radar profiles which contain enough feature information to discern one target from another to help maintain track or to identify the vehicle. To meet mission objectives, different decision-level and feature-level classifiers can be designed to achieve performance requirements such as the sensitivity of the number of features for a given location accuracy, identification confidence, timeliness (revisit rate and track length), and throughput of the number of targets tracked. For robust STID evaluation, repeatable scenarios, metrics, and data support is recommended for comparisons. This paper compares the ATR performance of a baseline single-look algorithm to the performance of decision level and feature level fusion ATR algorithms through multilook assessments to assess relative fusion performance gains. [C290]

## "Resolution improvement for UWB wallscanning radar applications"

An important quality criterion of radar systems is the maximum obtainable resolution. This limit is reached when echoes coming from adjacent objects overlap and it is no longer possible to distinguish between them. This paper presents an algorithm formulating the echo separation as an optimization algorithm. The basic idea is to model each received signal as a linear superposition of reference signals. The parameters of the model are obtained by using evolutionary optimization strategies. An example of imaging two pipes placed in a concrete wall verifies the proposed principle experimentally. [C291]

## "Automatic target recognition of aircrafts using neural networks"

The multilayered feed-forward neural network was applied to automatic target recognition using the high range resolution (HRR) profiles in this paper. To extract effective features from the HRR profiles, the product spectrum originally proposed for the speech signal processing was introduced to the radar target recognition community. The product spectrum was defined as the product of the power spectrum and the group delay function, which could combine the information contained in the magnitude spectrum and phase spectrum of the HRR profiles and carry more details about the shape of the aircrafts. A multilayered feed-forward neural network was selected as classifier. The HRR profiles were obtained using the two-dimensional backscatters distribution data of four different scaled aircraft models. Simulations were presented to evaluate the classification performance with the product spectrum based features. The results demonstrate that the product spectrum based features outperform the original HRR profiles and the multilayered feed-forward neural network is effective for the application of automatic target recognition of aircrafts. [C292]

## "The theory and application of an electromagnetic target recognition method based on natural-resonance for multi-targets"

This paper presents the application of an electromagnetic target recognition method based on natural resonance mechanism and MUSIC algorithm to the target sets containing single amd multi-targets. The simpler case of the proposed method was applied to single targets previously and successful results were obtained [1]. However, when multi-targets are added to the test target set, the method needs crucial modifications and these modifications are mentioned in detail in this study. Owing to these modifications, the method becomes highly invariant to aspect angle and the distance between the multiple targets observed at once. The final version of the mentioned method is applied for the recognition of a target set containing single and multiple perfectly conducting spheres and sufficient accuracy rates are obtained even for low signal-to-noise ratios. [C293]

## "Object-level fusion and confidence management in a multi-sensor pedestrian tracking system"

This paper describes a multi-sensor fusion system dedicated to detect, recognize and track pedestrians. The fusion by tracking method is used to fuse asynchronous data provided by different sensors with complementary and supplementary fields of view. The confidence in detection and recognition is calculated based in geometric features and it is updated using the transferable belief model framework. The vehicle proprioceptive data are filtered by a separate Kalman filter and are used to estimate the relative and the absolute state of detected pedestrians. Results are shown with experimental data acquired in urban environment. [C294]

## "An intelligent through-the-wall recognition system for homeland security"

The increasing demands for homeland security boost the development of an intelligent recognition system for through-the-wall sensing. A novel intelligent through-the-wall life recognition engine based on support vector machine (SVM) is provided herein. In this system, micro-Doppler signatures detected from through-the-wall radar are extracted and fed into a SVM classifier. Micro-Doppler effect has great potential for life recognition of human activities, nonhuman but vital subjects, and lifeless targets. Due to time-varying non-stationary characteristic of micro-Doppler feature and its high dimensionality, the SVM classifier is found effective in achieving both computation efficiency and accuracy for this application. Simulation results show that high classification performance is achieved using the proposed recognition system. [C295]

## "2D spatial model matching using HRR multi-radar data"

In this paper, the problem of target classification from multiple high range resolution (HRR) radars data is studied. The use of multi-sensor angle-diverse data aims at shortening of the required time before a decision is made, as compared to using single-sensor data. In order to avoid the high-dimensional HRR profile databases, involved in the classic automatic target recognition (ATR) approaches, the classification is based on 2D spatial target profile matching. Stochastic target modeling is further applied, as a more robust way to deal with more realistic target scattering behaviors at variant aspect angles. Raw video measurements are used, with the objective to circumvent problems due to missed detections and false alarms in the thresholded profiles. This paper proposes a new method, where the above elements are combined. Some first encouraging simulation

results are given. [C296]

## "A recognition algorithm for high voltage transmission lines at horizontal polarization millimeter-wave radar"

In this paper, the radar phenomenology of high voltage transmission line (HVTL) is studied for examining the feasibility of recognizing HVTL using the horizontal polarization millimeter-wave radar system. For this purpose, horizontal polarization RCS and high resolution range profile (HRRP) of some HVTL are calculated at 34 GHz. Based on the observed behavior, a horizontal polarization recognition algorithm that makes use of the scattering feature caused by the braided structure of HVTL is proposed. The performance of the algorithm is demonstrated experimentally. [C297]

## "Data fusion based on electronic and SAR imagery reconnaissance information"

With the rapid development of information technology, the battlefield environment is becoming more and more complex and emitter platform recognition becomes more and more difficult. Multi-sensorpsilas data fusion is a very important mean. This paper first proposes an electronic and SAR imagery reconnaissance data fusion system scheme, and then presents a viable method for platform recognition based on the D-S evidence theory. At last, the Simulation experiment shows that the method is applicable and effective. [C298]

## "Performance evaluation for ATR system based on backward cloud with less samples"

In the recent years, as the development of automatic target recognition (ATR) technology, the performance evaluation for it becomes more and more important. In order to solve the problems of needing artificial intervene and needing too many samples in the existent evaluation methods, we proposed a new performance evaluation method for ATR system based on the backward cloud. In this method, we use numerical value features which are contained in the recognition result samples to denote the performance of the ATR algorithm, therefore we can do the evaluation without artificial intervene and with much less number of samples compared with other existent ones. At last, the simulation proved the advantages above. [C299]

## "Micro-doppler feature extraction for ballistic missile warhead"

To elucidate the spinning signatures of ballistic missile warhead, the model of spinning motion for ballistic missile warhead is established and the mathematical formulas for micro-Doppler signatures caused by spinning motion is derived. Then the time-varying micro-Doppler signatures are analysed with high-resolution time-frequency transform, and the micro-Doppler frequency is calculated based on time-frequency distribution. Finally the computer simulation confirms theoretical analysis, providing theoretical foundation for warheads recognition by micro-Doppler signatures. [C300]

## "Two-touch type parking slot marking recognition for target parking position designation"

This paper proposes a target parking position designation method based on parking slot marking recognition for automatic parking system. To reduce the search range and memory requirement, the driver designates two seed-points which are the end-point of two line-segments separating the target parking slot from adjacent parking slots. As the method does not require marking line separating parking area from roadway, it can be applied to various parking slot marking types. The method was tested with two parking slot marking types, i.e. rectangular type and 11-shape type. [C301]

## "Automated detection of moving person from small pulse battlefield radar"

The paper presents algorithm for automatic detection of moving person, utilizing signal from small pulse battlefield radar. The automation process presumes real signal analysis from radar coherent channel, signatures recognition for aimed specific group of targets, following signal preprocessing to enhance the most suitable expected signal parameters and reduce jamming compounds and final appropriate algorithm development with respect to specific application constrains. The analytic portion was realized on the real moving persons (equipped with corner reflector) measurement basis and further algorithm verification on real samples of moving persons. [C302]

## "Parametric UWB radar target modeling using Particle Swarm Optimization"

This paper uses the particle swarm optimization for parametrically modeling the impulse response of radar targets segment by segment. Parametric modeling of UWB radar signatures has been used for target recognition [Carriere and Moses, 1992 and 1988]. The performance of the modeling techniques used in this paper is

comparable to traditional modeling schemes such as the Prony method, but makes no assumptions about signal statistics, and most importantly does not require a priori knowledge of model order (number of scatterers) but adaptively converges to the proper order. [C303]

## "IMMPDA vehicle tracking system using asynchronous sensor fusion of radar and vision"

This paper focuses on recognition and tracking of maneuvering vehicles in dense traffic situations. We present an asynchronous multi obstacle multi sensor tracking method that fuses information from radar and monocular vision. A low level fusion method is integrated into the framework of an IMMPDA Kalman filter. Real world experiments demonstrate that the system combines the complementary strengths of the employed sensors. [C304]

## "Research of radar automatic target recognition in practical high resolution range profile"

Radar target automatic recognition is a comprehension problem. We have researched the practical radar data and concluded some valuable viewpoint. With it we put forward a whole scheme to achieve radar automatic target recognition. First the OS CAFR and binary accumulation algorithm is taken to accurately detect target. Here we lower self-adapt threshold to get more targets which maybe be false target. Then we use target trace management to remove the illusion target. The novel algorithm, called as endpoint detection based on moving window, can get more valuable data to classification. For 3D target we must build more templets in classification. So we use Neural Net as classification algorithm to reduce memory space. The simulation results prove that this scheme can get better recognition results. [C305]

## "Performance evaluation for automatic target recognition based on cloud theory"

In the recent years, as the development of automatic target recognition (ATR) technology, the performance evaluation for it becomes more and more important. However, the existent evaluation methods always have shortcomings such as needing too many samples or needing artificial intervene to determine some parameters like weights. In order to solve these problems, we proposed a new performance evaluation method for ATR system based on cloud theory. In this method, we use numerical value features which are contained in the recognition result samples to denote the performance of the ATR algorithm and then use the weight clouds to replace the index weights in the fuzzy comprehensive evaluation. Therefore we can do the evaluation without artificial intervene and with much less number of samples compared with other existent ones. At last, we compared our evaluation method with the general fuzzy comprehensive evaluation through the simulations with real measurements and the simulation proved the advantages above. [C306]

## "Study on simulation of signal processing system of space surveillance radar"

This paper simply introduces the structure and working principles of one space surveillance radar simulation system, and analyzes the signal processing (SP) simulation system. In order to improve the radarpsilas ability to detect multiple targets and keep the false alarm probabilities constant, 2D-OS-CFAR and Clutter-Map CFAR are adopted as the algorithms of CFAR, and the detection threshold coefficient of OS-CFAR is studied and modified. Finally it gives the simulation results. The results show that the signal processing sub-system can detect the targets and their position, velocity exactly. And it can also satisfy the need of detecting far target, high measuring precision, the ability of detecting multi-targets and the false alarm probabilities in heavy clutter background. [C307]

## "Radar target simulation of space object"

This paper describes a target simulation which operates in non real-time to provide full closed-loop operation of the ground based multifunction phased array radar simulation system in support of ballistic missile defence experiments against countermeasure. By simulating the target scattering signature and dynamical signature, this target simulation provide realistic scenario source to evaluate the system performance of multifunction phased array radar, and the key algorithms verification and validation such as target tracking, multi-target imaging and target recognition. [C308]

## "A whole scheme for aircraft target identification in HRRP"

This paper describes the authorspsila efforts in practical high resolution range profile target automatic recognition. The practical high resolution range profile has more difference to simulation results, so this paper presents a novel algorithm to detect and extract the target range profile data and also create a whole scheme to deal with this difference. First it takes OS CAFR and binary accumulation algorithm to detect target. Here we lower self-adapt threshold to get more targets which maybe be false target. Then we use target trace

management to remove the illusion target The novel algorithm, called as endpoint detection based on moving window, can get more valuable data to classification. Practical data has more noise and low PSN, so K-mean algorithm can remove the bad data. Due to variation of target high resolution range profile we build a suffice sample set, which require us to use PCA algorithm to reduce the computer time and memory. Classification is N near classifier, which can get a nonlinear classification effect. The test results prove that this scheme can get better recognition results. [C309]

## "A Target Recognition Method of Multi-radar"

A target recognition method of multi-radar is proposed based on the kinematical information from multi-radar. The process of target recognition can be divided into three levels. First, air/sea target classification can be obtained based on the information from single radar including target height, velocity, acceleration, elevation rate and azimuth rate by using fuzzy synthetic evaluation. Then, type recognition of the air target classified from first level can be accomplished only by the target height information. Finally, the recognition results of multi-radar are obtained by the fusion of recognition results from single radar. The simulation results show that the method proposed in this paper is effective and can be facilitated to engineering. [C310]

## "Helicopter parameter extraction using joint time-frequency and tomographic techniques"

A technique based on time-frequency and tomographic analysis to extract helicopter blade parameters for the purposes of radar non-cooperative target recognition (NCTR) is investigated. The proposed algorithm shows that (under certain conditions) it is feasible to extract the number, blade length, blade tip velocity and angular velocity of a helicopterpsilas main rotor. Simulation results from a point scatterer model is validated through results on measured data from several different commercial helicopters. The developed technique is most suited to pulse-Doppler tracking radar and is shown to be feasible at a range of 11 km with a radar not specifically designed for this purpose. [C311]

## "Radar target classification in littoral environment with HMMs combined with a track based classifier"

One of the challenges of maritime radar applications is to address new kinds of threats, the so called anti asymmetric warfare role, which happens in the littoral environment. Besides the asymmetric warfare also the symmetric warfare is transformed more and more from the blue sea scenario into this environment. To realize information superiority one has to be able to deal with air, sea and land targets simultaneously. To fulfil the operational requirements (proportionality of counter measures, prevent collateral damage, etc.) the capability for a detailed classification of sea, land and air targets is of extraordinary importance (persons vs. vehicles, buoys vs. ships). [C312]

## "Analysis of rotating structures for stepped frequency radar"

Micro-Doppler caused by micro-motion structures contains movement and structure information which is useful for radar target recognition. The micro-motion modulation in high range resolution profile (HRRP) for stepped-frequency radar (SFR) is quite different forms that in spectrum for Doppler radar. Taking the basic micro-motion, rotation, as an example, this paper deduces its signal model for stepped frequency radar. Result shows that there exhibits a sinusoid shift of scattering centrepsilas position in HRRP sequence. A fast approach based on Hough transform is proposed to extract rotation parameters from HRRP sequence. Simulated and experimental results verify the correctness of the signal model and the extraction method. [C313]

## "Automatic Target Recognition by means of polarimetric ISAR images: a model matching based algorithm"

Automatic target recognition (ATR) is generally the reason why ISAR imaging systems are employed. Moreover, the use of fully polarimetric radar systems in radar imaging applications such as SAR and ISAR has enhanced both image quality and classification capabilities. In this paper, the authors propose a novel technique for ATR by using Polarimetric ISAR (Pol-ISAR) images. The proposed method is based on a model matching approach. Results are obtained by using real data that show the effectiveness of such technique. [C314]

## "Automatic Target Recognition of terrestrial vehicles based on polarimetric ISAR image and model matching"

An Automatic Target Recognition (ATR) algorithm has recently been proposed that makes use of Polarimetric ISAR images and a Model Matching approach. In this paper, the authors propose a variation of such an approach that is suitable for ATR of terrestrial vehicles. The effectiveness of the proposed implementation is

tested by means of real data acquired during a controlled turn-table experiment. [C315]

## "A technique to predict the time-of-arrival of a tumor response corrupted by clutter"

Radar-based microwave imaging has been proposed as a complementary modality for early stage breast cancer screening. A considerable challenge for the successful implementation of this technique is the reduction of clutter, or components of the signal originating from objects other than the tumor. To remedy problems that arise due to the breast shape, size and tissue variations, a novel technique is presented that identifies and localizes the source of a target response. The ability of the algorithm to predict the time-of-arrival of a tumor response in a signal corrupted by clutter is demonstrated. [C316]

## "Delay-doppler ambiguity function of ultrawideband-throb signals"

The performance of ultrawideband (UWB) radar in target detection, resolution, and recognition depends on the structure of the radar waveform. In this paper, the principles of waveform diversity and design (WDD) for generating periodic and orthogonal UWB-impulse signals are described. A mathematical model for a UWB-throb signal that yields the practical advantages of the widely used linear frequency-modulation (FM) ldquochirprdquo signal is presented. The structure of the UWB-throb signal is designed based on a pulse-time modulation scheme. The delay-Doppler ambiguity function of the UWB-throb signal is derived for performance analysis. Computer plots of the UWB-throb signal, its autocorrelation function, and ambiguity function are generated to illustrate its characteristics and advantages for high-resolution impulse radar. [C317]

## "The relationship between the radar bandwidth and recognition ability based on the ballistic target"

Reasonable bandwidth is important for a wideband ballistic missile defence radar. The relationship between bandwidth and recognition ability has great reference value. The paper analyzed the bandwidth effect on the resolution on the range profile. Then the relation between the bandwidth and the recognition accuracy rate is studied and the effect of the shape, the amount and the dimension of the targets on the relations is analyzed. Based on the HRRPs of six kinds of targets, the quantitative results are given. And the optimum bandwidth is calculated at different conditions. [C318]

## "Anti-RGPO method based on memory tracking"

The range gate pull off (RGPO) results in a disaster to radar target tracking. It is assumed that the jamming (i.e., RGPO measurement, the following are the same) pulls the range gate backwards in the conventional methods. However, the RGPO for some radar, e.g., linear frequency modulation radar, can pull onwards by modulating the Doppler frequency to the returned signal. Whatpsilas more, in conventional methods targets were modeled as point targets. Nevertheless, further studies are required when the target and jamming are extended in real-world environment. Previous researches failed to consider the lasting time of the anti-RGPO process, which is crucial under a certain condition. To avoid these drawbacks, a method based on memory tracking is studied. The method can detect the existence of RGPO and recognize the pulling-off direction of the jamming; and the method can make the jamming get out of the range gate earlier than the true target, thus the RGPO has little effect on the tracking. Some important factors in the method are analyzed. Experiments show that the total time of the anti-RGPO process is short. [C319]

## "Naпve Bayesian radar micro-doppler recognition"

A comprehensive evaluation of a naive Bayesian classifier used for micro-Doppler signature (mu-DS) radar automatic target recognition has been performed. An initial estimate of performance is made using the Bhattacharyya bound on the error probability that gives results of approximately 60% of the measured value. The classifier input data is pre-processed using the CLEAN algorithm, the Fourier transform and principal component analysis to provide feature vectors exhibiting only mu-DS information. The classifier includes ldquounknownrdquo input rejection that falsely declares known targets with a probability of just 0.07. The probability of correct classification is 0.94. [C320]

## "The concept of a forward scattering micro-sensors radar network for situational awareness"

The concept of a novel forward scattering micro-radar wireless network for ground targets detection and recognition is presented. The system topology and structure are described first, followed by a summary of the systempsilas capabilities and applications. Signal processing strategies used for target detection, parameter estimation and automatic target recognition are briefly explained and supported with experimental results. [C321]

## "Detection of buried objects using GPR change detection in polarimetric Huynen spaces"

Change detection is a useful method for detecting new events in a scene such as the placement of mines, and/or the movement of people, vehicles and structures. The basis of the approach is to examine an area via radar several times. Once, before there were targets planted there, and the other (or others) after. The change detection algorithm will notice if there are any changes after the first view was made. False alarm, that is a critical issue in this approach, can be reduced in a number of ways: exploiting additional information such as phase and polarization, and 2) exploiting critical attributes by computing changes in focused sub-spaces. In this paper we present anew approach for polarimetric change detection, whereby the target is represented not in terms of the complex scattering elements but in terms of phenomenologically-based Huynen parameters. Each element of the Huynen parameter set conveys useful physical and geometrical attributes about the scatterers thus augmenting the potential for significant false alarm mitigation. Results of the application of this approach on fully polarimetric signatures of simulated buried targets are provided. These results indicate that Huynen parameters are more effective for change detection than the scattering matrix elements in generating higher unambiguous autocorrelation peaks and less prominent cross-correlation peaks. [C322]

## "Radar Target Recognition Using LVQ Network and Majority Voting"

This paper describes a novel method for radar target classification based on high range resolution profile (HRRP). In view of the non-stationary characteristic of radar signal, adaptive Gaussian basis representation (AGR) is utilized to extract features from raw HRRP signatures to fully retain the physics information of target. Then learning vector quantization (LVQ) network is adopted to tackle the classification of single echo (after features extraction) with complicated space distribution. Finally ,a combined classification scheme combining LVQ networks with the majority voting rule is designed to circumvent the sensitivity of HRRP to target aspects based on sequential echoes. A actual example using three scaled aircraft model data collected in microwave anechoic chamber is presented to demonstrate the effectiveness of proposed scheme. [C323]

## "Radar target recognition based on a kernel double discriminant subspaces method"

Kernel Fisher discriminant analysis (KFDA) is a very effective tool used for dimensionality reduction and feature extraction in pattern recognition. However, KFDA also suffers from the so-called small sample size problem (SSS) which often exists in high-dimensional pattern recognition data. In this paper, we present a complete KFDA method, namely kernel double discriminant subspaces (KDDS). The new algorithm views the optimal discriminant vectors as a global transform in the feature space to some extent, and it makes full use of the discriminative information within both null and non-null subspace of the within-class scatter matrix, which makes KDDS a more powerful dicriminator. Experiments based on the measured airplanes database are conducted to evaluate the effectiveness of the proposed method, and the results show that it can obtain better classification performance. [C324]

## "Integrated target tracking and recognition via joint appearance-motion generative models"

We address the problem of joint target tracking and recognition by incorporating both appearance and motion information via two generative models. Specifically, a non-linear tensor decomposition method is used to develop an appearance generative model for multi-pose target representation. In addition, a target-dependent kinematic model is invoked to capture different target dynamics. Both generative models are integrated in a graphical model to work together for joint estimation of the kinematics, pose, and identity of the target. A particle filter is developed for inference in the graphical model where a Kalman filter is embedded to improve the proposal generation by taking advantage of motion cues. Tests on simulated infrared sequences demonstrate the advantages and potential of the proposed approach for joint tracking and recognition. [C325]

## "Ballistic Missile Target Recognition Based on Improved Bispectra Feature"

According to the characteristic of ballistic missile target recognition, the reduced-dimensional bispectra methods that are applied in high-resolution range profile recognition are studied, and an improved selected bispectra method based on extended Fisher class separability discriminant measure is proposed. The improved selected bispectra features are evaluated using computer simulation experiment. Compared to conventional selected bispectra and integrated bispectra methods, the improved selected bispectra method is highly discriminative and provides proper recognition of high-resolution radar ballistic missile target range profiles. [C326]

## "Target recognition of MMW radar based on FSVM"

The choice of fuzzy membership relates to the classification results of fuzzy support vector machine (FSVM). In this paper, membership based on distance and affinity among samples is researched. Aimed at the disadvantage

of membership based on affinity among samples that can not reflect the distribution of radar echo in feature space, super-ellipse is introduced to improve the membership and applied to FSVM to distinguish support vectors with outliers or noise. The results of experiments show that the fuzzy support vector machine, based on the improved affinity among samples, is more robust than others. [C327]

## "Radar HRRP Target Recognition Based on Optimal Transformation of Kernel Space and Cluster Centers"

How to extract effective discriminant features of high-resolution range profile (HRRP) is one of the issues for radar automatic target recognition (RATR). In this paper, a novel method for extracting discriminant features is proposed by using kernel optimal transformation and cluster centers techniques (KOT-CC). In addition, to alleviate the effect of independent noises on the discrimination, we propose a general algorithm for dealing with the singular cases of total scatter matrix, which are often encountered in various kernel methods, such as kernel fisher discriminant analysis (KFDA). Finally, experiment results on the measured radar data are compared and analyzed, which verify that KOT-CC is a powerful technique for extracting nonlinear discriminant features and improving recognition rate. [C328]

## "Flexible Feature Processing Mechanism of Radar Target Signal"

Extracting effective and reliable features is fundamental and critical for constructing target recognition systems. Flexible Feature Processing Mechanism emphasizes the integration of feature extraction arithmetic and the self-adaptation of feature selection. On one hand, it would try to dig up the valuable information on as many as possible aspects, so as to construct the feature extraction method sets. On the other hand, it emphasizes to select the distinct features and eliminate the redundant features. The series of feature processing methods have been applied in multiple radar recognition projects successfully. According to the observation and analysis on a large number of real-life data, and taking the thinking process and the description methods of radar operators for reference, a set of feature extraction and selection methods basing on visual effects for dynamic radar target echo series have been introduced. The effectiveness, robustness and extendibility have been proved by large amount of tests and applications. [C329]

## "Impact of signal bandwidth on airborne wideband radar echoes"

Model the output echo power from the matched filter of airborne radar receiver. Based on the same pulse time width, the same transmitted power and the same radar operation scene, signal-clutter-noise power ratio of the matched filter output is presented, and some new results different from the intuitionistic viewpoints is put forward. The impact of signal bandwidth on airborne radar echoes and target detector is discussed in detail. At last, computer simulations about typical airborne radar operation scene provide the verification and analysis. [C330]

## "HRR Signature Classification using Syntactic Pattern Recognition"

An automatic target classification system contains a classifier that maps a vector of real numbered features characteristic to a specific target onto a class label. Other features can be a string of symbols or alphabets that may not involve real numbers at all. There are certain orderings of the symbols in the strings governed by syntax rules, thus, generating a language, (that is, a collection of strings). Thus, a classifier would map a string to a class label. Such a classifier is called a syntactical classifier and varies greatly from its vector space counter part. This paper will give an overview of the construction of a grammar that generates a language then shows how they fit into a syntactical classification system. The performances of two syntactical classification systems with two and ten labels respectively are presented via confusion matrices. Experiments performed on public release DCS database indicate this approach has sufficient power to perform target detection using HRR signatures. [C331]

## "Image Quality Measures for Predicting Automatic Target Recognition Performance"

One important issue for Automatic Target Recognition (ATR) systems is to learn how robust the performance is under different scenarios. The quality of the input image sequence is a major factor affecting the ATR algorithm's ability to detect and recognize an object. If one can correlate the algorithm performance with different image quality measures, the recognition confidence can be predicted before applying ATR by predetermining the input image quality. In this paper, we address the utility of image quality measures and their correlations with performance failures of a principle component analysis (PCA) based ATR algorithm. Various image fusion approaches are examined to illustrate their abilities to improve ATR performance. Results show that the Shift Invariant Discrete Wavelet Transform (SiDWT) and Laplacian pyramid fusion schemes outperform other methods for improving the detection rate with the considered SAR images. Regression analysis is conducted to show that linear combinations of the selected image quality measures could explain about 60% of the variability in the non-

detections of the ATR algorithm. [C332]

## "Recognition of Moving Terrestrial Targets in the Presence of Terrestrial Clutters with a Pulse Doppler RADAR"

In this paper we propose an automatic target recognitionalgorithm to recognize and distinguish of three classes oftargets: personnel, wheeled vehicles and animals, based on thedoppler signatures they produce when moving, using a low-resolutionground surveillance pulse doppler RADAR. Using signal processingtechniques such as the short-time Fourier transform (STFT)and the chirplet transform, various parameters of the targets canbe extracted from the signal. This paper proposed classification ofmoving targets with use of the chirplet transform. The algorithmwas trained and tested on real radar signatures of multiple examplesof moving targets from each class and the performance wasshown to be invariant to target speed and orientation. [C333]

## "Polarization optimization for scattering estimation in heavy clutter"

Controlling the polarization information in transmitted waveforms enables improving the performance of radar systems. We consider the design of optimal polarization for the estimation of target scattering embedded in heavy clutter. The goal is to minimize the mean squared error of the scattering estimation subject to an average radar pulse power constraint. We show that such a problem is equivalent to the optimal design of a radar sensing matrix that contains the polarization information. We formulate the optimal design as a nonlinear optimization problem which can be recast it in a convex form and is thus efficiently solvable by semi-definite programming (SDP). We compare the sensing performance of the optimally selected polarization over the conventional approaches. Our numerical results indicate that a significant amount of power gain is achieved in the target scattering estimation through such an optimal design. [C334]

## "A Differential Based Approach for Sense-Through-Foliage Target Detection Using UWB Radar Sensor Networks"

In this paper, the foliage penetration measurement data is provided by Air Force Office of Scientific Research (AFOSR). When radar echoes are in good quality, the detection of target can be achieved by applying our differential based technology on received single UWB radar waveform. We compared our approach in case of no target as well as with target against the scheme in which 2-D image was created via adding voltages with the appropriate time offset. Results show that our approach can work much better. When radar echoes are in poor condition and single radar is unable to carry out the detection, we employ both radar sensor networks (RSN) and RAKE structure to combine the echoes from different radar members and successfully detect the target. [C335]

## "A new technique to measure RCS of large target at near distance"

In general, RCS measurement must meet the far-field condition, which need a vast measuring area or a costly compact range. To solve the problem, a new technique by extrapolation correction dealing with near-distance RCS measurement of aircraft targets is set up. The RCS of aircraft target under spherical wave illuminating can be adopted to extrapolate far-field RCS of them. The convolution arithmetic utilizing conductive board as a reference target deduces the phase-correction coefficient g(x) between spherical and plane wave, and in fact the convolution calculation of g(x) can be replaced by Fast Fourier Transform, which is related to the scattering field of the reference target measured in near-distance, thus the calculating procedure could be completed simply and quickly. By theoretical simulation for a simple target, the RCS extrapolated can be obtained correctly. Experimental results of complex aircraft target show that this new technique makes experiment agree to theory precisely, moreover, it permits the measurement distance reduced by 15 percent of the minimum distance of far-field. Also, there is no serious limitation of measurement for target in dimension of aperture and depth. [C336]

## "Target Localization from 3D data for On-Orbit Autonomous Rendezvous & Docking"

Neptec has developed a vision system for autonomous on-orbit rendezvous and docking that does not require the use of cooperative markers on the target spacecraft. The system uses an active TriDAR 3D sensor and efficient model based tracking algorithms to provide 6 degree of freedom (6DOF) relative pose information in realtime. The TriDAR (triangulation + LIDAR) sensing technology combines triangulation and time-of-flight (ToF) active ranging techniques within the same optical path. This configuration takes advantage of the complementary nature of these two imaging technologies and allows the system to provide fast and accurate 3 dimensional data at both short and long range. In partnership with the Canadian Space Agency (CSA), Neptec has developed a novel object localization algorithm that calculates the relative pose of a target spacecraft without requiring an initial estimate of the pose. This algorithm will be used to automatically initiate the model based tracking process

and recover if tracking is lost. The technique was specifically designed for real-time operations in space where a target spacecraft could be tumbling and processing power is limited. Most traditional approaches to object recognition and pose estimation algorithms require high resolution data arranged in a grid such that convolution based operators can be used. This generally means that data acquisition is slow and real-time data processing requires a powerful computer. Neptec's approach follows the more information less data (MILD) paradigm. It requires only a unorganized sparse 3D point cloud of the target, keeping the data acquisition time to a minimum. This paper presents an overview of the overall tracking system as well as results from testing the localization algorithm. The algorithm was tested with both simulated and TriDAR sensor data. [C337]

## "Automatic recognition of ISAR Images: Target shapes features extraction"

This paper presents a part of research study dealing with the initialization of an information system on radar automatic target recognition (ATR) chain. In this framework, we propose a set of helpful information at different levels of the ATR chain for decision making. The methodology used is the knowledge discovery process from data (KDD process).we focused in this paper on the data preparation step, more precisely Speckle denoising, edge detection and computation of features vector. We present the results of a several speckle filters that are largely used by ISAR imaging scientists (Lee, Frost, Kuan...). Fourier Descriptors have been used as features of the objects. Various similarity measures have been used and compared for target recognition. [C338]

## "Simultaneous clustering and tracking unknown number of objects"

In this paper, we present a novel on-line probabilistic generative model that simultaneously deals with both the clustering and the tracking of an unknown number of moving objects. The proposed model assumes that i) time series data are composed of a time-varying number of objects and that ii) each object is governed by a mixture of an unknown number of different patterns of dynamics. The problem of learning patterns of dynamics is formulated as the clustering of tracked objects based on a nonparametric Bayesian model with conjugate priors, and this clustering in turn improves the tracking. We present a particle filter for posterior estimation of simultaneous clustering and tracking. Through experiments with synthetic and real movie data, we confirmed that the proposed model successfully learned the hidden cluster patterns and obtained better tracking results than conventional models without clustering. [C339]

## "Road recognition in high resolution SAR image based on genetic algorithm"

Road recognition from SAR image is a very important problem. In this paper, a new method is proposed which can detect multiple roads in an image. Firstly binary edge image is gained by Canny operator and edge refining. Secondly, edge curves are encoded by reversible chained list, and fitness function is constructed based on SAR image road models, and optimal road boundary curves are linked by improved genetic algorithm. Thirdly, complete road boundaries are detected by curve fitting. At last, mated long road edge curves are found out and road surface are stuffed. The experiment shows that this algorithm can realize roads recognition and eliminate influence of other non-road. [C340]

## "Tracking a target in wind using a micro air vehicle with a fixed angle camera"

Target tracking in wind with micro air vehicles (MAVs) can be a difficult problem. Traditional tracking systems such as radar are too heavy to mount on a MAV and are often too large for a small airframe. Cameras, laser rangers, and ultrasonic sensors provide a viable alternative and are light enough to mount on a MAV. However, each of these sensors are directional and are often mounted at fixed angles requiring airframe control to maintain the sensor on a target. We propose a method of target tracking using a fixed angle camera and derive a closed-loop guidance strategy to fix the target in the image frame using the position and velocity of the target in the image plane to command a heading rate. The resulting motion of the MAV is an elliptical orbit around the target with the target positioned at a focus of the ellipse as predicted in previous open-loop methods. [C341]

## "Trajectory analysis and semantic region modeling using a nonparametric Bayesian model"

We propose a novel nonparametric Bayesian model, dual hierarchical Dirichlet processes (Dual-HDP), for trajectory analysis and semantic region modeling in surveillance settings, in an unsupervised way. In our approach, trajectories are treated as documents and observations of an object on a trajectory are treated as words in a document. Trajectories are clustered into different activities. Abnormal trajectories are detected as samples with low likelihoods. The semantic regions, which are intersections of paths commonly taken by objects, related to activities in the scene are also modeled. Dual-HDP advances the existing hierarchical Dirichlet processes (HDP) language model. HDP only clusters co-occurring words from documents into topics and automatically decides the number of topics. Dual-HDP co-clusters both words and documents. It learns both the numbers of word topics and document clusters from data. Under our problem settings, HDP only clusters

observations of objects, while Dual-HDP clusters both observations and trajectories. Experiments are evaluated on two data sets, radar tracks collected from a maritime port and visual tracks collected from a parking lot. [C342]

## "MIMO radar performance in clutter: Limitations imposed by bounds on the volume and height distributions for the MIMO radar ambiguity function"

In multiple-input multiple-output (MIMO) radar, the efficiency of target detection in clutter that is distributed over a certain range bin-Doppler frequency region depends on the sidelobe level of the waveformspsila auto- and cross-ambiguity functions within this region. We introduce the MIMO ambiguity function as the sum of all auto- and cross-ambiguity functions of the K MIMO radar waveforms, with the integral of this function over some range-Doppler region serving as a measure of the orthogonality (separability) of the waveforms within this region of interest. We derive an upper bound on the attainable ldquoclear areardquo for the MIMO ambiguity function, and show that, with respect to the conventional single-waveform ambiguity function, the maximum clear area is K times smaller for the MIMO system. [C343]

## "Chirplet-based target recognition using RADAR technology"

In this paper, q-chirplet based signal processing is applied to data from a low-resolution ground surveillance pulse Doppler RADAR, to classify three classes of targets: personnel, wheeled vehicles and animals. We utilize Zernike moments (ZM) over the chirplet parameters to determine the pertinent features. Our work provides a new approach for multiresolution analysis and classification of non-stationary signals with the objective of revealing important features in an unknown noise and clutter environment. The algorithm is trained and tested on real RADAR signatures of multiple examples of moving targets from each class. The results show the proposed algorithm invariancy against speed and orientation of the targets. [C344]

## "A method to select optimal feature parameters of radar targets based on rough set theory"

Based on rough set theory, a method to simplify information systems was well studied, and applied to select optimal feature parameters of radar target recognition in this paper. The radar target recognition system is treated as a kind of decision-making information systems. Firstly, the original crude information caught by sensors was transformed to information table. Then, distinguish matrix method was adopted to simplify the table and delete redundant information. Finally, the optimal feature parameter group was mined, and the simple and accurate rules of target recognition were obtained. The validity and advantage of this method were demonstrated by an example. [C345]

## "Recognition techniques and feature extraction for space targets based on RCS"

Radar recognition of space targets has gained popularity for space surveillance and peaceful uses of outer space. RCS of Space Object is nonstationary time-series, feature extracting and identification from RCS is difficult using commonly methods. Considering the changing regular of RCS reflecting figure of space target, this paper presents a novel method of space target recognition for attitude characteristics. The method makes use of CWT and fuzzy Decision to extract feature of RCS and classificate. The result shows that 90% of recognition rate is achieved when this method is applied to practical data. [C346]

## "Performance analysis of a weighted max CFAR processor"

In this paper, we study the performances of a novel CFAR in homogeneous environment. This processor consists to take maximum power of cells in the reference windows and multiply it by a coefficient alpha (alpha < 1) to obtain the background level estimate. We assume that the target is embedded in a white Gaussian noise and fluctuate according to a Swirling I model. Closed form expressions of the probabilities of detection and false alarm are determined and the performance of the proposed detector is investigated. [C347]

## "Polarimetric calibration-a comparison of different approaches"

Polarimetric calibration is performed by applying distortion matrices acting on transmit and receive. Two different approaches to determine these distortion matrices are compared to each other, a statistical one, and an approach that uses radar reflectors. The effect of polarimetric calibration is demonstrated by means of two examples pertaining to polarimetric detection, and to feature based target recognition. [C348]

## "The probability of target detection"

The paper deals with the most interesting problem of the probability of radar target detection. In this paper there

are derived probability relations of radar target detection in a covered radar zone for a single-frequency and double-frequency radar sensors. The starting point of the analyses is fluctuations of radar cross section. The Swerling theory has been used. In this paper there is an execution and mutual comparison of two types of radar sensors from the point of view of target detection, which confirm advantages of usage of a double-frequency radar sensor. The range detection of double-frequency radar sensor is doubled. [C349]

## "STAP/GMTI analysis using SAR data from simulated scenarios"

The surveillance of ground areas is one of the essential tasks for modern manned and autonomous flying platforms. Especially a SAR/GMTI sensor is essential because itpsilas all weather capability, but often demands large size antennas which must be designed under aerodynamic aspects with compromises regarding the ideal SAR processing need. The customerpsilas exigency for long-term observation capabilities requires furthermore the employment of automatic recognition systems. Both aspects require a SAR sensor design to platform, to performance and not at least to costs. This paper presents a performance assessment tool for both aspects, i.e. the influence of antenna imperfectnesspsilas to the (coherent & multi-channel) SAR data and also the impact to the target recognition capability. The tool combines the EADS SAR simulation program ldquoPIRDISrdquo which is able to deal with nearly arbitrary antenna patterns and produces coherent multi-channel signals in the range/Doppler domain, with a new ldquoground moving target indicationrdquo (GMTI) module working in the post-Doppler modus. The plot extractor regards only that information available also in an operational system and delivers (moving) target alarms (and also false alarm candidates, depending on scenarios and radar parameters). The results are compared with the ground truth known from the scenario generation in terms of accuracy of localisation, probability of detection and false alarm sensitivity. [C350]

## "Model based adaptive detector with low secondary data support"

In this paper the problem of adaptive target detection in structured Gaussian clutter is considered. The clutter is modeled as an auto-regressive process with known order but unknown parameters. Here a detection algorithm which can manage the cases with few secondary data is proposed. We have modified a well known adaptive detector in four different forms. First of all, we estimate the AR parameters based on secondary data and use the results in covariance matrix estimation. The performance of the proposed detectors have been evaluated using Monte-Carlo simulations and compared with each other. [C351]

## "A Bayesian algorithm for object detection in GPR data"

An algorithm for underground object detection in GPR data is presented in this paper. It combines the advantages of Kalman filtering approach, suggested by Carevic (1999) with the robustness of hybrid Bayesian estimation technique. The objective is to increase the reliability of target detection and target-background separation while keeping a small false alarm rate. In addition, sequential change detection (CUSUM) test is studied for the purposes of ground layers segmentation and object recognition. [C352]

## "DSP implementation of a Range Azimuth CFAR processor"

In this paper, we present DSP architecture for target detection based on range azimuth cell averaging constant false alarm rate (ARCA-CFAR) processor with non coherent integration. The proposed architecture has been designed to deal with parallel processing and to be configured for the RACA-CFAR algorithm implementation. The design has been implemented on a Texas Instruments TMS320C6711 digital signal processor board with a good performance improvement. The proposed system scheme and the real time implementation results are presented and discussed in this paper. [C353]

## "Comparative analysis of dimension estimation methods of fractal surfases and fractal target detection"

The aim of this paper is comparative analysis of different fractal dimension estimation methods according estimation accuracy point of view and differentiation fractal and "non-fractal" objects conditions at the image depending on observation window size and target area to window area proportion.The analysis of fractal dimension estimation of real SAR images for validation obtained during the simulation results was executed. [C354]

## "Impact of Wavelet based signal processing methods in radar classification systems using Hidden Markov Models"

A classification technology is presented that uses a Wavelet based feature extractor and a Hidden Markov Model (HMM) to classify simulated and real radar signals from six classes of targets: person, tracked vehicles, wheeled

vehicles, helicopters, propeller aircrafts and clutter (no match). Similar to techniques that have been well proven in speech and image recognition, the time-varying nature of radar Doppler data is exploited. The method classifies the targets by their different Doppler characteristics. The Wavelet technique has been tested on radar data where the classical signal processing methods failed. The purpose of this paper is to demonstrate the ability of Wavelet methods combined with a Discrete Hidden Markov Model (DHMM) in radar target recognition tasks. [C355]

## "Combined neural networks for radar target recognition from radar range profiles"

This article proposes a new architecture of combined neural networks, which is used to recognize the radar targets from radar range profiles. Combined neural network consists of an invariant neural network and a neural network classifier. The efficiency of these networks is proved by the experimental results. Proposed combined neural networks can be applied to divergent areas of pattern recognition, such as recognition systems of periodic signals, images, numerical series.... [C356]

## "Automatic target classification in a low frequency FSR network"

This paper presents the evaluation of a low-frequency forward scattering radar (FSR) network for the classification of ground targets. The experimental results of automatic targets classification for different operational frequencies are presented and discussed. The possibility of target recognition is shown for system operating frequencies in the VHF band. [C357]

## "Survey of radar target identification for noise polluted radar measurements"

Itpsilas important to develop reliable approach of radar target identification for low signal-to-noise ratio (SNR) situation, especially when the radar is used in battle field. A feature selection method is proposed in this paper. The one nearest-neighbor (1-NN) classifier is used as classifier. The effectiveness of radar target identification based on the methods is investigated in computer simulation for both data sets including standard sample and new data sets, all them are mixed with heavy noise. [C358]

## "The SOSTAR-X program achievements"

The SOSTAR-X European program started in 2001 and ended in 2007 with successful in-flight tests and operational demonstration. This demonstrator was funded under a R&D contract based on a governmental MoU between France, Germany, Italy, Spain and The Netherlands. This document presents the scope, content and main results achieved by SOSTAR-X partners. [C359]

## "Validation of PCA and LDA for SAR ATR"

Both principal component analysis (PCA) and linear discriminant analysis (LDA) have long been recognized as tools for feature extraction and data analysis. There has been reports in the open literature regarding the performance of both LDA and PCA as feature extractors in various types of classification and recognition problems. Many of the reports claim a better performance with LDA than with PCA. However, the grounds of comparison have mostly been quite narrow. In the current paper PCA and LDA based classifiers are evaluated for the problem of synthetic aperture radar based automatic target recognition problem. The results show that in terms of absolute performance, PCA outperforms LDA. Results of PCA based classifier are also found to be of higher confidence than those from LDA based classifiers, as observed from the error-bar analysis of the classifiers.With decreased amount of training dataset, the degradation in the performance of the classifiers are almost similar in nature. The current work concludes that LDA is not suitable for radar image based target recognition task. This is in line with reports from some works in the open literature which claim that the success of LDA will depend on the type of data and whether there is exhaustive data available during the training phase or not. [C360]

## "Optimized Multilooking for Robust SAR Image Indexing"

Compared to conventional optical images, the classification of remote sensing SAR images represents a rather difficult task. As a rule, the various SAR imaging and product options, the high dynamic range of SAR images, and the presence of speckle noise prevent us from obtaining robust classification results. In the following, we try to circumvent these difficulties by proper pre-processing and despeckling of high resolution SAR images. Our approach aims at adapting the radiometry and the resolution of the scenes to the optimal target recognition capabilities of a classification algorithm. To this end, we have to apply systematic adaptations that provide optimized multilooking of our input data. Then these adapted data can be fed into a scene classification system. [C361]

## "A comparison of clustering fully polarimetric SAR images using SEM algorithm and G0 P mixture modelwith different initializations"

This paper presents a comparison between two types of initializations for multilook polarimetric SAR image segmentation: a random partition and a sample quantile partition. These are the inputs of a stochastic expectation-maximization algorithm that uses a mixture of G0Pdistributions to describe the data. The parameters are unknown, and estimated by the moments method. The G0Plaw is able to describe different type of targets, like urban areas, vegetation and pasture. The experimental results on real PolSAR data are reported, showing that the use of G0Pmodel with quantile partition inicialization provide good segmentation results with few iterations. [C362]

## "Detection and tracking of marine vehicles in video"

This work presents a novel technique for automatic detection and tracking of marine vehicles in video of open sea. The source of video is a video camera mounted on a buoy platform in open sea. Such system is intended to work autonomously, taking video of the surrounding ocean surface and analyzing them on presence of marine vehicles. The proposed technique is based on detection of marine vehicles in individual video frames and tracking the detected targets through the video sequence with the help of a tracking algorithm. Several performance metrics are utilized for performance evaluation of the proposed approach. Accuracy of detection in 90% range is shown on a dataset of 30 short video sequences taken by a prototype of the system. [C363]

## "A new algorithm about transforming from near-field to far-field of radar target scattering"

In order to meet the approximate plane-wave irradiating condition, adequate large field or compact range system is needed for RCS measurement of large aircraft targets. However, an outside testing field site or a compact range system is very expensive, so a new RCS extrapolation method named Hankel algorithm based on near-distance testing has been presented. According to the fact that objective reflectivity spatial distribution is unchanged with measurement state in ISAR imaging, here the multi-scattering center model is built. Then, the height of stealth target is always short, and the far-field condition can easily be satisfied on vertical plane, so the incident spherical wave is equivalent to cylindrical wave. Once more, the relationship between far-field and near-field is deduced by regarding image of the target as secondary radiating source. Finally, the RCS of target can be obtained with the scattering information of near-field extrapolated at full angular aspect. Taking derivative of the near-field data with respect to frequency in algorithm, the error can be reduced in simplifying formula, and just meet the requirement of stepped-frequency system. The results of simulation and experiments show that the algorithm is precise as well as effective. [C364]

## "A Novel Radar Target Recognition Algorithm Based on SVM"

To solve the problems and defections of existing methods of support vector machine (SVM) classification, an improved Gaussian kernel based on SVM is proposed and a improved SVM model selection scheme combining leave-one-Out method with one-validation method is presented in this paper, Based on the high resolution range profile (HRRP) of three types of target, a preprocessing method is introduced, the novel classification algorithm for HRRP based on the improved SVM is applied. Finally, experimental results prove that the improved SVM classifier has better performance on target-aspect stability, training set-size stability and anti-noise ability than traditional SVM. [C365]

## "Methods to Recognize False Target Generated by Digital-Image-Synthesiser"

The difference of the image generated by real target and digital-image-synthesiser (DIS) is analyzed. Then two methods are deduced to recognize deceivable jamming generated by DIS. One is the uncontinuity of the false target in Doppler section which is caused by the quantization of phase increment. The other is the target number and pose in the imaging field after ISAR processing when the pulse repetition frequency (PRF) of the DIS mismatches with the opposed radarpsilas PRF. With the two methods, the limitations of DIS deceivable jamming are found, and the false target generated by DIS is effectively recognized according simulation. [C366]

## "Adaptive Localization through Transfer Learning in Indoor Wi-Fi Environment"

In a Wi-Fi based indoor localization system (WILS), mobile clients use received Wi-Fi signal strength to determine their locations. A major problem is the variation of signal distributions caused by multiple factors, which makes the old localization model inaccurate. Therefore, the transfer learning problem in a WILS aims to transfer the knowledge from an old model to a new one. In this paper, we study the characteristics of signal variation and conclude the chief factors as time and devices. An algorithm LuMA is proposed to handle the transfer learning

problem caused by these two factors. LuMA is a dimensionality reduction method, which learns a mapping between a source data set and a target data set in a low-dimensional space. Then the knowledge can be transferred from source data to target data using the mapping relationship. We implement a WILS in our wireless environment and apply LuMA on it. The on-line performanceevaluation shows that our algorithm not only achieves better accuracy than the baselines, but also has ability for adaptive localization, regardless of time or device factors. As a result, the calibration efforts on new training data can be greatly reduced. [C367]

## "Identification of Severe Precipitation Radar Echo Reflectivity with Back-Propagation ANN"

In this thesis, the radar echo reflectivity of severe precipitation in the flood season of Changjiang-Huaihe area was identified by a Back-Propagation (BP) Model of Artificial Neural Network (ANN). The trained network was applied in a precipitation progress in the same area in 2001. The results illustrate that: the single hide-layer BP ANN can be used to identify the target radar echo at a high succeed rate. It is also validated that the performance of the network is influenced by following factors: the quality and input sequence of the training sample, the framework of hide layer and the learning rate. [C368]

## "Two-dimensional clustering-based discriminant analysis for SAR ATR"

This paper gives a new image feature extraction technique coined two-dimensional clustering-based discriminant analysis (2DCDA), which is based on 2D image matrices for constructing the scatter matrices and assumes that the data obeys the multimodal distribution. The detailed procedure of 2DCDA is to first partition each class of the data into multiple clusters via fast 2D global k-means clustering algorithm, and then try to find some directions such that the projections of every pair of clusters from different classes are well separated while the within-cluster scatter is minimized. Therefore, it fully exploits the cluster information and alleviates the linearly unseparable problem to some extent. According to the projection fashion, we divide 2DCDA into two versions, the right 2DCDA (R-2DCDA) and the left 2DCDA (L-2DCDA). They compress the image row or column only, so they need more features. To solve this problem, two-directional 2DCDA ((2D)2CDA) is developed, which compresses the image row and column simultaneously. Experiments have been carried out for recognition of three types of ground vehicles in the Moving and Stationary Target Acquisition and Recognition (MSTAR) public database to evaluate and compare the performances of the proposed algorithms with other methods. Results demonstrate that 2DCDA and (2D)2CDA are effective. And, the highest recognition rate is up to 97.89%, which is the best ever reported in the literatures. [C369]

## "High resolution radar cross section imaging based on complex target backscattering simulation"

Pixel method which is enlightened from the graphic electromagnetic computing (GRECO) is introduced in this paper and realized by OpenGL and VC programming. Using simulation data, the wideband features of the target can be obtained for radar automatic target recognition(RATR). Some of the calculated features including RCS, range profile, and SAR image which are also refered to zero-dimensional image, one-dimensional image, and two-dimensional image of the target are discussed in detail. Results show that the task of complex target backscattering simulation is effective for initial research and development(R&D) of radar automatic target recognition. [C370]

## "Performance Comparison of Time-Frequency Analysis Methods for Radar Signature Analysis"

In this paper, four different time-frequency analysis techniques are applied to the scattering analysis of radar targets. Short-time fourier transform (STFT), continuous wavelet transform (CWT), adaptive wavelet transform (AWT) and evolutionary AWT (EAWT) are applied to scattering analysis. The two scattering phenomenon which are important for radar target signature analysis are scattering centers and resonance frequencies. In the simulation using wire target (Caravelle-like) data, the comparisons of four different time-frequency analysis techniques are presented. The results show that the EAWT is the best technique to analyze the scattering centers and resonance frequency simultaneously. [C371]

## "Micro-Doppler extraction of frequency-stepped chirp signal based on the Hough Transform"

The micro-Doppler (m-D) effect induced by the rotating parts in a radar target or mechanical vibrations of the target body provides a new approach for auto target recognition. In this paper, the m-D effect in frequency-stepped chirp signal is analyzed. Compared with that in the traditional chirp signal, the m-D effect in frequency-stepped chirp signal appears some new characteristics. To extract these m-D characteristics and so to obtain the micro-motion information of the target for auto recognition, the extended Hough Transform is applied into detecting the parameters of the curves on the range-slow time plane after the analytical expressions of the curves deduced. Computer simulations have proved the validity of the proposed method. [C372]

## "Resonance based radar target identification using principal component analysis"

In this paper, a novel technique, based on principal component analysis (PCA), is used to enhance the resonance based target identification process. PCA is used to combine the backscattered signatures of the target from different incident aspect angles. The dominant CNRs of the target are then extracted from the fused signature. [C373]

## "Octree based technique for fast analyzing shadowing relationship of complex target"

In this paper, we have described an accurate and efficient shadowing recognition method based on octree data structure for efficiently judging the illuminated regions in electrically large objects. The physical optics method is used to calculate a bistatic RCS curve for target VFY-218. The theory of shadowing recognition is a hybrid method consists of traditional method and the octree data structure. This novel method is able to analyze the shadowing relationship precisely with less calculation time when compared with traditional method. Finally, numerical experiments and results show the accuracy and efficiency of this method. [C374]

## "Correlation of Target Transfer Functions and range profiles as a function of aspect angle and resolution"

An experimental rig was constructed in order to investigate the variation of the radar signature of a 1:32 scale model tank with changes in aspect. By illuminating the target with a wideband stepped frequency waveform, a high range resolution profile was obtained with an associated frequency spectrum that approximated the target transfer function (TTF). It was found that both TTFs and range profiles de- correlated within a 1deg change in target azimuth, more rapidly than previously thought. It was also found that coarser range profiles correlated better than finer ones, but at the loss of a significant amount of distinctive target information. These results have implications for the size of the reference library employed in correlation-matching within the field of non-cooperative target recognition, and also for the number of different waveforms required to enable matched illumination of a target from all aspects. [C375]

## "ROEWA based detector for SAR automatic target recognition"

Edge detection is a fundamental issue in automatic target detection using synthetic aperture radar (SAR) images. Edges are associated with intensity changes in the image and are efficient descriptors of the image structure. Due to the presence of speckle, edge detection in SAR images is extremely difficult. Several detectors have been developed for the detection of isolated step edges in speckled images like MRoA and RGoA edge detectors which use predefined thresholds. The modified RGoA detector defines an automatic threshold determining method. But all these edge detectors, apart from detecting the target edges, detect a number of false edges. In this paper we have proposed a new ROEWA based algorithm that automatically discriminates the object boundaries and the false edges. The principle of entropy is introduced in this classification process. Real SAR images are used to verify our method and the results are compared with the modified RGoA and entropy based MRGoA edge detectors. Experimental results show that the proposed method is robust and efficient. [C376]

