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ТЕМАТИЧЕСКИЙ РЕФЕРАТИВНЫЙ СБОРНИК № 41-2/2

“Radar Target in Clutter”
(«РЛ цель на фоне помеховых отражений»)

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"Rain Clutter Filtering from Radar Data with Slope Based Filter"

One type of volume clutters is rain clutter that is caused by rain droplets. Moving weather systems will have a nonzero Doppler response the rate at which the rain droplets approach to the radar system. The complete data radar collects contain the returns of both the target and the clutter. The signal processing block in a radar system uses filtering operations to extract the target information while suppressing the clutter. Typically the filters are designed based on Doppler frequency using a Fourier filter bank. In this paper, we study the slope based filtering algorithm, and present some results obtained using that filter. Our experiment is indicating two interesting results. Firstly, the slope based filtering algorithm filter rain clutter at least as well as the Fourier filter bank. Secondly, the slope based filter performed better than the Fourier filter bank in the case of the generated Gaussian white noise. The experiments were performed in MATLAB environment and the data was real radar rain clutter data from Finnish Air Force medium range air surveillance radar (low PRF). Fifty different rain and snow situations have been recorded into data [C801]

"Characterisation of a Multistatic Radar System"

In this paper we report on the initial characterisation and calibration of a multistatic radar system, which has been designed using 'commercial off the shelf components'. This initial test strategy will provide a useful gauge of how effectively the system can detect certain simple targets and thus pave the way for further work looking at developing multistatic radar systems [C802]

"The Influence of Transmitter Phase Noise on FMCW Radar Performance"

It is generally agreed that the main challenges in designing a frequency modulated continuous wave (FMCW) radar are; (i) frequency sweep linearisation and (ii) controlling leakage of transmitter phase noise into the receiver. This paper addresses the latter and focuses on the seldom mentioned and often neglected problem of reflected noise from large, distant targets causing an increase in the receiver noise floor. Work has been presented since the early 1960s on techniques for reducing the effect of transmitter phase noise leakage desensitising the radar receiver of CW and FMCW radars (O'hara, 1963),(Beasly, 1990). All of this work has concentrated on the problems of direct, short path length leakage around the transmit/receive antenna [C803]

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"DPCA Processing Based on Digital All-Pass Interpolation of Array Elements"

A DPCA (displaced phase center antenna) approach based on digital all-pass interpolation of array elements for side-looking phased array radar on moving platforms is proposed, this technology employs a class of maximally flat digital fractional-delay systems to realize interpolation of array elements followed by DPCA processing, and it does not require conventional DPCA condition. It is shown by the results of simulation that this technology exhibits good GMTI (ground moving target indication) performance, so it can be used as a good choice of GMTI technologies for airborne or space-based phased array radar. (ICCCAS'06) [C805]

"Fast and Accurate Method for PCL Radar Detection in Noisy Environment"

A new fast and very accurate method for target detection in PCL radars is presented. This algorithm in noisy environment with SNR up to -60 dB could provide the perfect and accurate detection. Presented initiative algorithm apply a special filter bank to the target signal and clean the additive noise of the environment from it and detect the multiple targets with different RCSs [C806]

"Distributed Pre-Processed CA-CFAR Detection Structure For Non Gaussian Clutter Reduction"

This paper deals the cell averaging constant false alarm rate (CA-CFAR) distributed RADAR detection of targets embedded in a non Gaussian clutter. We develop a novel pre-processing algorithm to reduce spiky clutter effects, notably a non linear compression procedure. This technique is similar to that used in non uniform quantization where a different law is used. Two approaches to combine data from the pre-processed CA-CFAR detectors are proposed The performance characteristics of the proposed CA-CFAR distributed systems are presented for different values of the compression parameter. We demonstrate, via simulation results, that the pre-processed procedure combined with distributed systems when the clutter is modeled as alpha-stable distribution, are computationally efficient and can significantly enhance detection performance [C807]

"The IEEE Seminar on Target Tracking: Algorithms and Applications"

The following topics are dealt with: distributed air target tracking; particle filtering; data association; Viterbi algorithm; Riccati equation; infrared image sequences; multiple object tracking and video sequence. [C808]

"Design of test software for Over-The-Horizon Radar system"