## "Bat-inspired adaptive design of waveform and trajectory for radar"

We propose to design jointly the waveform and trajectory of a radar mounted on a moving platform, in order to improve the system performance for tracking maneuvering targets. Inspired by bats, we develop an adaptive algorithm that chooses the optimal pulse repetition interval (PRI) and path of the radar. Our method automatically schedules a low PRI when it recognizes that the target executes a maneuvering action. Simultaneously, it selects the radar trajectory which provides the best estimation of the target parameters. We derive our approach under a framework of sequential Bayesian filtering and implement it with a particle filter. We consider a library of target state models associated with different PRI values and use multiple model to schedule the optimal PRI. We apply the posterior Cramer-Rao bound to measure the system performance and decide on the optimal radar path.We demonstrate the advantages of the adaptive radar scheme using numerical examples. [C377]

## "Time-frequency analysis of the non-stationary multi-frequency signals by using parametrical short-time bispectral density estimation"

A new approach to time -frequency analysis of multi-component frequency modulated signals is represented. The suggested approach is based on the extraction of phase -coupled instantaneous frequency pairs containing in the broad-band Doppler signal spectrum. For this purpose, the computation of the sequence of short-time parametric bispectral density estimates of transient signal segments separated by a sliding window is used. The

parametric autoregressive (AR) modeling has been employed to obtain high frequency resolution. Time-frequency distributions of the phase-coupled instantaneous frequencies are represented for non -stationary multi-component signal models as well as for experimental Doppler radar records obtained for signals backscattered by a moving human. The latter radar signatures demonstrate evolutionary behaviour of phase-coupled instantaneous frequency pairs in the time -frequency domain. The given results can be useful as new information features for automatic target radar recognition. [C378]

## "A radar target signature based on resonance and dual polarization features"

A physically based radar target scattering signature is derived from observable data using a frequency domain scattering model that incorporates the backscattered radar target polarization response at the target natural resonance frequencies (NRF). Two rotationally symmetric targets of simple but similar characteristic geometry are used to demonstrate the theoretical feasibility and the ability to distinguish the two similar targets by this proposed signature. [C379]

## "Quad Polarimetry SAR Target Recognition Based on Parametric Statistics and Multidimensional Analysis"

Diverse parameters decomposed from quad-polarimetric SAR could become the important basis in target recognition, classification and other applications.During the target recognition, due to the sidedness of single parameter or two parameters decomposed by same algorithm, obvious differences exist among the results extracted by different parameters. In this paper, a parametric statistics and multidimensional analysis algorithm will be applied in target recognition from quad-polarimetric SAR image. The proposed algorithm looked the backscattering characters of land cover targets as the basis of analysis. Through parametric statistics, the dominant scattering mechanisms of every decomposing algorithm would be picked out such as volume scattering and sphere scattering of paddy. They become the data of multi dimensional analysis. In the multi-dimensional analysis, the targetpsilas location of parametric space will be the basis of target recognition. The application on land cover and land use by the proposed algorithm improved the monitoring capability of quad polarimetric SAR. [C380]

## "Applications for remote laser vibration sensing"

Laser vibrometry based on coherent detection techniques allows to measure vibration characteristics of objects due to the high Doppler resolution. Examples for applications in the field of defense and security such as target classification and identification including camouflaged or partly concealed targets as well as the detection of buried land mines are presented. [C381]

## "Region Feature Extraction Based on Improved Regularization Method in SAR Image"

The noise existed in Synthetic Aperture Radar (SAR) image weakens the detailed features of region of interest (ROI) such as target and shadow. It also leads to the serious performance reduction of subsequent target detection, classification and recognition. The conventional regularization method could enhance target features in SAR image; however, the high computation complexity limits the real-time application of it. An improved regularization method is introduced in this paper, which increases processing speed of region feature extraction for SAR image significantly. It is theoretically proved that, by optimizing SAR projection operator, computation complexity could be reduced from O(M3N3) to O(MN) without ability losing of the region-based feature enhancement. MSTAR SAR image data is employed for algorithm experiment. The result shows that our method can increase target-to-clutter ratio significantly while restraining the noise in ROI, and then extract target and shadow from background clutters in SAR image more accurately. [C382]

## "A New Method of SAR Image Target Recognition based on AdaBoost Algorithm"

We propose a novel target recognition algorithm for classification of three types of ground vehicles in the moving and stationary target acquisition and recognition public release database. Algorithms that produce classifiers with large margins, such as support vector machines (SVMs), AdaBoost, etc. are receiving more and more attention in the literature. A real application of AdaBoost for synthetic aperture radar automatic target recognition is presented and the result is compared with conventional classifiers. And we also describe how AdaBoost algorithm can be used as a multiclass classification method as well as a feature fusion method. Results are presented to verify that, the performance of the recognition system is improved significantly, and the method presented in this paper is an effective method for SAR images feature fusion and target recognition. [C383]

## "SAR Target Recognition Based on MRF and Gabor Wavelet Feature Extraction"

This paper presents a method for synthetic aperture radar (SAR) target recognition based on Markov random field (MRF) segmentation and Gabor wavelet transform feature extraction. ICM algorithm which based on Markov random field is used to segment a SAR target chip into target and background two fields and generate a two-value figure. Gabor wavelet transform is applied to extract feature vectors from the two-value figure. The method is verified by recognizing three-class targets in MSTAR database. The highest average probability of correct classification arrives at 93.11%, which indicates that the approach proposed in this paper is an effective method for SAR target recognition. [C384]

## "Signal Processing Techniques for Feature Extraction and Classification using Small-Footprint Full-Waveform Airborne LIDAR"

Full-waveform digitizer hardware integration within discrete return LIDAR systems provides an enhanced capability to resolve vertical structure within the laser line of sight and potentially classify specific surfaces or objects. However, the subject of waveform signal processing as it applies to surface classification is fairly underdeveloped. This research includes the examination of LIDAR waveform pulse characteristics for known targets and vegetation types. Using these data, a number of signal processing techniques were investigated as precursors to classification engines without prior knowledge of surface slope, or obscuration density. Relevant waveform features were extracted using both Gaussian decomposition method and raw waveform features revealing surface classification distinctions. Preliminary results from this data set indicate that the total integrated waveform energy provides an efficient and rapid methodology for discrimination of vegetation from built surfaces. These results indicate that metrics derived from the full waveforms can be utilized to characterize and classify (to a limited degree) an environment without prior knowledge. [C385]

## "Automatic Target Recognition by Means of Polarimetric ISAR Images and Neural Networks"

Inverse Synthetic Aperture Radar (ISAR) images are often used for classifying and recognising targets. Moreover the use of a fully polarimentric ISAR image enhances classiication capabilities. In this paper, the authors propose a novel ATR technique based on the use of fully polarimetric ISAR images and Neural Networks. In order to reduce the amount of data processed by the classifier, the brightest scattering centres are first extracted by means of the Pol-CLEAN technique and then their scattering matrices are decomposed using Cameron's decomposition. The proposed ATR algorithm is finally tested on real data. [C386]

## "SAR Image Simulation of Man-Made Scenes based on Computer Graphics"

To enhance the computational efficiency and authenticity of Synthetic Aperture Radar (SAR) image simulation of man-made scenes, computer graphics (CG) method was introduced into imaging geometry simulation, graphical electromagnetic computing (GRECO) was used for the interested target scattering calculation. With these two methods, the targets' characteristics will be visualized in simulated image, such as shadow, foreshortening, layover and simple scattering property. The simulated SAR images can be used for target recognition, target detection, system verification and other researches. [C387]

## "Very High Resolution Interferogram Acquisition Campaign and Analysis"

The ONERA RAMSES system is a flexible SAR system in constant evolution, developed mainly as a test bench for new technologies and to provide specific data for TDRI (Target Detection, Recognition and Identification) algorithm evaluation. It is flown on a Transall C160 platform operated by the CEV (Centre d'Essais en Vol). This paper presents the multi-pass interferometric acquisitions in very high resolution acquired over Salon de Provence, in south of France. The interferometric and coherence information capabilities are analyzed for this resolution. [C388]

## "The High Resolution Radar Image Simulation of Target on Rough Surface"

The high frequency method can deal with the metal material structure and get a good result. The other method should be used to describe the process of the shadow in the radar image. These shadows are important feature in the radar image. The stability of the shadow contour makes it helpful for the recognition process of the target body. Deterministic and statistical methods play different parts in the radar image simulation. The ray tracing techniques is constructed to describe whole simulation process. Corresponding to the MSTAR image, X band image is simulated under the same imaging condition. Comparing with the same attitude's images, the shadow contour looks similar; and the target part is well coincident too. [C389]

## "Parametric scattering models for bistatic synthetic aperture radar"

Parametric scattering center models match to radar scene attributes, aiding in automatic target recognition (ATR)

and scene visualization. In this paper, we develop parametric models of canonical shapes for bistatic synthetic aperture radar (SAR).We generalize geometric theory of diffraction solutions for scattering mechanisms in a plane to develop three-dimensional models for six canonical shapes: a rectangular plate, dihedral, trihedral, cylinder, top-hat, and sphere. The proposed models provide physically relevant yet compact scattering solutions that are easily implemented for radar signal processing and ATR applications. The derived models are shown to agree with results obtained from high-frequency, asymptotic scattering simulations. [C390]

## "A robust CFAR detection with ML estimation"

Any clutter edge in the reference window of a radar CFAR detection, produces an error in the clutter power estimation which reduces the detectability of the cell under test (CUT). In processors such as OS-CFAR, the designers have attempted to improve the detection performance, nevertheless, none of these processors applies an intelligent method of clutter edge recognition and destroyer data elimination. Therefore any of these processors are effective in some especial cases of non-homogeneous environment, but are deficient in other cases. In this paper an intelligent method is proposed for clutter edge recognition. This method determines the borders in which the clutter statistics are changing and then sets the decision threshold according to the appropriate clutter statistics. It is shown that the new processor improves the radar detection intensively in nonhomogeneous environment. [C391]

## "GRIFO Radar: Advances and developments in high-resolution modes for an expert avionic radar for fighters"

In the 90s, Galileo Avionica (GA Radar Systems Business Unit) has developed the GRIFO Radar, a multimode-multirole pulse Doppler radar, devoted to occupy an important role in the family of the radar for weapon release. In the last 15 years more than 400 units have been sold to five Air Forces, for more than 100,000 hours of operative flights. The need for the implementation of high-resolution modes, with seaborne targets identification for the Italian Navy, pushed to the extension of the Grifo Radar to high-resolution applications. This paper describes the results obtained with a modified version of this device, indicated as Experimental HR-Grifo, with high-resolution capabilities. Based on the low-resolution modes of the Grifo, this radar allowed to search and track the targets, and to acquire the pertinent high-resolution signals, making use of the Deramp On Receive technique. In the experimental version the signals were recorded and processed offline during the flight and in the lab, to tune the algorithms and to experience the problems related to the sub-metric resolutions. A number of flights, onboard the GA Aircraft, and ground sessions have been performed with air, ground and sea cooperative military moving targets. The experience in the hardware design and the amount of high-resolution data recorded has allowed the finalization of high-resolution modes (SAR and ISAR) in the last versions of the Grifo Radar which is going to flight test these applications in real time on November 2007. [C392]

## "Hough transform based automatic pipe detection for array GPR: Algorithm development and on-site tests"

GPR is one of the most reliable instrument to obtain information on underground assets. Since its diffusion, many efforts have been made in order to overcome one the main limitations of this technology: the ldquohuman factorrdquo in data interpretation. Actually, operators have to look and interpret a huge number of radargrams. This requires an enormous effort, about 2 days are usually needed for analyzing radar data gathered from a 3000 m2wide site Some useful tools like tomography has been developed, but their quality and reliability is related to the migration algorithm which is heavily depending on knowledge of the propagation velocity of EM wave in the soil. Hyperbolas automatic detection algorithm reduces human factor in radar data interpretation and aims to strongly lower the amount of time needed for data analysis. The algorithm works on each radargram, recognizes the presence of target by looking for the hyperbolic patterns and marks them. Then the operator can correlate those results from different radar maps and extract the position of the underground assets. The algorithm also gives an accurate evaluation of the propagation velocity of EM waves in the soil, so this estimate can be used by migration algorithm in order to obtain an improved tomography. Using both Hyperbolas Automatic Detection and tomography, time needed to analyze a 3000 m2wide area can be reduced up to less than 4 hours. [C393]

## "Stepped-frequency range profiling of multiple overlapped targets"

It is a challenging task all along for modern radar systems to detect and recognize multiple targets in heavy clutter. Stepped-frequency radar (SFR) can acquire high range resolution profiles (HRRP) to improve the performance of target recognition greatly. Moreover, SFR can suppress clutter by increasing the pulse repetition frequency (PRF) as well as decreasing the product of the pulse width and the frequency step. However, as PRF increases, range measurement becomes ambiguous, so multiple targets in the same formation will probably

overlap each other along the range axis. Accordingly, this paper puts emphasis on solving this overlap problem, namely, estimating HRRP of each overlapped target. It firstly analyzes the special characteristics of the SFR echoes received under the condition of range ambiguity. Then, considering envelop-weighting modification and non-modification to each HRR cell, it proposes two estimation methods, the first of which is based on maximum likelihood estimation (MLE) and reaches the Cramer-Rao low bound (CRLB). Monte Carlo simulation results have verified the validity of the theoretical analysis. [C394]

## "Adaptive calibration in UWB radar"

The progress of the late time response (LTR) method applied to the detection and identification of body-worn hidden weapons has been discussed in [1] and [2]. Efficiency of the target signature extraction and its correct interpretation depend on the system subcomponent characteristics as well as the processing algorithms used. Peculiarities in frequency domain (FD) measurements based on a stepped frequency radar technique introduce an ambiguity in the received signal interpretation. In this paper the real time domain (TD) experimentation system and new instant signal calibration procedure are described. Measurements were made in an anechoic chamber to provide complete signal control. Signal processing is based on adaptive filtering algorithms to provide equalization by a reference channel in order to remove any radio frequency (RF) system distortion of the received signal. A generalized matrix pencil-of-function (MPoF) approach is then applied to retrieve the parameters of LTR. [C395]

## "A method of establishing template database for high resolution radar target identification"

The performance of a target recognition method based on template matching depends on the quality of the template database to a large extent. This paper introduces a method of establishing an extensible template database of range profiles based on the minimum entropy rule. The new method guarantees the quality of the template database from two sides: the signal-to-noise ratio and the completeness of the database. And the new database is easy to update and maintain. Experimental results grounded on real data demonstrate that we can get stable and reliable recognition results with the new method. [C396]

## "ATR performance assessment of target type number for HRR radar"

Automatic target recognition (ATR) performance evaluation has become an important subject in ATR theory community since the last two decades. The extended operation condition (EOC) and system cost are two key aspects in ATR performance evaluation. For the situation of air-to-ground (A-G) ATR using high range resolution (HRR) data, this paper analyzes the influence of target type number on ATR system performance. The system cost is also considered in evaluation process. An experiential performance model of typical ATR systems is given. The performance model and the corresponding conclusions have useful reference to ATR system performance prediction and assessment in the similar A-G applications. [C397]

## "Automatic target recognition of aircrafts using translation invariant features and neural networks"

Automatic target recognition (ATR) of aircrafts using translation invariant features derived from high range resolution (HRR) profiles and multilayered neural network is presented in this paper. The HRR profile sequences are translation variant in the range resolution cell because of the non-cooperative target maneuvering. The differential power spectrum (DPS) is introduced to extract the translation invariant features. Several learning algorithms of feed-forward neural network are implemented to determine an optimal choice in the recognition phase. The range profiles are obtained using the two-dimensional backscatters distribution data of four different scaled aircraft models. Simulations are presented to evaluate the classification performance with the DPS based features and neural networks. The results show that this method is effective for the application of radar target recognition. [C398]

## "Symmetry in target recognition"

Symmetry has important consequences for target recognition. Rotation and reflection symmetry for targets near a ground or water surface not only help to identify the targets, but also aid in data processing to increase accuracy. While clutter (other scatterers) interfere with the target signatures, symmetry in the clutter can be used to suppress this interference. [C399]

## "More efficient ATR system using the decision fusion between HRR and video imaginary"

One of the most important methods to improve automatic target recognition (ATR) function is to use fusion techniques. In this paper we propose an application using an improved version of Sugenopsilas fuzzy integral to increase the target recognition performance based on high-resolution radar (HRR) and video imaginary. In order

to confirm the broached theoretical aspects, a real database was used. [C400]

## "High Resolution Radar Automatic Target Recognition Based on an Improved LDA Method"

A novel improved linear discriminant analysis (ILDA) method is presented. Comparing with LDA, under the condition of d < c -1, d and c are the dimensionality of feature subspace and the number of classes respectively, ILDA uniformly preserves the class distances of classpairs by rearranging the contribution of each class-pair to the generalized between-class scatter matrix after whitening within-class scatter matrix. Experiment results based on simulating data and measured radar data both show that, under the condition of d < c -1, the features extracted by ILDA are more efficient for multi-class classification than those extracted by LDA. [C401]

## "A Novel Approach Research on Low Altitude Passive Acoustic Target Recognition Based on ICA and HMM"

An approach is proposed to classifying simultaneous multiple low altitude targets in battlefield. Based on Independent Component Analysis (ICA), the mixed signal is separated into several single and pure signals, and the noise is removed from the acoustic signal. mel-frequency cepstrum coefficients (MFCC) which responses the characteristic of the sound more aggressively is extracted as characteristic parameters in the system. For the hidden Markov models (HMM), in order to work better performance in representing the time-variant signal, the HMM are employed to simulate the model change of the sound signals as the with time going. K-means algorithm is used as clustering MFCC to produce training and identifying eigenvector. Simulation results indicate that this approach's is effective in target recognition. [C402]

## "A method of separating target from cluster by polarization in unknown and time-varying circumstance"

This paper discusses a method of recognizing target from unknown and time-varying cluster in polarization domain, by receiving from both vertical and azimuth channel of full polarization radar. First, the principle of the cluster removing algorithm, the determination of original parameter and calculating step are presented. Then, the signal after being removed cluster is simulated, and the result justifies the affectivity of the algorithm. In the end, the polarization characteristic of target is gained from the echo wave, and in further the recursive algorithm is proposed, which is confirmed by simulation. [C403]

## "A fuzzy recognition method of emitter based on Variable Precision Rough Set Model"

In order to settle the problem of emitter recognition, the method of feature weights setting which applies variable precision rough set model is researched in this paper. Because this weight setting method is completely decided by data itself, it is more impersonal and practical. The description of object classpsila condition attribute in conception positive region can be used to get the plenary condition of this conception. The weights of feature parameters in emitter recognition can be gained by the dependences between knowledge; at the same time, the fuzzy theory is combined to form an emitter fuzzy recognition method based on feature weight by variable precision rough set model. At last, this mixed method is applied in radar emitter type recognition, simulation and the results show it is effective and feasible. [C404]

## "A Shape Reconstruction Method Using IR-UWB by Illuminating the Target from Multiple Aspects"

The impulse radio ultra wide band (IR-UWB) signal has been applied to many imaging systems such as through-wall-imaging, ground penetrating radar etc., due to the ultra wide frequency band and the simplicity of IR-UWB. Several imaging schemes, such as delay-and-sum (DAS), Capon beamforming-based method etc., were proposed in the previous literatures. But there is few method whose aims were to reconstruct the shape of the target. In this paper, a shape reconstruction method employing IR-UWB signal was proposed. The proposed method is based on the DAS imaging algorithm. Multiple aspects of the target were illuminated in the proposed method to obtain more information about the target than what can be obtained through only one aspect in the traditional imaging systems. The finite-difference time-domain (FDTD) method was employed to simulate the received data for the 2-D imaging using the proposed method. From the image results, the shape of target can be recognized. The capability of the proposed shape reconstruction method is verified, and it can be concluded that the more aspects were illuminated, the more precise shape of the target can be obtained using the proposed shape reconstruction method. [C405]

## "Feature Extraction and Recognition Based on SVM"

As a mature detection technique, ground penetrating radar (GPR) is applied into many fields. The GPR signal explanation and recognition is so important that it affects the result reliability and accuracy of the detection. The

support vector machines can obtain the overall optimal solution in sample less situations. It has solved the inevitable partial minimum problem and overcome the disadvantage, which the traditional neural network cannot avoid. In this paper the GPR signal explanation model is established based on the support vector machine and the dyadic wavelet transform (DyWT) theory. It is applied in the counterfort of railway disease detection. The experiment result proved the method is valid, and it can enhance GPR explanation precision and efficiency. The recognition ratio can reach 91.2%. [C406]

## "Radar target recognition method with MUSIC algorithm: Application to aircraft targets with measured scattered data"

This paper demonstrates the usefulness of an ultra wideband target recognition method in the case of realistic and complicated target geometries at resonance region. The method utilizes the MUSIC algorithm to extract the natural resonance-related scattering features of targets. The resulting features give the power distribution maps of targets. These maps are called as fused MUSIC spectrum matrices and used as the main target recognition feature in the method. The fusion process is needed to reduce the aspect dependency of target features, which increases the accuracy rate of the classifier. In this paper, the method is applied to classify three small-scale aircraft targets. It is demonstrated that the method provides high accurate classification rates although the target geometries are highly complex, the measured scattered data is incomplete and only a few different reference aspects are used in recognition design process. [C407]

## "Multistatic Micro-Doppler Signature of personnel"

For the first time the multistatic Micro-Doppler Signature (mu-DS) of personnel targets has been collected using University College Londonpsilas NetRAD radar system. The data demonstrates that using a multistatic mu-DS is a viable approach to overcoming the problem of self-occlusion, where a target obstructs its own mu-DS, in automatic target recognition. The data analysis is supported by extending the theory of micro-Doppler into the multistatic domain, and a simplified model of human locomotion is developed. These advances lead to a computer simulation of the multistatic personnel mu-DS that is contrasted with the real data. [C408]

## "Multi-feature based automatic recognition of ship targets in ISAR images"

This paper deals with the problem of automatic target recognition (ATR) of non cooperative targets. Specifically the focus is on the ATR of ships in ISAR images. To fulfill this task a multifeature based technique is proposed which uses a number of features extracted from the ship radar image. Both cases of known/unknown target aspect angle and single/multiframe based processing technique are considered in order to assess the performance improvement arising from the a priori knowledge of the aspect angle and from the joint use of the features extracted from a number of different frames. The performance of the proposed technique is investigated in depth by means of simulated data. Moreover results of its application to live ISAR images of ship targets are also provided showing the effectiveness of the proposed approach. [C409]

## "Cross-range scaling for aircraft ISAR images based on axis slope measurements"

Inverse synthetic aperture radar (ISAR) has been highly exploited for target recognition due to its high resolution imaging capability. Scaling of the ISAR image is a necessary step to the reliable target recognition. Usually, the target motion is unknown. The amount of rotation during the observation cannot be determined, so it is difficult to perform the cross-range scaling. In this paper, a technique aiming at achieving cross-range scaling of aircraft ISAR images is developed. The rotation rate of the aircraft is firstly estimated from the under-scaling image by measuring slopes of the aircraftpsilas two axes, i.e. the fuselage axis of symmetry and the cross (pitch) axis. Then, with the generally known observation time, the cross-range scale factor can be determined. Since all the operations are performed in the image domain, the scaling technique is used with ease. Moreover, the aircraft orientation relative to the radar line of sight (RLOS) and its flying velocity can be roughly estimated simultaneously. Results of real data processing confirm the effectiveness of the proposed technique. [C410]

## "A Method to Recognize Ship Target in SAR Imagery Using an AAM"

This paper presents a new method to recognize ship target in SAR imagery using an active appearance model (AAM). The AAM can describe both shape and grey-level appearance of target which can present the target more accurately. The AAM is used as a basis for ship targets recognition. The whole method contains two steps: building an AAM firstly, then searching the target use it. The more detailed realization is discussed in this paper. It obtains good results for different ship by this method. An identification rate of 90% was achieved. The experiments prove that AAM is good in ship target recognition in SAR imagery . [C411]

## "Fusion of multiple-look synthetic aperture radar images at data and image levels"

Synthetic aperture radar (SAR) and inverse synthetic aperture radar (ISAR) have proven capabilities for non-cooperative target recognition (NCTR) applications. Multiple looks of the same target (at different aspect angles, frequencies, etc.) can be exploited to enhance target recognition by fusing the information from each look. Such fusion can be performed at the raw data level or at the processed image level depending on what is available. At the data level, physics based image fusion techniques can be developed by processing the raw data collected from multiple inverse synthetic aperture radar (ISAR) sensors, even if these individual images are at different resolutions. The technique maps multiple data sets collected by multiple radars with different system parameters on to the same spatial-frequency space. The composite image can be reconstructed using the inverse 2-D Fourier transform over the separated multiple integration areas. An algorithm called the matrix Fourier transform (MFT) is proposed to realize such a complicated integral. At the image level, a persistence framework can be used to enhance target features in large, aspect-varying datasets. The model focuses on cases containing rich aspect data from a single depression angle. The goal is to replace the datapsilas intrinsic viewing geometry dependencies with target-specific dependencies. Both direct mapping functions and cost functions are presented for data transformation. An intensity-only mapping function is realized to illustrate the persistence model in terms of a canonical example, visualization, and classification. [C412]

## "Automatic Target Recognition in Synthetic Aperture Radar image using multiresolution analysis and classifiers combination"

Automatic target recognition (ATR) is an important capability for defense application. ATR removes the human operator from the process of target acquisition and classification, reducing the reaction time to possible threats and can be used to gun target engagement. This paper presents one technique used to solve the automatic target recognition problem in synthetic aperture radars (SAR) images, that is independent of target pose in the images. The classification is performed by a combination of three different classifiers the minimum distance classifier (MDC), the quadratic Gaussian classifier (QGC) and a multilayer perceptron (MLP) neural network, using a voting architecture. [C413]

## "Target recognition and polarimetric SAR"

This tutorial presents a state-of-the-art survey of advanced applications of Synthetic Aperture Radar (SAR). Applications include: the detection and recognition of targets in SAR imagery, and the detection of targets under trees (and in the open) using change detection (coherent change detection, full-polarization change detection, etc). A fully polarimetric SAR sensor is described. Models of clutter and targets are developed from analysis of full-polarization SAR imagery. Algorithms for optimum (GLRT) processing of full-polarization data are derived, including the polarimetric whitening filter (PWF) and the polarimetric matched filter (PMF). Polarization-based discrimination features (polarization entropy, anisotropy, etc.) are developed and applied to SAR image terrain classification. Model-based and template-based target recognition systems are described and classifier performance results versus resolution and polarization are summarized for 10-and 20-target classifiers. Super-resolution algorithms are applied to SAR imagery and target recognition performance improvements demonstrated. Multi-polarization and multi-pass change detection algorithms are developed and demonstrated using UHF SAR imagery of targets under trees; fusion of multi-polarization coherent and non-coherent change detection algorithms is demonstrated. The effect of SAR image compression on change detection performance is quantified. Change detection performance using multi-pass VHF SAR imagery of targets under trees is demonstrated using data gathered by the Swedish CARABAS SAR system. [C414]

## "Scatterer excursion compensation in sequential radar image projections"

Summing of registered radar images, taken from multiple aspects, can be extremely useful for target recognition of both human and automatic kinds. Combining the imagery, however, is not straight forward, when the imagery is taken under varying imaging geometries,-that is with varying radar elevation (grazing angle), squint and bistatic angles, for example. This paper addresses the problem of combining high elevation turntable imagery, where the target projection in the radar images can vary substantially. The mathematics developed here, however, can be generalized in a straightforward manner to the other radar modes, as will be described below. A method of focusing scatterers at given heights is found and demonstrated. [C415]

## "A new approach to moving terrestrial targets recognition using ground surveillance pulse doppler RADARs"

In this paper we propose a new automatic target recognition algorithm to recognize and distinguish of three classes of targets: personnel, wheeled vehicles and animals, using a low-resolution ground surveillance pulse Doppler radar. Using the chirplet transformation, a time-frequency signal processing technique, the

parameterized radar signal is then used by the Zernike moments (ZM) for the pertinent features of the targets. The current work provides a new approach for multiresolution analysis and classification of non stationary signals with the objective of revealing important features in noisy and cluttered environment. The algorithm is trained and tested on real radar signatures of multiple examples of moving targets from each class. The results shows the proposed algorithm invariancy against speed and orientation of the targets. [C416]

## "Multistatic target classification with adaptive waveforms"

Traditional radar systems rely on a predefined suite of waveforms and post-measurement signal processing to achieve such goals as target detection, classification, and tracking. Cognitive radar (CR) is a newly proposed framework in which the radar actively interrogates the propagation channel and adapts its operating parameters in order to maximize performance. We apply CR to a target classification problem by calculating custom waveforms that maximize the information received from the target echoes. A new MIMO waveform is proposed which maximizes the mutual information between a Gaussian random target and the received data under AWGN. The results indicate that the new frequency-domain formulation offers superior performance compared to both a non-adaptive approach and an ad hoc application of spectral waterfilling to the MIMO setting. [C417]

## "High Range Resolution (HRR) profiling within low elevation search mode"

In this paper, we describe the high range resolution (HRR) profiling technique for generating the target range profile while the radar is in the low elevation search mode. The major advantage of this concept is reuse of the moving target detection (MTD) radar data for formulating the target range profile to provide the early target classification, discrimination, and identification (CDI) decision for all targets. This technique is developed for air missile defense pulse Doppler radar in which transmitting frequency is changing within the transmit pulse width. Here, we also discuss the effects of phase variation introduced by radial target motion and address how to compensate those effects. [C418]

## "Estimation of the parameters of the K-distribution using Fuzzy Neural Networks"

This paper addresses a novel approach based on neuro-fuzzy inference system to solve the estimation problem of the K-distributed parameters. The method is based on a network implementation with real weights and the real genetic algorithm (GA) tool is applied for an off-line training of the fuzzy-neural network (FNN) shape parameter estimator. The proposed FNN estimator is based on the arithmetic and geometric means computed from the data in a manner which significantly reduces the computational requirements when compared to Raghavanpsilas and the maximum likelihood methods. The simulation results are presented to demonstrate the validity of the approach as well as the successfulness of the FNN estimator for low variances of parameter estimates when compared with existing MOFM (method of fractional moments) and ML/MOM (maximum-likelihood and method of moments) approaches. In addition, the method yields parameter estimates with lower computational complexity compared with standard techniques. [C419]

## "Radar classification evaluation"

In this paper five parameters for classifier performance evaluation are introduced. They are the probabilities of correct classification, declaration, and false alarm along with the reliability and generalisation capability. The use of Receiver Operator Characteristic (ROC) curves is also considered. These parameters are not always accepted or acknowledged in literature, yielding ambiguous and non exhaustive classification performance analysis. This paper gives a definition of the classification requirements and provides for an interpretation of the output of a classifier. [C420]

## "Hidden Markov models for multi-perspective radar target recognition"

This paper presents a novel fusion technique for automatic target recognition from high range resolution radar profiles when observations from multiple viewpoints are available. The fusion technique entails only a straightforward modification of the transition probabilities of a single-viewpoint target model in which a Hidden Markov Model is used to represent the unknown target orientation. Evaluations using the MSTAR database indicate that the new technique can reduce classification errors by about two orders of magnitude when compared to single viewpoint observations and, in a 10-target classification experiment, gave almost perfect recognition. [C421]

## "Target identification in a MIMO environment"

A MIMO radar system with M transmitters and N receivers is used for target identification of unknown non-cooperative radar targets. The radar system is assumed wideband with sufficient bandwidth to obtain a target

impulse response that shows significant scattering mechanisms and correlates well with the geometry of the target. Contributions in this paper are threefold: First, target identification in a Multi-Input-Multi-Output radar framework is established. Second, the system relies on real scattering signatures as seen by a wideband radar system. Third, the system is tested using real radar signatures collected in a compact range environment using a single-antenna stepped frequency radar interrogating commercial aircraft models at various azimuth angles. [C422]

## "Radar signature analysis using information theory"

The ability to make radar signature databases portable for use within similar sensor systems is critical to the affordability of airborne signature exploitation systems. The capability to hybridize measured and synthetic signature database components will maximize the impact of the investment required to build complex radar signature databases. Modal mutual information is developed as a measure of similarity to compare measured field data to modeled synthetic data. The approach is demonstrated using synthetic signature sets comprised of both ldquosimilar targetsrdquo and ldquodissimilar targetsrdquo. [C423]

## "Polarization studies in the UWB radar target response using joint Time-Frequency analysis"

The polarization dependent nature of ultra wideband (UWB) scattering from a radar target is studied using time-frequency (TF) analysis. The UWB frequency responses of the target under linear and circular polarization incidence are studied. The results demonstrate that the Q-factor of the resonant peaks vary as the incident polarization changes, indicating that different layer SEM poles are extracted for different polarization incident states. [C424]

## "Optimal radar bistatic angle by statistical analysis of scattering patterns"

In this work, we introduce the concept of optimal bistatic angle such that the scattered radar target signal has a robust strength level irrespective of the target aspect. The concept involves statistically analyzing the scattering patterns as a function of the target aspect to a fixed and known incident radar direction. Henceforth, statistical quantities like mean and standard deviation are used to obtain statistics patterns for radar scattering patterns of an ellipsoid, a cylinder, and a square shape targets. Since different targets are likely to have different optimal angles, we propose using the optimal angle concept to improve the signal-to-noise ratio of a target of interest. This benefit can be further exploited in a radar target classification process. [C425]

## "Hardware implementation of an SAD based stereo vision algorithm"

This paper presents the hardware implementation of a stereo vision core algorithm, that runs in real-time and is targeted at automotive applications. The algorithm is based on the sum of absolute differences (SAD) and computes the disparity map using 320 times 240 input images with a maximum disparity of 100 pixels. The hardware operates at a frequency of 65 MHz and achieves a frame rate of 425 fps by calculating the data highly parallel and pipelined. Thus an implemented and basically optimized software solution, running on an Intel Pentium 4 with 3 GHz clock frequency is 166 times outperformed. [C426]

## "Light Stripe Projection based Parking Space Detection for Intelligent Parking Assist System"

This paper proposes a novel light stripe projection based free parking space recognition method in order to overcome the common drawbacks of existing vision based target parking position designation methods in dark indoor parking site. 3D information of parking site is recognized by light stripe projection method. By analyzing the 3D information, system can recognize discontinuous points, pivot, and opposite-site reference point. Experiments show that the proposed method can successfully designate target position in spite of dark illumination condition and the black reflective surface of vehicle. Furthermore, because the proposed method can be implemented just by adding a low-cost light plane projector, it is economically practical solution. [C427]

## "The Application of KL Transform to Remove Direct Wave in Ground Penetrating Radar Records"

In ground penetrating radar (GPR) records, because of different kinds of noises, especially direct wave of ground surface, the real target is not seen clearly in the radar echo section, which makes the detection of real targets difficult. Considering that the direct waves among traces are not change greatly and have strong correlation, so it can be restrained by certain methods. KL transform often be used to pick up coherent noises and random noises in multi channel seismic records[U 4]. In this paper, KL transform is used to GPR data processing, which fully uses the different second-order statistic characteristics of their correlations on the direct wave, target signals in multi channel GPR data. The target signals are successfully separated form noises according to the corresponding relation of the eigenvalue's magnitude of the correlation matrix and correlation strength of each

component in the multi channel GPR data. [C428]

## "A Fast SAR Target Recognition Approach Using PCA Features"

The real-time ability and recognition rate are two primary goals for evaluating the performance of an SAR image target recognition system. This paper concentrates on the analysis of key factors which influence these two goals. According to the analysis, a fast SAR target recognition approach is proposed, which utilizes a self-organizing neural network trained with the Hebbian rule to extract the principal component features and a multi-layer neural perceptron network as the classifier. The experimental results show that it consumes little memory and runs very fast with a considerable recognition rate, thus can be used in a real-time application. [C429]

## "A Knowledge-Based Target Recognition Method For Remote Sensing Image"

This paper proposed a knowledge-based target bridge detection method from remote sensing images. Firstly, the prior knowledge about bridge can supervise the low and middle image processing and analysis to detect the edges of bridges and riversides. Secondly, knowledge about the different characters of the bridge edges and riverside edges was used to wipe off the riverside edges and remain the lines of bridges, so that the purpose of recognition on bridge can be achieved. The method was tested on spot remote sensing images and the result shows it can detect the bridges exactly from images. [C430]

## "Cross-band Inverse Synthetic Aperture Radar (ISAR) Image Fusion"

Research on image fusion is making rapid progress recently, because multiple looks of the same target from different aspects will increase the available knowledge and allow more useful target information to be extracted. Studying on the physical principle of constructing radar images, especially inverse synthetic aperture radar (ISAR) images, make the fusion from multiple individual images generated by radars at multiple locations becomes possible. However, it is a challenge for image fusion if the source images are of different geometric resolutions, which are determined by radar system parameters, for example, the bandwidth of transmitted signals. This paper analyzes the influences caused by the different image resolutions, modifies the data fusion method proposed by previous research, and applies the modified method to an actually measured database. The performance of the modified image fusion algorithm is evaluated by the image attribute rating (iar) curves. The results show that the data collected by radars working at X-band and Ka-band can be fused successfully, and the information contained in the signals at these two frequency bands are complementary to each other. Therefore, the fusion improves target feature detection and thereby enhances target recognition. [C431]

## "Precise Registration of 3D Models To Images by Swarming Particles"

The precise alignment of a 3D model to 2D sensor images to recover the pose of an object in a scene is an important topic in computer vision. In this work, we outline a registration scheme to align arbitrary standard 3D models to optical and synthetic aperture radar (SAR) images in order to recover the full 6 degrees of freedom of the object. We propose a novel similarity measure which combines perspective contour matching and an appearance-based Mutual information (MI) measure. Unlike previous work, the resulting similarity measure is optimized using an evolutionary particle swarming strategy, parallelized to exploit the hardware acceleration potential of current generation graphics processors (GPUs). The performance of our registration scheme is systematically evaluated on an object tracking task using synthetic as well as real input images. We show that our approach leads to precise registration results, even for significant image noise, small object dimensions and partial occlusion where other methods would fail. [C432]

## "Echo theoretical analysis from chaff cloud and research polarization targets recognition"

Chaff is a constantly used method of passive disturb, and it is difficult to find an efficient method to depress and recognize chaff in both time and frequency domain. This paper tries to recognize chaff and target like warship in polarization domain under the theoretical analysis of the polarization scattering cross section of chaff. In order to find target more exactly, methods of non-linear polarization transformation and polarization smoothness were applied to process the polarization information of chaff and ship target. The resulting recognition was notable by simulation. [C433]

## "Study on a Nonlinear Frequency Modulation Signal with Polarization-Coded Modulation"

This paper proposes a kind of complex radar signal with polarization agility based on nonlinear frequency modulation (NLFM) signals. This signal has the characteristics of NLFM signals and the anti-jamming ability and performance of low probability of intercept (LPI) can be improved by using the polarization-coded modulation technique. The mathematical expression of the signal is given and the methods of signal processing and target

detection are discussed. The performance of the signal is analyzed and simulated when the target signal and the interference are in the different range cells, the results indicate that the target can be detected and the interference can be suppressed by two dimension signal processing when the target can be distinguished from the interference in polarization domain. [C434]

## "An UWB Wall Scanner Based on a Shape Estimating SAR Algorithm"

This paper describes a complete pulse based high-resolution radar system. This includes the transmitting and receiving unit as well as the signal processing of the down-sampled echoes. The main focus of the hardware design was on the usage of low-cost components. The signal evaluation is based on the shape reconstruction of simple targets in order to use the proposed radar system for wall scanning applications, e. g. the detection of water pipes. [C435]

## "The Modeling and Simulation of A near-distance microwave imaging system"

For the purpose of diagnosing the scattering points of radar target exactly, a near-distance microwave imaging system is designed. The theoretical equation of imaging can be gained by mathematical model with cooperation object. Imaging equation can be solved by spherical wave filter back projection arithmetic quickly. The simulation result show that good performance 2D image with high resolution can be obtained by utilizing spherical filter back projection arithmetic, which can digest the scattering points exactly and in detail. [C436]

## "Multipath Effects Cancellation in ISAR Image Reconstruction"

When radar illuminates targets at low elevation angles, radar returns will change due to multipath interference. For inverse synthetic aperture radar (ISAR), the multipath effects introduce two artifacts in its reconstructed images, which greatly hinder radar target recognition and classification. A novel technique requiring no apriori knowledge of target motion parameters is developed in this paper for multipath effects cancellation in ISAR image reconstruction. This technique is based on a parametric estimation method using two-dimensional image entropy as its cost function and realized via simulated annealing (SA) algorithm to search the optimum parameters corresponding to the minimum image entropy. Simulation results shows encouraging qualities of ISAR images after multipath effects cancellation, which also confirms the feasibility of this technique. [C437]

## "A recognition method depended on enlarge the difference between target and chaff"

This paper proposed a target recognition method to distinguish ships from chaff by polarization information, aiming at fully polarized dual-channel radars with low resolution. The method expands the original single polarization radar system to dual polarization radar system with both left and right circular polarizations by receiving and processing the full polarization information of radar echoes. It recognize the target by taking advantage of the difference of the left and right circular depolarization characteristic parameters of the target and chaff in radar echoes, after enlarging the difference between the cross- polarization component and co-polarization component of the radar echoes involving both target and chaff, furthermore, non-linear polarization transformation is adopted to increase the chaff and targets respectively, and to improve the recognition rate in result. In the end, the recognition result is proved to be more desirable by processing information in polarization domain than in time and frequency domain. [C438]

## "Modified Generalized Discriminant Analysis For Radar HRRP Recognition"

Generalized discriminant analysis (GDA) is a nonlinear extension of the classical linear discriminant analysis (LDA) via kernel trick. As a feature extraction method, it has been proven successful in many applications such as radar high-range-resolution profiles (HRRP) recognition. However, GDA often suffers from the so-called small sample size problem (SSS) which exists in high-dimensional pattern recognition data. To overcome this weakness, we present a new algorithm for solving GDA by utilizing the idea of direct-LDA (DLDA) in this paper. Experiments based on three measured airplanes data are conducted to evaluate the effectiveness of the proposed method. From the results we can see that the new algorithm is more transparent and easier to be implemented than the traditional one, while keeping competitive classification accuracy. [C439]

## "Recognition of Radar Target Based on Kernel Projection Subspace using Range Profiles"

A novel subspace method of radar target recognition, which is named as kernel projection subspace (KPS) method, is proposed in this paper, in which geometric relations are preserved according to prior class-label information and nonlinear variations of range profiles are represented by nonlinear mapping. So, the KPS can be used to extract target feature for enhancing local within-class relations. The experimental results of four kinds of planes demonstrate the efficiency of approach proposed in this paper. [C440]

## "Estimating Three-Dimensional Scattering Centers of a Target using High Resolution Techniques"

In this paper, we present high resolution techniques for application in three-dimensional (3D) scattering center extraction for a radar backscattered signal. We propose a 3D pairing procedure, a new approach to estimate 3D scattering centers. This pairing procedure is more accurate and robust than the general criterion. 3D MEMP with the 3D pairing procedure first creates an autocorrelation matrix from radar backscattered field data samples. A matrix pencil method is then used to extract 3D scattering centers from the principal eigenvectors of the autocorrelation matrix. An autocorrelation matrix is constructed by the MSSP (modified spatial smoothing preprocessing) method. The observation matrix required for estimation of 3D scattering center locations is built using the sparse scanning order conception. In order to demonstrate the performance of the proposed technique, we use backscattered field data generated by ideal point scatterers. [C441]

## "Multi-sensor Based Lane Detection and Object Tracking Method"

Considering the relation between the movement of vehicles and the lane parameter, a novel fusion method of lane detection and object tracking is proposed. Though millimeter radar can accurately provide longitude range and velocity information of vehicle ahead, it can not recognize lateral position and road state, which makes it easy to loss targets when vehicle ahead turns or changes its lane. To solve this problem, lane information achieved from image is integrated with radar-filtered information. With the selected road shape model and the intensity feature of lane image, an optimization algorithm was established to maximize likelihood function evaluating how well the image gradient data on an assumed lane marking supports a given set of template parameters. Lane curve parameter can be transformed into vehicle front wheel orientation, and finally the fusion estimation of vehicle state can be achieved by UKF (uscented Kalman filter) estimator and least-squares based data fusion algorithm. Simulation results validate the proposed method can improve vehicle's pose tracking accuracy significantly. [C442]

## "A Novel Proximal Support Vector Machine and Its Application in Radar Target Recognition"

The samples are assumed to distribute normally in the solution of the standard proximal support vector machine (PSVM). But in many application problems, the data set for each class is generally unbalanced, where a poor performance can be gotten by PSVM. For this, a novel PSVM is presented, namely the modified PSVM (MPSVM). By adding a new diagonal matrix in the primal optimization problem, the new algorithm assigns the different penalty coefficients to the positive and negative samples respectively. Therefore the samples in different classes can make different contributions to the learning of the decision surface. Based on the sufficient experimental results on the UCI datasets, MPSVM is also applied to the measured radar range profile images and the results illustrate the effectiveness of the proposed method. [C443]

## "SVM Target Identification Method Based on HRRP Sample Partition"

On the basic of analyzing the quality and characteristic of high resolution range profile (HRRP), aim at its azimuth sensitivity and feature instability, one kind of sample partition method based on the HRRP's inner correlation coefficient threshold value was proposed, and it was adopted to partition experiment targets' HRRP into some subspace. The support vector machine (SVM) was trained by the sample that made up from some HRRP selected from the some sample subspace. The targets were identified by the trained SVM, and the correct identification rate is clearly better than the SVM trained by random sample. So, the method was a sort of valid and correct target identification method. [C444]

## "Feature Fusion for Robust Object Tracking Using Fragmented Particles"

Tracking people or objects across multiple cameras and maintaining a track within a camera is a challenging task in applications such as video surveillance. Some of the major challenges while tracking a target are illumination/scale changes and partial occlusion. In this paper, we propose a novel tracking framework using particle filter to efficiently track an object within a camera and a blob-based target association scheme for tracking across cameras. The proposed particle filter tracking algorithm uses a fragment-based approach to model the target and track it by fusing color and gradient features. Also, the proposed solution incorporates coarser level spatial information by fragmenting each particle and is shown to be beneficial for tracking under partial occlusion. A fast yet robust model update is employed to overcome illumination changes. Experimental results show (i) the robustness of the fragment-based tracking approach with respect to illumination/scale change and partial occlusion and (ii) tracking persons across two cameras. [C445]

## "Genetic-Based EM Algorithm for Classification of SAR Imagery"

A valid unsupervised and multiscale classification method of synthetic aperture radar (SAR) imagery is proposed based on the Expectation Maximization and the genetic algorithm (GA-EM). This algorithm is capable of selecting the number of classification of SAR image using the Bayesian information criterion (BIC) for Gaussian mixture model. Our approach benefits from the properties of Genetic algorithms (GA) and the EM algorithm by combination of both into a single procedure. The population-based stochastic search of the GA explores the search space more thoroughly than the EM method. Therefore, our algorithm enables escaping from local optimal solutions since the algorithm becomes less sensitive to its initialization. Some experiment results are given based on our proposed approach, and compared to that of the other algorithms. The experiments on the SAR images show that the method based on the GA-EM outperforms the other method. [C446]

## "Cluster Sorting of Radar Signals Using Intra-pulse Feature"

Common parameters for signal description can hardly meet practical requirement of radar signal sorting and recognition. Aiming at the problem of signal sorting system, DCT (discrete cosine transform) features and BT (product of bandwidth and time width) feature are introduced to form a new description vector. DCT features not only can reflect modulation mode but also are not sensitive to noise. BT feature can reflect some parameters of modulation. Both of DCT features and BT feature are easy to get. At last, results of weighted dynamic cluster show that DCT features and BT feature are effective for sorting. [C447]

## "Radar Target Recognition Using A Modified Kernel Direct Discriminant Analysis Algorithm"

The small sample size (SSS) problem is one of the major problems encountered when traditional kernel discriminant analysis methods are applied to high-dimensional pattern recognition tasks. Different methods have been proposed to solve this problem. In this paper, we introduce a new kernel discriminant analysis algorithm, which is able to effectively address the SSS problem and extract a set of optimal discriminant vectors without any lose of useful discriminant information. Experiments performed on radar target recognition using range profiles indicate that the proposed method outperforms some existing kernel discriminant algorithms, such as generalized discriminant analysis and kernel direct discriminant analysis, in terms of recognition rate. [C448]

## "A Novel Statistical Recognition Method Based on Hypersphere Model for Radar HRRP ATR"

Different from general Gaussian-distributed data, L2normalized samples are applied to HRRP-based recognition to deal with the amplitude-scale sensitivity problem, therefore, geometrically speaking, power transformed HRRP samples spread on a unit hypersphere. This paper proposes a novel statistical recognition method for power transformed HRRP samples under the jointly multivariate Gaussian distribution hypothesis, in which the hyperspherical spread of HRRP samples and the effectively discriminating information contained in the noise subspace can be fully utilized without increasing computation complexity. The experimental results based on measured data show that our proposed method can greatly improve the recognition performance. [C449]

## "Time Reversal Target Classification from Scattered Radiation"

This paper proposed the M-ary hypothesis testing algorithm for classifying radar backscatter signals from hidden targets in a rich scattering environment using time reversal. The target recognition algorithm is to be designed to distinguish measurements of the radar backscatter from an unknown object as belonging to one of a set of M classes. The proposed time reversal target classifier is, in essence, a correlator that calculates the cross-correlation of the normalized target signature waveforms with a data dependent quantity obtained from measurements. The algorithm requires a priori empirical statistical knowledge of the scattering channel, which is dependent of configurations of the scatterers in the environment. By incorporating time reversal, the proposed algorithm provides a significant performance improvement compared with the conventional method. Proof of concept is provided using electromagnetic data collected in a laboratory environment. [C450]

## "Satellite Target Recognition Algorithm Based on BP Neural Networks"

For high resolution range profile (HRRP) is sensitive to pose and translation, back-propogation (BP) algorithm is proposed to be used to process even rank central moments of HRRP in target recognition. Wavelet denoising is used to enhance the signal noise rate (SNR) of HRRP. Then central moments are extracted from the denoised HRRP. Even rank central moments can be used as features for target recognition because they are more stable and the dimension is reduced. BP algorithm is used to process the central moments feature vector. The experimental results based on real satellites data show that the proposed method achieves good recognition performance based on its low storage and computational complexity. [C451]

## "Minimax Robust Waveform Design for MIMO Radar in the Presence of PSD Uncertainties"

In this paper, we consider the problem of mini-max robust waveform design for multiple-input multiple-output (MIMO) radar based on mutual information (MI) and minimum mean square error (MMSE) estimation for target identification and classification. Recognizing that a single, precise characterization of target power spectral density (PSD) is rare in practice, we assume the PSD lies in an uncertainty class of spectra bounded by known upper and lower bounds, which markedly relaxes the required target a priori knowledge. Based on this band model, we develop minimax robust waveforms for MIMO radar under both MMSE and MI criteria. These robust waveforms bound the worst-case performance at an acceptable limit, and also could insure performance will be sufficiently good for any PSD in the uncertainty class. Our findings also indicate that the MI and MMSE criteria lead to a different minimax robust waveform solutions, which is in contrast to the case of the perfectly known target PSD. [C452]

## "Electromagnetic Target Recognition with the Fused MUSIC Spectrum Matrix Method: Applications and Performance Analysis for Incomplete Frequency Data"

The aim of this paper is to apply an electromagnetic target recognition method, which is based on the use of fused MUSIC spectrum matrices, to the case of incomplete frequency domain data. The aforementioned method was suggested recently and succesfully applied to both canonical and complicated targets in the presence of complete frequency domain data [1]. However, most of the real world applications involve the use of severely incomplete frequency data, especially missing low frequency information. In this paper, the performance of mentioned target recognition method is investigated for various incomplete frequency bands and for a group of five small-scale aircraft targets. As a result, the mentioned target recognition method is demonstrated to give still high correct decision rates even when the frequency band is reduced by 300 MHz at low frequency end and at the signal-to-noise ratio is decreased down to -5 dB level. [C453]

## "A new method to create a virtual third antenna from a two-channel SAR-GMTI system"

Two-channel SAR-GMTI systems are suboptimal for moving target motion parameter estimation. Indeed, the ATI phase estimate of the across-track velocity component for a moving target is biased to lower values depending on the target signal to clutter ratio and the target across-track velocity. Additional antenna diversity can introduce additional degrees of freedom that can eliminate the bias problem. Aperture switching is an accepted method to virtually increase the number of channels without adding new hardware. One such mode is the RADARSAT-2 toggle mode (S. Chiu and C. Gierull, 2006). This paper proposes a new processing method to create a similar effective phase center configuration as the RADARSAT-2 Toggle mode from already recorded two-channel SAR data. This is achieved by delaying and combining the recorded two-channel measurements. The combination operation manifests not only a third phase center halfway between the phase centers of the two-channel system, but also a different antenna length of the virtual third antenna which requires a modification of the DPCA-ATI processing algorithm. The DPCA-ATI performance of the new mode is assessed and compared to ATI from the original two-channel mode. [C454]

## "The Research of Network Planning Risk Element Transmission Theory Model Based on Neural Network"

In order to solve the network planning problem considering risk elements efficaciously, we redefine the network planning in this paper and transform the classical network chart to the new network chart based on combining neural network theory. On this basis, a risk classification is listed for the construction project, and we give the evaluation activity indexes using the expert assessment. Then, a risk classification is listed for the construction project. In order to get the total risk degree of all the network routes, after setting a certain weight and threshold value, we regard the indexes as the neural network input vector and calculate the risk degree of various activities. Thus, the total risk degree of all the network routes can be got. Finally, the model algorithm is illustrated with a case study. [C455]

## "Satellite Recognition Base on Wavelet Denoising in HRRP Feature Extraction"

Wavelet denoising is proposed to be used in radar high resolution range profile (HRRP) feature extraction because the HRRP is sensitive to the target pose. It is proposed that wavelet denoising is used to process the HRRP before extracting features, and noise threshold is used as the detecting threshold of strong scattering centers. Denoised HRRP shows that the wavelet threshold denoising can eliminate the influence of the spurious scattering centers outside of target region and reserve the original HRRP characteristics of target region well. Experimental results show that wavelet denoising enhances the HRRP features stability and recognition rate greatly. [C456]

## "Target classification by echo locating animals"

In this paper, the principal mechanisms by which bats are assumed to classify targets are reviewed. Particular attention is paid to the ways in which bats might extract information from echoes. Classification mechanisms differ fundamentally according to signal design. It is shown how bats design their emitted waveforms according to whether they need to classify on the basis of micro-Doppler or range profile information. Throughout, analogies are made with radar (and sonar) systems, drawing attention to some ways in which engineers might learn from the classification mechanisms proposed for echo locating animals. [C457]

## "Optimising bistatic HF radar configurations for target and environmental signature discrimination"

HF radars are large and expensive systems whose performance is strongly dependent on the scattering geometry. There have been several cases where such radars have been poorly deployed, with consequent failure to achieve the surveillance objectives. This paper formulates the problem of radar site configuration in terms of objective mission-related metrics and outlines the optimisation procedure. [C458]

## "Pedestrian detection based on automotive radar"

Automotive radar sensors are able to measure the target range, azimuth angle and radial velocity simultaneously with high accuracy and update rate even in multiple target situations. Target recognition of radar objects is still a technical challenge and one of the most important topics to support future advanced driver assistance systems (ADAS). There is especially a large interest to distinguish between radar echo signals from human beings and from other objects in the target recognition scheme. Therefore, this paper elucidates the motion sequence of a walking pedestrian and describes this complicated process in a suitable technical model with different reflection points and related Doppler frequencies. Based on some measurements with a 24 GHz radar sensor several signal features are generated, which are used for the target recognition procedure. [C459]

## "Robust radar detection of moving ground targets with STAP"

Airborne radar sensors are able to detect small and slow moving ground targets using short dwell times by distinguishing the weak target signature from the dominant ground clutter signal. The capability of a Ground Moving Target Indication (GMTI) sensor is principally governed by the Probability of Detection (PD). Other capabilities such as geolocation, tracking and recognition are derived from these detection data. One method used to enhance the PD for platforms with multiple phase centres is Space Time Adaptive Processing (STAP). In this paper we report an experimental assessment of a robust STAP algorithm [1, 5, 6] using the QinetiQ Enhanced Surveillance Radar (ESR) data. From our results it is apparent that robustness may be introduced if a selective training methodology is employed to estimate the data covariance. Results are given for both Pre- and Post-Doppler STAP [C460]

## "Time-frequency analysis of late time electromagnetic transients from radar targets"

Radar target recognition based on late time target resonance detection has been widely reported in the literature. Determination of the commencement of the late time period is crucial when extracting such resonance information because including the early time components significantly degrades the accuracy of the extraction due to the time-varying behaviour in this portion of the signature. In this paper an investigation of the late time commencement point is carried out in the Time-Frequency domain using the example of a wire scatterer. [C461]

## "On the application of pattern recognition to identification of simple targets based on resonance and polarization diversity"

In this paper, target radar features based on extracting the polarization matrix of each of the radar target's complex natural resonances (CNRs) in the time domain is investigated. These resonance frequencies and their complex residues (amplitudes) in a co- and cross-polar configuration form a polarization matrix decomposition of the target in late time and are also related to the principal dimensions of the target and their relative physical orientation. We have developed and investigated new radar target features, whereby, for incident circular polarization we generate horizontal and vertical complex residue patterns for each known target at the first few dominant resonance frequencies over a number of aspect angles. [C462]

## "Sparse Manifold Learning with Applications to SAR Image Classification"

Nonlinear data-driven dimensionality reduction techniques have recently gained popularity due to the emergence of high dimensional data sets. The algorithmic complexity and storage requirements of these techniques, however, can make them prohibitive in resource-limited applications. It is therefore beneficial to reduce the number of exemplar samples required for performing an out-of-sample extension to a test point. In this paper, we propose a novel method for selecting a minimal set of exemplars and performing the out-of-sample

extension. In the case of two-class target recognition with synthetic aperture radar (SAR) data, we compare the efficacy of the proposed approach with other approaches for selecting a subset of the available training samples. We show that the proposed algorithm outperforms the existing methods by providing low-dimensional embeddings that maintain interclass separability using fewer retained exemplars [C463]

## "Fourier Approach to Moving Target Indication and Detection in Multichannel SAR Data"

This paper outlines a solution to the multi-channel synthetic aperture radar (SAR) moving target indication and detection (MTI/MTD) by means of inverse systems approach. A novel model of the problem is presented and an approximate analytic solution to it will be given. It will be demonstrated how a moving target indicator can benefit from a multichannel SAR system as opposed to a traditional approach that separates MTI and SAR systems. It will be shown that the problem of separation of moving targets from stationary ones can be solved completely by using multi-channel approach and in such a way that a spatial distribution of the stationary targets does not play a role [C464]

## "Clustering Polarimetric SAR Image Under Deorientation Theory"

In natural complex terrain surfaces, scattering targets with random orientations produce random fluctuating echoes which lead to confused classifications by directly using target decomposition on polarimetric SAR (PolSAR) image. In order to reduce the influence, the target vector is transformed into the state with minimization of cross-polarization. Then a set of new parameters u/v/w are used to characterize scattering mechanisms under the deorientation theory, and the fuzzy membership is adopted instead of "hard" division of parameter plan. Characterizing the sample coherency matrices as complex Wishart distribution, the PolSAR image is clustered based on Bayes maximum likelihood (ML) criteria. Experiment is carried out on an L-band NASA/JPL SIR-C PolSAR image over Danshui town, Guangdong, China. Comparison results with the popular used methods show that the proposed method provides a significant improvement in classification and the associated scattering mechanism of class is more accurate and beneficial for automatic terrain recognition. [C465]

## "Blind Adaptive Algorithm for M-Ary Distributed Detection"

In a parallel distributed detection system each local detector makes a decision based on its own observation, then transmits its local decision to a fusion center. Given fixed local decision rules, in order to design the optimal fusion rule for the M hypotheses, the fusion center needs to have perfect knowledge of the performance of the local detectors as well as the prior probability of the hypotheses. Such knowledge may not be available in practice. In this paper, we propose a suboptimal algorithm for M-ary decision fusion based on binary groupings of multiple hypotheses. Simulation results show that this method is effective in practice [C466]

## "Hidden Markov Models in radar target classification"

A classification technology is presented that uses Hidden Markov Models (HMMs) to classify simulated and real radar signals from five classes of targets: personnel, tracked vehicles, wheeled vehicles, helicopters and propeller aircrafts. Similar to techniques that have been well proven in speech recognition, the time-varying nature of radar Doppler data is exploited. The method classifies the different targets by their different Doppler characteristics. The purpose of this paper is to make a comparison between three kinds of HMM Methods: 1. HMM with continuous outputs (CHMM) 2. HMM with discrete outputs (DHMM) 3. Semi-continuous Hidden Markov Models (SCHMM) [C467]

## "Multiperspective micro-Doppler signature classification"

Multiperspective automatic target recognition is considered to assist underlying classifiers by providing more views of the target. For the first time data from netted radar has been analysed for micro-Doppler signature content and a multiperspective dynamic time warping classifier developed. Despite limitation in the multiperspective data, identification is achieved with a probability of correct classification of 0.99. The results are contrasted with a monoperspective approach. [C468]

## "Fine micro-Doppler analysis in ISAR imaging"

In ISAR imaging, it's well known that rotating parts of a target such as wheels or rotors induce additional features in the Doppler frequency spectrum. These features are called micro-Doppler effect and appear as sidebands around the central Doppler frequency. They can provide valuable information about the structure and motion of the rotating parts and may be used for target identification. In this paper, we propose a fine analysis of the Doppler returned by reflectors of a rotating wheel. Thanks to the to micro-doppler signature we are able to

extract information on its geometrical features (position, orientation). The method has been performed on simulated and experimental data and provides satisfactory results. [C469]

## "Performance evaluation for imaging laser radars with focal plane array"

Recent advances in lasers and optical detectors have made feasible the development of laser radar systems capable of providing real time images, one need regarding the growing interest on automatic target recognition applications. These imaging applications require the use of a focal plane array rather than a scan mechanism. In this paper we describe, from a new quantum point of view, the different contributions of signal and noise involved in incoherent laser radars systems based on a focal plane array in reception. This model allows evaluating the performance of these systems. A comparison with a real incoherent ladar is also given. [C470]

## "Recognition of convoys with airborne adaptive monopulse radar"

A technique for recognition of extended targets on the ground, in particular convoys, by air- or spacebased radar is presented. The technique is based on adaptive monopulse in conjunction with space-time adaptive processing for clutter and interference rejection. It is demonstrated that the standard deviation of the azimuth and radial target velocity estimates of the space-time adaptive monopulse can be exploited to recognise a potential spatial extension of a moving target. [C471]

## "Application of HRRP even rank central moments features in satellite target recognition"

Because high resolution range profile (HRRP) is sensitive to pose and translation, HRRP even rank central moments are proposed to be used as a kind of stable target feature in satellite target recognition. HRRP SNR is enhanced by wavelet denoising, then translation-invariant central moments are extracted. In order to reduce the feature vector dimension, even rank central moments are proposed to be used alone. Nearest neighbor fuzzy classifier (NNFC) that is very fit for combined features is introduced to process the central moments features vector. Experimental results with real satellite data show that good recognition performance is obtained. [C472]

## "Fractal feature based radar signal classification"

Automatic target recognition (ATR) using radar, is a much researched area with a demand for better and more accurate classification algorithms. In the present work, the local fractal dimensions of a synthetic aperture radar image have been used as features to classify ground targets. The performance of the fractal feature based ATR algorithm was compared with that of three other established ATR algorithms, viz. the simple yet powerful template matching ATR algorithm, the Gaussian model based Bayesian classifier, and the recently proposed principal component analysis based nearest neighbour algorithm. The fractal feature based classifier was shown to outperform all the other algorithms. [C473]

## "System simulation for a multi-function phased array radar"

This paper describes a system simulation which operates in non real-time to provide full closed-loop operation of the ground based multifunction phased array radar simulation system (MFRSS) in support of ballistic missile defence experiments against countermeasure. This system simulation provides capability to evaluate the system performance of multifunction phased array radar, and key algorithms verification and validation such as target modelling, multi-target imaging, target recognition and resource scheduling. [C474]

## "Radar target-ground interaction"

An investigation of the X-band (  10GHz) Electro-Magnetic (EM) scattering of a complex vehicle in-situ is reported. The aim of this work is to characterise radar multi-path effects in Synthetic Aperture Radar (SAR) imagery, and further to demonstrate how an appropriate choice of polarimetric basis can allow its mitigation. Ground-target multi-path effects reduce the interpretability of imagery by adding artefacts. Additionally, multi-path impacts on Automatic Target Recognition (ATR), because for any given situation it will not be clear what kind of ground should be employed for the training database. [C475]

## "Sample Size Analysis for Confidence Interval Estimation of Performance Metrics in ATR Evaluation"

In this paper, we address the problem of sample size requirement for confidence interval estimation of performance metrics in ATR evaluation. The sample size of test data in ATR evaluation application has been reviewed firstly. We choose the Bayesian method to analyze the problem and select "minimum length criterion" to obtain the shortest confidence interval (CI) with the same estimation accuracy. The binomial probability density

function is regarded as the likelihood function to calculate the posterior distribution about the metrics. Then CI accuracy requirement in ATR evaluation is discussed. Because the posterior distribution of the metrics depends on the test result, criteria to eliminate the uncertainty from the test result must be considered. The worst outcome (WOC) criterion is chosen to calculate sample sizes for various CI accuracy requirements and the corresponding sample sizes are listed in Table I. Table I shows that the sample size is very large when the CI accuracy requirement is high. Two approaches (specifications and prior information) to reduce the sample size are proposed and discussed. The absolute number of the sample size reduction is great when using the specifications in ATR evaluation applications. Table II contains those minimum sample sizes with various specifications, and its comparison with table I is shown. Whereas the sample size reduction is not large when using prior information because precise prior information about the metrics is always absent. The approximate sample size reductions can be got from table III and IV when considering beta distribution as the prior distribution. [C476]

## "Point Spread Function Characterization of a Radially Displaced Scatterer Using Circular Synthetic Aperture Radar"

This paper presents results for characterizing the point spread function (PSF) behavior of radially displaced point scatterers for circular synthetic aperture radar (CSAR). For SAR data collection systems utilizing a circular aperture for target recognition, it is important to know how a target's PSF behaves as a function of various radar functional parameters and different target positions. Using the backprojection image formation algorithm, we generate point target PSF responses using various point target locations. Consistent with previous studies, the three dimensional PSF for a point target located at the image center is cone shaped and serves as the basis for comparing and characterizing the PSFs for radially displaced scatterers. Simulated results show impulse response of a radially displaced point scatterer is asymmetric and tends to become an elliptic shaped. [C477]

## "Signal Detection using the Correlation Coefficient in Fractal Geometry"

Using the Fractal Geometry in Signal processing has been extended nowadays. They have found several applications in signal detection and recognitions. They use the chaotic feature of the noise and clutter and try to distinguish between the noise, clutter and the desired target. Recent works show that lots of clutters like sea and ground clutters have fractal behavior so this kind of approach to the signal detection has been extended these days. In this paper we have used the Box-Counts of a signal rather than the Fractal dimension of a signal as will be defined later in the text. By applying the new defined concept we have developed different methods of signal detection. We use the correlation coefficient of the Box-Count and the time domain range for different ranges. By using the difference in the behavior of these coefficients when we have or don't have a target, we can set statistics from these variables and set up some detectors to determine whether the received signal contains a target or not just by comparing the statistics with some thresholds. One of the applications of the method is in high resolution radars. The received signal contains the Range Profile of the target which is unknown in our point of view. So using matched filters cannot be such helpful. In this paper the proposed detectors can act much better the common detectors of these signals. We have shown the advantage of the new methods. They bring us about 3 db increases in SNR. [C478]

## "Range Migration Algorithm in Bistatic SAR Based on Squint Mode"

In this paper, the imaging model for the translational invariant case of bistatic synthetic aperture radar (SAR) is deduced, based on the monostatic squint mode. A derivation of the point target responses both in two-dimensional (2D) frequency and time domains is presented. Using these results, the range migration algorithm (RMA), which could solve the large squint angle in monostatic SAR, is transplanted to the bistatic case. Especially, the key operation of Stolt mapping is interpreted. The simulation results show that, the RMA in bistatic SAR could focus the bistatic large squint very well. [C479]

## "Extracting Global 3D Scattering Center Model of Radar Target from Multiple HRR Profiles"

Global 3D scattering center model represents the radar target in optical region by a set of point scatterers in three dimensional space with spatial scattering patterns. Such a model is useful in scattering analysis, data compression and target recognition. R. Bhalla et al. have proposed to extract such a model from multiple 3D radar images at viewing angles on a mesh grid covering the space extent of interest. Here we propose another method to extract the model from multiple 1D radar images, i.e., high range resolution profiles. This alleviates the tremendous task of collecting enough data for 3D imaging at each viewing angle. We explore the fact that the projected 1D locations of a fixed scattering center at different viewing angles are on the same sphere and we devise a 1D-3D scatter map (OTSM) to visualize those spheres. Though OTSM gives a straightforward demonstration of the 3D scattering center model, we devise a procedure to extract the model automatically,

which makes use of algorithms such as Hough transform and morphologic operation. The model we extracted contains the stable scattering centers of the target and is valid in a large space extent. It can be used to restore the target signatures such as RCS and 1D to 3D radar images at any viewing angles in this space extent and at any frequencies in or near the band of the original data. Examples using both simple and complex targets demonstrate the validity of this method. [C480]

## "Model-Based Classification of Aircraft Range Profiles using Data Association Algorithms"

This paper deals with aircraft recognition from an airborne platform. The data available are high-resolution radar range profiles. The classification method is probabilistic and supervised. It consists in modelling targets by scattering centers and a further association of peaks from the measure to these scattering centers. The global nearest neighbour algorithm performs the association. [C481]

## "Developments in Modern Synthetic Aperture Radar"

Since their origins in the 1950s, the techniques of synthetic aperture radar have come a long way, and SAR is now routinely used, both from satellites for geophysical remote sensing and from aircraft for high-resolution surveillance. This paper presents a subjective and selective review of some developments in systems, techniques and results. [C482]

## "Automatic Detection of Power Transmission Series in Full Polarimetric SAR Imagery"

An automatic extraction scheme of power transmission tower series in full polarimetric synthetic aperture radar is presented. Through analyzing the amplitude of four scattering powers in terms of scattering matrix elements based on four-component decomposition model, point-like targets including the power transmission towers are detected in the helix scattering component using the multi-resolution statistic energy level method. Due to the geometrical properties of power transmission tower series, radon transform is used for extraction by applying it to the graph structure which constructed by linking all the isolated power transmission towers. Using L-band Pi-SAR images, the effectiveness of the extraction method is validated. [C483]

## "Ultra-Wide Band Near-Field Imaging System"

An experimental ultra-wideband radar system prototype is presented for imaging objects located in the near field of the radar antennas. The system is primarily intended for through-matter, e.g. through-wall, target detection and imaging. The radar hardware is based on several novel technical solutions in the design of its electromagnetic (EM) and circuit components including a new antenna element with wide impedance and gain bandwidth. The same elements are employed for the transmit channel and the two-element receive array. The signal processing and target imaging algorithms are presented. Some results of indoor tests to image in 2-D the spatial position of a cylindrical object are reported. In particular, a brightest-spot recognition technique is demonstrated that uses a number of special radar calibration routines to set properly the time/range scale required for precise target localization and imaging while avoiding appearance of false target responses. [C484]

## "Moving Target UWB Radar Demonstration using Real-Time Sampling"

Moving target bistatic 2D UWB radar trial with two receiving antennas using modification of time-domain back-projection technique with use of 50 GHz equivalent sampling oscilloscope in comparison of two channel 1 GHz real time sampler is presented. Sub nanosecond first derivate Gaussian pulse with peak-peak amplitude 1.2 V was used. As a target a metal barrel was chosen and his movement by shifting with 5 cm step simulated. Using real-time sampler was the goal. Acquired data were processed and the radar images shown. [C485]

## "Target recognition by means of spaceborne C-band SAR data"

The relative low resolution (~25 m times 5 m on the ground) of spaceborne C-band SAR data as acquired e.g. by ESA sensors ERS and Envisat can be significantly increased (up to sub-meter precisions (Perissin and Rocca, 2005)) by processing coherently long series of images. Moreover, by analyzing the amplitude of the radar signal, the main radar characteristics of urban targets can be estimated and a system for automatic recognition of a set of scattering structures can be developed. In this work, we present the methodology and the results obtained on the test-sites of Milan and Shanghai by combining data acquired from ascending and descending passes and from parallel satellite tracks. [C486]

## "Development of an Experimental Prototype Multi-Modal Netted Sensor Fence for Homeland Defense and Border Integrity"

Potential terrorists/adversaries can exploit a wide range of airborne threats against civilian and military targets. There is no effective, low-cost solution to robustly and reliably detect and identify small, low-flying airborne vehicles such as fixed-wing aircraft or unmanned aerial vehicles (UAVs) that might be carrying out chemical, biological or nuclear attacks, or smuggling drugs or illegal immigrants across the border. This paper presents a low-cost and low-power methodology for performing key 24/7 sentry functions that can be used for the protection and the surveillance of critical infrastructure from airborne threats. The methodology is based on joint multi-sensor fusion technology. It consists of a forward-based fence comprised of a mixture of selected low cost, low power, netted sensors including a simple radar, acoustic microphone array and optical (infrared and visible) cameras to detect, track and discriminate potential airborne targets. An experimental prototype end-to-end proof of concept system with deploy able software, hardware and connectivity is built using COTS component. Multi-modal senor fusion algorithms employing Kalman filter for target tracking and acoustic and image recognition algorithm for target classification are implemented. Results from field tests reveal reasonable detection and discrimination among candidate aircraft. [C487]

## "Development of diver detection and sensor integration for wharf surveillance software"

The underwater security sonar system is the port surveillance system which surveys over harbors and ships in order to protect harbor facilities such as wharfs, oil refineries, airports and vehicles, from the terrorism attack under or on the sea. For our surveillance system, it is required to develop the software which can perform "automatic detection of doubtful target" by processing the signal of sonars, and which can provide the high surveillance performance and usability by integrating the information of the sensors. For this purpose, we developed the algorithm for auto-detection and tracking of doubtful target. Also, we developed the algorithm for data acquisition and image processing specialized for the infrared camera for this system. [C488]

## "A Target Recognition Method Based on Non-Linear Polarization Transformation"

This paper proposed a target recognition method to distinguish ships from chaff by polarization information for the fully polarized dual-channel radars with low resolution. The method expands the original single polarization radar system to dual polarization radar system with both left and right circular polarizations by receiving and processing the foil polarization information of radar echoes. It recognizes the target by taking advantage of the difference of the left and right circular depolarization characteristic parameters of the target and chaff in radar echoes. The recognition rate were improved in results by enlarging the difference between the cross-polarization component and co-polarization component of the radar echoes involving target and chaff employing non-linear polarization transformation. In the end, the recognition results were proved to be more desirable by processing information in polarization domain than in time and frequency domain. [C489]

## "Nanosecond Gigawatt Radar: Indication of Small Targets Moving Among Heavy Clutters"

For indication of low-RCS targets moving among natural clutters, radars with short high-power transmitted RF pulses are known (Skolnik, 2001) to be advantageous over radars with relatively long broadband-coded pulses of the same energy. In accordance with the theory(Skolnik, 2001), an experimental X-band nanosecond-gigawatt-pulse radar proved to be efficient for detection, recognition and tracking of ~1 m2RCS planes, helicopters and motor boats moving within forest and sea clutters. Further upgrades of the radar are possible. [C490]

## "Theoretical Analysis of Polarization Recognition between Chaff cloud and ship"

Chaff is a kind of passive disturbance which is commonly used. It is difficult to find an efficient method to depress and recognize chaff in both time and frequency domain. This paper tries to recognize chaff and target such as warship in polarization domain under the theoretical analysis of the polarization scattering cross section of chaff. In order to find target more exactly, non-linear polarization transformation and polarization smoothness were applied to process the polarization information of chaff and ship target. The resulting recognition was effective by simulation. [C491]

## "A new method of ship and chaff polarization recognition under rain and snow cluster"

In Warfare on the sea, passive interferences include not only chaff but also surrounding atmosphere such as rain and snow, these factors will influence final recognition of targets. This paper solves the problem by polarization theory. This method is based on the radar which can receive both left and right circularly polarized wave and obtain the full polarization information of echoes. Firstly, the path influence of rain and snow from polarization power matrix is eliminated in order to correct the power matrix of targets. Secondly, the distinguishing rate of targets from chaff is increased employing non-linear polarization transformation to increase the polarization range ratio of echoes. Finally, Simulation experiments show the method is effective. [C492]

## "Detection and recognition of radar objects at sounding by high-power ultrawideband pulses"

By present, ultrawideband (UWB) radiation sources with megavolt efficient potential have been created. This is technical basis for development of UWB radars for remote object sounding. The paper gives special attention to analysis of investigation results of methods for detection and recognition of remote radar objects at sounding by high-power UWB pulses. To detect UWB signals at the noise and interference background, an approach based on the joint use of matched filtering and inter-period correlation processing is suggested. A genetic function method and parametric methods were developed for object recognition. Compression of the data bank is of importance in the latter methods. [C493]

## "Two-dimensional PCA for SAR automatic target recognition"

In this paper, a new technique for synthetic aperture radar (SAR) automatic target recognition (ATR) is developed, which is builded upon two-dimensional principle component analysis (2DPCA). First, 2DPCA is applied to extract features in frequency domain, which is based on image matrix directly. Then support vector machine (SVM) is used for classification. Experimental results on MSTAR dataset show that the 2DPCA method both gives higher recognition rate, and are computationally more efficient than PCA. [C494]

## "Radar automatic target recognition based on InISAR images"

A novel interferometric inverse synthetic aperture radar (InISAR) imaging method, include an efficient phase unwrapping approach, is proposed, which can work very well under very low signal noise ratio condition. Based on which, an InISAR image based target recognition method are proposed. The rotation and scale invariant features are extracted from the transformed InISAR images, namely, the polar images. The simulation results are provided to show the efficiency of the proposed methods. In addition, some system parameters, such as baseline length, target aspect, target speed, etc, are analyzed from the viewpoint of recognition performance. [C495]

## "Analysis of PC number selection in SAR ATR"

The effect of PC (principal component) number upon SAR ATR (synthetic aperture radar automatic target recognition) performance based on PCA (principal component analysis) is analyzed. First, PCA features are extracted with different PC number, and then SVM is used to classify. Experimental results based on MSTAR data sets show that the performance is optimized when the accumulative contribution rate of the selected PC is 70%. Compared with the common selected method of PC number, the new selection method improves recognition performance and also reduces computational complexity. [C496]

## "Multi-scale feature analysis method for bridge recognition in SAR images"

Target recognition is an important field in remote sensing image processing. This paper handles with the problem of bridge recognition in Synthetic Aperture Radar (SAR) images. Based on features of bridges, rivers and land in different spatial resolution SAR images, a method of multi-scale analysis is proposed. The original data is split into low and middle resolution level. The bridge candidates are located in low level by automatically detecting river. And regions of interesting (ROI) are obtained in middle one. So, bridges are recognized by analyzing those regions. The example results indicate that the processing speed can be greatly improved and the precision of recognition can also be ensured. [C497]

## "SAR ATR based on multi-subspaces of independent component analysis"

In this paper, a SAR (synthetic aperture radar) ATR algorithm based on multi-subspaces of Independent Component Analysis (ICA) is proposed. Features of each target SAR images are extracted by using ICA firstly, and then the Feature images of the target compose a subspace. All targets can compose multi-subspaces. Finally, we combine all the subspaces to a big new subspace by using PCA. We test our method on MASTAR database. The experiment result shows that the performance of this method is superior to other methods. [C498]

## "Sequential discrimination with multi-features to remove false ROIs in SAR ATR"

Because the prescreening usually adopts an anomaly detection approach to highlight the vehicle-targets in SAR image, many false regions of interest (ROIs) are produced to reduce hardly the efficiency of the ATR. A new method based on sequential discrimination with multi-features is proposed to remove these false ROIs in this paper. By quantitatively analyzing the redundancy, robustness and separability of the candidates, the optimal features are selected to form an orderly vector, which is compared with the vector of threshold to finish a sequential discrimination. The performance of the above algorithm is validated by the X band MSTAR data, and

is compared with the quadratic distance discriminating (QDD) method. [C499]

## "Multiresolution feature extraction in target detection of UWB SAR"

This paper firstly analyzes the difference between high-frequency synthetic aperture radar (SAR) and low-frequency ultra-wide band synthetic aperture radar (UWB SAR) in extraction of multiresolution feature. And then we establish the equivalent models of target and trunk clutter in UWB SAR images and analyze the differences of multiresolution characteristic between target and trunk clutter as image resolution is varied from fine to course. Two forms of first-order autoregression (AR) model are introduced to model multiresolution sequences, and a two-dimensional (2-D) definition of generalized likelihood ratio (GLR) is presented to improve the robustness of multiresolution feature extraction. At last a feature extraction experiment of multiresolution based on region of interest (ROT) is accomplished. The results of experiment testify that the multiresolution feature is effective to improve the performance of UWB SAR target detection. [C500]

## "Man-made target discrimination based on scattering mechanism identification and spectral correlation property analysis of POLSAR images"

In this paper, a novel discrimination method is proposed to automatically discriminate man-made targets in diverse natural clutter environments of polarimetric synthetic aperture radar (POLSAR) images .The novel method, which makes fully use of the difference between man-made target and natural clutter on scattering mechanism type and spectral correlation property, permits to obtain a clear and credible target discrimination effect .The validity of our novel method is verified by fully polarimetric L-band POLSAR data acquired by DLR 's airborne E-SAR system. [C501]

## "Automatic target recognition of ISAR images based on Hausdorff distance"

A method of ATR of ISAR images is addressed in this paper. In this method, the edge images of ISAR images are applied as features and the THD method is applied as classifier. The edge image has the advantage of less demand on storage space and computation time, which is superior in practical system. The recognition based on Hausdorff distance is invariant to rotation after the scale and the signal level of the images are normalized. The experimental results demonstrate that the method performs very well. [C502]

## "SAR image compression based on image decomposing and targets extracting"

With the bandwidth restriction in airborne synthetic aperture radar (SAR)-based human-in-the-loop applications, the acquired SAR images should be compressed with loss to overcome the conflict of image quantity and the response time. In this paper we described a framework of SAR image compression. The SAR image is decomposed into two components, namely structural and textural components. The target region mask is used to retain the important target information by allocating more bits during compression, while less bits is allocated for the background region. The obtained result showed that the compressed image using the proposed algorithm has better visual effect under the same bit rate compared with JPEG2000 algorithm. [C503]

## "Ridgelet transform with application in ground penetrating radar processing"

Ridgelet is the new development of wavelet dealing with line singularities in signals. In goundpenetrating radar (GPR) signal, the direct wave is a strong noise which has line singularity. In time-space domain, the useful information in GPR signal is badly polluted by strong direct wave so that the underground targets can not be recognized correctly. Ridgelet overcomes the disadvantages of wavelets in dealing with high dimensions that it can effectively represent singularities along lines or hyperplanes. Concerning the characteristics of GPR signals, the ridgelet transform is employed to remove the background noise and separate the direct wave. The simulation results for real GPR signals demonstrate its effectiveness. [C504]

## "A kind of trading off algorithm of object classification based on intelligent data fusion"

A kind of trading off algorithm of target classification combined with double mode intelligent fusion is presented, Applying neuron-fuzzy technique to the synthesis of the complementary information between radar and infrared, through combining neuron-fuzzy technique with D-S evidence fusion theory, the ability of target classification could be improved. At the same time, according to the effective detection range of sensors, reasonably select the target features that can ensure the accurate target classification so that the computation load of the algorithm can be largely decreased compared to the infrared single model fusion. Simulation results illustrate that the trading off algorithm is effective. [C505]

## "Target recognition in SAR images with Support Vector Machines (SVM)"

This paper addresses object recognition problem in SAR images with SVM classifier; the work has been mainly focused on feature vector definition. Actually, each object is represented by a feature vector and SVM aims to estimate the best hyperplanes that separate classes in the feature space. Very robust definition of feature vector is proposed and tested on real data (MSTAR database). Confusion matrices prove that a very good recognition rate is reached, even for mixed incidence angles configuration. [C506]

## "Small-shaped space target recognition based on wavelet decomposition and support vector machine"

A kind of method for small-shaped space target recognition was proposed in this paper based on feature extraction with wavelet decomposition and formative support vector machine (FSVM) with sequential minimal optimization (SMO) algorithm. Firstly, the significance and characteristics of space target recognition were discussed and a two-stage recognition strategy was designed. And then aiming at the characteristics of small-shaped space target recognition, a new method was implemented based on feature extraction with wavelet decomposition and FSVM with SMO algorithm. Simulation results show the good performance of the algorithm proposed in this paper: the correct rate is more than 97% within 1360 simulation samples of ten classes of small shaped space targets; meanwhile the algorithm is characterized with high speed of near real time in both implementation of training and testing. [C507]

## "Maneuvering target tracking using the optimal stochastic jump filtering algorithm"

The problem of maneuvering target tracking is addressed in this paper. Based on the 'current' statistical model, two-structured stochastic jump system is constructed in which the acceleration covariance switching to each other. The parameters are estimated with optimal stochastic jump filtering algorithm, and the tracking ability is improved much more after using the covariance non-linear adjustment. Finally, numerical simulation is performed and the simulation result demonstrates that this tracking algorithm outperforms original adaptive algorithm and improves the precision and tracking ability at the same time. [C508]

## "Algorithm of target classification based on target decomposition and support vector machine"

Since Huynen's original work, there have been many other proposed target decomposition theorems. In this paper, we provide a review of the different approaches used for target decomposition theory in radar polarimetry and classify three main types of theorems: those based on Mueller matrix, those using an eigenvector analysis of the coherency matrix, and those employing coherent decomposition of the scattering matrix. Support vector machine (SVM), as a novel approach in pattern recognition, has demonstrated a success in many fields. Here we first extract scattering mechanisms of radar targets by target decomposition and color composite. Then we propose a new algorithm of target classification by combining target decomposition and support vector machine. We conduct the experiment on the polarimetric synthetic aperture radar data. Experimental results show that: it is feasible and efficient to target classification by designing SVM classifiers using target decomposition, and the effects of kernel functions and its parameters on the classification efficiency are significant. [C509]

## "Research on real time range profile of marine targets and its characteristics"

Against dechirping pulse signals, this paper proposes a real-time range profile algorithm suitable for marine targets, and analyses the characteristics of range profile of marine targets with real raw data, the common ways to deal with the characteristics are given as well. Finally envelope alignment and exponential transformation used in radar recognition preprocessing are analyzed. [C510]

## "Using FRFT to estimate target radial acceleration"

Radial acceleration of radar target is characteristic of relative motion between radar and target, and is significant for maneuvering target recognition and tracking. To estimate radial acceleration from radar echo, fractional Fourier transformation (FRFT) was used in this paper. The acceleration estimation formula was deduced firstly, and then its estimation flow was given out. Differences in antinoise interference capability between FRFT, WVD-HT (Wigner-Ville distribution and Hough transformation) and WVD (Wigner-Ville distribution) in estimating chirp signal parameters were analyzed. Then the relation between acceleration measurement accuracy and angle search step was deduced, and lastly simulations were made, proving that the method can improve operational speed, control operational precision and be also of better antinoise interference capability than other methods. [C511]

## "Automatic target recognition based on SAR images and Two-Stage 2DPCA features"

2-dimensional principal component analysis (2DPCA) has received more and more attentions in recent years, since it can evaluate the covariance matrix more accurate than PCA in extracting features from 2-dimensional images. However, a drawback of 2DPCA is that it needs more features than PCA because 2DPCA only eliminates the correlations between rows. In this paper, two-stage 2DPCA is proposed to extract features from synthetic aperture radar (SAR) images to further compress the dimension of features and decrease the recognition computation. Experimental results based on MSTAR data indicate that two-stage 2DPCA can decrease feature dimensions significantly, and the target recognition performance can be improved at the same time. [C512]

## "Targets detection and analysis in coastal area using Polarimetric SAR images"

Polarimetric SAR (PolSAR) is sensitive to orientation and characteristics of object thus may yield several new descriptive radar target detection parameters and leads to improvement of radar detection algorithms. Ship detection is one of the most important tasks of the seaport surveillance. In this paper, some methods, such as polarimetric target decomposition, time-frequency analysis, and radon transform, are proposed to detect and analyze moving targets using PolSAR image. We generate a validity test using multi-look X-band PolSAR image acquired by PiSAR in coastal Area. Both moving target and stationary target are included in the images. Results show the potential capability of proposed methods for moving target detection and analysis. [C513]

## "Nonlinear Target Identification and Tracking Using UKF"

In this paper, we implemented target identification algorithm using Dempster Shafer theory (DST) and tracking algorithm using extended Kalman filter (EKF) and unscented Kalman filter (UKF). A tracking filter is developed and simulated based on UKF to track nonlinear, ballistic and reentry targets. Comparison of EKF and UKF for nonlinear targets tracking are presented based on the simulation results. Simulated results gives more supporting points to use UKF for nonlinear target tracking rather using EKF. [C514]

## "Feature extraction of radar targets using Evolutionary Adaptive Wavelet Transform"

In this paper, the evolutionary adaptive wavelet transform (EAWT) is applied to the feature extraction of radar targets. The two features which are important for NCTR are scattering centers and resonance frequencies. EAWT algorithm use evolutionary programming (EP) for the time-frequency parameter extraction instead of FFT and the bisection search method used in conventional adaptive wavelet transform (AWT). Therefore, the EAWT has a better performance than the conventional AWT. In the simulation using wire target (Airbus-like) and simulated MIG-25, the comparisons with the conventional AWT are presented to show the superiority of the EAWT algorithm in the feature extraction of radar targets. The EAWT can be effectively applied to the radar target recognition. [C515]

## "Four-dimensional discretization for detection of moving objects in Wide Band SAR"

This paper addresses four-dimensional ground moving target indication (GMTI) using a multi-channel wide band (WB) synthetic aperture radar (SAR) system. With no acceleration attached to the target the motion of the target is related to two ground and two speed coordinates. However, four other dimensions are used in WB SAR GMTI processing during the detection phase: azimuth, range, bearing, and the relative speed between the object and the SAR platform. In the detection phase, blind hypotheses are used, and the discretization steps between the hypotheses are a trade-off between the number of hypotheses tested and detectability. As the integration angle increases, the step size in the image dimensions and in the relative speed has to be reduced. In this paper we determine the discretization step in all four dimensions for moving target detection, and relate it to radar system parameters. The discretization is derived from the moving target impulse response, assuming independency between the dimensions. In the paper the number of hypotheses per square meter is given for an airborne low frequency and a microwave GMTI WB SAR system. [C516]

## "Ultra-wideband radars for high-resolution imaging and target classification"

UWB technology in radar allows for a very high accuracy ranging, rigidity to multi-path propagation and external EMI. If added to high-cross range resolution capabilities, ultra-wide operational bandwidth can be also used to obtain high-resolution images of targets. As a next step, image-based classification of detected targets can be done. In this paper different approaches to high-resolution imaging with UWB radars are discussed and compared. Examples of system architecture are given. Possible image-based features of targets are discussed and examples of image-based target classification are presented. [C517]

## "On the analysis of electromagnetic transients from radar targets using smooth pseudo wigner-ville

## distribution (SPWVD)"

Time frequency analysis of electromagnetic transients scattered from wire radar targets has been investigated. The results demonstrate that the SPWVD is capable to providing another level of confirmation on the existence of particular resonant modes when the incident aspect and polarization changes, and graphically indicates whether a particular angle will excite a relevant mode. Such kind of information becomes critical for automatic target recognition (ATR) problems where the incidence angle(s) is usually not known in advance. Further work will be focused on applying the technique to more realistic targets, using another TF distribution which provides better time resolution for the early time. Using the combined information, a hybrid target identification scheme that makes use of the information from TF plots in conjunction with resonance based model will be constructed. [C518]

## "Utilizing the energy of each of the extracted poles to identify the dominant complex natural resonances of the radar target"

A novel technique, based on utilising the energies of the CNRs, has been introduced in this paper to identify the dominant poles, from a pool of extracted CNRs, of a simple PEC target in free space with different Signal-to-Noise ratios. The proposed dominant poles identification scheme does not require any knowledge of the modal order of the system. Applying this new technique to low Quality-Factor (Q-Factor) target and dielectric target will be the subject of further investigations. [C519]

## "Study of Radar Target Identification Based on Cepstrum and Complex Cepstrum"

A cepstrum analysis based method for radar target identification is proposed firstly. The traditional one nearest-neighbor classifier is used as a classitier. The computer simulation shows that the correct identification rate based on complex cepstrum and cepstrum feature is batter than that based on spectrum. [C520]

## "The music algorithm-based electromagnetic target classification for isolated targets from incomplete frequency domain data"

This paper investigates the performance of a new electromagnetic target classification method to recognize isolated targets in the presence of scattered frequency domain data which may be severely incomplete at low frequencies. The suggested method utilizes multiple signal classification (MUSIC) algorithm to construct approximate pole location maps of the targets without determining the exact pole values. In this work, this method is validated for small-scale aircraft targets modeled by thin, conducting wires with incomplete data, which brings additional difficulty in target classification problems. It is shown that the method provides high accurate classification rates even when incomplete frequency domain data with low signal-to-noise ratio values are utilized while it needs only a few different reference aspects and small memory storage in classifier design. [C521]

## "Performance analysis on subsurface target depth detection using the E-Pulse Technique"

Numerical models of a hip prosthesis model sited within two different realistic human tissue models have demonstrated that the E-Pulse technique is capable of detecting target depth changes inside a frequency dependent lossy halfspace. The performance is highly related to the dielectric properties of the half space and the excitation frequency. The dispersive attenuation factor of the halfspace and the frequency response of the same target below two different halfspaces were also studied and it is concluded that the attenuation factor, the resonance frequency of the target and the Q factor of the resonant peaks are all closely related and directly affect the E-Pulse detection performance. [C522]

## "A Golay code based approach to reduction of the PAPR and its consequence for the data throughput"

OFDM is considered as the basis of a radar system that combines radar and communication for fusion of target information from several radars. High PAPR of OFDM causes signal distortion during amplification. PAPR control by coding trades communication throughput for radar performance. The novelty of the paper is in the approach to this trade-off. Several relations between phase sequences with the same PAPR value are investigated. Bit rate reduction due to PAPR limiting by Golay complementary sequences is considered. It is shown that with increasing number of carriers the fraction of Golay sequences of all sequences satisfying a PAPR limit declines rapidly. [C523]

## "Fully polarized radar target scattering center extraction"

A new method for fully polarized radar target scattering center extraction is proposed using Coherent Polarization Geometrical Theory of Diffraction (CP-GTD) model. Unlike the traditional single fixed-polarization GTD method, the new method can overleap the step of scattering centers association and can estimate coherent scattering matrices of scattering centers accurately. It also provides a better performance and a reduced computation burden because the full-polarization information is used. The superiority of the CP-GTD is verified by experiment results based on simulated data. The method can also be easily extended for SAR/ISAR. [C524]

## "1-D high resolution range profiling technique for wideband solid state active phased array radar under active jamming situations"

High resolution one dimensional (1-D) range profile for wideband phased array radar is of great significance for ballistic missile recognition. It is always a matter of great interest for radar engineers to make an imaging radar function well in modern electronic warfare. Based on the stretch processing of LFM signal, the paper proposes a method named fully adaptive space-temporal ADBF at subarray level to achieve target imaging in active jamming situations. Computer simulation demonstrates the effectiveness of the current method. [C525]

## "A variational level set approach for automatic target extraction of SAR images"

A variational level set approach for automatic target extraction of SAR images is presented in this paper. Target extraction of SAR image is a hard work due to the presence of speckle noise. The proposed approach defines an energy criterion that consists of a region term derived from a mixed Gamma model of speckle noise and a boundary term related to the image gradient. Both of the terms are directly defined on the level set function. It is obviously different from the energy functional defined on parameterized curve in early level set approach. Target extraction is implemented by minimizing the energy criterion via variational level set approach. The performance of the approach is verified by MSTAR data. The experimental results show that the approach takes account of the speckle noise effect and sufficiently uses the boundary information of SAR images, thus accurately extracts the target but does not need speckle preprocessing step. [C526]

## "An effective SAR-GMTI technique based on eigen-decomposition of the covariance matrix"

An effective multi-channel SAR-GMTI technique based on eigen-decomposition of the covariance matrix is proposed. The variation of the sum of small eigenvalues of the covariance matrix is used to detect moving targets which can avoid clutter suppression. The radial velocity of the moving target is estimated by two steps. Firstly, using the interferometric phase of two SAR images to get the coarse radial velocity estimation, then the more precise radial velocity is obtained by searching the space-domain steering vector of the moving target. It overcomes the sensitivity of the interferometric phase to clutter and noise. The performance of the approach is analyzed in detail. The merit of the presented technique is demonstrated by simulated and measured SAR data. [C527]

## "Airborne ISAR imaging of ship side view"

In airborne ISAR imaging of ship targets, the complexity of the ship's rotation relative to the radar line of sight (RLOS) increases the difficulty in achieving high quality ship images. When imaging from long distance, the rotation induced by the tangential motion between the radar and the ship can always be neglected. The images obtained by exploiting the ship's own sway are generally the ship side view. However, when the rotation induced by the relative tangential motion cannot be neglected, the obtained images are the mixture of the ship top view and side view, which are not suitable for the ship recognition. In this paper, a method of obtaining the ship side view images under this circumstance is presented. Its main idea is to estimate the Doppler frequency derivative, which can be approximated by the chirp rate in a short imaging interval. A concentration measure is introduced to increase the estimation precision of the chirp rate in the dechirp process. The effectiveness of the proposed method is verified by the experiments on the simulation data. [C528]

## "Modification of resonance poles of a conducting target by a dielectric coating"

In resonance domain, the radar scattering response of any object can be modelled by natural poles of resonance with the formalism of the Singularity Expansion Method. The mapping of these poles in the complex plane, gives useful information for the discrimination of radar targets, as the general shape, the characteristic dimension and the constitution of the target. In this paper, we propose to study the effect on the resonance poles of a dielectric coating on a conducting target. For that, we present results of mapping of poles as a function of the thickness and the permittivity of the coating. [C529]

## "Performance analysis of RADARSAT-2 multi-channel MODEX modes"

It has been recognized that a two-aperture approach to ground moving target indication is sub-optimum and that target parameter estimation is often compromised by clutter interference or poor signal-to-clutter ratios. This paper investigates the ground moving target indication (GMTI) performance of several virtual channel concepts proposed for the RADARSAT-2 moving object detection experiment (MODEX). These are capable of increasing the spatial diversity of RADARSAT-2 by exploiting its very flexible antenna programming capabilities and allowing the two-channel SAR system to operate like a three or four channel radar. A high fidelity space-based radar moving target indication simulator (SBRMTISIM) is used to generate virtual channel raw GMTI data for analysis. Moving targets are detected using a combination of the factored space-time adaptive processing (factored STAP) and the cell-averaging constant false alarm rate (CA-CFAR) detector. The detection performance of virtual multi-channel MODEX modes are analyzed and compared with those of the standard two-channel MODEX mode and a true three or four channel space-based radar system. [C530]

## "Optimal bayes joint decision and estimation"

Many problems involve joint decision and estimation, where qualities of decision and estimation affect each other. This paper proposes an integrated approach based on a new Bayes risk, which is a generalization of those for decision and estimation separately. Theoretical results of the optimal joint decision and estimation that minimizes the new Bayes risk are presented. The power of the new approach is illustrated by applications in target tracking and classification. [C531]

## "Performance analysis of RADARSAT-2 multi-channel MODEX modes"

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## "Oral Session 3a: Target Recognition 1"

First Page of the Article [C533]

## "Statistical Modeling and ML Parameter Estimation of Complex SAR Imagery"

Accurate statistical models for the complex pixels forming fine-resolution synthetic aperture radar (SAR) images are needed for several engineering applications, including coherent signal detection in SAR clutter, automatic target recognition, and automatic SAR RCS calibration without calibration targets. We derive the maximum likelihood estimator for the parameters of a complex generalized Gaussian distribution and show that it can be efficiently computed. Applying this to fine-resolution SAR images representing a wide variety of scene contents, we show that this model very accurately captures both the central regions and tails of the data distribution. [C534]

## "In Situ Adaptive Feature Extraction for Underwater Target Classification"

This research compares the performance improvements of image-based sonar target classification algorithms when they are adapted to changing clutter environments. The distribution of seabed pixels in the sonar imagery is modeled as a correlated, K-distributed random variable allowing for a quantitative representation of seabed environments in the various testing scenarios. Parameterized environments comprising various target-like seabed textures are generated synthetically and used to examine adaptive classification performance. Results demonstrate that optimizing classifier parameters respective to specific environments improves overall classification performance compared to optimizing classifier parameters against a pooled dataset that includes all possible environments. [C535]

## "Copyright"

The following topics are dealt with: radar systems; multistatic radar; detection and tracking; synthetic aperture radar; target recognition; waveform design; ECCM; antennas; passive radar; and space-time adaptive

processing. [C536]

## "Radar Target's Angular Glint Based on the RCS"

A method of analyzing and calculating the angular glint of complex targets is presented. By dividing the target into very small size cells, and using high-frequency approximation, the Radar Cross Section (RCS) is calculated based on the SCTE prediction system. The angular glint is then calculated by the phase gradient. The results show that the angular glint can be calculated exactly and efficiently in the SCTE system. [C537]

## "Using watersheds segmentation on ISAR image for automatic target recognition"

This paper deals with the processing adopted for shape extraction from the ID-presentation (image) in radar automatic target recognition field. The goal is to provide helpful information to human operator for target recognition. However, extracting the target characteristics from a radar echoes is the rather difficult task. Hence, several kinds of radar signatures can be employed to acquire information about target [10, 11]. In this paper, we present one approach for retrieval system for target recognition bused on ISAR-images in radar experimentation field. Then, we propose efficient features that deals with target shape which are extracted using Watersheds transformation. Of course, the target shape gives a better human interpretation. [C538]

## "An Efficient Algorithm for the Radar Recognition of Ships on the Sea Surface"

In this paper, an efficient algorithm is proposed to the angular-diversity radar recognition of ships with noise effects taken into consideration. The goal is to identify the similarity between the unknown target ship and known ships. The content of this paper is divided into two parts. In the first part, the angular-diversity radar recognition of ships is given by transformation based approaches, i.e., the principal components analysis (PCA), with noise effects taken into consideration. The goal is to identify the similarity between the unknown target ship and known ships. In the second part, the linear discriminant algorithm (LDA) is utilized to increase the recognition rate. Initially, the angular-diversity radar cross sections (RCS) from a ship are collected to constitute RCS vectors (usually large-dimensional). By changing the elevation angle or the ship type, different RCS vectors are obtained to produce a high-rank covariance matrix. By choosing some of the largest eigenvalues and their corresponding eigenvectors, all the RCS vectors are projected onto the eigenspace (usually small-dimensional). Similarity between the unknown target ship and known ships can be identified in the eigenspace with high recognition rate. This will reduce the complexity for radar recognition of RCS characteristics from ships. However, the separating ability for such an elementary recognition is usually poor. This poor separation of radar target recognition will make the prediction results unreliable. The PCA gives the major features for the projected data of the two classes. While the LDA gives the best separation for the projected data of the two classes. To enhance the separating ability of radar target recognition, the projection features on the PCA space are further projected onto the LDA space and the recognition is performed on the LDA space. Our simulation shows that the separating ability for RCS based recognition of targets is greatly increased by using the LDA in the rada- r recognition process. In addition, the use of LDA in the recognition process increases the ability to tolerate noise effects. This study will be helpful in many applications of radar target recognition. [C539]

## "Adapting to Change: The CFAR Problem in Advanced Hyperspectral Detection"

Newer, realistic models of targets and backgrounds used in hyperspectral detection do not always lend themselves to a CFAR (constant false alarm rate) formulation. Several advanced techniques are considered here. It is found that incorporating a particular empirically validated method of target evolution permits an exact CFAR version of a large class of advanced detectors based on elliptically contoured distributions. Other validated detectors are considered, for which no closed form normalization exists to convert them to CFAR form. For these a geometrical approach to achieving approximate CFAR performance is described and analyzed. [C540]

## "NEW-CATR: Network-enabled Electronic Warfare for Collaborative Automatic Target Recognition"

Network-enabled Electronic Warfare (NEW) is to develop modeling and simulation efforts to explore the advantages and limitations of network-enabled electronic warfare concepts. The advantages of linking multiple electronic support measures (ESM) and electronic attack (EA) assets to achieve improved capabilities across a networked battleforce have yet to be quantified. In this paper, we will use radar sensors as ESM and EA assets to demonstrate the advantages of NEW in Collaborative Automatic Target Recognition (CATR). We apply the NEW to CATR via waveform diversity combining and and propose maximum-likehood (ML)-ATR algorithms for nonfluctuating target as well as fluctuating target. Simulation results show that our NEW-CATR performs much better than single sensor-based ATR algorithm for nonfluctuating targets or fluctuating targets. Conclusions are drawn based on our analysis and simulations and future research works on this research topic are discussed. [C541]

## "A robust method to determine relevant target vehicle using vehicular radar"

In order to solve the problem of the instability in the selection of relevant target, caused by the complexity of the measurement environment of vehicular radar, a robust method to determine the relevant target using vehicular radar is proposed. Based on analyzing the measurement environment, the method uses the principle of the nearest object in the same lane for target pre-selection. The Kalman filter is applied to predict the target information and the relevance verification of the pre-selected target is done by the consistence checking. The target decisions are made through a "relevant target life cycle" method. The verification tests show that by efficiently eliminating the effects of ghost objects, other disturbances and the bumping and swinging of vehicle, the proposed method can accomplish the determination of relevant target under different conditions. [C542]

## "Development of a high resolution UWB Sensor for Estimation of Transfer Function of Vocal Tract Filter"

UWB sensor has been considered as a good candidate for non-invasive medical imaging of human body. In this paper an FCC compliant UWB pulsed radar sensor is proposed. The transmitter transmits a pulse using a broadband monopole antenna. The pulse shape is similar to fifth derivative of Gaussian bell shape. The homodyne receiver is designed such that it correlates the received signal with a known template signal. The radar is capable of measuring millimeters of target motion. This radar is used for measurement of windpipe wall and glottal structure motions. Also corresponding acoustic signals can be measured using a simple microphone. These data are used in estimation of transfer function of the vocal tract filter (VTF). The transfer functions obtained for an individually pronounced sound element can be further used in applications like speech regeneration, voice recognition and background noise filtering. [C543]

## "Collaborative Multi-Target Detection in Radar Sensor Networks"

In many military and civilian applications, estimating the number of targets in a region of interest plays a primary role in performing important tasks such as target localization, classification, recognition, tracking, etc. Such an estimation problem is however very challenging since the number of targets is time-varying, targets' states are fluctuating, and various kinds of targets might appear in the field of interest. In this paper, we develop a framework for estimating the number of targets in a sensing area using Radar Sensor Networks (RSN): (1) the multi-target detection problem is formulated; (2) signals, interference (e.g., clutter, jamming, and interference between radars), and noise at radar sensors are modeled; and (3) a Maximum Likelihood Multi-Target Detection (ML-MTD) algorithm is proposed to combine received measurements and estimate the number of targets present in the sensing area. We evaluate multi-target detection performance using RSN in terms of the probability of miss-detection Pmd and the root mean square error (RMSE). Simulation results show that multi-target detection performance of the RSN is much better than that of single radar systems. [C544]

## "3D Organization of 2D Urban Imagery"

Working with New York data as a representative and instructive example, we fuse aerial ladar imagery with satellite pictures and Geographic Information System (GIS) layers to form a comprehensive 3D urban map. Digital photographs are then mathematically inserted into this detailed world space. Reconstruction of the photos' view frusta yields their cameras' locations and pointing directions which may have been a priori unknown. It also enables knowledge to be projected from the urban map onto georegistered image planes. For instance, absolute geolocations can be assigned to individual pixels, and GIS annotations can be transferred from 3D to 2D. Moreover, such information propagates among all images whose view frusta intercept the same urban map location. We demonstrate how many data mining and visualization challenges (e.g. identify all photos containing some stationary ground target, observe some structure from multiple perspectives, quantify match between two pictures, etc) become mathematically tractable once a 3D framework for analyzing 2D images is adopted. Finally, we close by briefly discussing future applications of this work to photo-based querying of urban knowledge databases. [C545]

## "Poster Session 7c: Target Recognition"

First Page of the Article [C546]

## "Oral Session 9a: Target Recognition 2"

First Page of the Article [C547]

## "Region feature extraction based on improved regularization method in SAR image"

The noise existed in synthetic aperture radar (SAR) image weakens the detailed features of region of interest (ROI) such as target and shadow. It also leads to the serious performance reduction of subsequent target detection, classification and recognition. The conventional regularization method could enhance target features in SAR image; however, the high computation complexity limits the real-time application of it. An improved regularization method is introduced in this paper, which increases processing speed of region feature extraction for SAR image significantly. It is theoretically proved that, by optimizing SAR projection operator, computation complexity could be reduced from O(M3N3)to O(MN) without ability losing of the region-based feature enhancement. MSTAR SAR image data is employed for algorithm experiment. The result shows that our method can increase target-to-clutter ratio significantly while restraining the noise in ROI, and then extract target and shadow from background clutters in SAR image more accurately. [C548]