Due to the relatively coarse resolution in range and azimuth, low detection probability, various clutters or interferences, and time-varying ionospheric propagation channel, the measurements of targets collected from Over-The-Horizon Radar(OTHR) has much uncertainty. Furthermore, ambiguity on target returns derived from the ionospheric multimode propagation effect makes data association and tracking more difficult. In this paper, according to the real requirements of data processing subsystem, a test software package has been discussed and developed for the design on data processing software. It provides an assistant platform for testing, debugging, and verifying some key techniques, such as data pre-processing, adaptive association and tracking, propagation mode identification, and multi-path cancellation. [C809]

"Transmit waveform diversity for space based radar"

Space based radar (SBR) has been investigated for decades and has once again made an appearance as a viable means of performing the ground moving target indication (GMTI) mission. However factors such as launch vehicle payload constraints, satellite altitude and velocity, pulse repetition frequency (PRF) and Earth rotation (ER) impact radar performance metrics such as clutter mitigation and ground moving target minimum discernable velocity (MDV). This paper will describe several methods of improving SBR GMTI performance through mechanical orientation and transmit waveform agility. The emphasis is on countering the mainbeam clutter Doppler spectral spread due to ER and range ambiguous operation [C810]

"Improved Target Detection and Tracking in Littoral Environments Using a Self-organising Spatio temporal CFAR"

This paper describes a self organising spatio-temporal radar CFAR system that uses multiple intelligent software agents to detect and adapt the processing to features in the environment. By combining both temporal and spatial data gathering sufficient samples can be collected to allow both the first and second order moments of the clutter distribution to be approximated for each cell. By gathering higher order statistics to a useful accuracy, more stable thresholds may be produced. [C811]

"Data Fusion for Ground Moving Target Tracking"

The aim of ground surveillance is the large scale, continuous and near real time determination of a dynamical ground picture. This task comprises detection and tracking of moving single targets and convoys, mobile weapon systems, and military equipment. The sensors of choice are airborne GMTI-radar (GMTI: ground moving target indicator) and SAR (synthetic aperture radar). As ground target tracking often suffers from dense target situations, high clutter, and low visibility, the integration and fusion of external background information is essential for providing precise and continuous tracks. We present multi hypotheses techniques for tracking several targets in complex ground situations with clutter. Methods to incorporate topographic information, in particular digital road maps, are described and demonstrated [C812]

"ML-PDA track validation thresholds"

The maximum likelihood probabilistic data association (ML-PDA) algorithm, developed for very low observable (VLO) target tracking, will always provide a candidate track that must then be either validated or rejected. By comparing the value of the log likelihood ratio (LLR) at the parameter estimate to a threshold value, track validation is accomplished. Using extreme value theory, we show that in the absence of a target the LLR global maximum obeys approximately a Gumbel distribution and not the Gaussian distribution previously ascribed to it in the literature. It is shown that the Gaussian approximation yields inaccurate false track acceptance probabilities. Using a Gumbel distribution, the probability of false track rejection can be obtained for a given threshold value. The probability of true track detection is obtained assuming the LLR global maximum obeys approximately a Gaussian distribution in the presence of a target. A system operating characteristic (SOC) is developed that unifies the detection processing and track algorithm performance into a single performance metric. The performance of this test is demonstrated through simulations [C813]

"Incorporating Doppler Velocity Measurement for Track Initiation and Maintenance"

Performance of multiple target tracking algorithms in complex environments heavily relies on the success of track initiation and measurement-to-track association algorithms. Doppler velocity measurement is the major discriminant of clutter from the target of interest with relatively higher velocities. This work summarizes the analytical derivations and presents simulation results about track initiation and maintenance using Doppler velocity reports along with the 3D position measurements extracted by a phased array radar. [C814]

"Waveform-Agile Sensing for Tracking Multiple Targets in Clutter"

In this paper, we consider the problem of scheduling the waveform transmitted by waveform-agile radar sensors to track multiple targets in clutter. A number of generalized frequency modulated chirps with trapezoidal envelope form the library of waveforms available to the sensors, which obtain measurements using a nonlinear observation model. A joint probabilistic data association filter is used to track the target, and the waveform selection is made so as to minimize the predicted mean square tracking error. We provide simulation results to show that the scheduling improves the tracking performance of multiple targets even in the presence of clutter. [C815]

"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 [C816]

"Discerning Objects from Ground and Target Pose Estimation in ladar Data using Robust Statistics"