## "Fine micro-Doppler analysis in ISAR imaging"

In ISAR imaging, it's well known that rotating parts of a target such as wheels or rotors induce additional features in the Doppler frequency spectrum. These features are called micro-Doppler effect and appear as sidebands around the central Doppler frequency. They can provide valuable information about the structure and motion of the rotating parts and may be used for target identification. In this paper, we propose a fine analysis of the Doppler returned by reflectors of a rotating wheel. Thanks to the to micro-Doppler signature we are able to extract information on its geometrical features (position, orientation). The method has been performed on simulated and experimental data and provides satisfactory results. [C549]

## "Very high resolution interferogram acquisition campaign and processing"

The ONERA RAMSES system is a flexible SAR system in constant evolution, developed mainly as a test bench for new technologies and to provide specific data for TDRI (Target Detection, Recognition and Identification) algorithm evaluation. It is flown on a Transall C160 platform operated by the CEV (Centre d'Essais en Vol). This paper gives an overview of the latest upgrading to acquire large data set without on board deramp-on-receive mode and then present the acquisition campaign at X band for very high resolution single pass interferometric multi-baseline mode. The multi- baseline mode used is a ping-pong mode where four antennas are used. The goal of this campaign was to acquire interferometric data in very high resolution mode, better than 0.3 m along slant range axis with a large slant range swath of 2400 m. [C550]

## "Clutter analysis of high resolution millimeter-wave SAR-data in the spatial and wavelet domain"

This paper presents the analysis of high resolution millimeter SAR clutter data, measured in a joint Swiss-German flight campaign. The generalized Gaussian function and the Kolmogorov-Smirnov test are considered to test the hypothesis of Gaussian clutter process. 35 GHz and 94 GHz data are compared. The results are presented in the time and wavelet domain, as the wavelet domain is an import transform domain for the development of terrain classification, target recognition and data compression algorithms. [C551]

## "ISAR imaging of targets with moving parts using micro-doppler detection on the range profile image"

In ISAR imaging, most works have assumed the target to be a rigid body, a body without any rotating, vibrating or moving parts. The rotation of structures in a target, such as the rotor of a helicopter or the turret of a tank target, may induce frequency modulation on the returned signals and generate sidebands about the center frequency of the target's body Doppler frequency, known as the micro-Doppler phenomenon. In this paper we present a new method based on range grouping of the target's range profile for the separation of the rotating or moving parts from the target's body. The method is carried out on the Range Profile Image, different from other methods that do the separation at the signal level. [C552]

## "A Wave Front Extraction Algorithm for High-Resolution Pulse Based Radar Systems"

The resolution of a pulse based radar system is restricted by the pulse width. Overlapping echoes in time domain of adjacent objects make a wave front evaluation of B-scans difficult. In this paper, a new algorithm for the wave front detection is proposed. Based on a reference impulse response of a large metal plate, the algorithm is able to determine the number of targets. Furthermore, two narrow adjacent spheres were detected as two different objects although the pulses of the two targets were overlapping. In the resulting radar image their shapes could be reconstructed. [C553]

## "The equivalence of Cameron's unit disc and Poincarй's sphere for symmetric scattering

## characterisation and classification"

Cameron's coherent target decomposition and classification is able to represent a symmetric scatterer onto a unit disc in the complex plane, and assign it to one of the six symmetrical elemental scatterer classes. Recently, Touzi et al. proposed a variation of Cameron's method by introducing a coherent analysis. Moreover the Poincare's sphere, was used instead of the unit disc for representing symmetric scattering because it was considered a more suitable domain. The aim of this work is to demonstrate the equivalence of using Poincare's sphere domain and Cameron's unit disc, in term of characterisation and classification of symmetric scattering types. [C554]

## "Radiation, scattering and receiving of pulse signals for subsurface object identification"

In many papers there are approaches for solving subsurface sensing and identification of subsurface objects based on FDTD methods with original method of identification (Pockok et al., 1998, Rao et al., 2002). There are not efficient for complex objects and lengthy object (its geometrical size is larger than pulse longitude). In this paper a numerical model for calculating far field scattered by complex objects is described. An evaluation is based on analytical evaluations. The results for some testing objects are represented. [C555]

## "Experimental consideration on the synthetic range-profile processing by stepped-frequency radar"

In radar system, separation of the target from the background clutters requires high range and cross-range resolution. To improve the range resolution, shorter pulses and wideband-FM pulses are utilized. However, they tend to complicate system architecture and to increase implementation cost due to the necessity of a wideband receiver. The synthetic range-profile (SRP) processing has been proposed to realize high range resolution without using the wideband receiver. The principle of the processing is that the echoes of stepped-frequency pulses are synthesized by IDFT in the frequency domain. This enables us to obtain short pulses in the time domain. This paper proposes the SRP radar composed of high-speed wideband exciter, which generates the stepped-frequency pulses. Through experiments, effectiveness of the proposed system is verified. [C556]

## "Evaluation of Edge Detection Techniques towards Implementation of Automatic Target Recognition"

The vision of Automatic Target Recognition (ATR) is through an integrated command identification architecture that combines non-cooperative and cooperative identification sensors and systems. The ATR implemented shall support development of situational awareness i.e., overall, general knowledge of the tactical battlefield environment, including the location of friendly, neutral, and enemy forces and plan of action for battle. The required operational capability will then be achieved by combining onboard data from multiple sensors and systems with indirectly supplied off board information. Edge Detection is one of the major image-processing requirements for achieving efficient and accurate target recognition in difficult domains. The on-board sensors used on combat aircraft are Electro-optic Targeting Sensors (EOTS), Infra-red (IR) sensors, Radar, Synthetic Aperture Radar (SAR) and Inverse SAR (ISAR) providing vast amount of images with different characteristics helpful for detecting targets. This paper concentrates on the assessment of advanced edge detection techniques on all types of sensor input images obtained for the implementation of automatic target recognition for air-to-air, air-to-sea and air-to-ground applications. This paper also describes the approach towards implementation of automatic target recognition for the entire range of sensor inputs. The proposed algorithm for automatic target recognition is for implementation on airborne systems with potential use on ground stations. [C557]

## "SVMs ensemble for radar target recognition based on evolutionary feature selection"

A novel radar target recognition method based on SVMs ensemble is presented, in which a set of suitable feature subsets are selected for component SVMs by Immune Clonal Algorithm, a new artificial immune system algorithm. With Immune Clonal Algorithm, high quality and high diversity of the components for SVMs ensemble are ensured. Experimental results on one-dimension radar high resolution range profiles demonstrate the validity and reliability of this new radar target recognition method. [C558]

## "Applying the Fourier-Modified Mellin Transform (FMMT) to Doppler Distorted Waveforms"

The magnitude spectrum of a time domain signal has the property of delay-invariance. Similar to the delay-invariance property of the Fourier transform, the Mellin transform has the property of scale-invariance. By combining these two transforms together one can form the Fourier-Mellin transform that yields a signal representation which is independent of both delay and scale change. Due to the undesired low-pass property of the Mellin transform (MT), the modified Mellin transform (MMT) which is also scale-invariant is applied in our approach. Therefore the Fourier-modified Mellin transform (FMMT) of the original signal and the Doppler-

distorted signal will be identical. This signal representation is useful in signal detection and target recognition. Several examples dealing with different waveforms have been simulated to illustrate the applicability of this approach. The performance of the Fourier-modified Mellin transform under different levels of noise in the signal are also illustrated in this paper. [C559]

## "A Novel Approach of Automatic Target Recognition using High Resolution Radar Range Profiles"

Generalized information cut (GIC) based on the nonlinear feature mapping using the kernel function is invariant for the linear transformation and the coordinates shift. By comparison and analysis of the angle similarity measurement and generalized information cut, the criterion of generalized information cut is proposed to solve the automatic target recognition using high resolution radar range profile. Feature mapping and inner product is synthesized in the feature space. The range profile data established from four different scaled aircraft models in unclassifiable low dimensional space is mapped into classifiable high dimensional space via the kernel function, and then the linear classifiable pattern transformed from nonlinear unclassifiable pattern is accomplished. Experimental results suggest that the target recognition technique based on the proposed method achieves better anti-noise performance, and is much more efficient in the improvement of recognition ratio of four different aircrafts than using the conventional angle similarity coefficient (the vectorial angle cosine). [C560]

## "Focusing problems of subsurface imaging by a low-frequency SAR"

ONERA radar RAMSES was recently upgraded with low frequency band (P-band, 435 MHz). In P-band, frequencies penetrate through the ground and through forest canopy. Unfortunately, the formation of the subsurface radar images presents a number of new specific challenges that include algorithm validity, calibration methods, radio-frequency interference, and image focusing and analysis. This paper addresses the aspects of focusing images from an airborne low frequency SAR of buried targets in a lossy and dispersive soil. The hydrological model (Richards' equation) was used to model the multilayer case. [C561]

## "2D Imaging Algorithm for the Evaluation of UWB B-Scans"

This paper proposes an ultra-wideband imaging radar system using B-scans for the target identification. The two dimensional inverse boundary scattering transform was successfully applied for through-wall imaging applications. Using this algorithm it is not only possible to detect the target but also to reconstruct the surface curvature of a cylinder behind a wall. Moreover, it is shown that only 24 different positions of the antennas are sufficient to estimate the target shape which results in a low computation time [C562]

## "Decision Tree Based FPGA-Architecture for Texture Sea State Classification"

The target detection process in sea clutter background involves the use of different types of CFAR (constant false alarm rate) algorithms. These algorithms and their parameters should be configured to obtain the maximum detection probability and minimum false alarm probability at the current sea state (Beaufort scale). This paper present an FPGA-architecture for automatic classification based on texture recognition of sea states. The sea state texture classification allows select the appropriate CFAR algorithm and its parameters for the target detection process. The paper is centered in the hardware implementation for sea state texture classification, based on decision tree. The rules for decision tree are obtained from the analysis of the grey levels co-occurrence matrix features applied in an image of the sea state obtained in a radar scan. Results with simulated and real data are presented and discussed [C563]

## "The Institution of Engineering and Technology Seminar on High Resolution Imaging and Target Classification"

The following topics were dealt with: high resolution imaging; target classification; radar imaging; sonar; military radar; speech recognition; SAR; and Doppler radar [C564]

## "Automatic Target Recognition: The Problems of Data Separability and Decision Making"

This paper treats the problem of target recognition as a decision process. The nature of the decision to be made has a bearing on the data gathered and the subsequent processing. A key factor in the processing is the separability, i.e., the ability to distinguish, of radar images of similar but distinct objects. A number of recognition algorithms are considered and their suitability for data sets of various types is discussed. In addition some simple measurements of the transfer functions of two targets are considered. Observation suggest that the examples have characteristics that may make them readily separable. As with all recognition techniques the quality and quantity of training data available will place a limit on the performance of any recognition technique and this discussed in the text. The view is formed that a single technique is unlikely to be successful and several

techniques cued by gross-features of the image may be more appropriate [C565]

## "Semi-Supervised Image Classification in Likelihood Space"

This paper studies the problem of using limited amount of labeled data and large amount of unlabeled data in the training of a generative model for image classification, and proposes a likelihood space approach to improve the classification performance. Frequently when labeled data is limited, unlabeled data can help to improve classification performance if the assumption of the generative model structure in the classifier is correct. But classification accuracy can be degraded if the model structure assumption is incorrect. In this paper, we compare raw data space classification and likelihood space classification in semi-supervised learning framework, and we show that the classification performance can be improved in likelihood space when model is misspecified. We apply this likelihood space semi-supervised learning method in automatic target recognition on SAR images, and experimental results demonstrate the effectiveness of this proposed approach [C566]

## "Enhanced SVM versus Several Approaches in SAR Target Recognition"

This paper presents a comparative study between different automatic target recognition (ATR) approaches in the application of synthetic aperture radar (SAR) target recognition. Four different categories of approaches are investigated and compared. The first is distribution-based where a statistical data model is assumed for the SAR image data. The second category contains one approach that is based upon principal component analysis (PCA). The third category employs different neural network architectures. The last category utilizes support vector machines (SVM). It contains the classical SVM implementation and an enhanced implementation proposed elsewhere by the authors in which the traditional Euclidean kernel is replaced by a new one that is more suitable for the application in question. Experimental results are presented. It is shown that the enhanced SVM approach outperforms all other investigated approaches in both the classification performance and the confuser rejection [C567]

## "UWB Radars for Chalenging Applications"

A number of challenging radar applications (such as antipersonnel mine detection and human being detection) has been discussed. In these applications UWB technology has a number of advantages of over the traditional narrow-band approach, in particular very high positioning accuracy, rigidity to multi-path propagation and target classification abilities. On a number of examples recent advances of UWB technology in radar have been demonstrated and remaining challenges have been discussed [C568]

## "Road Recognition in High Resolution SAR Image Based on Genetic Algorithm"

Road recognition from SAR image is a very important problem. In this paper, a new method is proposed which can detect multiple roads in an image. Firstly binary edge image is gained by Canny operator and edge refining. Secondly, edge curves are encoded by reversible chained list, and fitness function is constructed based on SAR image road models, and optimal road boundary curves are linked by improved genetic algorithm. Thirdly, complete road boundaries are detected by curve fitting. At last, mated long road edge curves are found out and road surface are stuffed. The experiment shows that this algorithm can realize roads recognition and eliminate influence of other non-road. [C569]

## "Collaborative Signal Processing Using Radar Sensor Networks"

In this paper, we propose a collaborative signal processing framework using waveform diversity in radar sensor networks (RSN). We study waveform diversity using constant frequency (CF) pulse waveform and linear frequency modulation (LFM) waveform, and compare their performance in automatic target recognition (ATR) with delay-Doppler uncertainty. Simulation results show that CF pulse waveform and LFM waveform can achieve very similar performance in ATR with delay-Doppler uncertainty using radar sensor networks. The ATR performance can tremendously be improved with larger number of radars in RSN [C570]

## "Estimation of the Target Detection Radar Noise Stability at the Ultrawideband Jamming Influence"

The field structure formation of an ultra wideband signal on the input of the target detection radar receiver device with working frequency 1 GHz is considered. The algorithms of the fields temporary structure definition based on the equations Kirghoff-Kothler with the subsequent estimation of the ultra-short impulse accidental jamming power characteristics necessary for specification of accepted signals processing algorithms are offered [C571]

## "SeeCoast: Automated Port Scene Understanding Facilitated by Normalcy Learning"

SeeCoast is a prototype US Coast Guard (USCG) port surveillance system that provides automated scene understanding support for watchstanders. A major SeeCoast objective is to reduce operator workload while maintaining optimal domain awareness by shifting operators' focus from having to detect events to being able to analyze and act upon the knowledge derived from automatically detected anomalous activities. Analyst-defined vessel activities are recognized from pre-scripted patterns and anomalous vessel activities are detected using machine learning techniques. The baseline SeeCoast system interfaces to the USCG Hawkeye prototype and uses (a) machine vision technology to produce target tracks from streaming video data; (b) multi-INT fusion technology to correlate radar, automatic identification system (AIS), and/or video track data into a single coherent track picture; (c) vessel activity analysis and learning technology to provide alerts for events of interest according to user-defined criteria; and (d) visualization of those alerts embedded within the common operating picture. The video processing component tasks and controls Hawkeye cameras to detect vessels in motion and generates vessel track and classification (based on vessel length) information. SeeCoast detects unsafe, illegal, and threatening vessel activities using a rule-based pattern recognizer and detects anomalous vessel activities on the basis of automatically learned behavior normalcy models. Operators can optionally guide the learning system in the form of examples and counter-examples of activities of interest, and refine the performance of the learning system by confirming alerts or indicating examples of false alarms. This paper focuses on the learning-based activity analysis capabilities of SeeCoast [C572]

## "Development of a Method of Construction Radar-Tracking Images of the Air Targets"

In article the approach to the decision of a task of formation of authentic bidimensional radar-tracking images in conditions of movement of the flying device on any trajectory with the account of trajectory instability his flight is opened. At formation of images the principle of inverse synthesizing of the aperture is used. The estimation of efficiency neural recognition of models of the air targets under bidimensional radar-tracking images is carried out [C573]

## "Target Classification Using Bistatic SAR Images"

In a radar system, a bistatic configuration is the more generic version of a monostatic configuration. Hence, it is expected and has also been verified to a large extent, that bistatic configuration can increase the range of applications of radar systems. This has given rise to the recent thrust in research activities in bistatic radar development. However, it is an established convention that the new version of a system should be able to perform all the tasks, that its older version could perform 1. Hence, the applications that are currently possible using a monostatic system 2, should be achievable using a bistatic system. One such application is that of automatic target recognition (ATR), for which monostatic radars have proved to be quite effective. The present paper would present some experimental results, which in turn would establish the feasibility of bistatic ATR. In the present paper, ATR exercises have been performed on bistatic synthetic aperture radar (SAR) images. These SAR images have been generated synthetically, using an electromagnetic simulator. In the main paper, few sets of experiments along with their results would be discussed, to analyse various aspects of the bistatic ATR problem. First of all, the dependence of bistatic ATR performance on the bistatic angle of imaging, would be analysed. Bistatic ATR performance decreases with an increase in the bistatic angle of imaging. The reason behind this would also be expounded. In the second set of experiments, the performance of monostatic and bistatic ATR would be compared. It would be shown that contrary to held reserves, bistatic ATR performance is not drastically worse than the monostatic ATR performance. Lastly, the effect of multi-polar bistatic data on ATR performance would be looked into. Even though, multipolar data analysis in bistatic domain is more complicated, still multipolar data do give more information (than single polarisation data) about the target and help in improving the bista- tic ATR performance. Conclusions from the work presented in the paper, are quite encouraging. Even though bistatic data handling is more complicated, still a good ATR performance can be achieved by using bistatic radar. Bistatic multi-polar data is also exploitable. These conclusions in turn make a case for further research into bistatic radar systems [C574]

## "A STAP approach to estimate drift angle and aircraft velocity"

Space-time adaptive processing (STAP) is a powerful two-dimensional filtering algorithm for moving target detection and clutter suppression. However, most previous studies of STAP theory have focused on side-looking array radar (SLAR). This paper addresses the issue of non-sidelooking array radar from a STAP point of view. From the pattern of the minimum variance distortionless response (MVDR) spectra, we can accurately estimate the drift angle by applying some fitting algorithms. We also exploit the fact that the Doppler and spatial frequencies are almost proportional to estimate the aircraft velocity in the same manner as the drift angle. The merits of these methods are studied by using the real data from multi-channel airborne radar measurement (MCARM) system. [C575]

## "Aspect dependent drivers for multi-perspective target classification"

In this paper, a 2-D classifier using radial basis function neural networks (RBFNNs) has been implemented combining two imageries collected by different locations to prove the classification rates enhancement given by aspect diversification. Principal components analysis (PCA) is applied to features extracted from a masked version of the SAR image using the sole target's backscattering and shadow information. The classification performance, examined in terms of receiver operator characteristic (ROC) curves is presented using MSTAR data for a population formed by six classes plus two unknown and two independent targets. The resulting performance shows a reduction of the probability of false alarm, related to an improvement of probability of declaration and correct classification in comparison with the traditional single aspect case. [C576]

## "New Spatial FCM Approach with Application to SAR Target Clustering"

This paper develops a new fuzzy clustering approach that is suitable for image processing applications. The developed approach is based upon the classical fuzzy c-means (FCM) and referred to as the spatial FCM (SFCM). Its effectiveness is due to two mechanisms. The first is the replacement of the Euclidean distance traditionally used to measure similarity between input images and clusters prototypes by a novel similarity measure that considers spatial relationships between image pixels and thus becomes less sensitive to image perturbations. The second SFCM mechanism for effectiveness is the addition of a similarity penalty term to FCM's objective function. The aim is to encourage clustering similar images into same clusters. The SFCM is compared to the FCM and some of its variants in the difficult application of synthetic aperture radar (SAR) target clustering. It is shown that the SFCM consistently yields better performance [C577]

## "A HRRP Recognition Method Based on KFD"

High resolution range profiles (HRRP) could accurately reflect the structure of target, so it is an important method for radar target recognition. Kernel Fisher discriminant (KFD), which is a machine learning method based on kernel function, is suitable for classification of high dimensional samples which couldn't be separated by linear classifier. In this paper, KFD were used for HRRP classification with KMOD kernel function. A multiple classifier was proposed, and better anti-noise performance was achieved with phase-subtraction alignment and a special rejecting method. The experimental results by three classes of measured HRRP data proved out the effectiveness of KFD [C578]

## "Target track classification for airport surveillance radar (ASR)"

The aim of this paper is to identify false tracks that arise from weather and biological targets, and to increase the air traffic security and safety level by detecting aircrafts lacking secondary surveillance radar (SSR) data. In this paper a single-source target classification after tracking using support vector machines (SVM) is introduced, which gives each track an updated probability value based on its likelihood behavior to conform to aircraft and non-aircraft targets. We introduce various features and evaluate different combinations in order to achieve the highest clustering index. The experimental classification results with real radar data provide good evidence that machine target classification is viable, with the capability of being implemented in real time. [C579]

## "The analysis of wideband conformal microstrip array antenna with cosecant-squared beam shaping"

The characteristics of new ultra wideband (UWB) like fractal microstrip patch antenna element and 24Ч10 elements wideband conformal microstrip array antenna using non-uniform photonic bandgap (PBG) substrate structure whose gap positions enhance some modes and weaken others have been analyzed using a full 3D electromagnetic field inside a structure based on the finite element method (FEM). The cosec2elevation beam shape is ideal for the detection of small and large targets at both short and long range, including where the antenna is mounted on a high tower or hillside. The array antenna has wideband approximately in range of 5 GHz to 10 GHz and radar cross section (RCS) up to 0.00001 meter square for some frequencies and high gain up to 44 dB depend on the operating frequency. The proposed antenna element is constructed on ground plane of thickness 0.1 mm and FR-4 glass epoxy substrate of thickness 1.6 mm with relative permittivity 4.4. The radiation characteristics for the designed antenna element and array antenna such as return loss, input impedance, near field, gain, RCS, 3D-polar and E-plane radiation patterns are obtained using numerical simulations. [C580]

## "The Application of Speech Recognition Techniques to Radar Target Doppler Recognition: A Case Study"

This paper reports some preliminary results of an examination into the feasibility of recognising the Doppler signatures of targets using speech recognition processing techniques. The rationale is that human operators typically listen to the Doppler audio output from the surveillance radar to detect and possibly identify targets. A feature of speech recognition is that pre-processing is used that takes account of the voice mechanisms that produce speech and the characteristics of the human ear. Three different recognition techniques, with identical pre-processing, were implemented. After validating the recognition algorithms with speech the recognisers were retrained with Doppler signals from a number of sources. It was found that the best of the speech recognisers, HMM-GMM, was also the best of the Doppler recognisers with 88% recognition. The work has been compared with that of others using a similar technique and a good agreement has been found. Some recent discoveries in neuroimaging are quoted that suggest that the human brain and that of several other mammals performs visual recognition in a manner common in speech recognition [C581]

## "Template Based Micro-Doppler Signature Classification"

The micro-Doppler signature of a target is a time varying frequency modulation imparted on the radar echo signal by moving components of the target. Battlefield radar output the baseband signal as audio and soldiers listening on headphones are able to identify the target from its micro-Doppler signature. Automation of this capability is desirable for improved reliability and reduction in classification time. For the first time dynamic time warping (DTW), a speech recognition technique, has been applied to the problem. Its performance has been compared with the common k-nearest neighbour (k-NN) classification method since both approaches utilise a template library [C582]

## "Target Recognition in Synthetic Aperture and High Resolution Sidescan Sonar"

The accurate detection and identification of underwater targets continues as a major issue, despite, or perhaps as a result of, the promise of higher resolution underwater imaging systems, including synthetic aperture sonar and high frequency sidescan. Numerous techniques have been proposed for computer aided detection to detect all possible mine-like objects, and computer aided classification to classify whether the detected object is a target or not. The majority of existing techniques employ supervised classification systems which are reliant on training data. The success of these systems can be highly dependant on the similarity of the test data to the training data, which includes the effect of the background region on which the target was located. This paper will briefly discuss and compare two possible solutions to this problem. The first is a model based system for classification and the second utilises an augmented reality simulator to produce training data [C583]

## "Radar Target Recognition Based on Micro-Doppler Effect"

Micro-Doppler effect is of great potential for radar target recognition since the micro-dynamics of structures on the target can be detected with it. The recognition process includes time-frequency analysis of the returned radar signal, feature extraction from time-frequency distribution images, and classification according to the feature set. In this paper, the time-frequency distribution images of four different types of micro-dynamics, which are vibration, rotation, coning and tumbling, are given and analyzed first. Then a method is proposed for feature extraction from time-frequency distribution images of micro-Doppler dynamics. Simulated experimental results have shown that high classification performances for different classifiers have been achieved [C584]

## "A Nearest Neighbor Fuzzy Classifier for Radar Target Recognition Using Combined Features"

This paper presents a nearest neighbor fuzzy classifier (NNFC), which is very suitable to process the combined features with different data types and scales. The NNFC does not require the combined features with the same data types and scales, and it is not necessary to perform any pre-processing. It uses the fuzzy membership function to process each feature of the combined features. Experiments with real satellite data show that the NNFC can effectively perform radar target recognition of multiple features combination [C585]

## "Wavelet Quasi-Superresolution in Marine Applications"

Possible marine applications of superresolution are in both military and civilian purposes, such as computer vision, target recognition, detection, identification, surveillance, synthetic aperture radar, etc. In this paper, a new algorithm for superresolution is proposed. The algorithm is based on wavelet theory and morphological structure of the image. Quasi-superresolution means usage of a single image for analysis instead of several. Wavelet quasi-superresolution can be applied with less complexity than standard superresolution, because wavelet interpolation of interlaced data and statistics of different images are skipped. New criterion for comparison of original and processed image is proposed. The result is single scalar which is easy to compare [C586]

## "Radar Sensor Networks for Automatic Target Recognition with Delay-Doppler Uncertainty"

Automatic target recognition (ATR) in target search phase is very challenging because the target range and mobility are not yet perfectly known, which results in delay-Doppler uncertainty. In this paper, we firstly perform some theoretical studies on radar sensor network (RSN) design based linear frequency modulation (LFM) waveform: (1) the conditions for waveform co-existence, (2) interferences among waveforms in RSN, (3) waveform diversity in RSN. Then we apply RSN to ATR with delay-Doppler uncertainty and propose maximum-likelihood (ML) ATR algorithms for fluctuating target and nonfluctuating target. Simulation results show that our RSN vastly reduces the ATR error comparing to a single radar system in ATR with delay-Doppler uncertainty [C587]

## "Coherent multilateral radar processing for precise target geolocation"

This paper analyzes the target geolocation performance of coherent processing of target signals observed by several radar receivers in a multilateral configuration. Each radar sensor is designed with a sufficient bandwidth to support good target range resolution but without the benefit of a narrow radar antenna beam for useful cross range measurement of the target position. The analysis results demonstrate the ability of coherent multilateral radar signal processing to achieve accurate target geolocation via triangulation and to eliminate target ghosts in a dense, multiple target environment. [C588]

## "Effect of terrain modeling and internal clutter motion on space based radar performance"

This paper addresses the impact of Weibull-type terrain modeling and wind motion on target detection performance from a space based radar platform. For "site-specific simulation effects", a NASA map provides terrain information that is used to generate scattered returns from the field of view. This land cover map categorizes the Earth into 16 land types (desert, lake, forest, etc.) with specific grazing angle dependent mean radar cross section values that can be characterized using Weibull-type distributions. Wind induced internal clutter motion (ICM) is modeled using the Billingsley spectrum. Depending on the carrier frequency and wind speed, it is possible to model the ICM as equivalent to a low-order sum of damped sinusoids and decaying exponentials. Performance analysis shows that increasing wind speed results in inferior performance in general, whereas for a given clutter-to-noise ratio, non-uniform terrain significantly affects performance. [C589]

## "Study on the Detection Algorithm of Bridge over Water in SAR Image Based on Fuzzy Theory"

Target detection and recognition is the ultimate aim in computer intelligence. Given an example of linear target, bridge over water in SAR image, the algorithm of denoise and segmentation is designed based on fuzzy theory, the detection of bridge edge is realized by minimum and Radon transform, and a measurement of judging parallel is proposed in this paper. In the process of designing algorithm, some problems have been considered and solved, including: (a) restrain furthest the multiplicative noise and enforce the feature of target; (b) obtain the area of bridge over water in complicated background; (c) get the edge of bridge, namely extraction of linear feature; (d) the final work in detection and recognition of bridge such as parallel judgment. The experimental results show that the algorithm is effective [C590]

## "Atomic decomposition for ISAR imaging"

We explore the capabilities of atomic decomposition (AD) for ISAR imaging. On the contrary to our previous work with AD where our research was focused on radar signal detection and maximization of sensitivity, the main concern in ISAR imaging based on AD is to obtain focused images, target feature extraction and low computational burden. [C591]

## "Detection of Small Changes in a Hip Prosthesis using the E-Pulse Technique"

A subsurface target identification scheme based on the E-pulse technique is proposed and investigated. The target inside a homogenous medium is approximated using Baum's transform. An E-pulse is constructed with the transformed complex natural resonances (CNRs) and convolved with the target returns from subsurface targets. Numerical examples of a hip prosthesis implanted within a homogenous half space shows that the proposed technique is capable of differentiating small physical changes between two hip prosthesis models at least under a homogeneous half-space condition. The proposed method can also be applied to other subsurface target detection problems such as UXO recognition, and for a dielectric target, the problem of recognition of malignant lumps within human breast tissue [C592]

## "Resonance Based Radar Target Identification with Multiple Polarizations"

In this paper, the problem of target identification with multiple data sets is investigated. A fixed incident aspect

with multiple polarization angles is considered. Three different approaches of analyzing the multiple aspect information as used in the literature is discussed and exemplified using the scattering data from an L shaped wire target [C593]

## "Human and Object Detection in Smoke-filled Space using Millimeter-wave radar based Measurement System"

In recent years, crisis management's response to terrorist attacks and natural disasters, as well as accelerating rescue operations have become an important issue. In rescue operations of fire disaster, one of the biggest problems is that the firefighter's view is obstructed by dense smoke. We considered the most important task for firefighters is to understand the inside situation of the dense smoke space. Therefore, we aim to develop a system visualizing the situation of the space. First, we scanned target space by using millimeter-wave radar combined with a gyro sensor. Then, due to detect humans and objects, we construct a 3D map from signal-reflection datasets using 3D image processing techniques. In this paper, we introduce our system and report the results of the measurement experiment in the real smoke space situation. [C594]

## "Blind source separation for extraction of target scattering centers"

This paper focuses on using blind source separation of complex signals to extract scattering centers of radar targets that can then be used for target identification. The concept introduced in this paper assumes that the signal returned (or scattered) from a target is linear or convolutive mixture of several scattering centers along the body of an unknown aircraft. This information can then be used in a pattern recognition scheme for the purpose of identifying the non-cooperative unknown target. The results presented prove the concept using synthetic radar data. Work is ongoing to apply this concept to real radar data as received through an array of sensors (antennas) [C595]

## "DDD Method Based on Joint Target Cancellation for Circular Array Antennas"

Circular array antennas have three merits such as all-orientation space scanning, flexible search and track mode and good beam bearing etc. relative to common linear array antennas. However, when conventional space time adaptive processing (STAP) algorithms are used, there may be a small loss in performance when compared with a uniform linear array (ULA). With some care in the choice and implementation of the STAP algorithm, the majority of the degradation is at close ranges, where the target returns are relatively strong. At long ranges performance is barely affected. This paper proposes a novel direct data domain (DDD) method based on joint target cancellation, and the proposed method can enhance the ability of target detection in nonhomogeneous environment in comparison with conventional DDD methods, using a circular antenna array [C596]

## "A noncoherent approach to radar localization through unknown walls"

A simple and practical noncoherent approach to through-the-wall radar detection and localization in the presence of unknown walls is presented. The technique corrects for the shifts introduced in target location estimates due to ambiguities in the wall thickness and dielectric constant. Data is collected using three independent monostatic single-antenna radar units, employing stepped-frequency signals, at two or more different standoff positions of the radar system from the wall. In post-data acquisition processing, one of the wall parameters assumes a fixed value. Localization is then performed, for different assumed values of the other parameter at different standoff positions, using a trilateration-based technique that incorporates the presence of the wall. Target displacement trajectories, each corresponding to a different standoff position, are then formed and the cross-over point is estimated to be the target location. The results show that the radar system is able to correctly locate targets behind unknown walls. [C597]

## "Focusing ISAR images using the AJTF optimized with the GA and the PSO algorithm-comparison and results"

Algorithms based on the genetic algorithm (GA) and the particle swarm optimization (PSO) algorithm were designed for focusing inverse synthetic aperture radar (ISAR) images that suffered from degradation due to Doppler smearing. These algorithms optimized the adaptive joint-time frequency (AJTF) algorithm by replacing the exhaustive search as the primary search tool used to determine focusing parameters. The use of the PSO for ISAR image focusing is a unique application of this evolutionary search. Performance of the GA and the PSO were compared with the PSO producing the optimal results of being able to focus a 211pulse ISAR image in 9 seconds or 24% of the cost function calculations required for an exhaustive search. This paper also introduces a new method of determining basis function suitability using the fast Fourier transform. [C598]

## "Maximum a-posteriori adaptive masking for clutter suppression in automatic radar target recognition"

To suppress the effect of clutter in automatic target recognition we propose a maximum a-posteriori adaptive mask that isolates the target scattering centres in the data. This improves the quality of the construction of the target feature vector which results in an improved classification performance. We evaluate the technique on a closed-set identification task using targets from the MSTAR database and, on a 10-target forced-choice experiment, obtain a recognition error rate of only 1.2%. We also conduct an open set identification experiment and show that the technique can achieve an equal error rate of 1.82%. [C599]

## "Target Classification and Pattern Recognition Using Micro-Doppler Radar Signatures"

Micro-motions, such as vibrations or rotations of an object or structures on the object, induce additional frequency modulations on returned radar signal, which generates sidebands about the object's Doppler frequency, called micro-Doppler by V.C. Chen et al. (2002). In this paper, we investigated statistical classification methods for target classification using their micro-Doppler signatures. At this stage only simulated data are studied, and two models are used to generate simulation data: point scatter model and RCS model. Both models are tested and compared for their performance on target classification [C600]

## "Single-Stage Waveform Selection for Adaptive Resource Constrained State Estimation"

We consider the problem of optimal waveform selection. We would like to choose a small subset from a given set of waveforms that minimizes state prediction mean squared error (MSE) given the past observations. This differs from previous approaches to this problem since the optimal waveforms cannot be computed offline; it requires the previous observations. Since the optimal solution to this subset selection problem is combinatorially complex, we propose a convex relaxation of the problem and provide a low complexity suboptimal solution. We present a specific model and show that the performance of this suboptimal procedure approaches that of the optimal waveforms [C601]

## "Radar Signal Classification Using Pca-Based Features"

Principal component analysis (PCA) has been used in many applications ranging from social science to space science, for the purpose of data compression and feature extraction. Usage of PCA for synthetic aperture radar (SAR) image classification, though widely reported by remote-sensing researchers, has not been exploited much by automatic target recognition (ATR) community. In the present paper, PCA has been used in SAR-ATR using the MSTAR data base, and comparison has been made with the conventional conditional Gaussian model based Bayesian classifier (M.D. DeVore and J.A. O'Sullivan, 2002). The results have been compared based on percentage of correct classification, receiver operating characteristics (ROC), and performance with limited amount of training data. By all standards of comparison, the PCA based classifier was observed to outperform the conditional Gaussian model based Bayesian classifier (CGBC) or at the worst it performs at par. And given the computational and algorithmic simplicity of PCA based classifier, the new algorithm was concluded to be a highly prospective candidate for real time ATR systems [C602]

## "Hip Prosthesis Detection based on Complex Natural Resonances"

Resonance based radar target detection has been applied to ground penetrating radar (GPR) applications for the detection and recognition of landmines. Target detection is achieved by searching for certain target dependent complex natural resonances (CNRs), which could be considered as a feature set for identification. In this paper, detection of a hip prosthesis under human tissues using resonance based target detection technique is investigated [C603]

## "Focused ISAR images of maritime targets using a high resolution LFMCW millimeter-wave radar"

The generation of high resolution ISAR (inverse synthetic aperture radar) images is reaching protagonism at the present time. A major application is coast surveillance. The recognition and the identification of maritime targets are important tasks. In this paper experimental results of ISAR images of maritime targets are reported. The data were captured with an LFMCW (linear frequency modulated continuous wave) millimeter-wave radar. High resolution ISAR images are obtained, since a great bandwidth (1 GHz) is transmitted. In ISAR the target motion can degrade the quality of the final images and motion compensation algorithms are necessary to improve the focus of these images. An autofocusing technique based on the shift-and-convolution algorithm is used to compensate the translational target motion and a two-phase algorithm (slant range rotation compensation (SRRC) and cross range rotation compensation (CRRC)) is used to correct the migration through resolution cells (MTRC) associated with the target rotation. The effectiveness of the focusing techniques is verified with

simulated and real (maritime targets) radar data and compared with the standard range-Doppler algorithm (RDA) [C604]

## "Pulse-to-Pulse Stability Characteristics of Robust Design Centered High Performances/Low Cost T/R Module"

In radar applications any pulse-to-pulse amplitude and phase change in the transmitted/received signal can affect the radar performances in terms of cancellation and MTI (moving target indicator). The present paper will focus on the characterization of a high performances/low cost T/R Module and related components: in particular PM and AM pulse-to-pulse measured stability better of 75 dBc will be shown [C605]

## "Waveform Design and Diversity in Radar Sensor Networks: Theoretical Analysis and Application to Automatic Target Recognition"

In this paper, we perform some theoretical studies on constant frequency (CF) pulse waveform design and diversity in radar sensor networks (RSN): (1) the conditions for waveform co-existence, (2) interferences among waveforms in RSN, (3) waveform diversity combining in RSN. As an application example, we apply the waveform design and diversity to automatic target recognition (ATR) in RSN and propose maximum-likelihood (ML)-ATR algorithms for nonfluctuating target as well as fluctuating target. Simulation results show that our waveform diversity-based ML-ATR algorithm performs much better than single-waveform ML-ATR algorithm for nonfluctuating targets or fluctuating targets. Conclusions are drawn based on our analysis and simulations [C606]

## "Retrieving 3D Relief by Using a Single-Antenna, Squint-Mode Airborne SAR"

In the paper, a novel method is proposed for retrieving 3D relief of ground surface by using a single-antenna, squint-mode airborne SAR. The main idea of the method is based on the fact that the spatial 3D location of a target can be found as the intersection of the range sphere, the Doppler cone, and the elevation plane of the antenna pattern. An accurate estimation of Doppler centroid values at each range gate is required for relief retrieving. Flight tests have proved that the proposed method is adequate and reasonable [C607]

## "Radar as a Tool for Antiterrorism"

Recognizing of peoples and group of peoples on the native environment with different conditions is an important task for antiterrorism activity in many different regions (Chechnya, Afghanistan, Iraq, etc.). Report describes the possibilities of radar technologies for solution of this task for different conditions. The base of new methods and equipments is a polarization optimization for selection of radar target. Main parameters for polarization optimization are: different kinds of native environment (woods, rocks, beaches, etc.), weather (snow, rain, wind, etc.), temperature, pressure, etc [C608]

## "Comparison of Fusion Methods for Successive Declarations of Radar Range Pro les"

Classification of high-range-resolution profiles is a viable method of non-cooperative target identification. In order to increase the reliability and robustness of the classification result, methods of decision-level identity fusion can be applied. Different approaches have been used for a cumulative fusion of declarations of successively recorded radar range profiles. Besides probabilistic techniques such as the Bayesian fusion, non-probabilistic methods based on Dempster-Shafer or voting algorithms have come into focus. In this paper these different approaches are compared for typical situations which can arise in aircraft identification scenarios [C609]

## "Joint IMM/MHT Tracking and Identification for Multi-Sensor Ground Target Tracking"

After giving an overview of the design of the IMM/MHT tracker, this paper discusses a joint tracking and identification approach to the multi-sensor ground target tracking problem. It is widely recognized that the requirements for the continuous tracking of important targets can only be achieved by incorporating feature data and behavioral information. Consequently, a Dempster-Shafer approach has been applied in the integration of multi-sensor classification with the target behavior so that an estimate of target type may included in the data association decision process. The ID information that may be potentially derived from HRR profiles may be combined with conventional IMM/MHT tracking techniques in order to aid the track-observation association process. Issues such as the inevitable loss of track identity due to track switching as well as the presence of confusers must be addressed. Thus, the paper discusses methods to include the effect of confusers and to efficiently reestablish track identity after a track-switch [C610]

## "Radar Target Recognition Method Using Improved Support Vector Machines Based on Polarized

## HRRPs"

Target recognition based on high range resolution (HRR) polarized radar using support vector machines (SVMs) was studied in this paper. A fuzzy membership function was constructed based on SVM decision-making function in order to improve the performance of OAA and OAO classifiers for multi-class target, and HRR radar target recognition method using improved SVM was proposed: First, the polarized radar backscatter echoes were processed by incoherent integration and power-normalized, the location and length of target in echoes were estimated and range profiles of target were interpolated to certain radial length, then polarized profiles were integrated considering the relevancy of range profiles of same target in different polarization state, at last, the improved OAA and OAO classifiers were used for target classification. Simulation experiment results show that the proposed method has the advantage of little capacity of computation and can improve the performance of classifiers effectively [C611]

## "Remote Sensing Target Recognition Based on Contourlet and Kernel Fisher Discriminant"

An efficient feature extraction method for remote sensing target recognition was proposed in this paper, which was based on contourlet and kernel Fisher discriminant (KFD). After the contourlet decomposition, the contourlet features are fused (the weight for fusion is chosen by cross validation), and then KFD was used for further feature extraction, finally k-nearest-neighbor (KNN) was used for classification. Experimental results show that the proposed feature extraction method reach a higher correct rate than KFD and the method which use KFD on the lowpass filtered images. Moreover, when dealing with large scale images our method achieves a lower computation complexity than KFD [C612]

## "Short range detector of static or mobile targets in the ISM band 2.45 GHz"

This paper presents a RF design for a short range (10-50 cm) detector of static or mobile targets and a simple new method of signal processing. A brief study of classical detection systems is firstly presented. Then the new radar architecture and the principle of detection are experimentally validated in the ISM band 2.4-2.48 GHz [C613]

## "Automatic Target Recognition Based On Sequences of High Resolution Radar Range-Profiles"

In this paper, the potential for identifying airborne or ground targets using high resolution radar (HRR) range-profiles, in conjunction with a correlator, is investigated. One type of filter is described which maximizes the expected value of certain correlation peaks. The effectiveness of the filter was investigated in an identification experiment using a dataset of correlation filters from simulated radar range profiles for 4 different ground targets. The simulated range-profiles are produced by graphical electromagnetic computing (GRECO) method. The result suggests that reliable identification is possible provided target aspect information is used and identifications are based on multiple filters [C614]

## "Automatic Target Recognition Based on High-Resolution Range Profiles with Unknown Circular Range Shift"

In this paper, an automatic aircraft target recognition (ATR) framework is presented, which is based on the high resolution range profiles (HRRP) of aircraft targets. This work is divided into two major parts. First, we consider the generation of the HRRP, which includes the modeling and simulation of radar cross section (RCS), the design of step frequency waveform (SFW), and IFFT processing for HRRP synthesis. In practice, a possible circular shift of the received HRRP relative to the template HRRPs in target library may exist. In such a situation, we resort to the statistical classification technique to develop an ATR algorithm, which begins with using the Neyman Pearson criterion to determine whether a target is present or not, under a constant false alarm rate constraint. Then the circular correlation is used to estimate possible circular range shift, as well as the unknown phase shift and attenuation. Moreover, we adopt the Gram-Schmidt orthogonalization (GSO) procedure to construct a signal space, and then project the received HRRP onto the signal space. Finally, the target classification can be done in terms of maximum a posteriori (MAP) decision rule. Simulation results are also included to demonstrate the feasibility of this approach [C615]

## "UWB Radar Calibration Using Wiener Filters for Spike Reduction"

Ultra wide band (UWB) radar systems are used to get information from a detected target. This can be done by studying the shapes of incident and reflected pulses. To evaluate the target transfer function, a calibration is necessary to eliminate the influences of the system and the environment. The calibration includes deconvolution operations producing spike artifacts. In this paper a calibration approach for spike suppression by using Wiener filters in the deconvolution process is introduced [C616]

## "Lidar Equation Modification for Large Field of View Scannerless Lidar"

The common lidar equation is unsuitable when the field of view is very large; the back reflecting of different part of the target is not same but follows the Lambert distribution in this case, we make a modification for lidar equation, and finally the relationship between maximum acquisition range and emission power is discussed [C617]

## "Comparison of UWB Target Identification Algorithms for Through-Wall Imaging Applications"

In this paper an ultra-wideband imaging radar system using B-scans is proposed. Two imaging algorithms for shape recognition are explained and compared. Furthermore, for the first time the two dimensional inverse boundary scattering transform was successfully applied for through-wall imaging applications. The measured radar data of a cylinder behind a wall demonstrate that only 24 different positions of the antennas were sufficient to reconstruct the target curvature [C618]

## "Template Based Micro-Doppler Signature Classification"

The micro-Doppler signature of a target is a time varying frequency modulation imparted on the radar echo signal by moving components of the target. Battlefield radar output the baseband signal as audio and soldiers listening on headphones are able to identify the target from its micro-Doppler signature. Automation of this capability is desirable for improved reliability and reduction in classification time. For the first time dynamic time warping (DTW), a speech recognition technique, has been applied to the problem. Its performance has been compared with the common k-nearest neighbour (k-NN) classification method since both approaches utilise a template library [C619]

## "The Intelligent Identification of Air and Sea Targets in Coastal Radars"

Target identification is important in coastal radars to separate air and sea targets. In this paper a novel algorithm for identification of air and sea targets in coastal radars is presented. For this purpose, a multiple PRF technique along with a maximum likelihood frequency estimation method has been used. Then an intelligent algorithm, based on artificial neural networks, or a simple and efficient algorithm are utilized for resolving the Doppler frequency ambiguity and the classification of sea and air targets. Our simulation and practical results have shown that this method has an excellent performance to identify air and sea targets in coastal radars, even in low SNRs [C620]

## "Chaotic signals in radar?"

Chaotic signals add to the design repertoire for radar. This paper discusses the properties of chaotic signals, their generation and use, including transmitter hardware and efficiency, with reference to results in communications research and recent theoretical and practical results in sonar, and development throughout the world for radar. Practical issues arising from the unique properties of chaotic systems are considered. Phase locking and target identification benefits are also suggested. Results of sonar experiments and trials to support prediction from simulation findings are given. It is concluded that chaotic signals have the potential to offer exciting additional capabilities [C621]

## "Compounding segmentation method for SAR images"

Fast and accurate segmentation of synthetic aperture radar (SAR) images is important to SAR automatic target recognition (ATR). In this paper, a new compounding segmentation method is presented, based on the two-parameter CFAR segmentation method and Markov Random Field (MRF) -based segmentation approach. Following the initial segmentation obtained by the two-parameter CFAR method, the MRF-based approach is exploited only on the edge points of the targets and shadows. A comparative experimental analysis, using MSTAR (Moving and Stationary Target Acquisition and Recognition) images, of the proposed method against the other two approaches showed that the compounding segmentation method can achieve faster and more accurate results, which can be of practical use in the process of SAR ATR. [C622]

## "The Derivation of a Universal Model for the Modulated Characteristics of Aircrafts Rotating Parts"

Based on radar backscattering, a unitary model of radar returns from aircraft rotating parts, such as the propellers of propeller-driven aircrafts and the rotors of helicopters, is derived in detail and modulated characteristics in radar returns are analyzed. The results demonstrate that the modulation induced by the rotating parts of aircraft is relatively invariable, and in some flight conditions can offer additional information for target recognition in air surveillance radar [C623]

## "SAR ATR based on Support Vector Machines and Independent Component Analysis"

In this paper, a SAR (synthetic aperture radar) ATR algorithm based on support vector machines (SVMs) and independent component analysis (ICA) is proposed. Features of SAR images are extracted using ICA firstly, then we test our method on MA STAR database by using support vector machines classifier. The experiment result shows that the performance of this method is superior to other methods [C624]

## "Research on Ship Target Auto-Recognition Technique for Low Resolution Radar"

An auto-recognition method of ship with low resolution radar is presented in the paper using multi transform technique. The radar target echo is sampled and preprocessed to suppress clutter first. Then characteristic vectors of the target are extracted with FFT transform, Mellin transform, wavelet transform and frame correlation processing. Experiments are carried out for the proposed method with three kinds of real radar echo data of ship target, the results indicate that the characteristics vector extracted by the proposed method in this paper is valuable for target classification [C625]

## "Matching-Pursuits Based Feature Extraction with Reduced Aspect Sensitivity for Ultra Wide-band Radar Target Identification"

This paper presents a matching-pursuits based technique to radar target feature extraction for aspect sensitivity reduce of template, including a training algorithm of the feature atom dictionary to characterize the target scattering. There is an important contribution in our technique that finite basis atoms, as features, are used to represent the complicatedly scattering behavior of the whole scattering waveform without any prior parameterization model hypothesis. Furthermore, as demonstrated in this paper, the proposed technique can reduce effectively aspect dependence of the extracted extraction for wide-angle target identification. Synthesized scattered responses and measured scattering signatures in a chamber are used to demonstrate the effectiveness of dictionary feature proposed in this paper [C626]

## "Laser Radar Cross-Section of Conducting Targets Using Horizontal Polarization"

This work presents a study to handle the behavior of radar cross section (RCS) of partially convex targets of large sizes up to five wavelengths in free space. The nature of incident wave is an important factor in the remote sensing and radar detection applications. To investigate the effects of incident wave nature on the RCS, scattering problems of plane and beam wave incidences are considered. Targets are taking large sizes to be bigger enough than the beam width with putting into consideration a horizontal incident wave polarization (E-wave incidence). The effects of the target configuration together with the beam width on the laser RCS compared to the case with the plane wave incidence are numerically analyzed. Therefore, we will be able to have some sort of control on radar detection using beam wave incidence. . [C627]

## "A Processing Detection Project Research of Weak Targets in the Complex Ground Clutter"

The paper present a project of improving the weak targets detection capability in the complex ground clutter at the same time maintaining the hardware's simplicity for the air-ground millimeter-wave terminal guidance radar. The project use the wide band chirp-subpulse stepped-frequency signal to detect targets, and get the target region's quasi two dimension image by processing the echo signal both in the time and frequency domain, thereby improving the weak target detection capability and providing the real guidance information. The theoretical analysis and computer simulation result proved the project's validity. [C628]

## "Research on Typical Millimeter Wave Radar Target Characteristic"

The advantage of millimeter wave radar, radar cross section (RCS) and one dimension range profile are presented at this paper. With the high frequency approximate method, the typical millimeter wave (35 GHz, 94 GHz) radar target characteristics are simulated. With the comparison, it is found that the target's radar cross section at 94 GHz has more details and evident scattering centers, but the range profiles have similar scattering centers with the same band. [C629]

## "High-Frequency Radar Signature Simulation of Complex Targets"

This paper describes an approach to the simulation of radar signatures from large complex targets. Due to the difficult problems of actual measuring and scaling measuring for the signature of large-scale radar targets under the condition to wideband, an effective approach of computing high-frequency radar cross section (RCS) to complex targets is presented in advance, and then the target's ID range profile can be obtained. The result

suggests that it is possible to obtain satisfying simulated radar signature using this approach. [C630]

## "A New Approach of Target Identification Using Enhanced Radar Range Profiles"

Due to the aspect dependence of high resolution range profiles (HRRPs), traditional radar HRRPs target identification (ID) methods usually use averaged or weighted HRRPs as an aspect template. A major shortcoming is that HRRPs cannot provide information about target's cross-range. In this study, we present an application of statistics method on complex radar targets. The enhanced HRRPs extracted by this method were used in radar target identification. It is shown from simulation results that identification performance can be improved greatly by using the enhanced HRRPs features combined with a two-stage fuzzy classifier. [C631]

## "Radar Target Recognition Based on Low Frequency Bispectra"

Bispectra is widely used in the target recognition based on high resolution range profile (HRRP), but now using features generated from bispectra often need much storage and computation. In this paper, the low frequency part of bispectra is taken as the feature, then time domain processing and frequency domain processing are used to make the feature is more robust to the dimension change. Similarly the method is used to decrease the dimension of integrated bispectra, good result is obtained too. Experiments based on the measured data testified the efficiency of the proposed method [C632]

## "Target polarization recognition under rain and snow cluster"

This paper derived the polarization scattering matrix of both warship target and interferential chaff conditioned on the exit of rain and snow cluster, and furthermore, proposed a method to recognize chaff and warship by analyzing their corresponding polarization information. This method mainly aims to radar, which can receive both left and right circularly polarized wave, to catch the full polarization information of echoes, then, acquires the more accurate polarization characteristics of target and chaff after getting rid of the impacts of rain and snow cluster from the polarization scattering power matrix of echoes. In order to further improve the recognition probability, non-linear polarization transformation is introduced to make the separation of target and chaff more realizable. It indicates that the resulting performance is incredible for the traditional recognition in time and frequency domain [C633]

## "Radar Micro-motion Target Resolution"

Micro-motion such vibration and rotation induces unique phase modulation or Doppler modulation and offers a new way of characterizing objects. When multiple vibration/rotation targets detection and identification are considered, the echo signal is multi-component sinusoidal modulation signal. So far multi-target resolution is still a major challenge facing radar signal processing community. In this paper, A new conception, multi-target micro-Doppler is introduced, and then B-distribution (BD) is applied to implement micro-motion target resolution (MMTR). Based on multi-target micro-Doppler, a complete scheme is presented for micro-motion target resolution. BD for resolving multiple vibration/rotation targets is demonstrated with synthetic data, and simulation results confirm our expectations [C634]

## "An Efficient Kernel Optimization Method for High Range Resolution Profile Recognition"

A kernel optimization based on fusion kernel for HRRP is proposed in this paper. Based on the fusion of the 1-norm and 2-norm Gaussian kernels, our method combines the different characteristics of them so that not only is the kernel function optimized but also the speckle fluctuations of HRRP are restrained. Then on the radar measured data the presented method is employed to the kernel optimization of KPCA and the classification performance of the extracted is evaluated via a SVM classifier. Finally, experiment results are compared and analyzed, which prove our method effective [C635]

## "Model-based Adaptive Target Detection in Clutter Using MIMO Radar"

In this paper the problem of target detection using coherent pulse terrain in auto regressive (AR) clutter has been considered for MIMO radars. We have formulated this problem as a hypothesis test. Using the generalized likelihood ratio test (GLRT) an adaptive decision scheme has been developed for clutter with known order but unknown parameters. The performance of the proposed detectors have been evaluated using Monte-Carlo simulations. The results show the superiority of the MIMO radars with temporal coherent processing over the conventional phased arrays due to both angular spread and a newly presented phenomenon which is called Doppler spread in this paper [C636]

## "Maneuverability Calculation Based on Synthetically Targets Recognition"

Aiming at the coming ship's maneuverability calculation in the deterministic automatic collision avoidance system (ACAS), a new kind of ship maneuverability identification system was presented based on synthetically targets identification, which can identify the coming ship's type and length based on the echo data from multi sensors including ship radar, sonar and AIS. With help of ship navigation property database, the necessary ship characteristic parameters were estimated, with which parameters of the coming ship's maneuverability response equation can be identified by maneuverability calculation module [C637]

## "Target Detection with Adaptive Power Regression Thresholding for HF Radar"

High frequency (HF) radars are capable to detect and track targets at extremely long ranges. But the signal environment that includes external noise, different kinds of clutter and interference will significantly limit the detection performance and system capability. This paper considers a new approach to solve the target detection problem in a complex HF radar signal environment. It uses a conventional constant false-alarm-rate (CFAR) detection procedure but the thresholding scheme is based on regression analysis of power spectrum values along range and Doppler cells. The CFAR detection test rule was combined with a local peak determination procedure. The proposed detection scheme has been tested using real HF radar data and gave very promising results [C638]

## "The Performance Comparison of Adaboost and SVM Applied to SAR ATR"

In this paper, Adaboost and SVM are applied to SAR ATR (synthetic aperture radar automatic target recognition) respectively. The performance of these two classifiers is analyzed and compared in target aspect window with different size. First, PCA (principal component analysis) features are selected as target feature, and then Adaboost.MI and SVM are used to classify, respectively. Experimental results based on MSTAR data sets show that Adaboost classifier has better robustness than SVM classifier [C639]

## "Detection and Recognition of High-speed Anti-Radiation Missiles with Simple Multi-antenna VHF Radar"

A new warning radar for detection and recognition of high-speed anti-radiation missiles (ARM) is presented. The radar adopts a special antenna construct and is developed on the basis of the resonant effect of VHF bands, which makes RCS increase remarkably. Practical detecting method is analyzed according to the features of high-speed ARM. The system boasts the merits of simplicity, low cost and small size, etc. Experiment results are given to show the validity of the method [C640]

## "Informative characters in spectral-polarization images of backscattering from surface objects"

The frequency, spectral and polarization features of the signals scattered by transportation (wheeled, caterpillar) and biological objects (person, animals, birds) are studied with coherent radar in pulse and CW modes in wave bands 10 cm, 3cm, 8 mm, 4mm and 2mm. It's showed that Doppler spectrum of signals scattered by person contains dominant line which corresponds to velocity of target and pedestal (below the line at -10Г· -15 db ) caused by secondary phase modulation due to fine structure of target movement. In the case of transportation the pedestal is of ruled structure due to vibrations of the target. The characteristics of signals scattered that presented in the paper are of interest for target detection and recognition [C641]

## "Polarization-Spectrum Signatures of Above-Water and Surface Targets"

The results of experimental study of backscatter spectral-polarization features from above-water and surface objects are presented. Investigations were carried out with coherent systems both with the pulse and CW modes of millimeter and centimeter wave bands (from 10sm to 2mm). The informative features are concerned with modulation both the amplitude and Doppler translation are condition on modulation of scattered signal at the stroke rate for the oared boat and the frequency modulation concerned with hands and lags move of moving man as well are ascertained. For the scattering from the object body the small level of depolarization factor of the scattered signal is typical. Ascertained that for the coincident by frequency spectral components of the signal scattered from the objects on orthogonal polarizations the high values of cross correlation factor is typical. [C642]

## "Infrared Ship Multi-Targets Recognizing"

The technique of ship multi-targets recognizing is very important to anti-warship missile imaging guidance. In this paper, an algorithm is suggested to distinguish a ship target from the other ones in infrared images. The segmentation images by thresholds and by a mask of L inverted is used to draw ship targets out of infrared

image. The rates of frontier in each region and gray-level classes are also utilized to merge regions. Four features are defined to describe infrared ship targets. A criterion based on BP neural network with these four features is set up to distinguish one ship target from the other ones. A complete algorithm is presented. This algorithm was tested in simulating platform with twenty-five images. The results showed this algorithm is valid when the side of the ship faces the camera. The further studies are needed to do for more situations [C643]

## "Spatial-Temporal Differential Analysis for GMTD with Airborne Radars, Part 1: Theoretical Background"

We introduce a conceptually new approach to processing multiple synchronized radar signals. The method is referred to as the spatial-temporal differential analysis (STDA). STDA operates with spatial and temporal increments of the instantaneous signal power received from multiple channels. To improve the radar detection and tracking capabilities, STDA takes advantage of the signal scintillations, which are regarded as a harmful phenomenon by conventional signal analysis techniques. We present and discuss a simplified technique for ground-moving target detection (GMTD) using airborne radars with multiple receive channels. The technique is based on structure functions in a time domain, which are statistical moments of the increments. We demonstrate that STDA in the time domain "senses " different characteristics of the scatterers than conventional spectra-based techniques do. This new concept enables detection of weak moving targets in heavily cluttered environment. [C644]

## "Comparison of several algorithms for suppression of foliage clutter"

Detection and recognition of targets, obscured by foliage clutter is an active research area. We address here the important question of foliage clutter modeling. The observed clutter is an highly impulsive random process and can be modeled more accurately with symmetric alpha stable (SalphaS) random process. In fact this is the first objective of this paper. The second one is the comparison of several wavelet (wavelet-like) algorithms for foliage clutter suppression. These algorithms are evaluated through artificial doppler signal corrupted by artificial clutter, following SalphaS distribution and real radar clutter using X-band portable continuous wave radar. [C645]

## "Polarization-Spectrum Signatures of Above-Water and Surface Targets"

The results of experimental study of backscatter spectral -polarization features from above-water and surface objects are presented. Investigations were carried out with coherent systems both with the pulse and CW modes of millimeter and centimeter wave bands (from 10 sm to 2 mm). The informative features are concerned with modulation both the amplitude and Doppler translation are condition on modulation of scattered signal at the stroke rate for the oared boat and the frequency modulation concerned with hands and lags move of moving man as well are ascertained. For the scattering from the object body the small level of depolarization factor of the scattered signal is typical. Ascertained that for the coincident by frequency spectral components of the signal scattered from the objects on orthogonal polarizations the high values of cross correlation factor is typical. [C646]

## "Target identification with polarization dependent transfer functions"

In this paper the scattering behavior of two electrically conducting objects (sphere and cylinder) will be described. The objects have been illuminated by a quasi-monostatic ultra-wideband (UWB) radar system. Using very short pulses the transfer function of the targets could be calculated over a wide range of frequencies. Besides the frequency dependence the influence of the polarization was investigated. This allowed the target identification by using only A-scans in two different polarization planes. Furthermore, geometrical parameters of the targets, e. g., the diameter, could be determined from the calibrated data easily. [C647]

## "Time-Frequency Analysis of Radar Backscattered Signals using Phase Coupled Frequencies Extracted from Time-Varying Bispectrum Estimates"

A new approach to time-frequency analysis of radar echo responses obtained from moving objects is represented. The suggested approach is based on the extraction of phase-coupled harmonics from time-varying bispectrum estimates of transient sequences separated from the total radar backscattered signal by a sliding window. A coherent, homodyne, and continuous-wave radar has been employed for measuring multi-component, non-stationary, and nonlinear frequency modulated signals backscattered by moving objects. The experimental study underpinned with the theoretical assumptions of the suggested approach has demonstrated clean recovery of time-varying phase-coupled frequencies for test targets like a swinging metallic sphere or a walking human. The obtained time-frequency distributions of phase-coupled harmonics can be recommended as a new information feature in automatic radar target recognition systems. [C648]

## "RCS Aspects of Multi-Band Radar Systems Composed of "VHF," L" and "X" Band Radars"

An essential characteristic of any radar target is the measure of its ability to reflect energy to the receiving antenna. The parameter used to describe this ability is the radar cross section (RCS) of the target. Stealth techniques and technologies, which affect the efficiency of early warning radar systems currently in operation, are described in ref [1]. The problem is to find countermeasures that fully integrate new requirement capabilities into the current long-range radar net and infrastructure, keeping research & development, and maintenance costs, low. The netcentric approach recently proposed in ref [2] using VHF-based multi-band radar systems is a new concept for Recognized Air Picture production based on long-range radars, which offers a powerful solution for the surveillance of large areas at a reasonable cost. Target RCS behaviour, fluctuations due to aspect angle and frequency are of particular interest in these systems, because the antenna beam positioning of the "VHF", "L" (or "S") and "X" band radars should be synchronised in azimuth and elevation. Targets could change orientation, course and kinematical characteristics during the time required for beam positioning. Advance knowledge and accurate prediction of target RCS is therefore desirable in order to design and develop efficient (robust) discrimination algorithms for the optimisation of target detection, tracking and non-cooperative target recognition. This paper reviews the target RCS aspects in current radar systems of interest, and examines RCS behaviour for use in future multi-band radar system applications. [C649]

## "Detection and Recognition of Target Signals in Radar Clutter via Adaptive CFAR Tests"

In this paper, adaptive CFAR tests are described which allow one to classify radar clutter into one of several major categories, including bird, weather, and target classes. These tests do not require the arbitrary selection of priors as in the Bayesian classifier. The decision rule of the recognition techniques is in the form of associating the p-dimensional vector of observations on the object with one of the m specific classes. When there is the possibility that the object does not belong to any of the m classes, then this object is to be classified as belonging to one of the m classes or to class m+1 whose distribution is unspecified. The tests are invariant to intensity changes in the clutter background and achieve a fixed probability of a false alarm. The results obtained in this paper agree with the simulation results, which confirm the validity of the theoretical predictions of performance of the suggested adaptive CFAR tests. [C650]

## "Target Classification by Means of Fully Polarimetric ISAR Images"

In ISAR systems, fully polarimetric capabilities have not been fully exploited for target classification or recognition. In this paper, a full system that reconstructs the polarimetric ISAR image and classifies the target is proposed and tested on simulated data. [C651]

## "Research on the Algorithm of Target Recognition Based on Two-leveled RBF Neural Network and D-S Evidence Theory"

In this paper, we combine two leveled RBF neural network technique with D-S evidence fusion theory, and present an algorithm of target recognition based on double mode intelligent fusion of infrared and radar. An effective recognizing strategy is developed. Simulation on the algorithm is carried out and the results illustrate that the algorithm is efficient and effective. [C652]

## "Utilization of Support Vector Machine based on Neural Network to Suppress Ocean Clutter and Zero Frequency Disturbances"

The paper proposes a new multi-classifier for pattern recognition by combining neural network with SVM (support vector machine). The multi-classifier has the advantages of SVM and NN (neural network). According to the properties of Bragg peak, zero frequency disturbance and the target of moving with time-varying velocity among the echo signal of HFSWR (high frequency surface wave radar), the multi-classifier is utilized to process the result of decomposing radar echo with chirplet atom and separate them. Then the ocean clutter and zero frequency disturbances can be suppressed according the result of classifying. A new means by utilizing HFSWR to detect the target moving with time-varying velocity is provided in the paper. [C653]

## "Evaluation of eCognition for Assisted Target Detection and Recognition in SAR Imagery"

Defence R&D Canada-Ottawa (DRDC Ottawa) has been assessing custom off-the-shelf (COTS) software products and developing custom tools that can assist image analysts (IAs) to complete their tasks more quickly and efficiently. In some cases, IAs are tasked with detecting targets of interest within large-area surveillance operations, and these detection tasks may be repeated with a regular flow of incoming imagery. SAR imagery is a data source of choice for large-scale detection operations due to its ability to image in all weather conditions without external illumination sources. An activity was undertaken to evaluate ecognition (a COTS product) for

target detection in SAR imagery and as a means of facilitating workflow improvements in the course of target detection and surveillance activities. eCognition is segmentation-based classifier that uses fuzzy reasoning techniques, enabling users to represent fuzzy rules in a human reasoning-like form. It offers the promise of being a usable tool that fulfills the objective of providing improvements over the traditional practice of manual inspection for target detection and surveillance. This paper reports on the evaluation process and findings when using ecognition for ship detection and land vehicle detection in SAR imagery. [C654]

## "Fusion Recognition Method of Target's SAR Images Based on Modified D-S Evidence Theory"

The method of geometric hashing technology can effectively recognize the targets distorted partially. But when the known targets in training data set don't satisfy with the condition of 360 azimuths, the effect of recognition degrades. In this paper, we present two aspects improve the correct rate. Firstly, we use a CFAR detector based on power transformation to segment the SAR images. And also discuss the interval of power transformation' parameter when the data is Rayleigh distribution. Secondly, we present a method of modified D-S evidence theory which can solve fusion with a high degree of conflict. Experimental results with MSTAR dataset show that this fusion method is effective and feasible [C655]

## "Basic Study of Navigator's Recognition of Radar Target Direction"

The radio detection and ranging (radar) is one useful instrument which a navigator uses to attempt safe navigation in poor visibility and night navigation. In the case of poor visibility and/or many similar targets in a close area, navigators sometimes make an error in recognizing the direction when they find the target in the landscape from radar information-target direction, distance, echo size, echo shape, sweep and relationship among targets' echoes. Also, they can make errors when finding the radar target's echo from the target information in the landscape. We have to prevent the errors to ensure safe navigation. The purpose of this paper is to find characteristics of target recognition using simulated marine radar in two steps: 1) to propose a model for radar target recognition; 2) to evaluate the errors of target recognition on the radar monitor by using two basic experiments. [C656]

## "Change Detection using Multi-PASS and Multi- DATE Data at P and L bands"

First Page of the Article [C657]

## "SAR Imagery Scattering Center Extraction and Target Recognition Based on Scattering Center Model"

Based on a scattering center parametric model derived from the geometric theory of diffraction, main characteristic scattering center Fisher optimal discriminator is presented in this paper for the problem of multi-class ground targets. All aspect main characteristic scattering center recognition model and target outline characteristic curve recognition model are presented in this paper. Four-class targets (Sandia Laboratories Implementation of Cylinders II, BTR70 armored transport, T72 main battle tank and BMP2 infantry tank) in MSTAR public database are adopted in our experiments and the results are presented [C658]

## "Automatic Target Recognition Using Multiple Radar High Range Resolution Profiles"

Radar automatic target recognition (ATR) based on multiple high range resolution profiles (HRRPs) is concerned. To relax the target aspect sensitivity and use more statistical information of the HRRPs, in this paper we extract the average range profile and the variance range profile together as the feature vectors for both training data and test data representation. And a decision rule is established for ATR based on the minimum Kullback-Leibler distance (KLD) criterion. The recognition performance of the proposed method is comparable with that of adaptive Gaussian classifier (AGQ with multiple test HRRPs, but the proposed method is much more computational efficiently. Experimental results based on the measured data show the minimum KLD classifier is effective [C659]

## "A Method to Remove Rebound Jamming against Bistatic Synthetic Aperture Radar"

Rebound jamming, a kind of main-beam jamming, is effective to resist BiSAR. Due to simultaneous coherence between interferences and target echoes in both down-range and cross-range, it is difficult to remove the interference from received signal. Based on the principle of two-channel cancellation using for moving target detection, the paper proposes a method to remove rebound jamming against BiSAR, which can give satisfactory interference cancellation when interference parameters are known either completely or partially. The estimation of interference parameters is presented, too. Validation is confirmed by simulations [C660]

## "Sea Clutter Suppression Based on Radon Transform at High Grazing Angles"

During final guidance, as radar working over sea surface at a very high grazing angle, it is hardly to distinguish target from clutter background due to the strong reflection of the sea surface. A novel method is presented to suppress the sea clutter in this paper. The proposed method based on Radon transform utilizes edge detection technique to find a boundary to separate the target and sea clutter in range-Doppler map. Simulations for sea clutter suppression and target three-dimensional imaging on the sea are conducted. Results show the effectiveness of our method [C661]

## "Radar Target Recognition Using A Modified FastICA Algorithm plus GAs"

Independent component analysis (ICA) is a statistical method developed from the separation of blind signal, and now it has been successfully used in many fields. In this paper, we present an effective technique combined with a modified fastICA (M-FastICA) algorithm plus genetic algorithms (GAs) for radar high-resolution range profiles (HRRPs) feature extraction. As we all know that the most time-consuming course in fastICA is to compute the Jacobian matrix. So in this modified version, several iterations of fastICA are merged into one iteration but only needs to compute the Jacobian matrix once time. Thereby the convergence velocity of fastICA is accelerated while the performance is not degraded. To demonstrate the above feature extraction algorithm, the classification experiment on three types of radar targets are evaluated. First M-fastICA is applied to extract the independent components from the HRRPs. Then GAs is used to select the optimal basis vectors and thus build a feature subspace. The results show that the introduced method can achieve better classification performance than both PCA and ICA [C662]

## "Tracking a Variable Number of Human Groups in Video Using Probability Hypothesis Density"

We apply a multi-target recursive Bayes filter, the probability hypothesis density (PHD) filter, to a visual tracking problem: tracking a variable number of human groups in video. First, we use background subtraction to detect human groups which appear as foreground blobs. The PHD filter is implemented using sequential Monte Carlo methods; and the centroids of the foreground blobs are used as the measurements to update the PHD filter. Our experimental results show that when human groups appear, merge, split, and disappear in the field of view of a camera, our method can track them correctly [C663]

## "HF Radar Target identification Based on Optimized Multi-frequency Features"

In this paper, multi-frequency target radar cross section (RCS) of high frequency surface wave radar (HFSWR) is used for airplane target identification. Radar working frequency optimization selection is investigated for an optimization selection method based on the minimum classification error (MCE) rule in order to improve airplane target identification performance; Target RCS is compensated with the consideration of the influence of ground wave propagation attenuation and ocean wave additional loss. By using this method, identification results of ten types of airplane targets are given with different working frequency numbers in different signal to noise ratio (SNR). Simulations indicate that identification performance of frequency optimization is improved remarkably compared with the performance of random frequency selection, and the reliable airplane target identification using this method can be realized at lower SNR with fewer working frequency numbers [C664]

## "Detection, Velocity Estimation and Imaging of Fast Moving Targets Using Single Antenna SAR"

In conventional methods of velocity estimation of moving targets using single antenna SAR, if the Doppler-shift exceeds PRF/2, in other words, if the radial velocity of a fast moving target exceeds the "blind velocity", the radial velocity estimation ambiguity will occur. In this paper, a novel method is proposed to detect and image fast moving targets. Specially, this method can accurately estimate the velocities of fast moving targets beyond the "blind velocity" limit. Numerical simulation and real data are provided to validate the method [C665]

## "Effects of geometry on clutter characteristics of hybrid bistatic space based radar"

For hybrid bistatic space based radar (HB-SBR) which is composed of a transmitter on a satellite and a receiver on an airplane, clutter is a serious problem for detecting slow moving target. The authors discuss the effects of geometry on clutter characteristics, such as Doppler-angle traces, isorange and isodoppler contours, Doppler ambiguities and so on, of HB-SBR which applies space-time adaptive processing (STAP) in this paper. It is shown that some unique clutter properties appear due to the great differences of platform speeds and heights between the transmitter and receiver in the hybrid mode. Some suggestions about bistatic geometry design are also made to improve he performance of moving target indication (MTI) [C666]

## "Geometric Hashing Classifier Based on Modified D-S Theory in SAR Target Recognition"

Geometric hashing technology can effectively recognize targets with partially changed shape. But when the known targets in training data set don't satisfy with the condition of 360 azimuths, the effect of recognition degrades. The reason is that the imperfect training set and partially changed shape make the uncertain information increase. Dempster-Shafer theory can deal with the uncertainty successfully. However, Dempster-Shafer theory does not model well evidences with a high degree of conflict. In order to overcome the aforementioned problems, in this paper, a modified D-S theory combined with geometric hashing is proposed and used in SAR images recognition. Experimental results with MSTAR dataset show that this fusion method is feasible, and it can correctly recognize the targets with partially changed shape [C667]

## "A synthetical pose estimation of SAR imagery using Hough transform and 2-D continuous wavelet transform"

SAR target recognition close relates to target pose. When the pose of target is confirmed, the computational complexity can be deduced, which can increase the recognition probability greatly. Hough transform is an efficient approach to recognize the target pose. But, in general, Hough transform can obtain many poses for a single SAR target. The right pose can't be obtained only using Hough transform. In order to resolve this problem, in this paper, the angular energy density of 2-D continuous wavelet transform combined with Hough Transform is proposed. Many experimental results of MSTAR public target database show that this method is feasible and it can obtain the pose correctly [C668]

## "A Novel Approach Based on Wavelet-ICA for SAR Image Speckle Suppression"

In this paper we propose a novel speckle suppression method based on the joint of wavelet transform (WT) and independent component analysis (ICA). The method employs ICA to process the wavelet coefficients of images, extracting the independent components which represent the uncorrupt images. Experimental results based on SAR (synthetic aperture radar) images of MSTAR (moving and stationary target acquisition and recognition) dataset show that the proposed method suppresses speckle effectively, and outperforms ICA and Lee filter [C669]

## "A Novel Target Recognition Method Based on Neural Network and Gray Correlation"

In order to solve target recognition problems, D-S reasoning method based on information fusion is applied. The key problem to D-S reasoning is basic probability assignment function, so the algorithm implementation of D-S reasoning is a serious problem. For the special traits of target recognition, a new method of constructing basic probability assignment function based on neural network and gray correlation analysis is presented. Examples of recognizing the radar emitter purpose have been selected to demonstrate the new method. Experimental results show that this information fusion method is accurate and effective [C670]

## "A Practical Kernel Criterion for Feature Extraction and Recognition of MSTAR SAR Images"

Complete kernel fisher discriminant analysis (CKFDA) is essentially a practical nonlinear feature extraction criterion based on kernel trick. The process is divided into two phases, i.e., kernel principal component analysis (KPCA) and linear discriminant analysis (LDA). This work uses two different kinds of CKFDA methods to extract the features of MSTAR SAR images: one only obtains the regular information in "single discriminant space", the other gains regular and irregular information in "double discriminant subspaces". The inspiring recognition results verify that the features not only overcome aspect sensitivity existent in SAR images, but also are robust to variants within the target classes which have small configuration differences [C671]

## "Fusion-based Target Tracker for Sector Scan Radar"

This paper presents a fusion-based target tracker (FBTT) for tracking a target detected by sector scan radar. The tracker employs two Kalman filters (KF) in dual-path structure. Estimation of target state in minimum mean square sense (MMSS) is obtained through fusing estimations exported from two Kalman filters, respectively. With the framework proposed here, most prevalent maneuvering target tracking algorithms in annular scan radar system can be readily applied for sector scan radar without the overburden of computation. Performance comparison between FBTT and Kalman filter is demonstrated through simulations. Benefit and validity of the proposed method is verified [C672]

## "The Advanced Simulation System for MMW Imaging Radar Seeker onboard Air-to-air Missile"

Millimeter wave (MMW) radar is booming in application to target seeker onboard the air-to-air missile (AAM),

which has the capability to obtain all-weather radar images for auto target recognition (ATR) and intelligent active homing guidance. An advanced simulation system for MMW imaging radar seekers of AAM was introduced in this paper. The system is composed of parameter initialization module, signal simulation module and image formation module. It is capable of investigating and demonstrating the system performance of MMW radar seeker. The modeling of radar signal and the geometric model for missile-to-target were presented in particular. The echo signal for major radar operation modes could be generated by the system, including high-resolution range profile (HRRP) mode, Doppler beam sharpening (DBS) mode as well as the high-resolution burst-SAR mode. The image formation algorithms for each radar operation mode were integrated in the system to generate highly accurate radar imagery. Computer simulation results for an actual aircraft were presented, which validate the correctness of the simulation system. It is an advanced tool for the investigation of imaging algorithms and the optimization of the system parameter selection, as well as the demonstration of the radar scenario [C673]

## "Data Level Fusion of Multilook Inverse Synthetic Aperture Radar (ISAR) Images"

Although techniques for resolution enhancement in single-aspect radar imaging have made rapid progress in recent years, it does not necessarily imply that such enhanced images will improve target identification or recognition. However, when multiple looks of the same target from different aspects are obtained, the available knowledge base increases allowing more useful target information to be extracted. Physics based image fusion techniques can be developed by processing the raw data collected from multiple ISAR sensors, even if these individual images are at different resolutions. We derive an appropriate data fusion rule in order to generate a composite image containing increased target shape characteristics for improved target recognition. The rule maps multiple data sets collected by multiple radars with different system parameters on to the same spatial-frequency space. The composite image can be reconstructed using the inverse 2-D Fourier transform over the separated multiple integration areas. An algorithm called the matrix Fourier transform is created to realize such a complicated integral. This algorithm can be regarded as an exact interpolation, such that there is no information loss caused by data fusion. The rotation centers need to be carefully selected in order to properly register the multiple images before performing the fusion. A comparison of the IAR (Image Attribute Rating) curve between the fused image and the spatial-averaged images quantifies the improvement in the detected target features. The technique shows considerable improvement over a simple spatial averaging algorithm and thereby enhances target recognition. [C674]

## "Modeling of Target Shadows for SAR Image Classification"

A recent thrust of non-cooperative target recognition (NCTR) using synthetic aperture radar (SAR) has been to complement the extraction of scattering centers by incorporating information contained in the target shadow. When classifying targets based on the shadow region alone, it is essential that an image be well clustered into its respective shadow, highlight, and background regions. To obtain the segmentation, the intensity and spatial location of a pixel are modeled as a mixture of Gaussian distributions. Expectation-maximization (EM) is used to obtain the corresponding distributions for the three regions within a given image. Anisotropic smoothing is applied to smooth the input image as well as the posterior probabilities. A representation of the shadow boundary is developed in conjunction with a Hidden Markov Model (HMM) ensemble to obtain target classification. A variety of targets from the MSTAR database are used to test the performance of both the segmentation algorithm and classification structure. [C675]

## "MOMENT INVARIANTS OF OPEN CURVE FOR FUSION"

This paper presents a new set of moment invariants used for the fusion of open curve target. The moment invariants of open curve are reformulated on that of close curve. The indexes and rules for fusion of open curve target are founded on those invariants. Several retrieving methods of open curve in sparse sampling are compared to obtain appropriate ones. Determination of fusion threshold is discussed. Experiments show that these invariants were effective infusion of open curve target [C676]

## "Simulation of Automotive Radar Target Lists using a Novel Approach of Object Representation"

The development of radar signal processing algorithms for target tracking and higher-level automotive applications is mainly done based on real radar data. A data basis has to be acquired during cost-expensive and time-consuming test runs. For a comparably simple application like the adaptive cruise control (ACC), the variety of significant traffic situations can sufficiently be covered by test runs. But for more advanced applications like intersection assistance, the effort for the acquisition of a representative set of radar data will be unbearable. In this paper, we propose a way of simulating radar target lists in a realistic but computationally undemanding way, which will allow to significantly reduce the amount of real radar data needed [C677]

## "A New Radar Emitter Recognition Method Based on Variable Precision Rough Set Model"

Radar emitter information detected by multisensor system takes on uncertainty, illegibility and contradiction. In real reconnaissance environment, the patterns of radar classes often overlap, the accurate classification of the Pawlak rough set model restricts its application in the real world. In order to solve emitter recognition problem, a new method of finding decision rules is presented to classify radar emitter from the new point of view of variable precision rough set. This method is according to dependent degree of decision attributes on condition attributes. The decision rules proposed are more straightforward. At last, example of recognizing the radar emitter purposes is selected. During the experiment, discretization is conducted on extracted index data of radar emitter and metrical radar characteristic parameter firstly. Then, positive region of each condition attribute are calculated under the given error parameter, which is the basis of decision rules. Experimental results demonstrate this new radar emitter recognition method by finding decision rules based on variable precision rough set model is effective and feasibility [C678]

## "A Novel Preprocessing Approach for SAR ATR"

In this paper, a new preprocessing approach is proposed for SAR ATR. The effect of DC (direct current) bias among images on the ATR performance is studied and a new preprocessing method is proposed. The alignment, amplitude compensation and DC bias removal can be done efficiently in the frequency domain. Experimental results are provided to demonstrate the performance of the proposed approach [C679]

## "A Novel Approach for RCS Feature Extraction Using Imaging Processing"

In this paper, a novel approach for RCS feature extraction using imaging processing is proposed firstly. We take the frequency-angle RCS data sets normalized for every observation angle as intensity images with 256 gray levels, and find that different targets have different textures. This implicates that the particular textures of each image can be used to recognize the corresponding targets. Here, we chose the gray level co-occurrence matrix for texture feature extraction by using of discrete wavelet transform (DWT) to further enhance the performance of target recognition. The simulation results show that the proposed approach is of great perspective for target discrimination. By properly choice of texture features, it can provide good feature vectors for further pattern recognition [C680]

## "Adaptive Radar Clutter Suppression Based on Real Data"

Adaptive radar clutter suppression algorithm and realization are important things in radar signal processing system. The paper firstly discusses a method based on the maximum average improvement factor to compute the weight vector of adaptive clutter filter in theory, and then describes a simple, low-cost adaptive MTI system for bimodal clutter suppression, which uses precomputed filter coefficients stored in the weight coefficients library. Results of applying this adaptive MTI filter on real radar data demonstrate that the filter gives an extensive reduction of clutter in the radar image [C681]

## "An Adaptive Compensation of Moving Clutter Doppler Shift for Helicopter MTD Radar"

The accurate estimation and compensation of the moving clutter Doppler shift are essentials for the moving target detection of the airborne radar system. In this paper, a technique for the real-time estimation and compensation of the moving clutter Doppler shift due to the moving radar platform is presented for the airborne pulsed Doppler radar system. A new algorithm employs the dwell-time based clutter-lock MTD method in order to estimate and compensate the mean Doppler shift within antenna beam dwell time by using high speed DSP based Doppler FFT processing. Through the helicopter-borne radar flight test using real-time radar data acquisition system, the moving clutter Doppler spectrum is measured and analyzed in terms of various operational parameters [C682]

## "A Novel KICA Method for Ground Bounce Removal with GPR"

Nowadays ultra wideband ground penetrating radar (GPR) is widely used in landmine detection. For shallowly buried plastic landmines, the ground bounce is usually much stronger than the weak return from landmines and their arrival time is very close with each other, so ground bounce removal is very important for the following detection, imaging and target recognition. In this paper, kernel independent component analysis (KICA) is first introduced to ground bounce removal with GPR. A novel scheme is proposed for the automatic independent component (IC) selection, which is vital for any ICA based ground bounce removal algorithms. Experimental results based on field-test data show that the proposed method has good performance [C683]

## "Fully-Polarized Scattering Center Extraction and Parameter Estimation: P-SPRIT Algorithm"

In this paper, a novel method called P-ESPRIT algorithm is proposed for fully-polarized scattering center extraction and parameter estimation. The P-ESPRIT algorithm is a joint processing between polarization and super-resolution essentially. It is able to estimate the number, position, intensity and normalized scattering matrix of scattering centers instantaneously for each channel rather than the one which extracts parameters from each channel separately, and its performance is better than the latter because the fully-polarized information is used. It has computational advantage over other methods like MUSIC and ML because it needn't search. Its validity is proved by the experimental results based on simulated and real data [C684]

## "RSOM Algorithm for Radar Target Recogniton"

A number of general neural networks have several drawbacks such as how to decide their structures and scales, how to design their self-learning procedure and how to cope with a bulk of computation for the case of large data set classification and complex patterns recognition. In order to solve these problems, this paper proposes the RSOM tree classifier based on discrimination criterion approach. The RSOM tree classifier is composed of topology-preserved sub-SOM nets, and its scales is determined by discrimination criterion. The main advantage of this new neural network is that it adjusts structure and scale automatically with the large training data set, therefore, it maps the training data set very well. This makes it achieve high right classification rate in radar ship target recognition. The experiments in the end are very good proofs for this new network [C685]

## "Simulations for Evaluation of Sensor Systems Exposed to Countermeasures"

A methodology for simulation of multi-sensor systems exposed to countermeasures has been developed with the aim to investigate how multi-sensor systems are affected by different types of countermeasures and deployment tactics. The target recognition function of a combined radar/IR-seeker exposed to countermeasures is studied. Features extracted from simulated high range resolution radar data and IR images are fused. Sensor data are simulated for a seeker approaching ground vehicle targets moving on a grass field. The countermeasures consist of IR and radar attenuating smoke. The rate of correct classification is always higher for fused sensor data than for a single sensor as long as the proper confidence level of the data is considered [C686]

## "Precession Period Extraction of Ballistic Missile Based on Radar Measurement"

A method of extracting the precession period of ballistic missiles (BM) in the midcourse phase of their ballistic trajectories with radar cross section (RCS) sequence was presented. The motion of ballistic missiles in the midcourse phase was analyzed and modeled. Then the relationship between the precession period of missile warhead and its RCS sequence was discussed. Based on the variation characteristics flying in the RCS sequence, a method of extracting the precession period was proposed. Simulation results demonstrated the efficiency of the method [C687]

## "Radar Automatic Target Recognition Based on Complex High-Resolution Range Profiles"

Radar high-resolution range profile (HRRP) has received intensive attention from the radar automatic target recognition (RATR) community. Usually, complex HRRPs are not fully used for RATR but only their amplitude vectors, while the phase information of them is discarded due to the fact that the initial phase of a complex HRRP is strongly sensitive to target position variation. However, the phase information of complex HRRPs may also contain valuable target discriminant information, which may further improve the recognition performance. This paper concerns RATR using complex HRRPs. To' deal with the initial phase sensitivity of complex HRRPs, we extract the complex HRRPs' feature subspace within each target-aspect sector of each target via principal component analysis (PCA) as the corresponding template during the training phase, while in the test phase, project the test sample onto each feature subspace and search the optimal approximation of the test sample with the minimum reconstruction error to decide which target the test sample belongs to. It is shown that the whole process is independent of the initial phases of complex HRRPs. Furthermore, to make the proposed recognition method more practical, a fast time-shift compensation algorithm is proposed. In the recognition experiments based on measured data, the proposed recognition method using complex HRRPs achieves better recognition results than that using only the amplitude vectors of the complex HRRPs [C688]

## "Using the Amplitude Fluctuation Property of Target HRRP for Radar Automatic Target Recognition"

Due to the aspect sensitivity of high-resolution range profile (HRRP), traditional radar HRRP target recognition methods usually use average profile within some target-aspect region as the target-aspect template. Actually, the amplitude fluctuation property of target HRRP also represents some feature information of the target. Based

on the scattering center model, a new feature extraction method using the amplitude fluctuation property of target HRRP is proposed in this paper. The weighted HRRP feature extracted by the new method can represent the scatterer distribution in every range cell, thereby it can describe the scattering property of the target better. The experimental results based on measured data show that the new feature extraction method can greatly improve recognition performances [C689]

## "High Forward-looking Squint Image Processing for Air-to-air Missile-borne SAR"

The feasibility of millimeter wave (MMW) synthetic aperture radar (SAR) onboard the air-to-air missile (AAM) was theoretically investigated in this paper, with the intent of improving the accuracy of guidance and control for AAM. The burst mode was proposed as an optimum operation mode for the air-to-air missile-borne SAR system, considering the resolution requirements, the computational loads as well as the real-time processing efficiency. The ECS algorithm with the range cubic phase error correction was applied to process the high forward-looking squint data, basing on the equivalent slant-range model deduced from the simplification of missile-to-target geometry model. Formulas for geometric correction was presented to remove the serious geometry distortion in the high squint cases, in order to provide high accurate radar images for automatic target recognition (ATR) in the consequent processing. The computer simulation results of high forward-looking squint angle of 14.83 degrees were presented, which demonstrate the effectiveness of the image processing method [C690]

## "Outline Structural Representation for Radar Target Classification Based on Non-Radar Templates"

Automatic target recognition (ATR) is often based on statistical methodologies rather than using symbolic information relationships and properties. In this paper, a possible approach for the syntactic outline representation for radar target classification based on non-radar templates is presented, describing the outline extraction and tine detection algorithms to define a code-book of structures representing the target radar shape. The outline target recognition is attempted from a multi-perspective point of view: only the illuminated side of the target is preserved and then combined with other partial shapes collected from different nodes of a hypothetical radar network [C691]

## "Multi-target Imaging Processing Algorithms of ISAR Based on Time-frequency Analysis"

This paper analyzed the features of the Doppler frequency shift of multi-target of ISAR at different moving states. Based on the model of rigidity multi-target, several modified time-frequency analysis approaches were proposed to simulate ISAR imaging of multi-target. The results showed the feasibility of the ISAR imaging method and the ability of recognition for multiple targets [C692]

## "Analysis of Doppler Features of Spiral Maneuver of Reentry Missile with Time-Frequency Transform"

To have excellent penetration capability, the tactical ballistic missile (TBM) maneuvers during the process of reentry, which makes the realization of interception somewhat difficult. In this paper a kind of trajectory maneuver-spiral maneuver is researched. At first, the mathematical model of spiral maneuver is developed. Then based on a hit-to-kill missile, the simulation results verify the accuracy of the mathematical model. With the moving window Fourier transform, analysis of the time-varying Doppler signature in the joint time-frequency domain can provide useful information for target detection, recognition, tracking and interception [C693]

## "Micro-Doppler Signature Classification"

The micro-Doppler signature of a target is a time varying frequency modulation imparted on the radar echo signal by moving components of the target. Battlefield radar output the radar's baseband signal as audio and soldiers listening on headphones are able to identify the target from its micro-Doppler signature. Automation of this capability is desirable for improved reliability and reduction in classification time. For the first time dynamic time warping (DTW), a speech recognition technique, has been applied to the problem [C694]

## "Radar HRRP Target Recognition using influence region of samples"

The k-nearest neighbour (KNN) rule using Euclidean distance is actually the same as template matching method under the maximum correlation coefficient criterion (MCC-TIMM), which has been widely used in high resolution rang profiles (HRRPs) based radar automatic target recognition (RATR). The nearest neighbor rule treats each training sample equally without consideration of different recognition performances due to its congregation around the other samples coming from the same class and segregation from those of the rest classes. In this paper, we propose an adaptive method that takes into account the effective influence size of each training sample and the statistical confidence with which the label of each training sample can be trusted. The experimental results

confirm the effectiveness of the proposed method [C695]

## "Multi-perspective target classification"

Traditional radar classification is based on a single aspect view of the target. It is remarkably sensitive to the particular direction under which the target is sensed. A network of radars offers means of collecting backscattered radiation of a range of viewing angles. This offers multi-perspective data sets as an aid to improve radar target classification. By definition, this will provide a data set with higher information content. In this paper we examine whether this approach is useful for classification purposes. Results using full scale turntable demonstrate significant improvements in performance over and above the monostatic case. [C696]

## "Target classification using Gaussian mixture model for ground surveillance Doppler radar"

An automatic target recognition (ATR) algorithm, based on greedy learning of Gaussian mixture model (GMM) is developed in this work. The GMMs were obtained for a wide range of ground surveillance radar targets such as: walking person(s), tracked or wheeled vehicles, animals and clutter. Maximum-likelihood (ML) and "majority voting" decision schemes were applied to these models for target classification. The corresponding classifiers were trained and tested using distinct databases of target echoes, recorded by ground surveillance radar. ML and "majority voting" classifiers obtained classification rates of 88% and 96%, correspondingly. Both classifiers outperform trained human operators. [C697]

## "Empirical mode decomposition of micro-Doppler signature"

Micro-Doppler induced by mechanical vibration or rotation of structures in a radar target is potentially useful for target detection, classification and recognition. In order to exploit the time-varying micro-Doppler signature, time frequency analysis techniques are used. However, they can not represent this useful information clearly all the time. In this paper, we introduce a novel algorithm to extract the micro-Doppler signature using a technique called empirical mode decomposition. Both simulation and the experimental results indicate that EMD provides us an effective way to give better time frequency representation of the micro-Doppler signature. [C698]

## "Feature-enhancement of SAR images by Bayesian regularization"

SAR imaging has an increasing interest in the surveillance and aircraft combat fields. The final aim is generally automatic target detection and recognition applications for assisted interpretation. To help these recognition processes it is important to get good quality SAR images, without loss of resolution. Particularly, we propose to enhance the image feature by reducing the sidelobe artefacts and smoothing the speckle. The methodology is the resolution of an ill-posed inverse problem by Bayesian regularization. The solution is then the value which minimizes a well-chosen penalised criteria. The originalities are minimization algorithm choice and real data applications. [C699]

## "Scattering centers association and radar imaging based on multi-aspect measures"

Radar imaging is an important way to obtain the structural information of target. Based on the geometrical projection of scattering center on the line of radar sight, the principle of reconstructing scattering centers' 3-D distribution based on multi-aspect measures is provided in this paper. After analyzing the characteristic differences between true and false scattering centers, the multiple elastic modules (MEM) is introduced to perform scattering centers association and radar target imaging. The experiments are developed with simulated and experimental data, and experimental results show the feasibility and validity of proposed approach. [C700]

## "Nearest neighbor classifier based on Riemannian metric in radar target recognition"

A successful design for a nearest neighbor classifier based on Riemannian metric in radar target recognition is presented. In Riemannian space, obtaining feature coefficient using subspace methods can be regarded as an affine transformation, and the classifier can be deduced easily from the distance formula in Riemannian space. The classifier is compared with other classifiers and good performance is reported. This design for the classifier may serve as a guideline for dealing with the puzzle that how to combine feature extraction with classifiers reasonably in radar target recognition using range profiles. [C701]

## "Database generation of bistatic ground target signatures"

Automatic target classification has been an area of active study due to many of its significances. With there advent of bistatic technology in radar, the research into target classification in bistatic scenario seems quite timely. But the study of any classification algorithm demands for a suitable database. Due to the unavailability of

suitable field collected bistatic database, computer simulation of such a database is quite pertinent. The present work discusses the approach towards the generation of a similar database, using FEKO as the electromagnetic simulation tool. Various special needs of such a project and the answers of FEKO to those needs, have been discussed. The results conclusively show the suitability of FEKO for the project. [C702]

## "Man-made targets pose estimation using time-frequency distribution in UWB SAR"

{no data available} [C703]

## "Inversion of the low frequency UWB SAR"

{no data available} [C704]

## "A new method of SAR image target recognition based on SVM"

{no data available} [C705]

## "Classify of Underwater Target Utilizing Audio Fingerprint"

As well known, because of the complicated watery environment and the limitation of the detecting method, recognizing the underwater target precisely is always a Gordian knot to all countries. In this paper, we designed a genetic-based classifier system (CS) which recognizes a target utilizes audio fingerprints. Audio fingerprint technology extracts some unique feature from a given sound clip, and the classifier system does some classifying and recognizing works according to those features. In order to improve the performance of the classifier system, we designed some techniques: the comparing and matching algorithm would give the fitness value more explicitly statistical meaning; the hyperplasia operator gives the system persistent learning abilities, the refining classifier merges redundant rules and shrinks the rule set, and an alterable mutation probability increases the speed and the accuracy of the classifying operation. Experiments show that it's competent for the recognition [C706]

## "Vehicle detection combining gradient analysis and AdaBoost classification"

This paper presents a real-time vision-based vehicle's rear detection system using gradient based methods and Adaboost classification, for ACC applications. Our detection algorithm consists of two main steps: gradient driven hypothesis generation and appearance based hypothesis verification. In the hypothesis generation step, possible target locations are hypothesized. This step uses an adaptive range-dependant threshold and symmetry for gradient maxima localization. Appearance-based hypothesis validation verifies those hypothesis using AdaBoost for classification with illumination independent classifiers. The monocular system was tested under different traffic scenarios (e.g., simply structured highway, complex urban environments, varying lightening conditions), illustrating good performance. [C707]

## "Radar antenna architectures and sampling strategies for space based moving target recognition"

{no data available} [C708]

## "Radar shadow and superresolution features for automatic recognition of MSTAR targets"

Automatic target recognition from high range resolution radar profiles remains an important and challenging problem. In this paper, we present a novel feature set for this task that combines a noise-robust superresolution characterisation of the target scattering centres derived using the MUSIC algorithm with a representation of the target's radar shadow shape. To obtain the shadow shape features, three alternative spectral estimation methods are investigated. Using a hidden Markov model to represent aspect dependence, we demonstrate that the inclusion of the shadow features results in a significant improvement in recognition performance. Using azimuth apertures of 3° and 6° in a 10-target classification task from the MSTAR database, we obtain overall classification error rates of 1.3% and 0.2% respectively. These results are significantly better than those obtained by other published methods on the same database. [C709]

## "Hidden Markov models for radar pulse train analysis in electronic warfare"

We present a new approach to radar pulse train analysis in electronic warfare. We consider an alternative to the classical time-of-arrival (TOA) histogram technique commonly used for extraction of complex pulse patterns. We derive a hidden Markov model for the radar word templates, and develop a modified version of the Viterbi algorithm to extract radar words from noisy and corrupted pulse sequences. We argue the advantages of this

approach compared to the standard TOA histogram technique, and illustrate operation of the algorithm with computer simulation results. [C710]

## "Modeling, identification, and control of large-scale dynamical systems"

This paper highlights some fundamental issues involved in the study of large-scale dynamical systems. Two particular topics are discussed in some detail, one dealing with the management of active sensors via partially observable Markov decision processes, and the other dealing with the modeling, recognition and tracking of multi-function radars in an electronic warfare environment. [C711]

## "A multiresolution cooperating multiple-swarm pso algorithm for automatic target recognition in polarimetric SAR images"

First Page of the Article [C712]

## "Radar Target Recognition Using the Differential Power Spectrum"

In this paper we discuss the problem about the target recognition by the high resolution radar range profiles. Several feature extraction methods for computing shift invariants are simply reviewed: such as bispectrum, differential cepstrum, then the differential power spectrum (DPS) based features are introduced to this study. A multi-layered feed-forward neural network with simulated annealing resilient propagation (SARPROP) algorithm is selected as classifier. Simulations are presented to identify the range profiles of four different aircrafts. The results demonstrated that the differential power spectrum based features are effective and robust for radar target recognition [C713]

## "Radar high range resolution profiles recognition based on wavelet packet and subband fusion"

Radar automatic target recognition (ATR) using high range resolution profiles (HRRPs) is addressed. A subband fusion structure is proposed based on wavelet packet transforming. Multiple adaptive Gaussian classifiers (AGCs) are built for each subband, and the outputs of each of the subband classifiers are combined to make a final decision. Compared with the traditional wideband recognition approach, i.e., single band approach, the proposed approach can achieve better recognition performance, and is more robust to noise as well. Example results, based on the measured data, show the efficiency of the proposed method. [C714]

## "Automatic recognition of MSTAR targets using radar shadow and superresolution features"

Automatic target recognition from high range resolution radar profiles remains an important and challenging problem. In this paper, we present a novel feature set for this task that combines a representation of the target's radar shadow with a noise-robust superresolution characterisation of the target scattering centres derived from the MUSIC algorithm. Using an HMM to represent aspect dependence, we demonstrate that the inclusion of the shadow features results in a significant improvement in recognition performance. We evaluate our proposed feature set on a closed-set identification task using targets from the MSTAR database and show that it results in lower recognition error rates than previously published methods using the same data. [C715]

## "Automatic Target Classification — Experiments on the MSTAR SAR Images"

SAR (Synthetic Aperture Radar) can produce target images in range and cross-range with sufficient resolution for recognition. In this paper, we did an experimental test on three different feature extraction techniques (Principle Components Analysis PCA, Independent Components Analysis ICA, and Hu moments) by using different target SAR images taken from the MSTAR database. The performance of these techniques is analyzed. A number of classification techniques, such as Linear (LDC), Quadratic (QDC), K-nearest Neighbor (K-NN), and Support Vector Machine (SVM) are tested and compared for their performance on the target classification. Our experimental results provide a guideline for selecting feature extracting techniques and classifiers in automatic target recognition using SAR image data. [C716]

## "A multifrequency HF-VHF radar system for aircraft identification"

MOSAR is a multifrequency and multipolarization radar system used for analysis of aircraft radar cross section by means of measurements in the low VHF frequency band (20-80 MHz). At first, basic principles of this project are presented and technical choices are explained. After extraction of radar cross sections (RCS) from the MOSAR data, a target identification algorithm, based on a comparison with a numerical database containing RCS of commercial aircraft, is applied to measurements. The influence of signal to noise ratio (SNR) and flight level is evaluated. [C717]

## "Multipath signal resolving and time delay estimation for high range resolution radar"

High range resolution radar target signature is a promising signature for radar automatic target recognition (ATR), and the multipath time-delay is used for height finding in high range resolution radar recently. We address multipath time-delay estimation under the scenario of closely spaced multipath for high range resolution radar, the target scattered signature can be resolved via the estimated channel parameters. By using the prior information of the typical multipath channel structure in radar application, a channel constrained MODE-RELAX algorithm is proposed to estimate the channel parameters. The resolved target signatures are used to evaluate the classification performance. Numerical results show that the proposed algorithm can estimate the time-delay very well for many cases, and the classification performance can be improved via the resolved signal. [C718]

## "PCA and kernel PCA for radar high range resolution profiles recognition"

Radar high range resolution profile (HRRP) contains target structure information. It is shown to be a promising signature for radar automatic target recognition. As a method for data dimension reduction and feature extraction, principle component analysis (PCA) and kernel PCA have found wide applications in pattern recognition field. According to the characteristics of target pose sensitivity and shift sensitivity, a localized PCA and a modified KPCA are proposed for radar HRRP recognition. Also the methods for selecting the kernel basis vectors and handling the range-shift alignment are carefully addressed. Finally, support vector machine (SVM) classifier is used to evaluate the classification performance based on measured data. Experimental results show the proposed methods are effective and KPCA outperforms PCA. [C719]

## "Pattern recognition based on time-frequency distributions of radar micro-Doppler dynamics"

Radar micro-Doppler signatures are of great potential for identifying properties of unknown targets. An effective tool to extract information from the signatures is time-frequency analysis, based on which target identification and object recognition can be extended. In this paper, a method has been proposed for feature extraction and selection from simulated time-frequency distribution of micro-Doppler dynamics. Experimental results have shown that a highly discriminative feature set can be established by using this method. With this feature set, high classification performances both in training and testing stages for different classifiers have been achieved. [C720]

## "Moving target motion estimation and focusing in SAR images"

The phase history for a target with general motion can be calculated fairly simply when the SAR system moves along a straight line, and when the motion is reasonably small. The resulting phase history is a sum of two terms: one term depends directly on the range motion, while the second term depends on the azimuth motion multiplied with the platform motion. The two terms cannot be separated based on the phase history alone. The resulting expressions show that the SAR image will contain signatures corresponding to changing frequencies. Accordingly, time-frequency methods may be used to analyze the signatures. An experiment was designed with such signatures in mind. A target moved along a trajectory approximately in the azimuth direction, with superimposed oscillations in the range direction. The resulting signature was an azimuth smear in agreement with the predictions. The smear was very similar to a signature corresponding to a building. Using time frequency methods, the signatures could be transformed to the time-frequency domain, where a clear difference could be seen. The moving target was essentially a linear chirp with oscillations superimposed, entirely in agreement with predictions. The building signature showed a more complex structure, indicating a combination of scattering mechanisms from the building. All were different from the moving target signature. Time-frequency methods may thus be used to analyze possible moving target signatures. The methods help to discriminate between moving and stationary targets, as well as focusing and relocating them within the image. Ultimately, the processing should contribute to increased probability of recognition and possibly detection of moving targets. [C721]

## "Technique for selection of optimum polarimetric angles in radar signature classification"

In this paper an automated technique for adaptive radar polarimetric pattern classification is described. The approach is based on a genetic algorithm that uses probabilistic pattern separation distance function and searches for those transmit and receive states of polarization sensing angles that optimize this function. Seven pattern separation distance functions, the Rayleigh quotient, Bhattacharyya, divergence, Kolmogorov, Matusta, Kullback-Leibler distances, and the Bayesian probability of error, are used on real, fully polarimetric synthetic aperture radar target signatures. Each of these signatures is represented as functions of transmit and receive polarization ellipticity angle and the angle of polarization ellipse. The results indicate that based on the majority of the distance functions used; there is a unique set of state of polarization angles whose use leads to improved classification performance. [C722]

## "Algorithms for improve in the problems of angular resolution"

This paper describes how the angular resolution of radar systems can be improved in the problems of the target image identification. Rather simple algorithms, necessary for it, of an information reprocessing are proposed for practical embodiment. The outcomes of numerical experiments are introduced [C723]

## "ISAR imaging of the ship target at sea"

In this work, a generalized ISAR approach to solve the SAR problem for image reconstruction and ship target recognition is suggested. A new coordinate definition of the 3D SAR scenario is addressed. An analytical geometrical approach to define apparent Yaw, Pitch and Roll angle of the ship target at sea is implemented. Mathematical expressions to determine slant range distance are derived. The model of the SAR signal return is composed by a linear frequency modulated transmitted signal, geometry and reflectivity properties of sparkling points of the object. Image reconstruction procedure includes correlation range compression and fast Fourier transform azimuth compression. To verify the new ISAR image reconstruction concept with respect to SAR problem a numerical experiment is carried out. [C724]

## "Detection and Localization of Curbs and Stairways Using Stereo Vision"

We present algorithms to detect and precisely localize curbs and stairways for autonomous navigation. These algorithms combine brightness information (in the form of edgels) with 3-D data from a commercial stereo system. The overall system (including stereo computation) runs at about 4 Hz on a 1 GHz laptop. We show experimental results and discuss advantages and shortcomings of our approach. [C725]

## "A developed intelligent target recognition method by using wigner-ville time-frequency distribution"

{no data available} [C726]

## "Sensor data fusion in a simulated sensor environment"

This paper addresses the development of automatic target recognition (ATR) algorithms that have the potential to fuse information from multiple sensors to improve acquisition, tracking, and discrimination of threat objects in a simulated sensor environment. A powerful and versatile simulated sensor environment was created to investigate the ATR algorithms presented in this paper. ATR algorithms were chosen and implemented based upon a mid-course ballistic missile defense (BMD) scenario. Algorithms implemented include variations of the sample importance resample particle filter and Bayesian jump-diffusion. The particle filter algorithms handle detection and tracking for this scenario and performed to -10dB SNR for a single IR sensor and better than -18dB for fused IR sensors. The jump-diffusion algorithms were used for target discrimination and performed at as low as -1dB SNR for a single IR sensor and -1.5dB for fused IR and LADAR sensors [C727]

## "On SVM for classification of real and synthetic radar signatures"

This paper focuses on radar target identification using support vector machines (SVM). The radar features used in this study are impulse response features representing the down range profile of the target as seen by stepped frequency radar. The purpose of this paper is to shed additional light on the benefits of SVM in radar target identification (RTI) under various scenarios of adversity that are commonly addressed in the RTI literature. This paper attempts to maximize the performance of SVM in RTI but does not introduce new SVM kernels, or SVM training methods. The focus is on defining the rewards of SVM in target identification assuming a classifier that is presented with time domain signatures representing the target impulse response at a certain azimuth angle. In particular this paper focuses on assessing the SVM classifier performance in different scenarios, which are discussed in this paper [C728]

## "Dual-use bistatic multi-frequency HF radar for ship classification and mapping of oceanic currents and vector winds"

We discuss a dual-use bistatic HF radar design using multi-frequency operation over the HF band for ship classification and mapping of ocean current shear. The radar is based on a digital transceiver PCI card family that supports antenna arrays of four to 32 elements in a single PC computer, with larger arrays possible using additional PC. We show measurement and modeling examples of multiple frequency HF radar cross section (RCS) of ships to demonstrate target classification. Results of using 32 frequencies to measure the fine structure in ocean current vertical shear are also shown. [C729]