In this paper we present a novel way to analyze LADAR images and model its data. Having an aerial LADAR image as data source, our aim is to extract a parametric description of the ground of our scenario in order to discern between the data samples that belong to the ground and those that belong to vehicles, objects or clutter. In the second part of this paper we estimate the pose of the interesting objects by building its corresponding oriented 3D bounding box. Our method uses robust statistics in order to extract proper descriptions of both the ground and the oriented bounding boxes of the objects. Specifically, we use two robust parameter estimators: The least median squares and the Helmolth tradeoff estimator, part of our prior work, depending on the percentage of outliers that may be present in the different steps of our approach [C817]

"Development of Surveillance and Tracking Radar"

A high-resolution surveillance and tracking radar has been recently developed and tested at the Institute of Radio Astronomy. The radar is a monopulse, all-weather radar with mechanical beam steering. It works in a pulse mode, and a coherent FFT-based signal processing is utilized. The radar is equipped with a clutter suppression system and with a Kalman filtering scheme for trajectory calculation and extrapolation. The radar is suitable for long-range surveillance with a small volume-scanning time and for tracking of highly dynamic, low-sized targets.

This paper describes the setup of this radar, its main components, and the signal processing technique used [C818]

"Detecting Small Slow-moving Sonar Targets Using Bottom Reverberation Coherence"

The detection of small targets that appear suddenly or are moving slowly in strong bottom reverberation is a challenging problem for sonar surveillance in shallow water. Based on a new reverberation model, this paper proposes a target detection scheme that provides target sub-clutter visibility in the presence of reverberation. Experimental evidence shows that the bottom reverberation as seen by a stationary sonar is coherent, or at least partially coherent from ping to ping. Therefore, the bottom reverberation from a particular range cell is modeled as a complex signal composed of a stationary or slowly varying coherent component, plus a rapidly varying diffuse component. The coherent component is easily estimated using a recursive mean estimator and then removed by a simple subtraction so that the target need only compete with the diffuse component. Experimental results show a detection gain, as measured by the coherent-to-diffuse ratio, as high as 30dB [C819]

"Integrated Marine Mammal Monitoring and Protection System (IMAPS): Gray Whale Target Strength Measurements and the Analysis of the Back-Scattered Response"

The central IMAPS objective is to establish a global solution for systematic assessment and protection of the marine environment for the Navy, offshore industry, and scientific research community, through the development and implementation of a comprehensive, modular tool. The limitations of current technologies are that they are individually inadequate to fully achieve mitigation objectives. Visual monitoring, passive location, high frequency active sonar, and radar all have their inherent limitations such as weather conditions, a necessity for vocalizations, maximum detection range, and sea state limitations. Therefore, there is a need for all the sources of information related to the detection and classification of marine mammals to be fused and to operate in real-time in order to provide a robust protection, assessment, and research system. The other IMPAS direction is concentrated on the design and development of the active sonar modality representing just one component of the global system. The active sonar was designed, built and tested during the Marine Mammal Active Sonar Test (MAST 04), producing whale detections and whale tracks. The experiment was conducted in January 2004 off the coast of California. One of the objectives is to distinguish whale backscattered responses from the ones generated by the environmental clutter in a waveguide. Furthermore, it aims to identify and analyze the target signature features that are necessary for enhanced active sonar detection and classification of marine mammals. Over the years there have been very few documented attempts to capture and analyze the backscattering response of whales using an active sonar system. Nevertheless, whales, mostly owing to their size, their motion, and the aspect dependence of their backscattered field, possess desirable properties that help distinguishing their scattered response from clutter and other environment related false alarms. As an initial step, data collected during the MAST04-- experiment is presented, and gray whale target strength measurements are obtained. Results are compared to the previously published whale target strengths. Additionally, an investigation is conducted in an effort to provide whale feature identification points suitable for automated detection and classification, as means of relating gray whale active acoustic signatures to their inherent characteristics and their motion. During the MAST04 experiment, the active sonar component feasibility has been demonstrated, while the second generation system is being developed for the MAST 07 experiment. Tracking and classification algorithms are being further developed and they will be implemented and tested during the upcoming MAST 07 experiment. MAST 07 will feature a lighter, autonomous, fuel cell powered active sonar system, implementing real time marine mammal detection, tracking and classification algorithms [C820]

"Using Target's Polarization for Data Association in Multiple Target Tracking"

Data association plays an important role in multiple target tracking. Target's polarization information can't update target's track, but it can discriminate different targets and clutter effectively. Therefore, the non-determinacy of association is reduced. Given the target's polarization information, the generalized "nearest neighbor" algorithm is proposed according to the extended distance defined in the space-polarization joint domains. The simulation verifies that the "generalized nearest neighbor" outperforms the conventional "nearest neighbor" [C821]

"Detection of unknown nonlinear fm signals by time-frequency morphological filtering"

A new energy integration detection scheme is proposed to detect an unknown nonlinear frequency modulated (FM) signal buried in strong complex additive white Gaussian noise (CAWGN). In this scheme, the Smoothed-Pseudo Wigner-Vill Distribution (SPWVD) is used to realize local coherent integration of a signal and thresholding and mathematical morphological filtering are jointly used to extract the time-frequency (TF) support region of the signal from the time-frequency distribution (TFD) image of an observation. The simulated results show that the proposed scheme is effective in strong noise background. The scheme can be applied to the

target detection in the over-the-horizon radar (OTHR), such as the sky wave OTHR and the surface wave OTHR. [C822]

"Detection of Laser Radar Target Based on Wavelet Decomposition"

A novel approach for detecting laser radar target based on wavelet decomposition has been proposed. Usually, wavelet analysis has been used to de-noise a digital signal corrupted by noise. In our approach, we applied the wavelet decomposition in a multi-resolution sense to only get the approximation of a signal and detect the target. Without reconstruction, it is easy to realize on real time. Experiments show that our approach leads to an effective method to detect the laser target in a clutter background [C823]

"A New Data Association Algorithm for Multiple Passive Sensors"

This paper is concerned with the dynamic problem of associating measurements from S bearing-only sensors in the presence of clutter and missed detections. A new algorithm is investigated. Firstly, an S-D assignment method is utilized to partition LOS measurements and eliminate spurious measurements as possible. Then, the estimated positions of probable targets are sent to the following association algorithm (CJPDA) as the secondary measurements. Finally, iteration filter is implemented and the known tracks are maintained. Combining the two approaches reasonably, the proposed method generalizes the static S-D assignment to the dynamic S-D one and achieves good association performance. A simulation experiment is provided to compare the new algorithm with the wi-best S-D assignment by means of accuracies and the time requirements. The results demonstrate the effectiveness and efficiency of the proposed method. [C824]

"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 [C825]

"Spatial-Temporal-Frequency Diversity in Radar Sensor Networks"

In this paper, the spatial-temporal-frequency diversity to improve the detection performance of Radar Sensor Networks (RSN) in the presence of certain types of interference (clutter, jamming, noise and interference between radar sensors) is studied. In order to reduce the interference between radar sensors and maximize the signal-to-interference-plus-noise ratio (SINR), we propose a method using the orthogonality criterion to design waveforms for radar sensors in the network. Besides the interference between radar sensors, performance of the network depends largely on other interference, especially clutter, which is extended in both angle and range, and is spread in Doppler frequency. By using the spatial-temporal diversity, we can suppress effects of these interference. In this paper, we also propose a receiver for diversity combining in RSN. As an application example, we apply the spatial-temporal-frequency diversity scheme to improve the detection performance or reduce the missdetection probability at a low false alarm probability. Simulation results for both non-fluctuating targets and fluctuating targets show that the performance of our proposed scheme is superior to that of the single radar with the spatial-temporal diversity only. [C826]

"Validation Gating for Non-Linear Non-Gaussian Target Tracking"

This paper develops a general theory of validation gating for non-linear non-Gaussian models. Validation gates are used in target tracking to cull very unlikely measurement-to-track associations, before remaining association ambiguities are handled by a more comprehensive (and expensive) data association scheme. The essential property of a gate is to accept a high percentage of correct associations, thus maximising track accuracy, but provide a sufficiently tight bound to minimise the number of ambiguous associations. For linear Gaussian systems, the ellipsoidal validation gate is standard, and possesses the statistical property whereby a given threshold will accept a certain percentage of true associations. This property does not hold for non-linear non-Gaussian models. As a system departs from linear-Gaussian, the ellipsoid gate tends to reject a higher than expected proportion of correct associations and permit an excess of false ones. In this paper, the concept of the ellipsoidal gate is extended to permit correct statistics for the non-linear non-Gaussian case. The new gate is demonstrated by a bearing-only tracking example [C827]

"Adaptive Target Tracking in Slowly Changing Clutter"