## "MBE grown mid-infrared HgCdTe avalanche photodiodes on Si substrates"

Modern weapon systems need to detect, recognize, and track a variety of targets under a wide spectrum of atmospheric conditions. They include stationary and mobile targets against complex backgrounds and landmines. A number of active systems like hybrid LIDAR-RADAR systems, heterodyne detection as well as passive systems like thermal imagers have been proposed and developed to meet this objective. Most ground-based and air-based systems would operate at long distances. The return laser signal from the target is not only attenuated by absorption, reflection and scattering by air-borne gas, dust and liquid particles, but also by the emissivity and reflectivity variations of the target surface. High bandwidth detectors with internal gain are required. Avalanche photodetectors (APDs) are best suited for this purpose due to their high gain-bandwidth characteristics. Robust silicon-APDs are limited to visible and very near infrared region, while InGaAs works well up to certain wavelengths. On the other hand, it is important to realize that the atmospheric attenuation is wavelength dependent. Local changes in the air density yield random fluctuations in the refractive index, diverging the laser signal. Consequently, longer wavelength (MWIR: 3-5mum and LWIR: 8 -12mu m) source-detector systems are required to overcome the practical and seasonal conditions of the atmosphere. Previous efforts on HgCdTe APDs has been based on expensive CdZnTe substrates . The paper reports on the first HgCdTe based MWIR (3-5mum) APD grown on Si substrates by molecular beam epitaxy(MBE) [C730]

## "Some new results of radar target identification using high resolution range profiles"

High resolution range profiles (HRRPs) are known to have many merits as feature vectors for radar target recognition. The increasing availability of high resolution radars has encouraged the study of automatic radar target recognition (ARTR) or identification (ID). The paper focuses on the impact on target ID rate of varied bandwidths at different SNR, and also on the mutual influence between the optimal bandwidth and the SNR, when HRRPs are used as the feature vectors for ARTR. Using radar target signature simulation software, target ID experiments were conducted with different target groups, varied radar bandwidth and varied SNR. The results show that: (1) the correct ID rate is affected by both bandwidth and SNR; (2) the optimal bandwidth varies for different SNR and different sized targets; (3) the greater the SNR, the smaller the optimal bandwidth; (4) for similar ID performance, small-sized targets require greater optimal bandwidth. A 3D surface of ID rate as a function of both radar bandwidth and the SNR is obtained. [C731]

## "Recognition of the predetermined random signals involving the unknown signals"

Some practical peculiarities of random signals recognition methods are considered for non-traditional cases when the signals with unknown probabilistic characteristics are presented for recognition along with the signals predetermined in a probabilistic sense. The distinctive peculiarities of the present work is that it considers the solution signals recognition problem on the basis of different probabilistic models-in the form of autoregression processes, mixtures of standard distributions, expansions in orthogonal functions of random signals. The data on decision of recognition problems are considered. In particular, that is decision the different problems of recognition signals for radio control, recognition of any types of targets by signals features using narrow-bend signals and recognition signals for medical diagnostic [C732]

## "A high accuracy calibration and receive instrument for TerraSAR-X ground calibration"

TerraSAR-X is a new Earth observing satellite which is launched in spring 2006. It carries a high resolution X-band SAR sensor. For high image data quality, accurate ground calibration targets are necessary. This paper describes a novel system concept for an active and highly integrated, digitally controlled SAR system calibrator. A total of 16 active transponder and receiver systems and 17 receiver only systems will be fabricated for a calibration campaign. The calibration units serve for absolute radiometric calibration of the SAR image data. Additionally, they are equipped with an extra receiver path for 2D satellite antenna pattern recognition. The calibrator is monitored by a dedicated digital control unit. For antenna pattern estimation, an algorithm is presented. [C733]

## "Analyse the ultra-band electromagnetic scattering system by MoM-2MBPE"

The natural frequencies (poles) of a scattering object is one of the basic characteristics used to target recognition. Usually, an iterative method is used to find the solutions of the matrix equation coming from the MoM (Method of Moments). However, the method is very time-consuming. Whereas MBPE gives excellent results over a wide frequency band, and is much more efficient than the conventional point-by-point approach, in this paper the system function is constructed by using the MBPE twice. Finally, the poles of the scattering system are analyzed. [C734]

## "Ground Surveillance Radar Target Classification Based On Fuzzy Logic Approach"

The fuzzy logic approach to the automatic classification of moving target detected by ground surveillance radar is presented in this paper. The real audio Doppler signatures of various targets are analyzed by spectrogram. As a result of analysis, input and output variables with corresponding membership function are defined. The set of fuzzy rules is established. The defuzzification of the output fuzzy set is performed by computing the "fuzzy centroid". The three target classes (walking man, running man and wheeled vehicle) are successfully classified [C735]

## "Real-time ISAR image synthesis of ballistic targets"

Digital image synthesis (DIS) is a specific counter-ISAR technique which employs a false target synthesized to deceive the imaging radar. To make the synthesized false missile images more actual, the distribution of the scattering centers for the according false object must be similar to the real-time ISAR images of a true BM over the whole trajectory. This paper presents a novel process to synthesize the images along the trajectory which is used as the false target to be synthesized. The kinematic model of the BM is developed firstly and the trajectory is calculated based on such a model. Then the RCS of the BM as a function of the flight time is calculated and the time-dependent ISAR image sequences along with the trajectory are formed. The real-time ISAR images of a ballistic target along its trajectory being used in false image synthesis can improve the counter-ISAR capability of the DIS [C736]

## "A high accuracy calibration and receive instrument for TerraSAR-X ground calibration"

TerraSAR-X is a new Earth observing satellite which is scheduled for launched in spring 2006. It carries a high resolution X-band SAR sensor. For high image data quality, accurate ground calibration targets are necessary. This paper describes a novel system concept for an active and highly integrated, digitally controlled SAR system calibrator. A total of 16 active transponder and receiver systems and 17 receiver only systems will be fabricated for a calibration campaign. The calibration units serve for absolute radiometric calibration of the SAR image data. Additionally, they are equipped with an extra receiver path for two dimensional satellite antenna pattern recognition. The calibrator is monitored by a dedicated digital control unit. For antenna pattern estimation, an algorithm is presented [C737]

## "Unscented Kalman filter design for curvilinear motion models suitable for automotive safety applications"

Research in automotive safety leads to the conclusion that modern vehicle should utilize active and passive sensors for the recognition of the environment surrounding them. Thus, the development of tracking systems utilizing efficient state estimators is very important. In this case, problems such as moving platform carrying the sensor and maneuvering targets could introduce large errors in the state estimation and in some cases can lead to the divergence of the filter. In order to avoid sub-optimal performance, the unscented Kalman filter is chosen, while a new curvilinear model is applied which takes into account both the turn rate of the detected object and its tangential acceleration, leading to a more accurate modeling of its movement. The performance of the unscented filter using the proposed model in the case of automotive applications is proven to be superior compared to the performance of the extended and linear Kalman filter. [C738]

## "2005 7th International Conference on Information Fusion (FUSION)"

{no data available} [C739]

## "Analysis of forward scattering radar for ground target detection"

This paper describes aspects of ground target detection using a forward scattering micro radar (FSR). It begins with a brief description of the system, followed by a more detailed analytical study of FSR in terms of power budget analysis and potential cross-range resolution. From this analysis, theoretical models are constructed and compared to the experimental data [C740]

## "Vehicle control classification and identification through ISAR imaging"

The great advantages arisen in millimeter-wave frequencies have made possible the development of high range resolution radars. The capability of using high bandwidths (Gigahertzs) increases the range resolution allowing the obtaining of target's radar signatures. Through these signatures some patterns of the targets can be extracted like its size, velocity or maybe some specific features which facilitates its recognition, classification and even identification. The increase in azimuth dimension obtained, like it is explained in this paper, thanks to Doppler processing, allows to get better estimations of the targets characteristics [C741]

## "A novel approach for the detection of punctual isolated targets by means of the wavelet transform"

The detection of an isolated localized structure in a noisy background, with no a priori information about its presence, nor its shape presents multiple drawbacks. Nevertheless, this problem is present in a great number of applications as, for instance, ship detection from satellite radar imagery. Conventional algorithms for ship detection are conceived to discriminate an exceptionally bright localized pattern according to an established decision rule, expressed by the determination of a threshold. But the adjustment of thresholds involved in the decision step is complicated and relies on the existence of a considerable contrast between the vessels and the surrounding sea clutter which is not always reached. Thus, a novel method, based on the intrascale dependencies between wavelet coefficients in the different subbands, is proposed, justified and successfully tested on simulated and real images. [C742]

## "Emitter Recognition using Fuzzy Adaptation of ARTMAP Neural Networks"

Emitter recognition is the problem of classifying the radar type from intercepted radar signals. This capability is crucial for classifying approaching enemy ships and aircrafts. The sensed parameters may vary from their actual or reported values because of man-made variations in the form of agility or staggering. Another cause of variation could be dispersion because of atmospheric effects and equipment noise. Associating the measured radar parameter set with a known sighting is a pattern recognition problem in a multi-dimensional space. Several authors have attacked the problem with various data association tools with different merits and de-merits. Most of them are marred by the massive computing power required and unrealistically large training data requirements. In this paper a simple but elegant technique is proposed to solve the above problem using well-established framework of fuzzy logic and neural networks [C743]

## "Segmentation and aspect estimation in SAR image of target chip"

{no data available} [C744]

## "Radar imaging of PEC targets using limited scattered information"

Electromagnetic scattering information of a PEC target has been popularly used in modern radar systems. Among all the kinds of aircraft detection theory, target imaging has attracted increasing interest because it can give more particular details of the shape or location of the aircraft than others. The theory of inverse scattering identity using physical optics (PO) approximation was discussed by N.N. Bojarski as early as in 1982. He established a Fourier transform relationship between the PEC target and a form of the scattering field, but the method is hard to satisfy in practice. We mainly discuss 2-dimensional (2D) target imaging. We introduce inverse scattering theory based on PO. We then discuss the influence of the limited frequency, and use Pade-extrapolation to approximate the scattering information in all directions around the target from the result of limited scattering directions, which can be conveniently obtained in practical applications. [C745]

## "Sonar processing for short range, very-high resolution autonomous underwater vehicle sensors"

In an attempt to improve manual and automated sea mine classification results, autonomous underwater vehicles (AUV) are being outfitted with short-range, very high-resolution sonar sensors. To improve pattern classification results in this regime, artifacts caused by platform motion, sonar beam pattern, and the ocean bottom clutter are first removed from the image. Several preprocessing steps for high-resolution imagery are developed and integrated to help isolate and discover the enduring features of high value targets. Classical denoising, segmentation, and feature-based equalization preprocessing techniques for target localization are adapted and demonstrated. [C746]

## "Implementation of artificial neural networks for recognition of target and clutter images"

It is presented the development and comparison of two systems for the recognition of the targets and of clutter by means use artificial neural networks (ANN). Images SAR (synthetic aperture radar) of targets and clutter were obtained using a detect system of potential targets CFAR (Bhanu, 2003). Three forms of ANN training were used. The first one consists of the net training with images that are not contaminated by noise. The second one is based on training of the net with images that have been contaminated by noise. And, the third form used training with different level of noise. The results show the capacity and differences of the systems in recognition of radar images. [C747]

## "An effective method for underwater target recognition"

To recognize the underwater target precisely is always a hard problem to all countries. In this paper, we

designed a genetic-based classifier system which recognizes targets utilize sonar fingerprints. Exceptionally some improvements have been designed on it. The proposed Comparing and Matching algorithm would give the fitness value more explicitly statistical meaning, which would make user easier to explain the rules with background knowledge. The proposed hyperplasia operator can handle those instances which were not emerged before. It gives the system persistent learning abilities, so the system may be more compatible with the surroundings. The proposed refining classifier merges redundant rules and shrinks the rule set In addition, an alterable mutation probability is set in the genetic algorithm, experiment shows that this strategy increased the speed and the accuracy of the classifying operation. Sonar fingerprint technology extracts unique feature from an echo, it is similar to that one's fingerprint can identify a unique person himself, dissimilar echo leads to different fingerprint. And all these have none business with the echo's store way (analog or digital) or format (WAV, MP3, WMA, RM, and etc). The proposed underwater target classifier system is highly automatic, with quite finite hardware requirements in operating. [C748]

## "Target detection in Rayleigh-distributed sea clutter environment based on Hough transform"

The detection and false alarm probabilities of the Hough transform-based detector for nonfluctuating and four types of Swerling fluctuating targets in the Rayleigh-distributed sea clutter environments are derived in this paper. Simulation scenario and procedure are designed. Then random data obeying Rayleigh distribution is generated as surrogate of the sea clutter. The performance of target detection in surrogate data environment based on Hough transform-based detector is analyzed through Monte Carlo simulation runs. The simulative results show that, for a specified PD which is greater than 0.5, the target model sorted ascending for the required SCR is Swerling II, IV, nonfluctuating, Swerling III, I. [C749]

## "Using improved SVM decision tree to classify HRRP"

Radar target classification by using high resolution range profile (HRRP) as features has been studied in this paper. Support vector machine (SVM) has been used in range profile classification for its good generalization ability for the pattern classification problem with high feature dimension and small training set. In order to perform multi-class classification, decision-tree-based SVM has been studied. Based on the analysis of the structure and the classification performance of the SVM decision tree, and by introducing the defined separability measure that based on the distribution of the training samples into the formation of the decision tree, an improved algorithm for SVM decision tree has been proposed. The scheme of using the improved algorithm for SVM decision tree to classify HRRP has been studied. Experiments using the simulated range profile datasets prove the effectiveness of our scheme. [C750]

## "Linear and nonlinear spatial selection methods for small low speed target in sea clutter observation improvement"

In the process of detection of small surface objects in clutter, some specific problems appear. The main cause is the fact that useful signal amplitude is commensurable and in some cases is less than the amplitude of reflections. Most of all, for slow surface objects the desired signal spectrum is situated inside the sea clutter one. In that case, both spectral and amplitude selection and detection methods become ineffective. As is known, signal reflected from the sea surface is characterised by spatial periodic structure. At the same time, sizes of most surface objects do not exceed a radar resolution element and they can be considered as dotted ones. Therefore, to improve radar observation of small objects in sea clutter, it is possible to use information about noise spatial performances. The usage of spatial periodicity of sea-echoes allows one to improve efficiency of the small low speed targets in sea clutter observations. [C751]

## "Automated texture recognition system based on 2D minimum variance spectral estimation"

The primary feature of any image texture is the spatial frequency content. This paper proposed the use of a 2D minimum variance spectral estimation (MVSE) method for recognizing target multispectral image textures. The power spectral density of the target texture is estimated via MVSE. This estimate is then used as a feature to discriminate between target and nontarget textures. A remotely sensed multispectral image of a row crop agricultural field is analyzed and, the corresponding results are presented to illustrate the applicability of the proposed technique. [C752]

## "L-band SBR moving target detection in SAR-GMTI modes"

Space Based Radars (SBR) are being considered for a wide range of area surveillance tasks due to the global, all weather capability to image and detect moving targets. SBR has the capability of detecting either slow moving ground targets or high speed airborne targets, in addition to the familiar synthetic aperture radar (SAR) imaging mode. However, due to the high satellite velocity and long wavelength of an L-band SBR, detection of slow

moving targets is very difficult. Two radar modes are being considered: Multiple-Channel Ground Moving Target Indication Space Time Adaptive Processing (GMTI STAP), and Along Track Interferometry (ATI) SAR. The system implications and mode requirements are reviewed for efficient wide area surveillance. [C753]

## "SAR image segmentation by 2-D fussy entropy"

In the process of SAR (synthetic aperture radar) ATR (automatic target recognition), segmentation is the core procedure. In this paper, analyzing the characteristics of SAR images, we introduced a new method for segmenting SAR images. The method is based on 2D c-partition fussy entropy and adaptive genetic algorithm. 2D fussy entropy is used as the fitness function, and adaptive genetic algorithm is used for optimizing thresholds. The results of the segmentation procedure are presented in this paper and it shows a promising output [C754]

## "Improving landmine detection using frequency domain features from ground penetrating radar"

Landmine detection is an important and yet challenging problem remains to be solved. Ground penetrating radar (GPR) is an effective sensor to detect landmines that are made of plastic or have low metal content. Most GPR signal processing algorithms apply processing in the time (depth) domain. This paper proposes to use the frequency domain features from the GPR signal to improve the detection of weak plastic mines and to reduce the number false alarms due to clutter objects. The motivation comes from the fact that the energy density spectrum may be different between mine targets and clutter objects, although both may have strong GPR signal return in the time domain. Experimental results based on clutter lane data collected at a test site corroborate the effectiveness of the proposed spectral features to increase the accuracy for landmine detection [C755]

## "High resolution DBS imaging and the moving target trajectory forming with raw SAR/GMTI Data"

DBS (Doppler beam sharpening) technique is widely used in military. In this paper, the basic theory of DBS imaging is introduced at first, and a conclusion is reached by analysis that range cell migration correction technique and azimuth dechirping technique can improve image quality effectively on SAR/GMTI (synthetic aperture radar/ground moving target indication) mode. And it is possible to form the moving target trajectory on the image because of the high resolution. Lastly, some satisfactory results based on the raw radar data are presented [C756]

## "On the debugging of a high clutter tracking system"

The Raytheon High Clutter Tracker (HCT) enables conventional marine radars to detect and track small targets such as swimmers, life rafts and open boats in heavy seas and at long range. In this article a general introduction to the project is given. Then, three debugging and diagnosis software tools are presented. Examples are given to demonstrate the ideas and how the tools are helpful for real world system diagnosis and system performance tuning up. [C757]

## "Pulse compression radar processing based on atomic function windows"

In this work we have tested the use of atomic functions (AFs) in pulse compression radar applications.The results obtained during the windowing show that by applying AF fup6(x) we can achieve very similar characteristics as in the case of the Hamming function use. The advantage of this AF usage in comparison with Hamming windowing is the lower main lobe width. This can help to, detect sufficiently small targets. For more side-lobe reduction it is convenient to apply AF Fup9(x). This paper has also presented the architecture for radar receiver that can be used in wide radar applications. [C758]

## "Ultra wideband radar targets discrimination using frequency domain E-pulse method"

A frequency domain approach to the E-pulse radar target discrimination technique is introduced. This approach allows the interpretation of E-pulse convolution via the E-pulse spectrum. The addition of extra zeroes to the E-pulse structure has been suggested and its influence on increasing the discrimination accuracy has been proved. The results of discrimination scheme digital simulation by using the characteristics of the E-pulse parameters for known targets are presented. [C759]

## "Anomaly detection based on an iterative local statistics approach"

We introduce an iterative anomaly detection algorithm. The algorithm is based on an iterative characterization of the clutter in a feature space of principal components, and a single hypothesis scheme for the detection of anomalous pixels. The iterative procedure gradually reduces the false alarm rate while maintaining a high

probability of detection. Morphological operators are subsequently employed for extracting the sizes and shapes of anomalous clusters in the image domain, and identifying potential targets. Experimental results demonstrate the robustness of the proposed approach with application to sea-mine detection in sonar imagery. [C760]

## "Technique of ultra wideband radar target discrimination using natural frequencies"

An aspect independent radar target discrimination method based on the natural frequencies of ultra wideband radar targets is introduced. The sets of points in a multi-dimensional space corresponding to the poles on a complex plane (natural resonances) were offered as signatures of radar targets. This approach allows performing the automated discrimination algorithm of radar targets. The results of experimental research of the signals scattered by scaled aircraft models using the signatures algorithm and cumulant preprocessing are presented. [C761]

## "The arrival angle performances for signals scattered by the targets and sea surface and their usage for detection efficiency improvement"

The target angular noise is used for detection reliability improvement or as a criterion for pattern recognition. The experimental research of angular fluctuations is conducted using the impulse 8 millimeter-wave radar. Results have shown that the small surface target signals are characterised by a much smaller range of azimuth fluctuations in comparision to that of from the sea surface. While the average value of the surface target bearing coincides with right direction and has a rather small variance of fluctuations, the marine surface is characterised by arrival angle roaming in the limits of the whole highlighted area. Application of the angular noise for target detection is based on its statistical performance modification, when the compact reflector (surface target) appears on the background of spatially distributed sea surface reflections. [C762]

## "Architectural design issues for Bayesian contextual vision"

Sensor fusion technology has been so far developed for the fusion of camera and different sensors, e.g. radar, sonar, etc. The same techniques apply to integrating several vision algorithms into a multi-modular system. In this paper, we abstract our attempt on the matter and propose a uniform paradigm to integrate both "vision modules" directly observing targets (e.g. intruders in video surveillance) and "accessory modules" observing scene features that may trigger system adaptation to the current context. To be concrete, we completely develop a real example in re-designing a previous context-dependent video surveillance system. [C763]

## "Joint Doppler and polarization characterization of moving targets"

In through-the-wall imaging radar systems, the synthesized images may not provide sufficient range and cross-range resolution for visual classification and identification of the targets. Target movement and target Doppler characteristics can be used to combat resolution limitations and improve object discrimination. However, slowly moving targets and targets moving perpendicular to the incident waves render target motion ineffective in high-resolution imaging. We utilize the target's polarization properties and introduce time-varying polarization signature estimation based on polarization time-frequency distribution. [C764]

## "Radar backscatter analysis using fractional Fourier transform"

This paper focuses on analyzing radar backscatter returns using the fractional Fourier transform. This study is motivated by two factors: first, to examine the radar backscatter mechanism of standard small targets; and second, to extract pertinent scattering features that can be used in target recognition. Radar returns have been examined using time-frequency analysis techniques, particularly those targets with dispersive scattering behavior. The FrFT scattering analysis scheme is tested using real radar signatures of commercial aircraft recorded in the UHF range. [C765]

## "Target classification based on near-distance radar sensors"

Automotive radar systems offer the capability to measure very accurately target range, relative velocity, and azimuth angle of all objects inside the observation area. For future automotive applications like pedestrian safety systems, collision warning, turning-off and lane-changing assistance it will be necessary to have more detailed information about the target type. Therefore, a target classification technique, which is purely based on the range profile measured by a near-distance radar sensor, is presented in this paper. [C766]

## "A method for detecting RGPO/VGPO jamming"

This paper proposes a general approach to detect the presence of deceptive counter measures such as RGPO

or VGPO. The method which is based on the Kalman filter lays its foundation on drift between Doppler measurement and the Doppler information obtained from the range measurement of a target in track. By measuring this drift by Mahalonobis distance metric and comparing it with a predefined threshold; detection is performed. The performance of the proposed approach is illustrated through a simulation. [C767]

## "Target Tracking 2004: Algorithms and Applications"

First Page of the Article [C768]

## "Solid or not solid: vision for radar target validation"

In the context of combining radar and vision sensors for a fusion application in dense city traffic situations, one of the major challenges is to be able to validate radar targets. We take a high-level fusion approach assuming that both sensor modalities have the capacity to independently locate and identify targets of interest. In this context, radar targets can either correspond to a vision target- in which case the target is validated without further processing- or not. It is the latter case that drives the focus of this paper. A non-matched radar target can correspond to some solid object which is not part of the objects of interest of the vision sensor (such as a guard-rail) or can be caused by reflections in which case it is a ghost target which does not match any physical object in the real world. We describe a number of computational steps for the decision making of non-matched radar targets. The computations combine both direct motion parallax measurements and indirect motion analysis- which are not sufficient for computing parallax but are nevertheless quite effective- and pattern classification steps for covering situations which motion analysis are weak or ineffective. One of the major advantages of our high-level fusion approach is that it allows the use of simpler (low cost) radar technology to create a combined high performance system. [C769]

## "Comparison of the radar clutter cancellation performance of post- and pre-Doppler STAP for ground moving target identification from an experimental airborne surveillance radar"

Within this paper we report our study that compared the performance of pre-Doppler and post-Doppler STAP processing algorithms applied to the same radar trials data, collected by QinetiQ's Enhanced Surveillance Radar. The performance of these algorithms was quantified by clutter cancellation ratios and target signal improvement factors (the ratio of the signal to clutter plus noise ratios with and without STAP processing). We have shown that pre-Doppler and post-Doppler STAP may be tuned to give the same level of clutter cancellation. We present results in which bright target signatures are seen to affect the STAP processors and reduce the overall clutter cancellation. We have found that for our two phase center trials radar data, PRI staggered post-Doppler STAP gives greatly enhanced clutter cancellation compared to the simple fixed window post-Doppler STAP. The application of either moving window or auxiliary bin post-Doppler STAP was found to degrade the processor output. The importance of normalizing the final range Doppler map to prevent the amplification of thermal noise and remove the weight-norm variation as a function of Doppler is shown to be a critical step to allow interpretation and application of detection algorithms after STAP processing. [C770]

## "A Monte Carlo simulation based approach to a priori performance prediction for target detection and recognition in cluttered synthetic aperture radar imagery"

Multi-sensor systems for wide area surveillance and tracking are an area of increasing interest for civil and military applications. In order to design these systems to reliably achieve a specification, performance models are required for each of the system components, to allow synthesis of the overall system performance. The work presented in this paper addresses the problem of a performance model for the target detection and recognition performance of a SAR sensor component in a surveillance system. A Monte Carlo simulation based approach is described which is used to predict the receiver operating characteristic (ROC) as a function of the target, the clutter background and the sensor specification for a template matching recognition algorithm. Some initial results from an experimental validation trial are presented and it is concluded that there is sufficient similarity between the current model's predictions of performance and the actual performance achieved with representative real data to encourage further development work. [C771]

## "Vector-entropy reconstruction algorithm for SAR"

The biggest problem for automatic target recognition is the accurate and efficient extraction of features from - synthetic aperture radar (SAR) images. A new SAR image formation algorithm, which is recognition oriented is developed. The algorithm is based on a tomographic projection model of SAR observation, using vector-entropy optimization approach to reconstruct SAR images from projections. It provides images with higher resolution of scatters and better separate ability of different regions than traditional algorithms. We applied it on both synthetic

SAR scenes and the data from MIT Lincoln Laboratory ADTS dataset to show the validity of the algorithm. [C772]

## "Coherent radar in short millimeter wave band"

In this work, the coherent properties of a generator radiation in a near range radar. coherent signals, scattered by hydrometeors, vegetation and moving objects were studied. The structural constant nonstationary frequency fluctuations determines the coherent properties of radiation in near range radar. For moving target recognition the ranking features were formed. The coherent radars has wide applications in the design of industrial sensors. [C773]

## "Proceedings of the Thirty-Sixth Southeastern Symposium on System Theory (SSST04) (IEEE Cat. No.04EX792)"

{no data available} [C774]

## "A multiple hypotheses testing approach to radar detection and pre-classification"

This work presents a single-scan-processing approach to the problem of detecting and pre-classifying a radar target that may belong to different target classes. The proposed method is based on a hybrid of the maximum a posteriori (MAP) and Neyman-Pearson (NP) criteria and guarantees the desired constant false alarm rate (CFAR) behavior. The targets are modeled as subspace random signals having zero mean and given covariance matrix. Different target classes are discriminated based on their different signal subspaces, which are specified by their covariance matrices. Performance is investigated by means of numerical analysis and Monte Carlo simulation in terms of probabilities of false alarm, detection and classification. The extra signal-to-noise power ratio necessary to preclassify a target once a detection has occurred is also derived. [C775]

## "Millimetre Wave RADAR spectra simulation and interpretation for outdoor SLAM"

Millimetre Wave RADARs are more robust than most other sensors used in outdoor autonomous navigation in that their performance is less affected by dust, fog, moderate rain or snow and ambient lighting conditions. This paper describes a method to accurately simulate the range spectra using the RADAR range equation. This is very important in robot navigation (eg. SLAM) for generating predictions of what can be observed from different sensor locations and correspondingly, providing an interpretation for observed targets. To understand the MMW RADAR range spectrum and to simulate it accurately, it is necessary to know the noise distributions in the RADAR spectrum. A detailed noise analysis during signal absence and presence is carried out which shows various sources of noise affecting MMW RADARs. RADAR range bins are then simulated using the RADAR range equation and the noise statistics and are compared with real results in controlled environments. It is demonstrated that it is possible to provide realistic predicted RADAR power/range spectra, for multiple targets down range. Feature detection from the RADAR spectra based on target presence probability is then explained. The detection technique uses binary hypothesis testing. Results are shown comparing a new probability based feature detection with other standard feature extraction techniques such as constant threshold on raw RADAR data and Constant False Alarm Rate (CFAR) techniques. The results show that the proposed algorithm is more robust compared to other detection techniques as it does not require human assistance. This work is a step towards robust outdoor SLAM with MMW RADAR based continuous power spectra. [C776]

## "A robust algorithm for automatic target recognition using passive radar"

The goal of this research is to add automatic target recognition (ATR) capabilities to existing passive radar systems. We do so by comparing the radar cross section (RCS) of detected targets to the precomputed RCS of known targets in the target class. The precomputed RCS of the targets comprising the target class is modeled using a multi-step process involving programs such as the fast Illinois solver code (FISC). Advanced refractive effects prediction system (AREPS) and numerical electromagnetic code (NEC2). A Rician likelihood model compares the power profile of the detected target to the precomputed power profiles of the targets in the target class; this comparison results in target identification. Thus far, the results of simulations are encouraging, indicating that the algorithm correctly identifies aircraft with high probability at the anticipated noise level. Performance can be expected to decline as the noise power surpasses the maximum signal power. [C777]

## "Clutter statistical analysis for high resolution SAR data"

The ONERA RAMSES system (Radar Aeroporte Multi-spectral d'Etude des Signatures) is a flexible SAR system in constant evolution developed mainly as a test bench for new technologies and to provide specific data for TDRI (Target Detection, Recognition and Identification) algorithm evaluation. It is flown on a Transall C160

platform operated by the CEV (Centre d'Essais en Vol). Recently, the system was upgraded to include a very high resolution mode in X, Ku and Ka bands. The resolution cell is then only a few wavelength wide and the usual hypothesis underlying the speckle phenomena, i.e., a large number of scatterers per resolution cell, is not verified. This work presents the analysis made on the clutter statistical behavior and contrasts the change of behavior observed when shifting from medium resolution to high resolution to very high resolution. It is based on actual radar data acquired with the RAMSES radar system. A new parameter identifying the largest spatial resolution for which the natural surface can no longer be considered homogeneous (in a speckle based criteria) is proposed. This parameter characterizes the scale of the contributing scatterers. [C778]

## "An efficient Bayesian algorithm for joint target tracking and classification"

It is pointed our in this paper that a more appropriate description of the joint target tracking and classification (JTC) problem would be the simultaneous probability density function (pdfs) of target state and target class instead of the joint target state-class pdf. In this paper, models of different classes are combined info a unified set. The Bayesian optimal JTC algorithm based on pdfs of target state and target class is derived, which integrates a Bayesian multiple-model filter and a Bayesian classifier. Also given is a suboptimal JTC algorithm with much lesser computational complexity, which is suitable for real-time application. Simulation results reveal that the proposed JTC algorithm provides a theoretically attractive solution to a class of joint target, tracking and classification problems. [C779]

## "Influence of magnitude of target range profile on discrimination of baseline-based classifier"

The influence of the magnitude of radar target range profiles on the performance of the classifier based on the baseline method is studied. Then, a novel conception of the factor for magnitude registration is introduced with its formulation presented by the optimization. The computer simulation results show that employing the factor of magnitude registration apparently reduces the matching error and improves the performance of the baseline method. [C780]

## "Visual effects based feature extraction for dynamic radar target echo series"

Feature extraction is of great importance in radar target recognition. The extraction of effective and reliable features is fundamental and critical for the construction of target recognition systems. It is difficult to build target scattering models rigorously for regular low-resolution radars abiding by electromagnetic theories. Based on the observation and analysis on a large number of real-life data, and taking the thinking process and the description method of radar operators for reference, a set of feature extraction methods basing on visual effects for dynamic radar target echo series have been introduced. The application of these methods in multiple radar target recognition projects has testified their effectiveness and robustness. [C781]

## "UWBWA SAR imaging modeling and its time-frequency processing"

In the ultra wideband, wide-angle synthetic aperture radar (UWBWA SAR) imaging, scatterers often perform the aspect angle and frequency dependent reflectivity character, which usually is neglected in traditional imaging processing. A UWBWA SAR imaging model is studied in this paper first. Based on the model, a new imaging format with time-frequency processing is proposed. The new imaging format can extract the aspect angle and frequency dependent information of scatterers, which is valuable in targets recognition. Simulations show the precision of information extraction using the new imaging format. [C782]

## "Stochastic boats generated acoustic target signal detection in time-frequency domain"

This paper is devoted to theoretic algorithms development and experimental research of automatic target detection of acoustic signals, especially for boats generated signals. In this paper, an observation space is created by sampling and dividing input analog acoustic signal into multiple frames and each frame is transformed into frequency domain. In the created observation space, a median constant false alarm rate (MCFAR) and post detection integration algorithms have been proposed for an effective automatic target detection of boat generated acoustic signals, in which a low constant false alarm rate is kept with relative high detection rate. The proposed algorithms have been tested on real boat generated acoustic signals. The statistical analysis and experimental results showed that the proposed algorithm has kept a very low false alarm rate and relatively high detection rate. [C783]

## "Feature extraction and selection based on ATR of ISAR image"

In this paper, based on auto target recognition (ATR), two kind of feature in ISAR images are extracted: Fourier-transform coefficients feature and wavelet-transform coefficients feature. Three kinds of targets ISAR images

were done some recognition study based on the exact nearest neighbor algorithm and those extracted features. Experimental results show these two methods are effective. [C784]

## "Confusion relationship between patterns and its application in adaptive construction of hierarchical classifiers"

The hierarchical relationship and the objective patterns of subclassifiers is the primary difficulty to construct a hierarchical classifier. In order to solve this problem, firstly, the confusion relationship between patterns has been defined to describe the interweaving effects of patterns in the decision domain. Then a measurement of the relationship has been proposed by utilizing the confusion matrix. Abiding by the Fisher Principle, a multipattern confusion relationship analysis machine (MPCRAM) has been designed to adaptively construct the structure of a hierarchical classifier. Various data scenarios have been used to compare the hierarchical structures generated with the MPCRAM and the conventional ways. The results have testified that MPCRAM was effective, and it could prominently improve the performance of a hierarchical classifier. [C785]

## "Time-frequency analysis of polarimetric vector signal and its application in radar target recognition"

The time-frequency analysis technology for polarimetric vector signal is discussed in this paper. Considering the particularity of polarimetric vector signal, a series of time-frequency transforms for this kind of vector signal are presented. With these transforms, both the description of its energy property and of its polarization property can be obtained in the time-frequency domain, while using conventional methods, only the former can be obtained. Then, we apply these new methods to target recognition experiment, and the recognition results show that these new methods have better performance than conventional ones. [C786]

## "A new pixel-level multi-focus image fusion algorithm based on evolutionary strategy"

A new method is developed to merge two spatially registered images with diverse focus based on multiresolution wavelet decomposition and evolutionary strategy (ES). At first, the wavelet decomposition without down-sampling is used to perform an addition of wavelet high-frequency components of each image. Then, in terms of difference of area-based energy feature in two original images, ES is adopted to partition the region and perform the fusion. The experimental results show that the proposed method can achieve better fusion performance than wavelet transform (WT) method. [C787]

## "Influence of information technology on military radar systems"

The paper discusses influence of information technology (IT) on military radar systems and how this impacts upon conducting military operations. Applications of new technologies in three basic areas of military radar systems are considered: surveillance and automatic target recognition systems; tracking systems and data and signal processing. Some possible uses of radar data are shown along with how this will improve the efficacy of planning, coordinating, directing and controlling of military actions. [C788]

## "3D object recognition using ISAR image"

We propose a 3D object recognition method using inverse synthetic aperture radar images, which doesn't need any aspect information. It employs a simple support vector machine of linear kernel. Numerical experiments clarified that when the movements of the targets are ideally or practically compensated, it recognizes cones with up to 90% accuracy and cylinders with up to 100% accuracy. [C789]

## "Research on the underwater laser fuze target detecting technique"

Regarding a submarine as the target object, with blue and green laser as the detecting field, This work completes the design of an underwater laser fuze for a torpedo. It establishes an underwater target identification standard, an anti-interference standard and a direction identification standard, which can be used as the basic fuze signal handling standard. Using this standard as a foundation, the signal handling electronic circuit was designed. As proof, this project can satisfy the requirements of the underwater laser fuze war skill index. [C790]

## "A new GPR targets feature extraction based on kernel method"

A new ground penetrating radar target feature (GPRTF) extraction method based on kernel method is proposed. This paper also explains that the unsupervised methods (PCA or KPCA) aren't fit for the GPRTF extraction. The conventional GPRTF extraction method is the LDA (also called as FDA).It can minimize the within class scatter and maximize the between class scatter, but it extracts the GPRF in the low dimension GPR data space and the discriminability is limited. The kernel method can map the GPR data to the high dimension space by the non-

linear transformation and can so enhance the discriminability. Combine the virtue of the kernel and the LDA and make up for the flaws of them will benefit for the GPRTF extraction. The treatment comparisons of the measurement data show that the method proposed is superior to the others. [C791]

## "Multiscale segmentation of SAR imagery with bootstrap sampling"

In this paper, the main focus is on application of bootstrap method for segmentation of SAR imagery based on the multiscale dynamic model. Given an original SAR images, we randomly select a small representative set of pixels. Then, multiscale autoregressive (MAR) model, which captures multiscale stochastic structure inherent in SAR imagery, is used for SAR imagery segmentation. The results we obtain show that our method based on bootstrap sampling gives better results than the classical one both in the quality of the segmented image and the computational time. [C792]

## "A new chirp-coded radar waveform"

A new chirp-coded radar waveform (ICC-2) is introduced, relative to the old type intra-pulse chirp-coded (ICC-1) waveform described by Xu Qing (Syst. Eng. and Elect., vol.12, p.7-8, 2000). The waveform forming, ambiguity function and match filter output are discussed. From the discussion, it is found that the ICC-1 can achieve higher resolution than chirp and phased code waveforms and ICC-2 is not suitable for target position radar. The reasons are given by analyzing the spectrum, ambiguity function and match filter output. Finally, it is indicated that through some restructuring, ICC-2 can achieve good performance by stepping frequency etc. It is useful in radar target identification applications. [C793]

## "Recognition of objects on their complex natural resonance at ultra wideband sounding"

In this report, the RSO (radar subsurface objects) complex resonance frequencies are used as features of their recognition proposed. From these features the basis of the prior information about identifiable object scattering characteristics is described. However, for practical implementation of described algorithm of RSO recognition it is necessary to explore and to take into account effect of some complicating factors such as deformation of observed data. Thus from this report the algorithm of recognition of RSO is designed. [C794]

## "Comparative analysis of the narrowband and wideband methods of target recognition"

Results of comparative study of radar recognition with the use of narrowband and wideband signals as well as various recognition signatures are presented. The advantage of wideband radar signals is emphasized. The results show that use of wideband signals allow increasing the accuracy of radar measurements and radar immunity against interference providing the same detection range. [C795]

## "Natural resonance frequency extraction using an early-time and late-time responses combined technique"

In this paper, a pole extraction method using an early-time and late-time responses combined technique is presented. Without the determination of the beginning of the target transient response, the proposed method assumes an ARMA representation to approximate the complete target transient response, and a total least square method is applied to poles extraction. The proposed method is validated using a measured scattering data of a thin wire and a finite cylinder. The processing results show that the proposed method is superior to the KT method and matrix pencil method in an appropriate SNR [C796]

## "Simulation of target detection using a high range resolution radar"

The use of wideband radar signals is sometimes more preferable for solving not only the tasks of target resolution, recognition, measurement, and the illumination stealth, but the traditional task of detection too. The latter is due to the decreased fluctuations of echoes. However, if the signal has an excessively wide bandwidth, the losses of noncoherent integration increase and the threshold signals rise. We investigate the detection threshold signals for the targets of different sizes, for illumination signals of various bandwidths, and for detection of different type. [C797]

## "A highly automatic underwater target classifier system"

Due to the complicated watery environment and the limitation of the detecting method to the underwater target, recognizing them precisely is always a hard problem to all countries. In this paper, we design a genetic-based classifier system (CS), which recognizes a target utilizing audio fingerprints. Audio fingerprint technology can extract some unique feature from a given sound clip, and it is similar to that one man's fingerprint can identify a

unique person himself, dissimilar sound leading to different fingerprint. All these have none business with the sound object's store way (analog or digital) or format (MP3, WAV, WMA, etc.). Compared with traditional CS, the proposed comparing and matching algorithm would give the fitness value more explicitly statistical meaning, which would make us easier to explain the rules with background knowledge. The proposed hyperplasia operator can handle those instances, which have not been emerged before. It gives the system persistent learning abilities, so the system may be more compatible with the surroundings. The proposed refining classifier merges those redundant rules and shrinks the rule set. In addition, we set an alterable mutation probability to the genetic algorithm in the CS, and the experiment shows that this strategy increases the speed and the accuracy of the classifying operation. We propose a highly automatic underwater target classifier system, and we keep improving it. We expect it can be competent in the recognition with minimum hardware requirements. [C798]

## "Wideband radar (advantages and problems)"

Review of advantages and problems of wideband radar is given. Some criteria of wideband (UWB) radar are discussed to avoid misunderstanding when only the relative signal bandwidth is used as a criterion. Brief historical outline of the first and follow up experiments by different authors is presented. Advantages and disadvantages of bandwidth widening can be compared using the computer simulation of scattering. Experience of various simulation methods use, their applications to the target detection, tracking and recognition problems are briefly discussed and compared with experiment. Interference immunity, electromagnetic compatibility, stealth of radiation (low probability of intercept- LPI) for radar, and the possibility of creation of antiLPI passive radar are also discussed. [C799]

## "Neural recognition of aerial target types using a high range resolution radar"

The combination of the least mean squares and back propagation training procedures for the ANN training is considered on the example task of recognition between 11 types of aerial objects using a high range resolution radar (HRR radar) allowing to obtain single range profiles (RP) or trains of RPs. Results of simulation are presented. [C800]

## "Synthetic aperture radar image signatures of rotating objects"

This work develops the theory of image signatures of rotating objects in synthetic aperture radar images. The mathematical results are similar in form to the expressions describing vibrating objects. The differences lie mainly in the fact that the expansion parameters in the phase for rotating objects are typically too large to be expanded to first order, as is done in the micro-Doppler vibrational image analysis. These results have potential application in target recognition systems, as rotating components of larger targets cause specific types of identifiable image aberrations. [C801]

## "A parametric scattering centers model with frequency dependence for radar target recognition"

This paper shows that the scattered field data collected by using a radar with narrow bandwidth and small aspect angle sector is suitable for fast and handy radar imaging and recognition. Based on the conditions of low-resolution radar, a parametric model for the 2D radar target is described according to the theory of electromagnetic scattering and the geometrical theory of diffraction. A high-resolution estimation algorithm to extract the model parameters is developed by building the relation of the scattering model and Prony model. The simulated analysis shows that the accurate extraction of the diffraction coefficient of the scattering center is restricted by SNR, radar center frequency and bandwidth. [C802]

## "A method for characterizing a target in polarimetric radar remote sensing"

A method for characterizing a target is proposed in this paper, based on the eigenvalue decomposition of a scattering matrix. From this method, a set of parameters is derived. The parameters are not only independent of the spans of the scattering matrices, but also independent of the target orientation angles. With these parameters, we enhance the contrast between the road and forest of a SAR image, demonstrating the effectiveness of the proposed parameters. [C803]

## "Detection and velocity estimation of aircrafts in bistatic radar data using target back propagation technique"

"Target Back Propagation Technique" overcomes the problem occurring when radar targets migrate out of the resolution cells during scan integration time for surveillance radars. This paper addresses the technique where the idea is simply to back propagate possible targets with different velocities over the scans selected for integration and then detect the strongest response. Sampled radar data containing 6 aircrafts is presented. The

technique is used on an image with bistatic geometry averaged over 3 scans and with target back propagation locally applied for each aircraft. All aircrafts are sharpened in the image and this illustrates the usefulness of the "Target Back Propagation Technique", even if just three scans are used. [C804]

## "Proceedings. 33rd Applied Imagery Pattern Recognition Workshop"

{no data available} [C805]

## "Joint target recognition and tracking using class specific features"

Recognition and tracking ground targets using measurements from ground moving target indicator (GMTI) and high range resolution (HRR) profiles are considered jointly to enhance both the discrimination and tracking capability for closely-spaced targets. We propose a feature extraction technique based on the target kinematic information from the target state estimator. The classifier matches aspect angle dependent target features for different target types and provides target type information to the tracker. The likelihood of target type is incorporated into the assignment cost to solve the measurement-to-track association problem and improve the tracking accuracy. Results using HRR profiles from the MSTAR data set and GMTI measurements show that both target recognition and tracking accuracy are significantly improved compared with those using the classifier and tracker alone. [C806]

## "Minimizing uncertainty in determinants and ratios of determinants for invariant relationships employed in SAR imagery pattern recognition"

Invariant relationships involving ratios of determinants have been proposed for the classification of an object in SAR imagery. The target detection decision-making process depends on the uncertainty involved in the measurements. At fixed experimental resolution, some determinants are simply better than others because they are much less sensitive to uncertainty. A geometrical interpretation of determinants is applied to assess the minimum relative uncertainty expected for a determinant employed in invariant relationships. Because much larger relative uncertainties can occur in some determinants, a method based on the perturbation of eigenvalues is proposed to identify determinants that are less sensitive to element errors. Symmetric alpha-stable probability distribution functions are employed to characterize error distributions in ratios of determinants. [C807]

## "Multi-targets for high-resolution range profile of radar based on fuzzy support vector machine"

Multi target recognition of high-resolution 1D radar image is proposed in this paper based on the fuzzy support vector machine. The four classes of finite real measured data of radar range profile image are recognized. Better simulation results were obtained compared with the traditional support vector machine approach. It is showed that the improved fuzzy support vector machine has the characteristics of simpler calculation and better testing correctness. [C808]

## "Computer simulation of target backscattering as element of perspective radar design"

Method of computer simulation of aerial target backscattering is described. It is used for comparative study of wideband and narrowband radar signals in application to radar recognition, detection, coordinate measurement, and tracking. It is shown on the basis of examples that computer simulation becomes an important element of the perspective radar design. [C809]

## "Radar cross section reduction of dihedral and trihedral comer reflectors coated with radar absorbing materials (8-12 GHz)"

Corner reflectors form the major scattering centers in the radar signatures of ships, aircraft and vehicles. The radar cross section (RCS) reduction of these "flare spots" (corner reflectors) plays an important role in the design of these targets with reduced detectability in radar. This paper deals with the RCS reduction of square dihedral and trihedral corner reflectors, coated with radar absorbing material (RAM). The measurements were carried out in an anechoic chamber at Centro Tecnico Aeroespacial (CTA)-Ministerio da Defesa facilities, and the RAM coating was manufactured at Divisao de Materiais of Instituto de Aeronautica e Espaao (IAE)/CTA. The processed RAM applied on a flat plate was evaluated by reflection coefficient measurements by using the RCS self-calibrated technique. [C810]

## "Small target detection using enhanced SAR images"

This paper investigates the impact of SAR image enhancement on the performance of small target detection in SAR images. Three SAR image enhancement algorithms are evaluated on large SAR image data-sets. The

evaluation results show that image enhancement can greatly improve the performance of false alarm mitigation, and that the level of performance improvement is correlated with the resolution and background suppression of the enhanced images. The higher the resolution and the level of background suppression, the higher the level of performance improvement. [C811]

## "Automatic target recognition of slow moving ground targets using stap"

First Page of the Article [C812]

## "Vehicle identification technique using active laser radar system"

This paper describes a laser radar system equipped with a laser range finder and mounted on pan-tilt equipment. We propose a method for estimating vehicle direction using this system, and report experiments designed to confirm that the direction could be estimated to within four degrees. In addition, we measured vehicle shapes using the estimated results, and distinguished the vehicle model, thus confirming the effectiveness of our laser radar system. [C813]

## "Intelligent target recognition based on hybrid support vector machine"

In this paper we presented a new method of adaptive projective algorithm to improve the speed of SVM classifier. The idea is to pre-extract support vector from training pattern, so that the classification speed is increased with the same performance. Besides this method, the modifying kernel function method is used to achieve high precision approximation. Therefore a novel hybrid support vector machine based on adaptive projective algorithm and modifying kernel functions method for the intelligent target recognition can increase the generalization ability and the speed. It is shown that the radar target data can be classified, and consequently the separability between classes is increased and speed is well improved with this hybrid support vector machine. [C814]

## "Support vector machine for HRRP classification"

Radar target identification schemes by using high resolution range profile(HRRP) as features have been studied extensively. In practical systems we usually have only a very limited amount of training data. Therefore how to train a classifier with good generalization performance based on the training set is obviously a challenging task. This paper introduce the newest branch of statistic learning theory, support vector machine(SVM) to range profile classification. The range profiles of two targets were classified by SVM and LVQ (Learning Vector Quantization). Experiment results show that applying SVM to range profiles classification can get higher correct classification rate and better generalization performance. [C815]

## "Data fusion of FLIR and LADAR in autonomous weapons systems"

First Page of the Article [C816]

## "Joint multi-sensor kinematic and attribute tracking using Bayesian belief networks"

First Page of the Article [C817]

## "Recognition of the underwater target with an improved genetic-based classifier system"

Due to the complicated watery environment and the limitation of the detecting method to the underwater target, recognizing them precisely is always a hard problem to all countries. In this paper, we design a genetic-based classifier system (CS) and apply it to recognize the underwater target. This is an attempt to solve this problem with machine learning way. Compared with traditional CS, the proposed Comparing and Matching Algorithm will give the fitness value more explicit statistical meaning, which will make us easier to explain the rules with background knowledge. The proposed Hyperplasia Operator can handle those instances which are not emerged before. It gives the system persistent learning abilities, so the system may be more compatible with the surroundings. The proposed Refining Classifier merges those redundant rules and shrinks the rule set. In addition, we give and discuss an alterable mutation probability to the genetic algorithm in the CS, which increases the speed and the accuracy of the classifying operation. At last, the experiments to examine the system with the sample data which are collected from sonar echo samples. Experiments show that the recognizing results are satisfying. [C818]

## "Learn-while-tracking, feature discovery and fusion of high-resolution radar range profiles"

First Page of the Article [C819]

## "A framework for target identification via multi-sensor data fusion"

In this paper, the Dempster-Shafer theory is applied to target identification and a framework for battlefield platform identification is presented. The framework employs fuzzy logic to solve the problem of Basic Probability Assignments (BPA), and applies a recursive-centralized structure to the fusion of temporal-spatial information. To increase the efficiency and the robustness of the reasoning procedure, a novel conflict resolution strategy is adopted. Preliminary test results show that the framework is effective and valuable to be further developed. [C820]

## "Target discrimination in the S.A.R. systems by using radar polarimetry"

For a SAR system that coherently transmits and receives both signals from an orthogonally polarized antenna pair, the elements of the resulting scattering [S] matrix can be measured. As a result, polarimetric processed imagery is visually much clearer than single-polarization channel imagery. In addition, fully polarimetric SAR imagery improves the performance of an ATR system, compared to the performance achieved by using single-polarization channel imagery. This paper gives a brief description of some polarimetric tools and techniques used to analyze and process polarimetric data. Several polarimetric discrimination results are displayed, demonstrating the potential capability of characteristic polarization imaging and the usefulness of polarimetric radar in the target discrimination process. [C821]

## "STRAAP: space-time-radiating array adaptive processing"

This paper provides an overview of the physical and mathematical approach to the synthesis and analysis of a multidimensional adaptive radar system. Using a paradigm of distributed sensors, the characterized concept leverages the dimensional advantages gained in such a system by exploiting the inherent, space, time, and waveform domains for adaptive processing. Execution of space-time-radiating array adaptive processing (STRAAP) makes use of the full parametric domain. Data analysis within this extended space suggests system performance advantages in radar target detection, object isolation, and scenario depiction. [C822]

## "Context-sensitive state estimation"

First Page of the Article [C823]

## "Proceedings of the 2003 IEEE Radar Conference (Cat. No. 03CH37474)"

First Page of the Article [C824]

## "An efficient SAR ATR approach"

Automatic target recognition (ATR) based on synthetic aperture radar (SAR) imagery (denoted as SAR ATR for simplicity) is very important for battlefield awareness. Since SAR images are very sensitive to pose variation of targets, SAR ATR is a well-known very challenging problem. An efficient SAR ATR algorithm is given, which uses KFD (kernel Fisher discriminant) as feature extractor and linear SVM (support vector machine) as classifier. Experimental results evaluated with the MSTAR (moving and stationary target automatic recognition) public data sets provided by the DARPA/AFRL (Defence Advanced Research Project Agency/Air Force Research Laboratory) show that the proposed scheme performs much better than the conventional template matching and SVM methods, especially when the target pose uncertainty is large, which is desirable for SAR ATR. [C825]

## "Proceedings of the 2nd International Workshop on Advanced Ground Penetrating Radar (IEEE Cat. No.03EX680)"

First Page of the Article [C826]

## "Exhaustive search for Costas-type sequences for multi-target recognition"

Costas and sonar sequences were respectively introduced in [2] and [10] to deal with the following problem: "An object is moving towards (or away) from an observer, who wants to know effectively the distance to the object and its velocity." The solution to the problem makes use of the Doppler effect, which states the following: when a signal bounces off a moving target its frequency changes in direct proportion to the velocity of the object relative to the observer. In other words, if the observer sends out a signal towards a moving target, the change between the frequency of the outgoing and that of the returning signal will allow him to determine the velocity of the

target, and the time it took to make the round trip will allow him to determine the distance. [C827]

## "A Multi Target Track Before Detect Application"

This paper deals with a radar track before detect application in a multi target setting. Track before detect is a method to track weak objects (targets) on the basis raw radar measurements, e.g. the reflected target power. In classical target tracking, the tracking process is performed on the basis of pre-processed measurements, that are constructed from the original measurement data every time step. In this way no integration over time takes place and information is lost. In this paper we will give a modelling setup and a particle filter based algorithm to deal with a multiple target track before detect situation. In simulations we show that, using this method, it is possible to track multiple, closely spaced, (weak) targets. [C828]

## "General Data Association with Possibly Unresolved Measurements Using Linear Programming"

In this paper we formulate data association with possibly unresolved measurements as an augmented assignment problem. Unlike conventional measurement-to-track association via assignment, this augmented assignment problem has much greater complexity when each target originated measurement can be of single or multiple origins. The main point is that standard one-to-one assignment algorithms do not work in the case of unresolved measurements because the constraints in the augmented assignment problem are very different. A suboptimal approach is considered for solving the resulting optimization problem via linear programming (LP) by relaxing the integer constraints. A tracker based on probabilistic data association filter (PDAF) using the LP solutions is also discussed. Simulation results show that the percentage of track loss is significantly reduced by solving the augmented assignment rather than the conventional assignment. [C829]