False track discrimination performance of a target tracking algorithm in a heavy clutter environment depends on the track confirmation and the track termination thresholds. The optimum value of these thresholds depends on the environment, in particular on the given probability of detection and on the existing clutter density. When tracking ground targets the probability of target detection is nominally constant, whereas the clutter measurement density varies significantly. Previously it was shown that, for a wide range of target signal to noise (+clutter) ratio in a uniform clutter density environment, and given the opportunity to set signal detection thresholds, the optimum value of clutter measurement density is almost constant (and the probability of detection will vary). We propose a scheme where the feedback from the target tracking system corrects the detection thresholds for each sensor resolution cell to obtain the constant and optimal clutter measurement density in each cell, when the clutter statistics changes slowly. This results in better false track discrimination capabilities of the tracker and also replaces the CFAR block in the signal processing unit [C828]

"Fast and High Resolution Statistical Based Algorithm for PCL Radar Detection in Noisy Environment"

This paper presents a new statistical based clean algorithm for multiple target detection in noisy environments. For this purpose the variance and average of the ambiguity function as the output of matched filter will be computed. This information used for separating the real targets from the false ones, in noisy environment and heavy clutter up to -13 dB [C829]

"Receiving Signal Processing of MIMO Radar Based On Transmitting Diversity"

Multiple input multiple output (MIMO) radar is a new emerging radar technique developed recently. The principle of MIMO radar based on transmitting diversity is described and the method of receiving signal processing also is presented. Simulation results show that the proposed receiving signal processing method can simultaneously form multiple receive beams and surveillance multiple targets. It also can improve Doppler resolution [C830]

"Parameter Optimization for Bistatic PCL Radar"

In this paper the accuracy of measurement with respect to some parameters like baseline variance and DOA estimation and bistatic RCS is considered. The radar designer can find the appropriate parameters to having the minimum error in target localization and maximum coverage range [C831]

"Track Score and Target Existence"

Automatic target tracking in clutter initiates and updates both true tracks and false tracks. True tracks follow targets, and false tracks do not. False track discrimination is the procedure which confirms (vast majority of) true tracks, and terminates (vast majority of) false tracks. False track discrimination requires a measure of track quality to distinguish between true tracks and false tracks in a statistical sense. This paper compares two powerful track quality measures; the track score, as used in multi hypothesis tracking (MHT) and the probability of target existence, as used in integrated track splitting (ITS) filter. Both theoretical and simulation comparisons are presented in a single target tracking situation [C832]

"The GM-PHD Filter Multiple Target Tracker"

The Gaussian mixture probability hypothesis density filter (GM-PHD Filter) was proposed recently for jointly estimating the time-varying number of targets and their states from a noisy sequence of sets of measurements which may have missed detections and false alarms. The initial implementation of the GM-PHD filter provided estimates for the set of target states at each point in time but did not ensure continuity of the individual target tracks. It is shown here that the trajectories of the targets can be determined directly from the evolution of the Gaussian mixture and that single Gaussians within this mixture accurately track the correct targets. Furthermore, the technique is demonstrated to be successful in estimating the correct number of targets and their trajectories in high clutter density and shows better performance than the MHT filter [C833]

"Mixture weighted gating and its application to target tracking"

This paper presents a new approach to gating in target tracking. Here, the gate is defined as the region in which the tracked target is expected to exist. The observation vector in the gate is used for tracking. In tracking in a two-dimensional plane, various shapes can be conceived as a gate, including a rectangle, circle, and ellipse. Elliptical gate is optimal for linear Gaussian modeled systems and suboptimal for non-Gaussian systems. This paper introduces mixture weighted gating by generalizing Kalman filter to non-Gaussian linear systems. This

non-elliptical gate is applied in target tracking and its advantage respect to elliptical gate is shown [C834]

"A new class of Heuristic Polynomial Time Algorithms to solve the Multidimensional Assignment Problem"

The multidimensional assignment problem (MAP) is a combinatorial optimization problem arising in many applications, for instance in multi-target multi-sensor tracking problems. It is well-known that the MAP is NP-hard. The objective of a MAP is to match d-tuples of objects in such a way that the solution with the optimum total cost is found. In this paper a new class of approximation algorithms to solve the MAP is presented, named K-SGTS, and its effectiveness in multi-target multi-sensor tracking situations is shown. Its computational complexity is proven to be polynomial. Experimental results on the accuracy and speed of K-SGTS are provided in the last section of the paper [C835]