## "Improved HRR-ATR using hybridization of HMM and eigen-template-matched filtering"

A new 1-D hybrid automatic target recognition (ATR) algorithm is developed for high range resolution (HRR) profiles. The proposed hybrid algorithm combines eigen-template based matched filtering (ETMF) and hidden Markov modeling (HMM) techniques to achieve superior HRR-ATR performance. In the algorithm, each HRR test profile is first scored by ETMF which is then followed by independent HMM scoring. The first ETMF scoring step produces a limited number of "most likely" models that are target and aspect dependent. These reduced number of models are then used for improved HMM scoring in the second step. Finally, the individual scores of ETMF and HMM are combined using maximal ratio combining to render a classification decision. The results demonstrate that the hybridization technique achieves improved recognition performance when compared to the independent performances of either ETMF or HMM. [C830]

## "Ultra-Wideband Systems"

The current status of ultra-wideband technology and its main applications such as radars and telecom are presented. The main system approaches for radars and communications are discussed and compared. [C831]

## "Target recognition using wavelets decomposition"

Radar target recognition continues to be a challenging problem which has yielded considerable algorithmic and hardware advances, particularly in military applications. It has been known for many years that the echo received from a remote object in response to illumination by a radar system is dependant on the nature and shape of the object, leading to the idea that a system could be devised for an eventual recognition of objects of differing shapes from radar echoes. In the development of automatic target detection and recognition systems, the issue of image data interpretation commonly yields to very difficult deciding situations. This paper addresses the problem of radar target recognition using models and images along with a matching approach involving the radar cross section signature. [C832]

## "Radar target recognition based on orthogonal range profile extraction"

In this paper a novel approach to use orthogonal range profiles for effective real-time target recognition is proposed. The proposed system is based on the two netted monostatic radars located at different locations. The two radars simultaneously send two different specially designed wideband radar waveforms to generate a pair of orthogonal range profiles of the target from different incident angles at the same moment. The two-dimensional target scattering feature is thus extracted from the two orthogonal range profiles for efficient target recognition. The wideband waveforms used by the two radars are designed such that they do not correlate to each other, i.e. their cross-correlation function is almost zero, and each of them has thumbtack-like autocorrelation function. Therefore, the matched filter at the receiver of one of the radars outputs a strong processing result only with the input including the coding waveform transmitted by the same radar; while the target echo scattered from the

waveform transmitted by the other radar is mismatched at the receiver and behaves like a noise signal. [C833]

## "An automatic recognition algorithm of analogue modulated signals for disturbance rejection"

This paper presents an automatic recognition algorithm of analogue modulated signals provided that jamming signals exist near the carrier frequency of a target signal. The proposed algorithm is based on the decision-theoretic approach, is assumed to be used as surveillance system for radiowaves, and can distinguish LSB (lower side band), USB(upper side band), AM (amplitude modulation), and DSB-SC (double side band suppressed carrier). The performance of the proposed algorithm is evaluated through some simulations of modulation recognition. [C834]

## "Ground penetrating radar (GPR) studies at the ElectroScience Laboratory (ESL)"

There are a number of factors to be considered in making many GPR measurements. These include (a) electronic hardware (b) antenna systems (c) electromagnetic properties of the ground (d) target identification arid remote sensing concepts and (e) use of numerical simulations. The purpose of this paper is to review the contributions made at the ESL for these factors and to discuss future potential advances in the state of the art. [C835]

## "A comparison of segmentation techniques for target extraction in ground penetrating radar data"

In a typical GPR survey, a great amount of data is collected, and only a small percentage of this amount represent useful data (i.e. target data) whereas the majority of the data is considered non-useful. The first of the post-processing stages, which relies heavily on a skilled operator, involves pointing out the areas that may contain targets and suppressing others. Consequently, this process consumes considerable amounts of time and effort, apart from the fact that the existence of the human factor at this critical stage invariably introduces inconsistency and error into the interpretation. In this paper, three techniques for automatic GPR data segmentation are discussed and compared. The techniques rely on the computation of certain features from which a neural network can then arrive at a decision to classify the data segments in question as targets or otherwise. The first technique is based on extracting three statistical features from A-scan segments while the second technique computes statistical features from B-scan regions to produce the discrimination bases for the neural classifier to distinguish targets from non-targets. In the third technique, some regional properties of B-scan segments accompanied by the statistical features are used to achieve discrimination not only between targets and non- targets, rather between hyperbolic-shaped and non-hyperbolic-shaped targets as well. All three techniques were on different types of GPR data collected from a variety of sites, and they proved to be very efficient to form a robust automatic technique for data reduction and segmentation. [C836]

## "Analysis of target responses and clutter based on measurements at test facility for landmine detection systems located at TNO-FEL"

Target responses and natural clutter have been analyzed based on GPR measurements performed in July 2002 at the test facilities for landmine detection systems located at TNO-FEL. The object responses of four different types of antipersonnel mines (surface laid and buried at depths of one, five and six centimeters) in three different types of ground have been analyzed for different polarizations of incident and scattered wave, for different pulse durations and for different antenna configurations. Clutter levels have been defined for two different presentations of raw data and have been determined for three different types of ground. It is shown that detectability of targets by GPR is limited not by the sensitivity or the dynamic range of the radar, but by the clutter. It is demonstrated that it is possible to detect targets below clutter level using the statistical data analysis. [C837]

## "Two-body multiple scattering"

Summary form only given. To achieve improved target discrimination and identification has been the driving force behind the development of high-resolution radar systems. A method of target identification with wideband radar data is to form a synthetic aperture radar (SAR) or an inverse synthetic aperture radar (ISAR) image of the target by spatially isolating the individual scattering sources. However, to design a better radar signal processor requires a complete understanding of the interactions between isolated scattering sources. The multiple scattering of electromagnetic waves by several simple two-body targets was studied in terms of their sub-nanosecond pulse returns. The wideband target responses were analyzed through use of an asymptotic solution to a generic two-body scattering formulation; when considering the computed results, emphasis was aimed towards the coupling phenomenon. These coupling components between bodies were isolated experimentally using a coherent X-band high-resolution radar system, and the data were in good general agreement with the analytical solutions. It is shown that multiple scatterings can contribute significantly to the total radar cross-section even when the scattering sources are separated by many wavelengths. [C838]

## "Activity recognition using the dynamics of the configuration of interacting objects"

Monitoring activities using video data is an important surveillance problem. A special scenario is to learn the pattern of normal activities and detect abnormal events from a very low resolution video where the moving objects are small enough to be modeled as point objects in a 2D plane. Instead of tracking each point separately, we propose to model an activity by the polygonal 'shape' of the configuration of these point masses at any time t, and its deformation over time. We learn the mean shape and the dynamics of the shape change using hand-picked location data (no observation noise) and define an abnormality detection statistic for the simple case of a test sequence with negligible observation noise. For the more practical case where observation (point locations) noise is large and cannot be ignored, we use a particle filter to estimate the probability distribution of the shape given the noisy observations up to the current time. Abnormality detection in this case is formulated as a change detection problem. We propose a detection strategy that can detect both 'drastic' and 'slow' abnormalities. Our framework can be directly applied for object location data obtained using any type of sensors-visible, radar, infrared or acoustic. [C839]

## "Scattering of ultrashort electromagnetic pulses by nonlinearly reflecting targets"

Nonlinear radiolocation is very promising for future remote sensing systems and it has been proposed for sensible determination and recognition of objects, including elements with different nonlinear electromagnetic characteristics. It is based on the fact that generation of higher harmonics occurs under scattering of electromagnetic waves by nonlinearly loaded conducting targets. Investigating re-reflected harmonics, one can determine a nonlinear object, and also obtain additional information. The paper investigates numerically the scattering of ultrashort electromagnetic pulses by the following models of nonlinear scatterers: nonlinearly loaded vibrator; two-dimensional plate. The calculations give the possibility of determining optimal values of electromagnetic probing pulse duration needed to obtain the maximal useful reflected signal. [C840]

## "Modeling of multirate signal in radar target recognition"

Considering the uncertain for rotating velocity of spatial target and period of radar observation, there exists sampling rate variance between radar returns and template data, which decreases the degree of matching. In this paper, the autoregressive moving average (ARMA) model in multirate is provided, through which the power spectral density (PSD) of radar turns can be developed in the scale of template data, and then data can be matched in the same scale. Experimental result shows the validity of proposed method. [C841]

## "CFAR detection of targets under directional noise background"

For a radar or sonar system, target detection is a basic function of the system. In sensor array processing, target detection is facilitated by examining the beamformer output of the received signal. The conventional method integrates the beam power observations by simple summation or linear integration and no statistical information is used. However, if the noise environment is directional, this will result in non-CFAR (constant false alarm rate) detection performance. In this paper, we exploit generalized likelihood ratio test (GLRT) to design the detector. We divide the data sequence from all the sensors into different segments and calculate the power observation of each segment. Then the probability distributions of the power observation under both hypotheses are derived. The unknown parameters of the signal model can be estimated by moment estimation based on statistical properties of the observations. Compared with the conventional processor, the GLRT detector can normalize the background of the output test statistic so that it shows CFAR property. Under the noise with directionality, the new detector we developed can still work well while the conventional one will show a false result due to the directionality of the noise when the SNR is low. Simulation result shows that the GLRT detector can also be used for multiple targets situation. [C842]

## "Scattering signatures analysis using genetic algorithm"

A real-valued genetic algorithm is proposed as a means of extracting one-dimensional scattering centers. In terms of the extraction of scattering signatures from noise-corrupted data, the genetic algorithm has been compared to the state space approach, and the results show that this method has higher-noise immunity. [C843]

## "A modified quasi-best weighted order statistics CFAR algorithm with greatest of selection"

In order to improve the performance of OSGO or GOSGO, a CFAR algorithm based on quasi best weighted (QBW) order statistics CFAR method is proposed in this paper. The analytic results show that the performance of QBWGO is evidently superior to that of OSGO or GOSGO both in a homogeneous background and in multiple target situations. If the number of interfering targets is 4, the CFAR loss of QBWGO is 4.659, the CFAR loss of

OSGO is 5.357, and an improvement of nearly 1 dB by QBWGO is obtained. In the special case of M1=M2=0, N1=N2=0, QBWGO reduces to GO, and in the case of M1=N1=0, QBWGO reduces to MX-CMLD. [C844]

## "Automatic target recognition of ISAR object images based on neural network"

In this paper an integrate approach of automatic target recognition is proposed with a three-feedforward neural network. It includes images pre-processing, feature extraction and automatic target recognition and classification of ISAR object images. Using the log-spiral transform after moving the centroid of ISAR images to the original point makes the target recognition invariant on translation, rotation and scale. The approach improves the ratio of accurate recognition and reduces the amount of calculation. The results of experiments with field data show that the approach is effective. [C845]

## "Feature enhanced regularized reconstruction algorithm foe SAR"

The biggest problem for automatic target recognition (ATR) is the accurate and efficient extraction of features from SAR images. A new SAR image formation algorithm, which is recognition oriented is developed. The algorithm is based on a tomographic model of SAR observation, using Vector-Entropy optimization approach to reconstruct SAR images from projections. It provides images with higher resolution of scatters and better separate ability of different regions than traditional algorithms. We apply it on synthetic SAR scenes to show the validity of the algorithm. [C846]

## "Multi-focus image fusion based on wavelet decomposition and evolutionary strategy"

A new method is developed to merge two spatially registered images with different focus based on multi-resolution wavelet decomposition and evolutionary strategy (ES). At first, the wavelet decomposition without down-sampling is used to perform an adding of wavelet high-frequency components of each image. Then, in terms of differences of area-based energy feature in two original images, ES is adopted to partition the region and perform the fusion. The experimental results show that the proposed method can achieve better fusion performance than wavelet transform (WT) method. [C847]

## "Results of a multi-static synthetic aperture sonar experiment"

It has long been recognized that point targets in synthetic aperture sonar (or radar) imagery could be used to calculate the beamformer coefficients and the motion compensation functions for the system. One difficulty with this approach arises when no point targets are available. Another problem exists in the initial recognition of true point targets, or rather, the automatic separation of point targets from complex targets in the raw data. A multi-static synthetic aperture sonar (MSSAS) laboratory experiment, instructive to practical field applications, was conducted at Naval Surface Warfare Center, Dahlgren Division, Coastal Systems Station (CSS) Acoustic Test Facility (ATF) in December 2000. The experimental method and three dimensional imagery results are described. Practical field system designs suggested by this experiment are explored. Hyperbolic Frequency Modulation (HFM) transmissions in the 5-17 KHz band were sent to a vertical array that was four wavelengths high at 10 KHz. A horizontal aperture of 40 wavelengths (at 10 KHz) was synthesized. A bullet shaped shell, approximately 32 inches long, was used as the target. A simplified self-calibration technique is harnessed to simultaneously form the basic multi-static beamformer kernel, remove motion effects, and resolve the unknown distances among transmitter, receivers, and target. [C848]

## "An approach to multistatic spaceborne SAR/MTI processing and performance analysis"

Multistatic spaceborne SAR offers in addition to powerful Earth imaging and remote sensing the possibility to detect the presence of slowly moving objects due to the large baselines. In contrary to monostatic multi-subaperture systems with classical STAP processing the multi-satellite system overcomes the problem of blindness against certain directions of target motion. Moreover velocity and direction of target motion can be estimated with considerably higher accuracy when taking advantage of the geometry of the multistatic configuration. For this purpose non-classical algorithms have to be developed. Furthermore, the application of optimum detection schemes and the exact analysis of MTI performance are challenging tasks. Indeed the high system complexity and the huge amount of data to be analysed make the MTI processing exceedingly difficult. Therefore only sub-optimum methods can be implemented. In this paper we propose a sub-optimum approach for multistatic spaceborne moving target detection. First of all we define a signal model for both moving targets and clutter proceeding from an arbitrary multistatic configuration. Secondly, we present the sub-optimum statistical processing based on the exploitation of the covariance matrix describing the common statistical properties of the random vector composed of a selected number of resolution cells in the range-Doppler-space for all sensor channels. Then we analyse the MTI performance of representative multistatic configurations. Finally this method is applied to simulated data of multistatic satellite systems. [C849]

## "The processing of target resolving for radar extended target detection"

Based on the target plots data acquired from detection of the antiship guidance radar receiver, the phenomenon of extended target split caused by the radar high resolution characteristic is discussed. The repeated detection phenomenon of target and its influences brought by the feature of radar antenna scanning mode are described. At the same time, analyzed that the different target plots spread leads to the uncertainty between detected target numbers obtained by radar acquisition and actual target numbers (i.e. cause redundant target plots).The valid algorithm that agglomerating target split plots and implementing multi-target resolving is proposed. [C850]

## "Enhanced resolution in 3-D interferometric ISAR imaging using an iterative SVA procedure"

Multi-dimensional high resolution is one of the most important factors in automatic target recognition (ATR) using the synthetic aperture radar (SAR) or inverse SAR (ISAR) images. In this work, we propose a resolution enhancement technique in three-dimensional (3-D) interferometric SAR/ISAR (IF SAR/ISAR) imaging using an iterative sidelobe apodization procedure. [C851]

## "Characterization of shallow underground targets using wideband microwave reflectometry"

In this paper, the use of a combined signal processing technique of target discrimination for the step-frequency ground penetrating radar is investigated. To construct the radar range profile from the backscattered signal, a real part of the inverse discrete Fourier transform is multiplied by the pseudospectrum obtained from the same data via eigenvector method. The signatures of small underground objects can be subdivided in four categories designated conditionally as front wall; back wall; inclusion of high density; inclusion of low density. Experimental studies have shown that the technique is valid for both strong and weak scatterers. The approach can be extended to the discrimination of complex targets such as landmines by creating a set of templates. [C852]

## "Imaging of moving targets using a Doppler compensated multiresolution method"

Traditional radar imaging has difficulties in imaging moving targets due to Doppler shifts induced in the imagery and limited spatial resolution of the target. We propose a method that uses a multiresolution processing technique that sharpens the ambiguity function of moving objects to remove Doppler induced imaging errors and improves instantaneous resolution. This method allows for instantaneous imaging of both static an moving objects in a computationally efficient manner thereby allowing more real time radar imagery generation. [C853]

## "Multisensor & spectral image fusion & mining: from neural systems to applications"

We have continued development of a system for multisensor image fusion and interactive mining based on neural models of color vision processing, learning and pattern recognition. We pioneered this work while at MIT Lincoln Laboratory, initially for color fused night vision (low-light visible and uncooled thermal imagery) and later extended it to multispectral IR and 3D ladder. We also developed a proof-of-concept system for EO, IR, SAR fusion and mining. Over the last year we have generalized this approach and developed a user-friendly system integrated into a COTS exploitation environment known as ERDAS Imagine. In this paper, we have summarized the approach and the neural networks used, and demonstrate fusion and interactive mining (i.e., target learning and search) of low-light visible/SWIR/MWIR/LWIR night imagery, and IKONOS multispectral and high-resolution panchromatic imagery. In addition, we had demonstrated how target learning and search can be enabled over extended operating conditions by allowing training over multiple scenes. This has been illustrated for the detection of small boats in coastal waters using fused visible/MWIR/LWIR imagery. [C854]

## "A target discrimination algorithm for high resolution SAR imagery"

Target discrimination is an important stage of automatic target recognition (ATR). A region of interest (ROI) segmentation algorithm based on CFAR technique is described first. Then, a novel discriminator, the extended fractal (EF) discriminator, is proposed. At last, a discrimination algorithm composed of EF feature, target region area, and peak power ratio is designed to discriminate target from clutter ROIs. Experimental results using the MSTAR dataset show that this discrimination algorithm can eliminate most of the false alarms while maintain a high detection rate. [C855]

## "The statistical analysis of SAR target based on the correlation algorithm"

Utilizing MSTAR measured target data, we analyze statistical trend in the entire measurement training set every 1 deg in azimuth based on correlation algorithm. After segmentation and normalization, each test image was correlated with all the training images to generate correlation and classification statistics and correlation plots.

The correlation plots varied approximately sinusoidally with aspect, and all the training sets show that a target was highly correlated at both the correct aspect angle and the correct angle rotated 180 deg, and this two correlation scores corresponded to the two local amplitudes of the correlation plot. [C856]

## "2003 Proceedings of the International Conference on Radar (IEEE Cat. No.03EX695)"

First Page of the Article [C857]

## "An algorithm for remote sensing imaging of moving target with conventional narrow-band radar"

This paper studied the problem of imaging the moving target in cross range direction by using conventional narrow-band radar and indicates that the key technique to obtain the cross range profile of target is motion compensation. In this paper, after the analysis in theory, a motion compensation algorithm based on third order polynomial coefficients estimation was proposed. In order to optimize these estimating coefficients, an optimal criterion was also presented. Moreover, this paper also proposed an algorithm to estimate the cross-range resolution. Simulation results show the presented method of cross range imaging is effective and the algorithm of estimating the resolution is reasonable. [C858]

## "Improving the radar target classification results by decision fusion"

The need for decision fusion appears when the classification results obtained using only one target signature are poor and have to be improved. Our idea was to use four target signatures corresponding to various polarization combinations in order to make the final decision more robust and more effective. The fusion method is based on the Sugeno's fuzzy integral and has some important advantages over the traditional methods like the vote technique. The method is validated on both synthetic and real data obtained in the anechoic chamber of ENSIETA from Brest, using four scale reduced target models. Some perspectives are finally presented for integrating also the radar imagery results into the fusion process in order to better assist the human operator to make the most appropriate decision. The main application of our research work is related to the enhancement of the airborne traffic surveillance by avoiding any confusion and increasing the flight safety. [C859]

## "Advantages and problems of wideband radar"

The paper addresses the definition, properties and modeling requirements of wideband and ultra-wideband radars. It begins by establishing the criteria by which the designation 'wideband' might be specified, since the common definition based purely on relative bandwidth fails to invoke some important associations. Next, the role of simulation is discussed and a representative simulation environment is described. The advantages and disadvantages of increasing the signal bandwidth are then evaluated quantitatively in the context of signal detection, parameter measurement, and the recognition of aerial target classes and types, with reference to specific classes of interest. In practice, certain other issues arise, including the degree of immunity to interference and electromagnetic compatibility. These topics are discussed in terms of their dependence on signal bandwidth and the associated signal acquisition and processing. In addition, an emerging problem is the need to take into account the possibility of signal exploitation and LPI (low probability of intercept). The essence of the theory of unauthorized signal detection that limits the LPI possibilities is briefly considered. [C860]

## "Wavelet based signal processing algorithms for early target detection"

Detection of radar target earlier, that is, at a longer distance, amidst noise is a major issue since the received echo signal has very low input signal to noise ratio of the received signal. Further, it becomes very difficult due to unknown statistics and nonstationary nature of the received signal. This paper deals with the wavelet based signal processing algorithms which could detect target even with very weak received signal. Since the signals with identical spectra may have different time-frequency image in time-frequency domain. The algorithms use optimum bandwidth relative to the signal spectral width to maximize the output signal to noise ratio and hence probability of detection. Simulation results show that the wavelet filtering algorithm and entropy based basis algorithms are able to detect target from the input signal to noise ratio of -10dB. [C861]

## "Ultra-wideband systems"

The current status of ultra-wideband technology and its main applications such as radars and telecom are presented. The main system approaches for radars and communications are discussed and compared. [C862]

## "Analyses and compensation for radar target angular glint"

Angular glint caused by a target of dual point sources is discussed in phase gradient method. Deterministic

relation between phase gradient and RCS is deduced. On the basis of that, a RCS based compensation method of angular glint is presented. The validity is verified by simulation. For target of multi-point sources, compensation for angular glint error is similar if it is treated as a target of dual point sources. [C863]

## "Radar target imaging and identification using the advanced inverse scattering technique"

A new target recognition procedure is developed. In order to efficiently obtain feature vectors for target discrimination, the closed-form expression of geometrical wave fronts is also derived to provide efficient and accurate computation. Then, the resulting low dimensional feature vectors, obtained by the developed extractor, are identified using the well-known artificial neural networks (ANNs) classifier. In the illustrative experiments. three thin-wire targets are discriminated. The results show that the presented scheme gives successful automatic target recognition (ATR) in the low SNR with low computational costs. Therefore, the proposed technique has a significant potential for use in ATR. [C864]

## "Radar target identification based on adaptive joint time-frequency processing in high frequency domain"

A new radar target feature extraction method based on adaptive joint time-frequency processing is presented for radar target recognition in the high frequency domain. After applying the adaptive Gaussian representation to the range profile, some of the decomposing parameters are extracted as feature vectors used for identification. Comparing with range profiles, the extracted feature vectors proposed by this method increase the identification information and decrease the computation and storing burden significantly when compared to the adaptive spectrogram. The physical meaning is also more definite. This method is used for identifying six kinds of aircraft scale models. The experiment results show that the new feature extraction method is practical. [C865]

## "VHF/UHF synthetic aperture radar-principles and motivation"

At frequencies below 1 GHz, vegetation is becoming transparent, the more so the lower the frequency. Tree clutter on the other hand tends to be as strong as in the microwave regime as at frequencies above 200 MHz. Below 100 MHz, i.e. in the VHF band, tree clutter levels are significantly smaller. Foliage penetration SAR is feasible at both UHF and VHF but has to overcome significant challenges. For one, resolution must be high, viz. of meter order at VHF and submeter order for UHF. In both cases resolution of wavelength order is thus called for, requiring special processing methods which will be discussed here. Secondly, the signal-to-noise budget is critical due to the severe radio frequency interference below 1 GHz. In fact SAR operation at these frequencies is not feasible unless there are some means to identify and remove the RF1. Thirdly, for SAR surveillance the target detection method is crucial. VHF resolution is too low to make any target recognition scheme effective as a means to reduce clutter false alarms. At UHF, even though resolution can be made high, intense forest clutter level creates a very difficult environment for target discrimination. These concerns and their remedies are discussed in the paper. [C866]

## "L-band wide area surveillance radar design alternatives"

Wide area surveillance systems are becoming more important for border and homeland security, earth resources monitoring and mitigation of natural disasters such as floods and seismic activity. As the frequency spectrum is being utilized for communications and business networking, the available bandwidth for these important efforts is more difficult. Historically, airborne surveillance radars have been fielded at either UHF or S-Band for airborne vehicle detection, and at X-Band for surface vehicle imaging and moving target detection. This paper will examine the impact of new technologies on the design of L-Band surveillance radars that employ solid state active arrays, multiple phase center apertures and adaptive processing to enable fixed and moving target detection from air and space platforms. The operational advantages of the use of small apertures on business jets, medium apertures on high altitude platforms and very large apertures in space will be contrasted. [C867]

## "Novel PRF schedules for medium PRF radar"

Previous work has demonstrated that evolutionary algorithms (EAs) are an effective tool for the selection of optimal pulse repetition frequency (PRF) sets to minimise range-Doppler blindness of a medium PRF radar. This paper reconsiders the concepts of decodability in medium PRF radar, and how new and novel schedules can be generated using an EA. Traditionally, target data is required in a minimum of 3 PRFs (e.g. a 3 of 8 scheme). In this paper, we describe the generation of schedules requiring data in only 2 PRFs. Results are presented for a comparison between schemes requiring target data in two and three PRFs. The results indicate that blindness is minimised in schedules with greater numbers of PRFs and requiring target data in fewer PRFs. The concept of dynamic selection of PRI schedules that are fully decodable and have no blind velocities is outlined and is concluded to be feasible. [C868]

## "Target detection accuracy improvement in synthetic aperture radar"

This paper proposes a decision method to improve the target identification accuracy in a synthetic aperture radar processing algorithm. In the imaging algorithm, Fourier based processing algorithm is used to obtain the processed image from the measured 2D cartesian backscattered frequency domain data. In practical applications, the measured data is limited in frequency band and aspect angle interval and this leads to radar images with limited resolution. Besides, the noise in measured data affects the target identification accuracy. In this paper, a decision rule is proposed to improve the target identification accuracy by comparing the processed image with the images in the data bank. With the decision rule, one can assign a well known target distribution to the processed image. In this work, the effects of noise, frequency and aspect angle limitation in the decision accuracy are investigated and the results are presented. [C869]

## "Prescreening algorithm assessment within the analysts' detection support system"

This analysts' detection support system (ADSS) contains a suite of target detection algorithms for wide area aerial surveillance using synthetic aperture radar (SAR) imagery. The ADSS provides a framework to combine the operation of these algorithms in user-specified configurations. This paper compares and contrasts the performance of the various prescreening algorithms singly and in combination within the ADSS framework on a broad range of SAR imagery. The algorithms include adaptive threshold, K-distributed CFAR, average grey absolute difference magnitude map, and segmenting K-distributed CFAR. The performance of these algorithms is compared on polarimetric imagery to assess the contribution of polarimetry to target detection. [C870]

## "The analysts' detection support system for deploying a network of target detection and recognition algorithms in SAR exploitation"

A novel software system that assists analysts to find small targets in SAR imagery is described. The system consists of a set of image processing algorithms and a framework to undertake synchronisation, control and data flow between the algorithms. The system is designed to operate in near real-time, allowing processing on very large images to occur whilst sensor data collection proceeds. It allows algorithms to be connected in arbitrary ways and has functionality to facilitate system performance measurement. This paper discusses the design of the framework. [C871]

## "Performance evaluation for modern radars"

Modern radar systems are procured with tight specifications on a large number of different parameters. It is in the interests both of the customer and of the supplier that the procedures used evaluate radar performance are mathematically rigorous, precise and as cost-effective as possible. This paper describes some methods of evaluating the performance of different modes of modern radar system and discusses the accuracy of which they are capable. The important place of modeling within these methods is emphasized. [C872]

## "Demonstration of reduced false alarm rates using simulated L-band polarimetric SAR imagery of concealed targets"

Coherent scattering calculations have been performed to produce L-Band SAR images of targets below a forest canopy. The calculations, which are fully polarimetric, are described. High clutter levels permit detection of all concealed targets only at the cost of a very high false alarm rate. The simulated imagery is analysed using the entropy-alpha polarimetric decomposition technique. Using alpha and entropy in addition to a co-polar intensity channel, and combining the results of separate CFAR algorithms, the number of false alarms is reduced dramatically. The consequences for application of polarimetric SAR to concealed target detection and identification are considered. [C873]

## "Results from the Crusade ship detection trial: polarimetric SAR"

An experiment was conducted in March 2000 offshore of the Newfoundland, Canada coastline which involved several radar data sets. The objective of the experiment was to assess ship detection capabilities for several radar systems. In particular, image data were collected from RADARSAT, the polarimetric C/X SAR and the High Frequency Surface Wave Radar (HFSWR) at Cape Race, Newfoundland. These data were acquired over a period of ten days while three staged ships remained on site at specified positions. These types of experiments are very rare and hence the results from this experiment will be invaluable for validating ship detection techniques and providing direction for future research and experiments. HH and HV polarizations were found to be optimal for wide area ship detection applications. A moment method and polarimetric decomposition methods provided high ship detection rates. Polarimetric target decomposition results indicate potential capability for

recognizing targets and reducing false alarm rates. [C874]

## "The ONERA RAMSES SAR system"

The ONERA RAMSES system (Radar Aeroporte Multi-spectral d'Etude des Signatures) is a flexible SAR system in constant evolution developed mainly as a test bench for new technologies and to provide specific data for TDRI (Target Detection, Recognition and Identification) algorithm evaluation. It is flown on a Transall C160 platform operated by the CEV (Centre d'Essais en Vol). This paper gives an overview of the system and its recent upgradings. [C875]

## "Improving neural classifiers for ATR using a kernel method for generating synthetic training sets"

An important problem with the use of neural networks in HRR radar target classification is the difficulty in obtaining training data. Training sets are small because of this, making generalization to new data difficult. In order to improve generalization capability, synthetic radar targets are obtained using a novel kernel method for estimating the probability density function of each class of radar targets. Multivariate Gaussians whose parameters are a function of position and data distribution are used as kernels. In order to assess the accuracy of the estimate, the maximum a posteriori criterion has been used in radar target classification, and compared with the k-nearest-neighbour classifier. The proposed method performs better than the k-nearest-neighbour classifier, demonstrating the accuracy of the estimate. After that, the estimated probability density functions are used to classify the synthetic data in order to use a supervised training algorithm for neural networks. The obtained results show that neural networks perform better if this strategy is used to increase the number of training data. Furthermore, computational complexity is dramatically reduced compared with that of the k-nearest neighbour classifier. [C876]

## "Possible military requirements and applications of active and passive imaging sensors at micro- and millimeterwave frequencies"

In order to reveal the differences between military and civil applications of remote sensing common military user requirements for the detection, recognition, identification, and revisit time of military targets are discussed. Typical application examples of imaging SAR and radiometer systems are given as well as design examples for advanced sensor systems demonstrating the technological realisation and limits. [C877]

## "Active information fusion for decision making under uncertainty"

Many information fusion applications especially in military domains are often characterized as a high degree of complexity due to three challenges: 1) data are often acquired from sensors of different modalities and with different degrees of uncertainty; 2) decision must be made quickly; and 3) the world situation as well as sensory observations evolve over time. In this paper, we propose a dynamic active information fusion framework that can simultaneously address the three challenges. The proposed framework is based on Dynamic Bayesian Networks (DBNs) with an embedded active sensor controller. The DBNs provide a coherent and unified hierarchical probabilistic framework to represent, integrate and infer corrupted dynamic sensory information of different modalities. The sensor controller allows it to actively select and invoke a subset of sensors to produce the sensory information that is most relevant to the current task with reasonable time and limited resources. The proposed framework can therefore provide dynamic, purposive and sufficing information fusion particularly well suited to applications where the decision must be made from dynamically available information of diverse and disparate sources. To verify the proposed framework, we use target recognition problem as a proof-of-concept. The experimental results demonstrate the utility of the proposed framework in efficiently modeling and inferring dynamic events. [C878]

## "Detection of targets from electro-optical and SAR data using chaotic predictors and optimal CFAR detectors"

This paper presents a new clutter suppression and target detection technique for locating small land targets in SAR and electro-optical images. The method is based on adaptive nonlinear (chaotic) predictors which provide an estimate of the local SAR and electro-optical clutter and uses this estimate to suppress the clutter and hence increase the signal to clutter power. The residual errors between clutter estimates and actual data correspond to either clutter noise or target signatures. Hence, dedicated models are employed for clutter noise and targets. The modelling is performed using generalized statistical probability density functions. Statistically optimal Constant False Alarm Rate (CFAR) detectors are used to separate the targets from the residual noise. Although, some similarities may be found in the detection process, when multispectral and multipolarized SAR data are employed, the clutter and target statistics are quite different. The paper presents detection approaches that

extend those presented in the literature by including threshold statistics, clutter suppression techniques and generalized statistics. Finally, the issue of detection fusion from dissimilar sensors is addressed. For CFAR detection the optimal Order Statistics, Cell averager, Optimal Weibull, Optimal K-pdf and Optimal Generalized Gamma CFAR detectors are employed. The last three have been developed at A.U.G. Signals Ltd. [C879]

## "Elimination of false positives in vessels detection and identification by remote sensing"

The article describes how to eliminate the false positives generated by the basic model of an fast automatic algorithm for fishing areas control and vessel detection. [C880]

## "Tradeoffs between quality of results and resource consumption in a recognition system"

The implementation of computational systems to perform challenging operations often involves balancing the performance specification, system throughput, and available system resources. For problems of automatic target recognition (ATR), these three quantities of interest are the probability of classification error, the rate at which regions of interest are processed, and the capabilities of the underlying hardware (which is a function of the available computational resources and available power). An understanding of the inter-relationships between these factors can be an aid in making informed choices while exploring competing design possibilities. Combining characterizations of ATR performance, which yield probability of classification error as a function of target model complexity, with analytical models of computational performance, which yield throughput as a function of target model complexity and available resources, we can form a set of parametric curves which relate the quality of the results to the resources consumed. [C881]

## "Automatic target detection using PMMW and LADAR imagery"

The need for air-to-ground missiles with autonomous target acquisition (ATA) seekers is in large part driven by the failure of pilot-guided bombs in cloudy conditions (such as demonstrated in Kosovo). Passive-millimeter wave (PMMW) sensors have the ability to see through clouds; in fact, they tend to show metallic objects (such as mobile ground targets) in high contrast regardless of weather conditions. However, their resolution is very low when compared with other popular ATA sensors such as laser-radar (LADAR). We present an A TA algorithm suite that combines the superior target detection potential of PMMW with the high-quality segmentation and recognition abilities of LADAR. Preliminary detection and segmentation results are presented for a set of image-pairs of military vehicles that were collected for this project using an 89GHz, 18" aperture PMMW sensor and a 1.06 μ very-high-resolution LADAR. [C882]

## "Nonparametric algorithm for a detection of random process disorder in the signals of radar remote sensing"

A new nonparametric algorithm of radar signal disorder detection is considered. The algorithm is based on spectral estimation of a few signal samples of some close windows and application of a nonparametric Wilkockson's test to compare them. The algorithm can be used for radar signal detection specifically in the tasks of turbulence detection in clouds and precipitation as well as for moving target detection. The efficiency of the new algorithm is analyzed. [C883]

## "Objects identification in non-linear radars"

This article describes a method of clearer discrimination of returning nonlinear radar signals. By analyzing, and audio demodulating of received signals, more accurate results are achieved. A way of accurate discrimination between electronic targets and innocent objects is given. It is based on second harmonic analysis. There is no need for third harmonic analysis in the receiver because the dependence the relative strength of harmonics does not always have a single meaning. [C884]

## "Visual contour tracking based on sequential importance sampling/resampling algorithm"

The condensation algorithm can deal with non-Gaussian, nonlinear visual contour tracking in a unified way. Despite its simple implementation and generality, it has two main limitations. The first limitation is that in sampling stage the algorithm does not take advantage of the new measurements. As a result of the inefficient sampling strategy, the algorithm needs a large number of samples to represent the posterior distribution of state. The next is in the selection step, resampling may introduce the problem of sample impoverishment. To address these two problems, we present an improved visual tracker based on an importance sampling/resampling algorithm. Gaussian density of each sample is adopted as the sub-optimal importance proposal distribution, which can steer the samples towards the high likelihood by considering the latest observations. We also adopt a criterion of effective sample size to determine whether the resampling is necessary or not. Experiments with real

image sequences show that the performance of new algorithm improves considerably for tracking in visual clutter. [C885]

## "A particle filtering approach to FM-band passive radar tracking and automatic target recognition"

We present two stochastic filters for an FM-band passive air surveillance radar. The first system uses an extended Kalman filter and delay-Doppler measurements to track targets. The second system uses a particle filter to simultaneously track and classify targets. Automatic target recognition is made possible by the inclusion of radar cross section (RCS) in the measurement vector. The extended Kalman filter cannot take advantage of radar cross section measurements because there is no closed-form relationship between the state elements which determine target aspect and the resulting RCS measurement. We believe that this is the first work to propose the use of RCS for the purpose of target recognition within a passive radar system. We also present many simulation results for a challenging 2-target 3-sensor task involving trajectories which nearly coincide for a portion of their track length. [C886]

## "Target-aided fixed-quality-of-service compression of SAR imagery for transmission over noisy wireless channels"

We present a target-aided, fixed-quality-of-service (FQoS) system for coding synthetic aperture radar (SAR) imagery, whereby regions of interest and background information are coded independently of each other. A multiresolution, constant-false-alarm-rate (CFAR) detection scheme is used to discriminate between target regions and natural clutter. Based on the detected target regions, we apply less compression to targets, and more compression to background data. This methodology preserves the relevant features of targets for further analysis, and preserves the background only to the extent of providing contextual information. The background data is coded using channel-optimized trellis-coded quantization (COTCQ), while the target regions are coded using a combination of COTCQ and channel coding, depending upon the channel state. The combination of COTCQ and channel coding provides fixed target detection performance at the decoder, independent of the channel bit error probability. Additionally, all-pass filtering is employed, which significantly increases the detection performance at low encoding bit rates, while increasing the security level of the encoded bit stream. The proposed coder is evaluated in terms of target detection performance on the decoded SAR image for a wide variety of channel conditions and encoding bit rates. The resulting system dramatically reduces the bandwidth requirements of digital SAR imagery, and is shown to provide outstanding performance in adverse channel conditions. [C887]

## "A target detection method in range-Doppler domain from SAR echo data"

The direct evidence of radar target recognition is the backscatter energy and its distribution of objects, which is concluded by the imaging process of synthetic aperture radar (SAR) in a two-dimension image domain. Thus, the issues about automatic target recognition of SAR are often a "post-process" following SAR imaging. A method of target detection in the state of non-imaging based on analyzing the features of all kinds of targets on SAR echo data is presented in this paper, where the targets are defected in range-Doppler domain (RDD). Based on the analysis of target features in RDD, an algorithm of target detection in a RDD image is developed. The experimental results indicate the validity of the algorithm for special kinds of target detection. The algorithm is simple, able to recurrent, easy for real-time processing and hardware implementation. It can also be applied to getting target alarm with real-time SAR data for the pre-selected targets and do the imaging process selectively at the same time. [C888]

## "A new matrix method for pulse train identification"

In this paper a new matrix-based method is proposed for. identification of radar pulse train. The proposed method, which is called NASH, can be used to identify the PRI for constant, staggered, and jittered signal. Previous matrix-based methods can only identify the first type of signal, i.e. constant PRI. The complexity of computation in NASH is approximately equal to 2.5N2which is lower than histogram-based methods. Also NASH can find missing pulses' position in the pulse train. [C889]

## "ISAR feature extraction from targets with non-rigid body motion using adaptive chirplet representation"

A basic assumption in inverse synthetic aperture radar (ISAR) imaging is that the target is a rigid body during the data acquisition time. However, non-rigid body motions (associated with a target that is not a rigid body) can exist in many real targets. A chirplet-based adaptive signal representation is applied to the feature extraction of radar data from targets with non-rigid body motion. In particular, a four-parameter chirplet basis is used to

account for the joint time-frequency localization of the signal after we formulated a time-varying model for the radar signal. We also applied the method to two real-world data sets. In the aircraft data, it is shown that the aircraft body image can be better recovered after the removal of the return from the spinning jet engine blades. In the walking person data, we can more accurately estimate the rate of the swinging arms by autocorrelation analysis of the arm-only data. Our results demonstrate the potential application of the proposed method in radar target identification. [C890]

## "The results and perspectives in radar recognition system design"

Radar recognition is an urgent task. The efficiency of solving this task is determined by completeness of a priori known information on the images of recognized objects and quality of algorithms developed work. The recognition task is to be solved under conditions of unintentionally (active and passive) and intentionally created interference, which requires adaptation chains to object viewing conditions in recognition systems. [C891]

## "Benefits of high resolution SAR for ATR of targets in proximity"

In this work we present a new extraction and matching algorithms that enable to perform automatic target recognition (ATR) in high-resolution synthetic aperture radar (SAR) data and targets in proximity. Our motivation was to show benefits of high-resolution SAR for ATR and extend the current capabilities of ATR algorithms for targets in extended operating conditions (EOCs), for example, targets in proximity. We develop a new extraction algorithm for target signatures represented by a point pattern. Each point pattern is extracted using a resolution independent SAR peak model. Test and prototype target signatures are compared with a new matching algorithm. The matching algorithm is capable of identifying multiple signatures in a test point pattern. An experimental evaluation of ATR performance for targets in proximity at multiple data resolution is conducted. The contribution of this work is in (a) developing a peak extraction algorithm that uses a resolution independent SAR peak model, (b) designing a new matching algorithm that can identify multiple signatures in a single test pattern, (c) evaluating ATR performance for targets in proximity at multiple data resolutions. [C892]

## "Feature analysis using millimeter-wave real beam and Doppler beam sharpening techniques"

A challenging problem in digital signal and image processing is that of automatic target recognition (ATR) and object classification. In defense operations in particular, rapid object discrimination is critical. While this problem has been studied extensively, it remains a challenge, due to the complex and time-intensive methods of typical approaches. This study involved constructing features from the range profile signal returns, identifying the "best" set of features and performing ATR. Confusion matrices are presented for the targets of interest for simulation. Although the selection techniques for the features were not optimized, the results for ATR are promising [C893]

## "Nonlinear synthetic wideband waveforms"

Radars commonly use wide bandwidth pulses to attain high range resolution. However, when such wideband pulses are unavailable (or otherwise undesirable), high range resolution can still be achieved by coherently combining a sequence of narrowband pulses spanning the desired bandwidth. Collectively, such narrowband pulse sequences are said to compose a "synthetic wideband waveform" (specific variants are also known by the names "stepped frequency waveform", "frequency jump burst" and "frequency jump train"). Prior publications and reports have examined synthetic wideband waveforms that distribute energy uniformly over the frequency band. Such waveforms require heavy spectral weighting, highly overlapped pulses and/or nonperiodic pulses to control the range sidelobes and grating lobes; unfortunately, undesirable attributes are associated with each of these. We formulate synthetic waveforms that distribute energy nonuniformly over the desired frequency band. These new waveforms are shown to offer improved performance (i.e., lower range sidelobes, higher gain, higher range resolution and/or reduced grating lobes) when compared with traditional approaches. [C894]

## "Automatic ship identification in ISAR imagery: an on-line system using CMSM"

We have developed an on-line system which automatically identifies ships observed in a rapidly updating sequence of range-Doppler images produced by inverse synthetic aperture radar (ISAR). In order to cope with the invariable noise due to the physics of imaging, we propose to employ a multiframe image processing algorithm which stably extracts the profile as a basic feature reflecting the entire characteristics of a target. For ship identification, representing the extracted profiles as high-dimension vectors, we adapt vector analysis using the recently proposed constrained mutual subspace method (CMSM). The system currently works on an ordinary PC at 5 frames/sec and achieves a feasible identification performance. The system is verified using simulated data. [C895]

## "Radar target identification subject to its polarization properties"

Considers questions for the development of radar target identification systems subject to polarization portraits. The authors analyze the correlation of polarization portrait parameters with target characteristics. The structure of the identification system is adaptive to low-informative parameters of the received signal. An analysis is made of the potential performances of target identification subject to the statistical properties of the received signal, adaptation circuit errors and limited observation period. [C896]

## "Adaptive method for low velocity moving target detection"

In radar signal processing, when a target moves with a low velocity, it generates so small a Doppler frequency shift that the target reflected signals are submerged by clutter signals, and the radar cannot detect the target, especially under low signal-to-clutter ratio (SCR) environments. Because of its good performance in intelligent signal processing, an adaptive method is used to eliminate the clutter signals from the received signals in the signal's power spectrum figure according to the power spectrum distribution of the clutter. [C897]

## "Information fusion aspects related to GMTI convoy tracking"

Tracking of ground moving vehicles with GMTI radar is a challenging task, which calls for efficient exploitation of all information sources available. For well-separated vehicles as well as for convoy targets we focus on information fusion aspects comprising both, fusion of data from multiple dislocated sensors as well as incorporation of background information (refined models of the sensor performance, road maps, terrain screening, and simple tactical rules). Under suitably formulated modeling assumptions algorithmic solutions within the context of Gaussian sum approximations are discussed. Methods originally proposed for well-separated vehicles can be embedded into an expectation-maximization approach for dealing with collectively moving convoy targets. By this in particular, early detection of a stopping event is alleviated. [C898]

## "An efficient sequential procedure for detecting changes in multichannel and distributed systems"

In the conventional formulation of the change-point detection problem, there is a sequence of observations whose distribution changes at some unknown point in time, and the goal is to detect this change as quickly as possible, subject to false alarm constraints. It is known that in the case where the observations are i.i.d. and the change point is modeled as deterministic but unknown, the cumulative sum (CUSUM) detection procedure of Page (1954) and the randomized Shiryaev-Roberts detection procedure proposed by Pollak (1985) minimize the expected detection lag, subject to a constraint on the false alarm rate. In this paper, we are interested in the two generalizations of this problem. The first is the generalization regarding multichannel systems. Here all the channels are either statistically identical or the change occurs in one of them at unknown point in time. It is necessary to detect the change in distribution as soon as possible after it occurs, while controlling the rate of false alarms at a given level. The second generalization corresponds to the multi-sensor situation where the information available for decision-making is distributed across a set of sensors. The sensors send quantized versions of their observations to a fusion center where the change detection is performed based on all the sensor messages. We propose multi-channel and distributed versions of the CUSUM procedure and prove that they are asymptotically optimal as the average frequency of false alarms goes to zero. The general results are applied to the two important application areas-target detection in surveillance systems and attack/intrusion detection in distributed computer networks. Experimental results show that the proposed detection methods are highly efficient. [C899]

## "Research on recognition algorithm of moving-target on the battlefield"

A new target recognition algorithm based on the combination of radar and acoustic sensors is proposed in this paper. Firstly, the velocity, the first dominant frequency and the second dominant frequency of the target are taken as effective characteristics, and then the expression of the basic probability assignment function for the target character is obtained though fuzzy inference. Secondly, D-S evidential reasoning is applied to the combination of characteristics to get the reliable recognition of the target. Lastly, simulation is performed on the new algorithm, and the simulation results prove the algorithm is effective. [C900]

## "Use Pollaczek polynomials for analysis characteristics of radar target identification system"

An analytical method of calculating the recognition characteristics of a correlated normally distributed signal against correlated normally distributed background was developed. It is based on the representation of multidimensional probability density of a set of processing channels output signal by multidimensional series of Pollaczek (1950) polynomials. This approach allows one to obtain sufficient accuracy of approximation of probability density and analytical expression for M-dimensional integrals from probability density of recognition

system output signals. The advantage of this method is that it allows one to estimate recognition quality when using multidimensional portraits taking into account interchannel correlation and the difference between the distribution law of a processing channels output signal and the normal one. The result given in the article have a relatively simple form and may be used to carry out scientific engineering designs. [C901]

## "Structural adaptation of decision rule of radar recognition on basis of information characteristics"

The workmanship of a recognition system is characterized by conditional probabilities of proper recognition. These probabilities can be characterized by the estimates of informative characteristics being determined with the parameters of the radar portraits of targets, taking into account the jamming, and by recognition system properties on data retrieval. Recognition informative characteristics can be estimated in the process of observation and used for an adaptive change of the recognition system decision rule. [C902]

## "Radar target detection-identification by multifrequency and fluctuating portraits in multifrequency radiation radars"

The development of optimum statistical pattern recognition of a radar target by using fast digital processing procedures of regularly correlated portraits and Levinson's algorithm of matrix decomposition on the partial multiplicands are considered. [C903]

## "Target ranging and identification using timing modulation of a mode-locked laser"

The U.S. Air Force has an ongoing interest in improved techniques for ranging and high-resolution depth profiling of ground and air targets. We have investigated the feasibility of a target ID system based on a mode-locked laser and a high-speed detection system. Mode-locked lasers easily produce multi-Watt output with pulsewidths in the tens of ps for excellent resolution, and repetition rates in the tens of MHz allowing signal averaging over multiple pulse trains to improve sensitivity. While peak powers may be high, average powers are well below the damage thresholds of typical optics. One drawback inherent in this approach is aliasing caused by the high repetition rate. This is easily remedied by modulation of the laser output with a pseudo-random pattern. [C904]

## "A chaos-based method of target recognition for high-resolution radars"

Radar target recognition, particularly in the target recognition by high-resolution radars, is an important research trend in the high-technology field. In this paper, a new chaos-based method for radar target recognition is presented. The primary study shows that this method is a promising method. [C905]

## "Radar targets identification based on perfect parametric modeling using artificial neural networks"

In this paper, we have developed a new target recognition procedure. In order to efficiently obtain feature vectors for target discrimination, the closed-form expression of geometrical wave front have been derived to provide efficient and accurate computation. The resulting small dimensional feature vectors based on the developed extractor are identified using the well-known ANN classifier. The results show that the presented scheme gives successful correct automatic target recognition (ATR) in the low SNR with low computational costs. Although this work concentrates mainly on parametric modeling of electromagnetic target, further work should study more efficient ANN architecture when the number of candidates is dramatically increased in the practice. [C906]

## "An improved algorithm for the detection of vehicle group targets in high-resolution SAR images"

In this paper, the detection of vehicle group targets in high-resolution SAR images has been investigated. Theoretical analysis has been carried out by statistical methods and the formulas of threshold and parameter estimations of three detection algorithms are obtained. The results show that global parameter estimation is of good effect and there are more false alarms in conventional two-parameter CFAR and single look standard CFAR detection algorithms. We present an improved multi-look de-speckling CFAR detection algorithm, which shows exact target detection, little false alarm and clear target details. The parameter selection and optimal parameters are also given. [C907]

## "Multiple moving targets indication"

The use of moving target indication (MTI) and moving target detection (MTD) is an important aspect in radar detection systems. Delay cancelers is a class of such detection systems which is part of a radar receiver sub-system. Various delay canceler configurations and frequency responses were explored using Matlab. Simulations were performed in Matlab and verified with the experimental results using Signal Processing Workbench (SPW)

before the final implementation of the MTI/MTD processing. Various optimization techniques were explored in an effort to reduce the processing time. [C908]

## "An architecture for sensor data fusion target tracking"

Many geographic target tracking scenarios provide difficult geospatial environments for collecting reliable sensor data. As a result, multiple sensor data sources must be integrated to provide a reliable estimate of an object's position as it moves through various environments. We describe MTI-Net, a geospatial database dedicated to providing reliable sensor data for an object moving through various geospatial environments by integrating multiple sensor data sources together in a Web-based environment. MTI-Net is an integration of database and signal processing resources. [C909]

## "Differential cepstrum for radar HRR profiles-aligning"

The signal properties and the mathematical model of the high-resolution range profile of radar are studied. A novel tool, called a differential complex cepstrum (DCC), is then introduced for radar target recognition. Research into the radar signal model is conducted on the basis of the model, and two properties are derived. The DCC is suggested to be utilized for the statistics of airplane recognition. Simulations are given to show that the DCC is suitable for radar target recognition and the proposed algorithm is effective. [C910]

## "Sensor fusion for target detection and tracking"

Multipath can be a significant contributor to poor detection performance in radar ground moving target tracking systems. Recently, ground multisensor networks have been used to detect and track targets. Unfortunately, such networks can only be deployed in a limited area compared with the coverage possible using a radar. We show how, in those areas where multipath contributes to detection errors, the ground sensor network performance can be improved. Using integrated radar and ground sensor networks significantly improves the performance of radar target detection in a multipath environment. Such improvement in performance has implications for using more varied type of sensors to support the radar with statistics that complement the radar's receiver operating characteristic. [C911]

## "Using optical imagery to enhance radar tracking performance"

A difficult problem with ground moving target indicator (GMTI) radar detection is how consistently to track targets moving through non-homogeneous regions of clutter such as forest and urban boundaries. Although attempts have been made to mitigate this detection problem using terrain mapping data, such data does not give current clutter information due to changes in vegetation, roads, buildings, and seasonal variations. We propose to use electro-optical imagery to enhance the detection performance of GMTI radar We use a multiresolution Markov model to represent both target and background clutter. This multiresolution structure allows us to match GMTI clutter accurately with the geographically registered electro-optical imagery for consistent moving target detection through clutter boundary areas. [C912]

## "Research on fast ATR algorithms applied to AAM at endgame"

ATR has been the most important part of the research plan for detecting and recognizing targets in many countries. In this paper, we address fast ATR algorithms for air-to-air missiles (AAMs) flying at endgame. These algorithms can be used to detect, recognize and track a target as well as determine the vulnerable components of an object. It can estimate engagement parameters such as Tgo (time to go) and adaptively control burst-point in various missile and target encounter models. Experimental results have showed that the performance and the real-time of algorithms are both satisfied to general demand of missiles. [C913]

## "Electro-optic identification research program"

Electro-optic identification (EOID) sensors provide photographic quality images that can be used to identify mine-like contacts provide by long-range sensors, such as sonar systems. To help support the transition of these sensors to the fleet as well as to aid in the development of future EOID sensors, the Office of Naval Research (322-OP) has funded a five-year research program to investigate the performance properties of existing EOID sensors as a function of ocean environment. This paper describes the EOID research program and its objectives along with a brief discussion of supporting tasks such as validating existing electro-optic models, development of performance metrics, and development of computer aided identification and automatic target recognition algorithms. In addition, data from the recent field test are presented. [C914]

## "Target detection performance of PDI considering the change of the target distance"

In radar systems, PDI (post-detection integration) techniques are widely used to improve the target detection performance. In a conventional PDI, targets are assumed to be stationary, that is the distance between a radar platform and a target is almost constant. Conversely, if the target distance changes, the target detection performance of PDI deteriorates. To resolve the above problem, we have proposed shift PDI method. In this method, we conduct the PDI processing, based on the various assumptions of target velocity, which results in the increase of PFA (probability of false alarm rate). In this paper, we conduct the numerical formula to calculate the PFA for shift PDI procedure. Moreover, we estimate the target detection probability of the shift PDI with considering the increase of PFA in the shift PDI procedure. [C915]

## "FDTD analysis of plane wave scattering by slots on conducting targets loaded with anisotropic material"

This paper presented the finite-difference time domain (FDTD) algorithms of anisotropic material. Using this algorithm, the RCS of conducting targets slotted with different anisotropic material can be calculated. The characteristics of the electromagnetic scattering from negative and positive uniaxial material filled in the slot of the target were calculated and shown in this paper. [C916]

## "Bottom mounted active sonar for detection, localization, and tracking"

A bottom-mounted, wideband active sonar system designed to detect unfriendly vessels entering a closed area is described. We present signal processing algorithms for target detection, classification, localization, and tracking, and present performance predictions based on simulations. These algorithms are shown to be effective with state of the art, realizable sonar systems. The signals are binary phase shift keyed (BPSK) with a range resolution of approximately 0.01 m and Doppler resolution of 0.5m/s. Received signals from multiple directional receive beams are basebanded and Hilbert transformed to obtain complex representation. These signals are correlated with replicas of the transmitted signal time compressed or dilated to represent a number of different hypothetical target Dopplers, giving a processed signal with three dimensions: time, channel, and target Doppler. Background interference is estimated using a block-transversal filter. The processed signal is divided by the estimated background to obtain signal-to-interference ratio (SIR) and SIR threshold crossings are detected and contiguous detections are clustered. Range is estimated using arrival time. Bearing is estimated using amplitude comparison for adjacent receive beams. Elevation is estimated using split beam phase between signals from elements separated vertically. Finally, the crossings are clustered by location and Doppler. Clusters are classified based on amplitude and estimated physical extent and shape. Clusters with sufficiently high classification are passed to a tracking algorithm that computes a Kalman filter track using clusters derived from sequential transmissions. This filter operates using linked line of sight (LOS) coordinates, a technique long used in radar. The LOS coordinates used in this application are range, range rate, bearing, and elevation. Use of such coordinates is advantageous in this application because the errors in the coordinates are nearly independent of one another. Performance of this algorithm was investigated using active acoustic signals synthesized by the Sonar Simulation Toolset (SST), a digital program written by Robert Goddard at the Applied Physics Laboratory. This program generates a complex baseband representation of the acoustic signal in each chan- nel. This signal is processed by the detection, classification, and tracking algorithms. SST simulates effects of acoustic propagation including refraction and scattering and reflection from a target. Several simulated encounters with different target geometries are presented to illustrate detection, localization, and tracking performance. [C917]

## "Neuro-fuzzy pattern classification model with rule extraction based on supervised learning"

The main objective of this paper is to design a new method for generating fuzzy rules for pattern classification. To start with, separation hyperplanes for classes are extracted from a trained neural network. The convex existence regions in the input space for each class is approximated by shifting these hyperplanes in parallel using the training data set for the classes. Using the fuzzy rules the numerical input data is classified directly without the need of neural networks. The proposed method is verified for target recognition using radar cross section signals. [C918]

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First Page of the Article [C919]

## "Conference Record of the Thirty-Sixth Conference on Signals, Systems and Computers (Cat. No.02CH37387)"

First Page of the Article [C920]

## "Radar target feature extraction by wavelet transform and KCN"

Feature extraction of radar target recognition using high range resolution profiles is discussed. A feature extraction scheme by using wavelet transform and Kohonen clustering network (KCN) is proposed from the points of reducing feature dimension and feature numbers to represent a target. To compare the performance of different feature extraction methods, Fisher distance measure is introduced which reveals the within-class compactness and the between-class separation. Experimental results show the effectiveness of this method. [C921]

## "A preliminary research into the data fusion of double model homing head"

According to the characteristic of an air defense missile, the data fusion structure of an infrared/millimeter wave double-model homing head is analyzed. A double-layer fusion project, which includes characteristic fusion and strategic decision fusion, is used in detecting and tracking targets. The methods of characteristic fusion and strategic decision fusion are given. [C922]

## "Motion of ground moving targets and implications for aided recognition"

In air-to-ground radar imaging, the motion characteristics of ground moving vehicles are often ignored or implicitly assumed as being trivial. A pilot study conducted during September 2000 suggested that the motions are in fact far from simple. Results have been gained from a controlled experiment that measured the 3-axis rotation behaviour of a variety of military vehicles transiting different terrain. Typical rotation rates as high as 30° s-1were seen in more than one axis of rotation for a tracked vehicle moving at speed off-road, and these rates are encountered up to 2% of the time. These results suggest that significant attention should be paid to typical motion characteristics when considering moving target identification and imaging problems. [C923]

## "High-resolution full-polarimetric video impulse radar for landmine detection"

A full-polarimetric ultra wideband GPR front-end has been developed. The front-end is suitable for subsurface imaging with resolution sufficient for antipersonnel mine detection and recognition. In comparison with commercially available video impulse GPR systems the key advantages of the front-end are considerably larger bandwidth, ability to measure the polarimetric structure of the scattered field and very high precision of scattered field measurements. A principally new antenna system design and an ability to perform quasi-simultaneous measurements with two transmit polarizations and in two different frequency bands are main novelty aspects of the radar. [C924]

## "A mixture model approach to automatic radar target recognition using WinBUGS"

This paper considers the use of the software package WinBUGS for an application to a previously documented technique for automatic radar target recognition. Mixture models under a Bayesian formalism are used to model the probability densities of radar measurements from given classes. WinBUGS is then used to construct a Markov chain Monte Carlo sampler that allows implementation of this Bayesian approach. The model developed is applied to radar range profiles from seven classes of military ships. [C925]

## "The stability of polarimetric features for target classification from SAR imagery"

This study investigates the information content of polarimetric SAR imagery for use within automatic target detection and classification algorithms. Key questions such as the stability of polarimetric information and its relationship with image resolution are addressed. Using relatively simple polarimetric features, such as the percentage of pure odd and even bounce scattering events, we show how it is possible to identify the differences between two classes of military vehicle. The use of the radial power spectral density is proposed as a measure of the spatial distribution of these odd and even bounce scattering events, again enabling the two classes to be distinguished. [C926]

## "Radar 2002 (IEE Conf. Publ. No.490)"

First Page of the Article [C927]

## "Fractal dimension estimation using modified differential box-counting and its application to mstar target classification"

First Page of the Article [C928]

## "A robust Doppler classification technique based on hidden Markov models"

A classification algorithm is presented that uses hidden Markov models (HMM) to carry out recognition between three classes of targets: personnel, tracked vehicles and wheeled vehicles. It exploits the time varying nature of radar Doppler data in a manner similar to techniques used in speech recognition, albeit with a modified topology, to distinguish targets with different Doppler characteristics. The algorithm was trained and tested on real radar signatures of multiple examples of moving targets from each class and the performance was shown to be invariant to target speed and orientation and was able to generalise with respect to variants within a class. [C929]

## "Bistatic synthetic aperture radar"

Synthetic aperture radar (SAR) is becoming increasingly important in many military ground surveillance and targeting roles because of its ability to operate in all weather, day and night, and to detect, classify and geolocate objects at long stand-off ranges. Bistatic SAR, where the transmitter and receiver are on separate platforms, is seen as a potential means of countering vulnerability. This paper provides an overview of QinetiQ's on-going research into the processing techniques for bistatic SAR, the fundamental problems it introduces, and ways to overcome them. [C930]

## "Radar target recognition based on peak location of HRR profile and HMMs classifiers"

The location information of prominent points backscattering, extracted from the high resolution radar echoes by the Relax algorithm, is used as the feature for radar target recognition. The sensitivity of high range resolution (HRR) profiles to the LOS of radar yields an idea that the multiaspect radar echoes can be modeled by a hidden Markov model (HMM); it gives the spatial-temporal information of a target. Several HMMs are cascaded in a chain to model the pose of a flying objective and is used for automatic target recognition in a class-attributed and aspect-attributed manner. Computer simulations with radar data show that for a close-set recognition, an averaged recognition rate of 96.77% for aspect-recognition and 99.80% for class-recognition is achieved, respectively; that for a open-set recognition, the averaged class-recognition rate reaches 81.25% under a maneuver condition. [C931]

## "Phase coded continuous wave radar echoes analysis and recognition based on chaotic dynamics"

A detailed analysis is presented on the chaotic dynamics of moving target echoes produced by phase coded continuous wave (PCCW) radar. Based on real sampled data, the chaotic dynamics of different kinds of target are proved by three principal chaotic invariants, namely, correlation dimension, Lyapunov spectrum, and Kolmogorov entropy. The feasibility of target recognition based on these extracted features is discussed. [C932]

## "Bayes-optimality based feature transform for high resolution range profile identification"

Many feature transform methods have been used for radar target identification. But most of them are based on scatter matrices or other statistics of the data, which do not directly correlate to classification accuracy. In this paper, a Bayes-optimality based adaptive feature transform method is proposed for radar target identification using high resolution range profile results show that this method is effective on radar target identification. [C933]

## "An algorithm for cross-range imaging of moving target with conventional narrow radar"

This paper studied the problem of imaging the moving target in cross range direction by use of conventional narrow radar and indicate the key technique to obtain the cross range profile of target is motion compensation. In this paper, after analysis in theory, a motion compensation algorithm based on third order polynomial coefficients estimation was proposed. In order to optimize these estimating coefficients, an optimal criterion was also presented. Moreover, this paper also proposed an algorithm to estimate the cross-range resolution. Simulation results show the presented method of cross range imaging is effective and the algorithm of estimating the resolution is reason able. [C934]

## "High resolution range profile statistical property analysis of radar target"

When using high resolution range profile (HRRP) to radar target identification, we must know its statistical property including the stability and separability. This paper uses six kinds of aircraft scaling model data to analyze the statistical property of HRRP in detail. According to the analysis result, a modified method for the target identification is presented. [C935]

## "Target decomposition through polarimetric, disjoint Doppler and frequency band (I)SAR images"

A fully polarimetric (I)SAR image target decomposition process has been developed to aid automatic target recognition (ATR) for disjoint Doppler and frequency bands. In this paper the principle of target decomposition into scattering primitives is first demonstrated for a flat plate and then for a more complex target. [C936]

## "A system for detection, identification and tracking of a dense cluster of targets based on matched illumination and function filters"

We discuss a system based on a set of "function filters" which makes it possible to divide the target cluster into smaller groups so as to ease the tracking task. The concept of function filters is illustrated. [C937]

## "SAR image feature extraction and classification with fractal-based description"

In the field of synthetic aperture radar (SAR) image analysis, an effective feature extraction method based on a fractal Brownian increment random field (FBRIR) is introduced, and an effective classification method with a neuron network based on adaptive resonance theory (ART) is designed accordingly. At last the validity of this systematic approach is tested and compared using real data of Ku band SAR images. [C938]

## "Target recognition and classification using neural networks"

Intelligent systems such as neural networks and fuzzy logic or a combination thereof have been successfully applied to solving problems in the area of pattern recognition. Neural networks are modeled off the biological neurons in the body and their triggered responses to stimuli; while, fuzzy logic uses human linguistic and expert knowledge to make decisions. In many situations, there are multiple sensors making measurements of the environment. The objective is to combine the measurements (data fusion) in a way that provides an output that describes the environment. The development of a mathematical formulation for solving a problem like this is often very difficult. On the other hand, intelligent systems such as neural networks and fuzzy logic have provide good solutions in complex scenarios like this, where it is difficult to develop closed form mathematical solutions to multi-input/multi-output problems. Therefore, in this paper a neural network approach is used to recognize and classify airborne targets. The target recognition and classification problem was broken into two parts. The first part consists of using a neural network to recognize the existence of a target. Then, given the existence of a target, the next step consists of classifying the target type. Two case studies are presented showing the efficacy of using neural networks for target recognition and classification. [C939]

## "An efficient method of radar target detection in complex background"

An efficient method of radar target detection based on multifractals and a neural network is proposed and applied to armored target detection in a complex background. The detection experiment results are encouraging and show that the proposed method is superior [C940]

## "The hybrid signal applied for low-flyer detection and tracking"

This paper addresses a method for the design and processing of a hybrid signal for low-flyer detection. We combine the LFM (linear frequency modulation) signal and random hopped frequency signal together to form the hybrid signal, which possesses high-range-resolution (HRR) ability and better ECCM character. In the course of the signal processing, a two-stage pulse-compression technique is applied in order to get the range resolution less than 10 cm. Finally, the paper gives the actual experimental result that proves the correctness of the method [C941]

## "Scan-to-scan integration-correlation for the detection of small fast targets"

Conventional scan-to-scan integration-correlation (SIC) algorithms comprise a signal weighting part, scan-to-scan integration (SI), together with a signal selection part, scan-to-scan correlation (SC). Such currently used SIC algorithms can detect "small, stationary" targets, i.e., targets with low signal-to-clutter ratio and zero or low speed, but not "small, fast" targets, i.e., "small", relatively high speed targets. However, detection of these "small, fast" targets is the primary purpose of SIC. This paper presents a new SIC algorithm which fulfils this aim [C942]

## "A simple method for estimating the velocity based on the Doppler shift"

A simple method for estimating the velocity of a moving target is presented, based on the Doppler shift. The relationship between the ML estimation and the FFT is exploited to obtain a practical implementation. With the help of adaptive noise canceling to increase the input SNR of the FFT, high-precision analysis for the single-

frequency signal is easily accomplished. Simulation shows that the method presented meets the high demand required in practice [C943]

## "Extraction of characteristics of a target"

The similarity parameter between two scattering matrices is introduced. This parameter is not only independent of the spans of the scattering matrices, but also independent of the target orientation angles. From the definition of this parameter, we derive the parameters of similarities to the scattering matrices of a plate (sphere), a diplane, a wire and two helixes, which are very convenient for analyzing the characteristics of a radar target [C944]

## "An automatic target recognition (ATR) scheme in colored Gaussian noise based on parametric model and hybrid algorithm"

This paper firstly presents a concise and physically relevant parametric model for use in automatic target recognition (ATR), data compression and scattering studies. Then, the extraction algorithm of high-resolution target feature vectors for ATR in the presence of colored Gaussian noise is developed, which is not restricted by the low SNR and Rayleigh resolution limit. Therefore, an eight-stage ATR scheme based on the hybrid algorithm is proposed. The experimental results show its practicability in the application [C945]

## "A comparison of sea waves in open sea and coastal waters"

Detection of small targets in coastal waters is generally more difficult than in open waters. One reason for this might be the different behaviour of the sea waves as the sea waves are not fully developed in closed waters. The paper presents a comparison of measured sea clutter and wave rider buoy data in open sea and coastal waters [C946]

## "The modelling of sea clutter and its application to the specification and measurement of radar performance"

This paper concentrates on the problem of specifying and measuring the performance of airborne maritime surveillance radars that are required to detect small targets against a background of sea clutter. In particular, the need is identified for the very careful specification of the clutter models used for predicting and comparing the performance of competing radars. It is also shown how the appropriate specification of modelling or simulation methods can address some of the dynamic performance measures that are not covered by traditional specifications. Finally, the role of models in assessing performance is discussed [C947]

## "Target detection of high resolution and full polarization based on PWF and scattering points"

The target detection of high resolution and full polarization radar is discussed. Signal-to-clutter ratio is a determining factor for the detection problem. Raising SCR can bring about an improvement. Here, a cascaded detection scheme is presented. The enhancement of SCR at each stage result in the ultimate improvement of detection performance. At first, by exploiting polarization information, the fused and enhanced one-dimensional range profile is obtained. Then the target's detection is transformed to that of scattering points owing to the high resolving property. Finally, a simulation experiment verifies that the ultimate detection performance is improved [C948]

## "Netted radar sensing"

In this paper we consider a number of aspects illustrating how networks of radar sensor systems (rather than a single monostatic radar) can offer a counter to stealth technology whilst simultaneously providing more detailed information for improved target detection, classification and location. The netted radar equation is developed, coverage, detection and location performance are quantified, and the potential utility of additional information offered by a network together with countermeasure capability are discussed [C949]

## "An automatic tracking system for marine navigation"

A fully automatic tracking system is discussed in this paper. Compared with conventional tracking systems, a new detection approach based on image recognition is proposed for rejecting ground clutter. The multiple hypothesis tracking (MHT) method is applied in sea or weather clutter background to keep tracks more reliable and more stable. Tracking performance is improved. Thus, the major problems of clutter interference that mainly prevents the realizing of automatic tracking are solved. Finally, track presentation logic is discussed in detail [C950]

## "An approach to detecting the targets of aircraft and ship together by over-the-horizon radar"

The paper discusses the selection of over-the-horizon radar (OTHR) parameters for detecting aircraft and ship separately. Then, a method of detecting a high-flying target (i.e., aircraft) and a slow-speed target (i.e., ship) in parallel by OTHR is presented. The combination of range-Doppler 2-dimensional CFAR and superresolution techniques is the main problem in the process of detection. Simulation results of real (OTHR) data demonstrate the efficiency of the proposed method [C951]

## "HF shipborne over-the-horizon surface wave radar background clutter statistics"

Sea clutter statistics are very important in designing target detection algorithms in both shore-based SWR (surface wave radar) and shipborne SWR. The sea clutter statistical characteristics in shore-based SWR have been discussed (see Barrick, D.E. and Bsnider, J., IEEE Trans. on Antennas and Propagation, p.19-28, 1997), but the statistics of sea echo in shipborne SWR radar have not been reported. The statistical models of first-order Bragg lines and the second order components of sea echoes, which include the effect of motion of the radar platform, are established for shipborne SWR. The effects of radar platform motion on the statistics of sea echoes are analyzed and the results are verified by measured data. This provides a theoretical basis for some Gaussian-based target detection techniques to be used in shipborne SWR [C952]

## "On the increasing importance of simulations in the conception of new naval radar systems"

The purpose of this paper is to explain the increasing importance of adequate simulation tools in the design of new high-resolution radar systems for defence purposes. Changing demands on radar performance imply the need for a new scale of representation in simulations. To meet these new demands, the classical macroscopic descriptions no longer provide enough information. The radar chains, as well as the targets and environments, have to be represented on a microscopic scale, allowing for more detail [C953]

## "An effective method of anti-impulsive-disturbance for ship-target detection in HF radar"

This paper presents an effective method against impulsive disturbances resulting in the spectral base wholly rising, which may cover the spectra of ship target returns. The first-order sea clutter in the time domain is always dominant in amplitude and the impulsive disturbances would usually be covered. In order to eliminate impulsive disturbances, the first-order sea clutter is first cancelled in the frequency domain and then those impulsive disturbances which are dominant in amplitude in the time domain can be eliminated. The remainder is basically the weaker background noise and ship target echoes and signal detection becomes possible, especially for weaker targets [C954]

## "MTI radar stability measurement error"

The stability of MTI radar measured as the ratio of power of test signal residue in the target filter to power of the test signal in the clutter filter does not necessarily correspond to the actual system stability over the range of test signal-to-noise ratios. The stability measurement algorithm should be based on the signal-to-noise ratio for which both figures match each other (that in the general case depends on the number of pulses and set of coefficients used to create a canceler or Doppler filter bank) or a correction coefficient should be introduced to account for possible discrepancy between measured and actual stability figures [C955]

## "Adaptive search strategy in phased array radars"

In this paper, an adaptive region search strategy and its performance are studied. Firstly, the optimal illumination interval and the optimal search performance with the known target appearance probability are derived. Next, the influence of the target distribution density's estimation error on the optimal region search performance is analyzed and an adaptive search method, and its performance are investigated. Finally, the simulation results are provided [C956]

## "Radar permanent scatterers identification in urban areas: target characterization and sub-pixel analysis"

Summary form only given, as follows. The permanent scatterers (PS) technique, developed by the authors during the last three years, allows the identification of radar targets particularly suitable for SAR interferometric measurements. In fact, despite its remarkable potential, spaceborne SAR differential interferometry (DInSAR) has not been fully exploited as a reference tool for ground deformation monitoring, due to the presence of atmospheric artifacts as well as geometrical and temporal phase decorrelation. Both drawbacks are overcome by

using a multi-image framework of interferometric data (>30 images) in order to properly identify and exploit the subset of image pixels corresponding to coherent reflectors (PS). Whenever the sparse grid of PS is dense enough (more than 3-4 PS/km2, constraint always satisfied in urban areas); accurate phase measurements carried out on the sparse PS grid allow one to compensate data for the atmospheric phase contributions. Average ground deformation rate as well as full displacement time series (both along the satellite line of sight, LOS) are estimated with millimetric accuracy on individual PS locations, fully exploiting the long temporal series of SAR, data available in the ESA ERS-1/2 archive. Therefore, the PS subset of image pixels can be seen as a high-density (100-300 PS/km2, in urban areas) "natural" geodetic network. In this paper, we present some new results concerning the statistical characterization of the PS, both in terms of amplitude and phase returns. Moreover, it is shown how PS density can be significantly increased, in urban areas, by adopting a second-order model. Here, two individual scatterers per resolution cell are considered. Available data are then used to recover their reflectivity, elevation and LOS velocity. Problems related to over-fitting and model parameters estimation will be addressed. Results obtained processing 64 SAR images (ESA-ERS archive) acquired over Milan are shown. Finally, we present how PS can be exploited to carry out interferometric measurements using ERS-2 images acquired when the sensor was in emergency back-up mode (EBM). Both theoretical (signal processing) and practical issues are considered. First results obtained over Paris are discussed [C957]

## "Automatic mapping of linear structures in 3-dimensional space from ground-penetrating radar data"

Non-invasive geophysical techniques such as ground-penetrating radar allow rapid and low-cost investigation of the shallow subsurface for the detection of such features as utilities and plant. This paper presents a pattern recognition approach based on the 3-dimensional Hough transform for the detection of extended linear targets in ground-penetrating radar data. By transforming spatially extended patterns into spatially compact features in parameter space, a difficult global detection problem in data space becomes a more easily solved local peak detection problem in parameter space. Due to the sparseness and variability of the data, the accumulator peak detection stage is replaced by a novel algorithm called the adaptive non-accumulated Hough transform (ANHT) 3-dimensional clustering algorithm. This technique allows the combination of qualitative site information and ground truth in order to increase the accuracy of the final result. The user is presented with a 3-dimensional site survey report detailing the length, depth and orientations (azimuth and zenith) of any pipes, cables or the like. The ANHT performs substantially superior to the standard Hough transform implementation in computer memory requirement. Our experimental results on the artificial 3-dimensional linear objects indicate that method works quite well under various background conditions. The automatic mapping of linear structures in 3-dimensional space from ground-penetrating radar data is achieved by implementing the ANHT in the detection of linear targets in ground penetrating radar data [C958]

## "The properties of range profile of aircraft"

Wideband radar can obtain more target information, for its range resolution is high. With an airplane, because its size is smaller than the resolution of conventional radar, it can be regarded as a 'point'. But to wideband radar, with a few hundred MHz bandwidth, the range resolution is smaller than a meter, and the airplane echoes of one impulse compose a high resolution range profile (HRRP), which includes target shape information, so it can be used for automatic target recognition (ATR). It is difficult to recognize a target by observing range profiles by eye; although the range profile is divided into range resolution cells, every range cell still has many scatterers, so that the complex amplitude of one range cell echo can be regarded as the sum of the echoes of many scatterers. When the angle-of-sight has changed little, although the change of the range of each scatterer to the radar is small, it is great relative to the wavelength and leads to the phase difference being great, which results in the complex amplitude varying with aspect, that is, the aspect sensitivity is great. In order to use the range profile for target recognition, the properties of the range profile need to be studied. Preprocessing is needed to obtain stable range profiles [C959]

## "The resolving method of radar nonrigid multi-target"

Combined with the basic principle and method of radar multi-target resolution, the application of time-frequency analysis is discussed for nonrigid multitarget resolution. The integrated generalized ambiguity function (IGAF) is used to resolve a nonrigid multi-target, for it is an ideal tool to analyze polynomial phase signals, and it is proved to be effective by analyzing the radar data [C960]

## "Application of local discriminant bases to HRR-based ATR"

Wavelet-based signal classification and compression techniques have gained substantial popularity due to their low computational costs, excellent localization properties, and the ability to choose from a large number of bases

for signal representation. A difficulty with applying wavelet-based techniques is determining the best wavelet type and basis. For compression, the best-basis algorithm has been proposed to find the wavelet-packet basis with maximum energy compaction. The local discriminant basis (LDB) was previously introduced in the context of signal classification to find the best wavelet-packet basis with maximum class discrimination. In this paper, we apply the LDB to the problem of automatic target recognition. We describe the mechanics of the LDB as applied to one- and two-dimensional signals, and introduce a novel classification scheme that is tolerant to image scaling and moderate image translations and dilations [C961]

## "A multiple perspective spectral approach to object detection"

Many applications for detection of objects such as video analysis require that candidate objects be observed over a range of perspectives in 3 dimensional space. As a result we must have a robust model and detection process for these objects in order to accurately detect them through a range of geometric transformations. In order to keep our detection process computationally efficient, we use a compact multiresolution model to represent the range of geometric transformations possible in the object to be detected. Additionally, we form an integrated likelihood ratio detection statistic to optimize the detection performance over the entire space of targets being examined. To demonstrate the performance of this algorithm we apply our results to a compressed video sequence and show the improvement of our integrated three dimensional model as a function of model order [C962]

## "Target enhancement using steerable pyramid decomposition and multi-channel filtering"

Generally, targets are small as compared to the background and are obscured by the clutter. Therefore, for efficient automatic target recognition/detection (ATR/D) it is essential to enhance targets and reduce the background/clutter effect. In this paper, we describe a technique based on steerable pyramid decomposition and multi-channel filtering to enhance targets. The steerable pyramid decomposition offers the advantage of analyzing targets in different orientations and multi-resolution and hence, helps in extracting directional features across different bands that are mainly associated with targets. First, we preprocess the images (a) to remove the objects that are typically larger than the possible maximum size of the targets of interest and (b) to estimate the required levels of pyramidal decomposition. We then decompose the images into required levels by using a bank of steerable filters. Next, we apply a feature enhancement technique to all the sub-band images to generate enhanced feature based images. Finally, a novel multichannel filtering technique is applied to remove background clutter using these enhanced images. The result of filtering obtained at a lower resolution level is propagated into the higher resolutions. This has the advantage of greatly reducing the computation load and improving the target enhancement. We have applied the proposed algorithm to both simulated and real un-cooled infra red (IR) images. The experimental results show that the proposed algorithm is effective in removing the background clutter and enhancing the targets in both these cases [C963]

## "Efficient implementation of comb filters using block processing"

First Page of the Article [C964]

## "Evolutionary design of neural network classifiers for radar target recognition"

An automatic method of designing classifiers for radar target recognition by the range profiles is proposed. The classifiers are made of feedforward neural networks whose topology and weight distributions are evolved by a hybrid evolutionary algorithm [C965]

## "Pole patterns of radar-target scattering model based on ultra-wideband Gaussian pulses"

Time domain and frequency domain analysis of a radar-target scattering model based on ultra-wideband Gaussian pulses are presented. The scattering model is a useful tool for computing the range profile, or image, of a complex target that is illuminated by electromagnetic impulses. Computer plots of range profiles and pole patterns are obtained for a complex target that is composed of a finite number of scattering centers. The range profiles and the pole patterns are valuable information for radar-target classification and identification [C966]

## "Radar target recognition by a logarithm bispectrum-based method"

The paper starts with the definition of logarithm bispectrum and the presentation of its properties relative to target recognition. A relationship is established between the logarithm bispectrum feature of a target and that of the higher resolution range profile. As a result, the criterion for target recognition, based upon the relationship, is induced and its implementation is given. Simulation with some out-field acquired data is given to show that the approach is effective and advantageous over an existing one for rapid recognition [C967]

## "Optimal design of clutter rejection filters for MTI system"

Transversal digital high-pass filters are considered for extracting moving target signals from clutter. A new approach is suggested for the analytical design of clutter rejection filters. Based on the required filter pass-band response, a procedure for selecting suitable PRI (pulse repetition interval) values has been used. According to the requirements of the filter rejection-band response, a kind of high pass filter has been suggested as the prototype for determining the optimal filter weighting coefficients [C968]

## "Segmentation and recognition of bridges in high resolution SAR images"

Based on analyzing the features of SAR images, this paper presents a novel algorithm for automatic segmentation and recognition of bridges in high-resolution SAR images according to the idea of detecting the targets along the edges of the image. At the same time, wavelet analysis is successfully used in prefiltering and denoising; good recognition results are thus obtained [C969]

## "Efficient radar target classification using modular neural networks"

A radar target classifier based on modular neural networks is presented and its performance compared with that of a classifier based on non-modular neural networks. In this classifier, the response from an unknown target is sent to several waveform predictors that are BP neural networks trained by responses from known targets. The predictor errors are then sent to a classifier using the rule of maximum a posteriori or the rule of modified minimum squared errors. The simulation shows that the new classifier has a good performance on radar target recognition. The method also has other advantages such as easy realization, clear structure and easy expansion [C970]

## "A novel high-resolution polarization target detection method based on intense scatterer integration"

The problem of wideband high-resolution radar target detection in cluttered circumstances is studied. A high-resolution polarization target detection scheme is presented based on intense scatterer integration. Because of the intrinsic high-resolution characteristic of the wideband waveform, a one dimensional range profile of a radar target can be obtained. In connection with the target's polarization characteristics, the number and distribution of intense scatterers in the target's echo can be estimated. SCR (signal-to-clutter ratio) can be improved efficiently by integration of these intense scatterers in corresponding resolution cells. Experimental results show that the radar's detection performance can be improved significantly by using the presented algorithm [C971]

## "Optimal sampling of linear FM and conversion to digitized waveform having predictable sidelobe patterns"

Several advantages are achieved when discrete phased codes are used instead of continuous waveforms. The discrete structure of the phase code signal enables one to increase the freedom of waveform design when pulse compression scheme is considered. This may lead to an arbitrary design of the resultant sidelobe patterns and possibly wide dynamic range responses can be achieved for various applications. This paper shows how a particular sampling rate for linear FM signals may lead to a significant reduction of the peak sidelobe level (PSL) as well as the integrated sidelobe level (ISL) in pulse compression operation [C972]

## "Novel method for ground clutter cancellation of low speed targets based on space-time adaptive processing"

A new clutter model for multichannel SAR based on the analysis of features of space-time adaptive processing and SAR imaging is given. Based on this model, a new clutter cancellation algorithm suitable for multichannel SAR is proposed. A processing scheme for moving target imaging is also given. It is shown in simulation that the new method can effectively reduce the power of mainbeam ground clutter for low speed target imaging [C973]

## "Target-to-clutter contrast enhancement using radar Doppler polarimetry"

The connection between Doppler and polarimetric characteristics of targets is studied. It is shown that the Doppler polarimetric formalism provides more complete radar object description. These conclusions are supported by the model of simple compound object as well as by the radar observations of ground clutter. It is also shown that the clutter suppression which is based on Doppler polarimetric object description gives better contrast enhancement than the polarimetric optimization techniques [C974]

## "Wide-angle ISAR passive imaging using smoothed pseudo Wigner-Ville distribution"

We are investigating passive radar imaging of aircraft using reflected TV signals. UHF-band ISAR imaging requires wide-angle data to produce good cross-range resolution. We show that direct Fourier reconstruction (DFR) causes degradation of the reconstructed image due to aspect-dependent scattering. We find that a smoothed pseudo Wigner-Ville distribution (SPWVD) applied in the cross-range direction in place of the Fourier transform can generate a sequence of images, which shows the target reflectivity as a function of aspect angle. Compared to DFR results, these images have higher cross-range resolution. A final image can be synthesized from these images and used for target recognition. XPATCH is used to simulate monostatic data from an aircraft. The proposed SPWVD-based imaging method produces a useful image of the aircraft from this data [C975]

## "A general signal processing algorithm for MTI with multiple receive apertures"

Moving target indication (MTI) is demonstrated for general antenna arrays, especially sparse 3D arrays. The framework for space-time adaptive processing (STAP) is generalized to include frequency (fast-time) data and array elements offset in cross track dimensions. The degrees of freedom (rank) needed to represent clutter are derived for general systems. The clutter rank compared to the number of independent samples collected by a radar determine whether MTI is achievable. The optimum detector and the minimum norm eigen canceler (MNE) are implemented through simulation to demonstrate effective clutter cancellation [C976]

## "GMTI performance of ΣΔ-STAP for a forward-looking radar"

The GMTI performance of ΣΔ-STAP for a forward looking phased array radar is analyzed using the simulation tool RLSTAP. ΣΔ-STAP processes the returns from sum and difference antenna channels. When used in conjunction with partially adaptive STAP methods ΣΔ-STAP is shown to achieve good GMTI performance [C977]

## "Space-time processing for airborne high range resolution phased array radar"

This paper considers the clutter suppression and feature extraction of multiple moving targets for airborne high range resolution (HRR) phased array radar. We show how to use a vector autoregressive (VAR) filtering technique to suppress the clutter for HRR radar data, then a relaxation-based multiple moving target to demonstrate the effectiveness of the algorithm [C978]

## "Markov modeling of transient scattering and its application in multi-aspect target classification"

Transient scattered fields from a general target are composed of wavefronts, resonances and time delays, with these constituents linked to the target geometry. A classifier applied to transient scattering data requires a statistical model for such fundamental constituents. A Markov model is employed to characterize the transient scattered fields-for a set of target-sensor orientation over which the transient scattering is stationary-utilizing a wavefront, resonance, time-delay "alphabet". The Markov model is utilized in a classifier developed for multi-aspect transient scattering data, with a hidden Markov model (HMM) employed to address the generally non-stationary nature of the multi-aspect waveforms. Each state of the HMM is characteristic of a set of target-sensor orientations for which the scattering statistics are stationary, the statistics of which are characterized via the Markov model. The wavefront, resonance and time-delay features are extracted via a modified matching-pursuits algorithm [C979]

## "Comparison of GLR and maximal invariant detectors under structured clutter covariance"

There has been considerable recent interest in applying maximal invariant (MI) hypothesis testing as an alternative to the generalized likelihood ratio (GLR) test. This interest has been motivated by several attractive theoretical properties of MI tests including: exact robustness to variation of nuisance parameters, finite-sample min-max optimality (in some cases), and distributional robustness. However, in the deep-hide target detection problem, there are regimes for which either of the MI and the GLR tests can outperform the other. We discuss conditions under which the MI tests can be expected to outperform the GLR tests in the context of a radar imaging and target detection application. We also show that the relative advantage of the MI tests is robust to boundary estimation errors [C980]

## "Speech articulator and user gesture measurements using micropower, interferometric EM-sensors"

Very low power, GHz frequency radar-like sensors can measure a variety of motions produced by a human user of machine interface devices. These data can be obtained at a distance and can measure hidden structures. Measurements range from acoustic induced 10-micron amplitude vibrations of vocal tract tissues, to few

centimeter human speech articulator motions, to meter-class motions of the head, hands, or entire body. These EM sensors measure fringe motions as reflected EM waves are mixed with a local (homodyne) reference wave. These data, when processed using models of the system being measured provide real time states of interface positions or other targets vs. time. An example is speech articulator positions vs. time in the users body. This information appears to be useful for a surprisingly wide range of applications ranging from speech coding synthesis and recognition, speaker or object identification, noise cancellation, hand or head motions for cursor direction, and other applications [C981]

## "Dual frequency measurements of ocean forward scatter with an ultrawideband radar"

This paper presents an experiment description, along with data examples, for ultrawideband radar measurements of low grazing angle forward scatter associated with a test target mounted above a wind-disturbed sea surface. The measurement radar used sub-nanosecond transmit pulses (0.15 ns and 0.25 ns 3 dB pulse widths) at center frequencies of 9 and 4 GHz to achieve resolutions finer than 3 cm in the range dimension. This resolution was sufficient to fully resolve direct and multipath (both single and double bounce) contributions to the signal reflecting from a tower-mounted retro reflector. The geometry produced a nominal 3 degree grazing angle for forward scatter. Dual frequency measurements for a wind-disturbed ocean surface highlight changes in the magnitude and the location of the scatter components with time [C982]

## "Using neural networks for high resolution distance measurements in pulsed laser radar"

We have developed a new distance measurement method which can obtain distance information directly from the output waveform of pulsed laser radar (PLR). A simple digital signal processing technique and multilayer perceptrons (MLP) have been used to recognize the pulse shape and to obtain the distance information. The method has been implemented in a real PLR for high resolution distance measurements to improve the resolution and to decrease the nonlinearity error. Because of the ability of neural networks in decreasing the noise and preprocessing of the noisy input pulse shapes to the neural network, resolution and nonlinearity were greatly improved. Distance deviation of 53 μm-168 μm, full width at half power (FWHP) of 70 μm-190 μm and non-linearity of 187 μm have been achieved. All the measurements in the same situation has been performed by using the standard method to extract the distance information from time interval between the reference pulse and the reflected pulse. In comparison with the standard method, resolution in the best case and non-linearity were improved by 86% and 6.5% respectively. In this method if the PLR system is reasonably stable during the measurement, it is possible to use only the reflected pulse from the target to extract the distance information and this makes PLR simpler in hardware. Because the neural network decreases noise, it is possible to make the measurements with the same resolution of standard method but with the lower averaging in sampling unit and this dramatically increase the speed of the measurement [C983]

## "Performance comparison of fast-scan GMTI/STAP architectures"

This paper presents a study on multibeam radar architectures to provide wide-area fast-scan ground moving target indicator (GMTI) coverage. The minimum dwell time of a GMTI radar system is often determined by the Doppler processor. The revisit rate can be lowered, while still meeting dwell time constraints, by using multibeam techniques to cover more area in each dwell. The two multibeam techniques examined here are: (1) to spoil the transmit beam with a quadratic phase and digitally beamform on receive; and (2) to break each transmitted pulse into sub-pulses each with different center frequencies, pointed in different directions, and to beamform in the corresponding direction on receive. Space time adaptive processing (STAP) is used with these GMTI architectures to mitigate main beam clutter and to enhance detection of targets in severe interference environments. The antenna sub-arraying, used for beamforming and STAP, generates grating lobes in the receive pattern in multibeam systems. This can degrade performance because grating lobes cannot be suppressed in more than one direction at a time. Two different antenna designs are studied to determine the effect of grating lobes for each of the above fast-scan architectures; non-overlapping (contiguous) sub-arrays and 75 percent overlapping sub-arrays which allows greater control of grating lobes at the cost of greater array complexity. This paper presents signal-to-interference ratio loss (SIRL), probability of detection (P d) and minimum detectable velocity (mdv) for each system. A narrowband interference source is swept in angle to determine system performance degradation due to the grating lobes [C984]

## "Moving target imaging in foliage using polarimetric multi-frequency antenna array SAR"

Because of the low signal-to-clutter ratio, it is a difficult problem to detect and image moving targets in foliage. A multi-frequency multi-aperture polarimetric SAR (MFMA POLSAR) system is proposed for imaging of moving targets in foliage. The MFMA POLSAR extends the multi-frequency antenna array SAR (MF-SAR) system to multiple polarizations. Full polarization is used in MFMA POLSAR to achieve an optimal polarization adaptive to

the environment, such that the images obtained by different apertures are of the best coherence that is used to obtain the highest accuracy of the phase estimation. It is also shown that the MFMA POLSAR can not only accurately locate both slow and the fast moving targets, but also reveal moving targets in foliage [C985]

## "SAR image processing for moving target focusing"

A novel synthetic aperture radar (SAR) image processing technique has been developed to refocus the ground moving target signature from its smeared response in the SAR image of the stationary ground. The technique implements a matched moving target filter that is derived from the signal history along the target range-Doppler migration path mapped onto the SAR image from its real-space trajectory. The spatial filter is specified by both the apparent target range in the image and the magnitude of the relative target-to-radar velocity. Range dependence may also be eliminated in image filtering by performing the inverse Fourier transform of the SAR image data spectrum after a spatial frequency coordinate transformation [C986]

## "Development of a complete radar system model"

This paper describes an approach to modelling synthetic aperture radar (SAR) and ground moving target identification (GMTI) modes that is applicable to both monostatic and bistatic operation. We describe an extensible method for modelling large complex radar systems that can be used to model platform and target motion, analogue and digital electronic components and complex signal processing algorithms. The key to this approach is a common data file format that allows the user to exchange simulated datasets for real flight trials data or combine the two without any recompilation of the modelling [C987]

## "High range resolution radar signal classification a partitioned rough set approach"

In automatic target recognition (ATR) systems there are advantages to developing classifiers based on a portion of the signal. A partitioning technique is introduced in this paper that allows rough set theory to be applied to real-world size problems. Rough set theory (RST) is an emerging concept for determining features and then classifiers from a training data set. RST guarantees that once the data has been labeled all possible classifiers (based on that labeling) can be generated. There are multiple classifiers for each signal partition and multiple partitions for each signal. Classifiers based on a single reduct (classifier) or one partition do not perform well enough to be useful. We fuse all the reducts from all the partitions into one classifier. This fusion of partitioned reducts yields a synergistic result that produces a classifier with a high probability of declaration and good probability of correct classification [C988]

## "Netted radar sensing"

We consider how networks of radar sensors can offer a counter to stealth technology whilst simultaneously providing more detailed information for improved target classification. Specifically, it is shown how multiple independent sensors can provide an energetically more efficient collector of radar scatter. Further, the relative merits of non-coherent and coherent dependent networks are discussed particularly emphasising the balance between increased performance and increased complexity and cost [C989]

## "SAR prescreening using both target and shadow information"

The utility of fusing shadow and intensity detections in a SAR prescreener is evaluated over the MSTAR database. We use either power ratio, GLRT or two-parameter CFAR tests to extract the two detections. For any testing strategy, the addition of shadow information improves performance [C990]

## "Adaptive detection in dense target environments"

We consider the impact of target signals corrupting the covariance estimate when implementing STAP in ground moving target indication (GMTI) scenarios. Herein, we propose a model for seeding the radar data cube with target signals and calculate both asymptotic and finite training data detection losses. In general, both the location and strength of the corruptive target signals influence performance: under practical conditions, SINR loss can exceed 10 dB. Measured MCARM data confirms the presence of ample ground moving target signals in the radar field of regard under typical operating conditions. We conclude by briefly considering several mitigating strategies as well [C991]

## "Optimal transmission pulse shape for detection and identification with uncertain target aspect"

This paper investigates the optimization of the transmission radar pulse shape to maximize either target detection or identity discrimination between the T-72 and M1 tanks under conditions of aspect uncertainty.

Significant performance improvements in detection and identification are obtained using optimized transmission waveforms over that of standard chirped pulses [C992]

## "Ship detection in SAR images: a segmentation-based approach"

This paper deals with the problem of detecting ship targets in medium- and high-resolution SAR images. Achieving a controlled false alarm rate is a major problem for the presence of a highly non-homogeneous sea clutter environment due to the highly variable environmental and weather conditions in closely spaced areas. After highlighting the problems of conventional techniques, a new approach is proposed based on cascading a segmentation stage and a local CFAR detection stage. The former estimates the homogeneous backscattering regions, while the latter detects the ship targets inside the fairly homogeneous identified regions [C993]

## "Effects of various image enhancement techniques on FOPEN data"

An investigation of FOPEN target discrimination performance is summarized using UHF SAR data gathered at Grayling, MI by the USA Navy's P-3 SAR Sensor. The fully polarimetric data are processed using polarimetric whitening; superresolution processing is then applied to enhance the resolution of the whitened data. Several superresolution approaches are investigated and target discrimination performance achieved using superresolution processing is quantified. Discriminator ROC curves showing probability of detection versus probability of false alarm are used to compare performance; an eigenvector-based superresolution approach is shown to provide the best performance improvement [C994]

## "Reduction of interference in automotive radars using multiscale wavelet transform"

A technique is presented to minimise false decisions in automotive radars operating in close proximity. The technique also reduces the requirement on the power of the radar as signals can be detected with very low signal to noise ratios. The signal processing is achieved in real time using a field programmable array [C995]

## "Detection of ships using cross-correlation of split-look SAR images"

One of the main problems in ship detection is the presence of sea clutter inherent to coherent imagery. A traditional approach to differentiate a target embedded in noise is to utilize the statistical property of the clutter with some success. In this paper, we propose a new technique of ship detection based on cross-correlating split-look SAR images. If the inter-look images consist of the correlated images of a ship and clutter, the degree of mutual correlation increases, and from the difference in correlation, the ship can be identified. Applying the present method to RADARSAT (Standard 1) images, we have found the minimum detectable size of ships is 62.6 m. The SAR data used in this application were acquired under fairly calm sea states, such that the ships can be identified by the naked eye. Thus, the method has not been tested in an extreme limit of high sea states, and remains as a further study [C996]

## "A sequential detection method for moving targets under low SNR environments"

This paper proposes a moving target detection algorithm using the sequential detection approach. Radar target detection under low SNR (signal-to-noise ratio) environments is known as a highly difficult problem. To resolve these subjects, sequential detection algorithm using position and Doppler frequency measurements are proposed. Through several simulations, validity of this algorithm has been confirmed [C997]

## "Validation of a CFAR vessel detection algorithm using known vessel locations"

The National Oeanic and Atmospheric Administration (NOAA)/National Environmental Satellite, Data, And Information Service (NESDIS) is in the second year of a two-year demonstration of Synthetic Aperture Radar (SAR) derived products called the Alaska SAR Demonstration (AKDEMO). This demonstration provides near real-time SAR data and derived products, including wind images and vectors, hard target locations, along with ancillary data, to specific users in the government community. One of the derived products are vessel positions obtained from a constant false alarm rate (CFAR) vessel detection algorithm developed by Veridian ERIM. This algorithm has been tested and validated to maximize the number of ships found while minimizing the number or false alarms on one SAR image of the Red King Crab fishery in Bristol Bay on October 18, 1999. This resulted in using a detection statistic threshold of about 5.5, depending on image resolution used. Until now, this validation has been done with only general knowledge of fishing fleet size and location, but no in situ vessel information. This paper presents the results of a validation of the SAR vessel detection algorithm using observer reported vessel positions along with information on vessel size and local wind speed [C998]

## "Electro-optical systems for image recognition"

Detection and classification of targets by means of electro-optical sensors has been of interest for both defense and civilian applications for a number of years. In this presentation we emphasize two areas: extraction of more information from the sensors by polarimetric and frequency diversity, and reducing the processing and storage requirements by exploiting invariant attributes for detection and classification [C999]

## "A novel algorithm for reconstructing three-dimensional target shapes using sequential radar images"

Inverse synthetic aperture radar (ISAR) is one of the radar techniques used to observe two dimensional images of a remotely based target using radio waves. Since the "cross range" vector is ambiguous, estimating the three-dimensional shape of the target is difficult. However, it is possible to estimate the three-dimensional shape using moving pictures taken by a video camera, if the relative movement between the camera and the target is known. In this paper we propose an algorithm for reconstructing three-dimensional shape of the target by applying a similar technique to the ISAR images. The theory and the required condition of the proposed method are described and some results obtained by the computer simulations are shown [C1000]

## "Bistatic matched illumination radar involving synthetic aperture and synthetic pulse for signal to clutter enhancement and target characterization"

The "Radar Fence" is a bistatic multi frequency radar system. Based on the principles of frequency coding, time coding and space diversity we detect and characterize objects and geophysical phenomena. The system's capability is illustrated with results from detection of internal wave wake produced by a submerged vehicle. and aircraft identification [C1001]

## "Skywave over-the-horizon backscatter radar"

Skywave over-the-horizon backscatter radar (OTHR) has great potential for detecting such targets as cruise missiles, stealth aircraft, the powered trajectory of ballistic missiles and aircraft carriers over long distances and at the same time. This paper evaluates the detectability of OTHR for small targets through experimental research and emulation, and then brings forth directions for improvement to some shortcomings of this radar. Also, this paper inquires into several key considerations of this system for synthetic design of cost and effect [C1002]

## "Measurement and research on radar target signatures in China"

The emergence of a new radar system results from the requirement to solve the practical problems, which are often concerned with target characteristics. Some examples describing the corresponding relations are given. It can be said that the research on radar targets promotes the development of radar systems [C1003]

## "Fractal and multifractal analysis of sea SAR clutter data"

The goal of this work is to investigate on the fractality of the sea clutter collected by SAR systems like the existing ERS1-2 SAR. The analysis of data generated by simulation is performed by using two kind of techniques: 1) Multiscale fractal analysis; 2) Multifractal analysis. The results show that sea clutter retains a few fractal features of the sea. This study is very interesting for applications in the field of sea remote sensing like classification and target recognition [C1004]

## "Radar HRRP classification with support vector machines"

The SVM (support vector machine) has good generalization property and is proven to be a powerful classification method to a wide variety of applications. In this paper, the SVM classification method is applies to the HRRP (high resolution range profile) classification problem. Furthermore, we propose a preprocessing method and present a new SVM model selection method, the combined leave-one-out cross-validation scheme with VC bound method. Accordingly, the SVM classifiers for five aircraft are designed. Their anti-noise performance and tolerance to aspect variation are compared with that of MCM (maximum correlation method). The experimental results indicate that the preprocessing procedure and model selection method are effective and the SVM method has potential in radar complex target classification [C1005]

## "A new algorithm to calculate the reference image of ship targets for ATR using ISAR"

This paper develops a new algorithm to calculate the reference inverse synthetic aperture radar (ISAR) images of candidate targets for ship target recognition. To make reference images, cross range aids defined by the target's unknown angle velocity vector must be estimated for projection of reflectivity on the candidate targets to

the range-Doppler plane. To estimate cross range axis, we extract the centerline and the Doppler width of the ship target from the observed ISAR image. By using these information and the relation between the direction vector of the straight line in the space and the ISAR image formulated in this paper, the cross range vector can be estimated for each candidate target. The effectiveness of the proposed algorithm is evaluated by using simulated targets [C1006]

## "Backscattering spectral and polarization features of the surface targets in centimeter and millimeter waves ranges"

In this paper the results of studying the spectral and polarization characteristics. of the signals scattered from surface targets in the wave ranges 35, 4, 3, 0, 8 and 0.4 cm are presented. The mentioned signal parameters are connected with implementation of manoeuvring and vessel propulsion system operation (i.e. caused by vibrations and marine surface disturbance due to vessel motion) [C1007]

## "Reconstruction and recognition of the radar target image"

A method for generating the spatial image of several types of jets is presented. The method consists in applying the Radon transform to a data set containing discrete values of the frequency characteristic of the objects under study, for several illumination angles. A Matlab program was developed for image reconstruction. The contour shape of the images is used for recognition of jet type. Fourier descriptors are calculated in order to provide a good characterisation of the contour shape. An analysis of the quality of the image recognition is made with respect to the number of profile functions used for object image reconstruction [C1008]

## "Fractal selection of artificial objects from radar images on inhomogeneous background"

In addition to radar images signatures, it is promising to use fractal signatures as informative and stable characteristic features providing efficient object identification. Target detection can be based on such features as a full fractal signature, its part or its slope. In this report, we focus on measurements of fractal characteristics of optic and radar image of natural objects and present results of computer simulations of detecting artificial objects observed against a background of fractal terrain [C1009]

## "Identification of ground targets from sequential HRR radar signatures"

An approach to identifying ground targets from sequential high-range-resolution (HRR) radar signatures is presented. A hidden Markov model (HMM) is employed to model the sequential information contained in multi-aspect target signatures. Dominant range-amplitude features are extracted via RELAX for dimension reduction. A new distance measure is incorporated into the HMM to allow a direct matching operation in the feature domain without requiring interpolation. The approach is applied to the dataset of ten MSTAR targets and is shown to yield an average identification rate of 90.3% using sequential information from 6 degree angular spans [C1010]

## "Gigaop DSP on FPGA"

DSP algorithms such as sonar beamforming and automated target recognition, are a good match for FPGA technology due to their regular structure, available parallelism, pipeline-ability, and modest data word sizes. FPGA implementations of these applications outperformed their DSP and microprocessor counterparts by factors ranging from 10X on up with an equivalent sustained computational rate of more than 2 GOps/second per FPGA. This paper first describes each application and derives its computational requirements. The mapping process for each is then described followed by an analysis of the relative contributions to performance from pipelining, data parallelism, and memory usage [C1011]

## "A generalized regression neural network (GRNN) scheme for robust estimation of target orientation using back-scattered data"

The ill-conditioned nature of electromagnetic inverse scattering problems calls for newer approaches to the old problem. The problem of estimating the orientation of a conducting target is successfully handled by a generalized regression neural network (GRNN). The training data set consists of backscattered RCS data measured when the target is exposed to an incident single frequency TM plane wave. Noisy data sets are then provided to increase system robustness. The network response proves to be highly robust to problem setup non-idealities such as target scaling, sensor misplacements, sensor noise and template deformations. Further investigations show that even reducing the total number of sensors does not affect the general capabilities of the network much but slightly reduces the robustness, especially when the target is deformed. Also, confining the sensors to one half plane still maintains the generalization capability of the network but reduces its robustness. Time domain schemes, such as range profiling techniques, can utilize of this method to overcome their

difficulties in estimating the orientation of the target [C1012]

### "Isolating target returns through foliage"

Summary form only given. Foliage penetration synthetic aperture radar imaging requires large wavelength (VHF/UHF) as compared with standard SAR working in the X-band or at even higher frequencies. As a consequence, the identification of targets is difficult, since the low resolution essentially tends to eliminate the difference between the returns of different target features. The purpose of this work is to analyse the scattering characteristics of generic targets as well as applying inverse scattering algorithms to image point targets under foliage. The authors compare different methods and discuss the advantage of each method given a particular type of prior information. Special emphasis is given to the discrimination of different types of specular reflections [C1013]

### "Three-dimensional E-CSAR imaging of a T-72 tank and synthesis of its spotlight, stripmap and interferometric SAR reconstructions"

This paper presents the results of three-dimensional imaging of a T-72 tank using its angular azimuthal (turntable) and linear elevation synthetic aperture data at X band. This is achieved using an accurate and computationally-efficient wavefront (Fourier-based) reconstruction algorithm for elevation and circular (E-CSAR) data. The E-CSAR 3D images are then used to synthesize 2D spotlight and stripmap slant plane SAR images of the target at a desired range and squint angle. For this purpose, a procedure is introduced that incorporates the spatially-varying azimuthal and elevation Doppler signatures of individual reflectors on the target as well as the mean range, azimuth and elevation of the flight path. Results using the E-CSAR images of the T-72 tank are provided [C1014]

### "ISAR image analysis by subspace method: automatic extraction and identification of ship profile"

This paper deals with automatic identification of ships in images produced by inverse synthetic aperture radar (ISAR). The ISAR technique reconstructs a rapidly updating sequence of range-Doppler image frames of the target. Due to the physics of imaging based on the target's angular motions, however, images are invariably noisy, and not all frames contain equally useful information. The thrust of this research is to cope with these issues by introducing: (i) a multiframe algorithm to stably extract profiling as a basic feature reflecting the entire characteristics of a target; and (ii) subspace analysis for identification of the extracted profiling especially using the recently proposed constrained mutual subspace method (CMSM). Through preliminary experiments we demonstrate the effective performance of the proposed scheme [C1015]

### "(Automatic) target detection in synthetic aperture radar imagery via terrain recognition"

Surveillance of large areas of the Earth's surface is often undertaken with low resolution synthetic aperture radar (SAR) imagery from either a satellite or a plane. There is a need to process these images with automatic target detection (ATD) algorithms. Typically the targets being searched for are vehicles or small vessels, which occupy only a few resolution cells. Simple thresholding is usually inadequate for detection due to the high amount of noise in the images. Often the background has a discernible texture, and one form of detection is to search for anomalies in the texture caused by the presence of the target pixels. To perform this task a texture model must be able to model a variety of textures at run time, and also model these textures well enough to detect anomalies. We accomplish this with our multiscale nonparametric Markov random field (MRF) texture model [C1016]

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