"Probability Evaluation in MHT with a Product Set Representation of Hypotheses"

Multiple hypothesis tracking algorithms that rely on hypothesis probabilities for pruning typically generates the n-best global hypotheses. In some cases, the probability mass is diffuse in the space of global hypotheses and a large n is desirable, implying a high computational demand. In this work, we present an alternative method for evaluation of hypothesis probabilities. Global hypotheses are then represented with exclusive product sets. Each product set has the potential of representing many global hypotheses. A method that generates the product sets is introduced, including a recursive formulation for computational tractability. In numerical evaluations, the method is compared to an optimization based method that generates the n-best hypotheses. Both an improved ability of representation, and a reduced computational demand are demonstrated in a constructed example [C836]

"Inter-leaved filter structure using IMM for handling measurement association uncertainty in high clutter density"

The interleaved IMM filter structure presented in the paper is an improvement over the conventional IMM filter especially in high clutter density scenarios. The algorithm uses interleaving of the measurements in two parallel IMM filters. The performance benefits are in terms of lesser number of miscorrelations and false tracks i.e extended track life in high clutter density. [C837]

"Optimal Polarized Waveform Design for Active Target Parameter Estimation Using Electromagnetic Vector Sensors"

We develop optimal design methods of polarimetric radar signals that improve the estimation accuracy of the target parameters. A weighted sum of the Cramer-Rao bound (CRB) of the parameters of interest is used as the cost function of the optimization. We employ an array of electromagnetic vector sensors to fully recover the polarization information from the target returns. Simulation examples illustrate the improved system performance [C838]

"Target Model Effects on MIMO Radar Performance"

A simple comparison between "spatial MIMO" (multiple input-multiple output), "frequency MIMO", and coherent netted radar systems shows that better performance can be achieved by the incoherent processing approaches. This assumes that the MIMO techniques acquire independent samples and there is no a priori information available to the netted radar enabling the incoming signals to be phase-aligned (P.F. Sammartino et al., 2006). Here we consider a more detailed model for target backscatter in order to gain a deeper sight into the true potential of these radar signal processing techniques. The overall aim of this work is to understand the performances available when real targets are under surveillance and to understand which conditions make MIMO perform best or, at least, better than a netted radar system. The target models introduced here are a step towards this aim [C839]

"Stap for Clutter and Interference Cancellation in a Hf Radar System"

An alternative skywave line-of-sight (SkyLOS) high frequency radar architecture has been proposed for early detection and tracking of ballistic missiles. It consists of a skywave over-the-horizon (OTH) radar augmented by one or more ground-based systems for line-of-sight reception in the illuminated region. The line-of-sight systems provide additional Doppler-time profiles of the target with different observation geometry to improve flight trajectory estimation. Targets compete for detection against powerful clutter and interference from manmade and natural sources. We introduce a practical STAP technique to deal with operational signal environments and demonstrate its performance on live SkyLOS data [C840]

"Evaluation of antenna architectures for angle estimation of endo-clutter targets in airborne adaptive radars"

Adaptive beamforming techniques such as space-time adaptive processing (STAP) combine spatial and temporal degrees of freedom to detect slow moving targets in strong clutter backgrounds. Many techniques exist for choosing the spatial and temporal degrees of freedom. In general these techniques are typically evaluated based on their ability to provide good target detection performance using performance metrics such as signal to interference plus noise ratio (SINR). Since adaptive radars must also provide target location information it is important to also consider how the choice of spatial degrees of freedom will impact direction-of-arrival estimation performance. This paper will investigate the DoA estimation performance of various airborne array architectures including elements and fixed beams (beamspace). It will be shown that in some interference scenarios the spatial degrees of freedom required for good detection performance differ from those required for good DoA estimation performance. [C841]

"The clutter range-ambiguity in hybrid bistatic space-based radar"

For hybrid bistatic space-based radar (HB-SBR), which is composed of an illuminator on a satellite and a receiver on an airplane, range-ambiguous clutter is a serious problem for space-time adaptive processing (STAP). In this paper, based on a proposed spherical-earth assumption, it is shown that the range ambiguity of clutter returns is related to azimuth and bistatic central angle. Therefore, range ambiguities may be alleviated by proper configuration of illuminator and receiver. Simulation results demonstrate that the performance degradation of moving target indication (MTI) caused by range ambiguities can be mitigated with the proposed bistatic HB-SBR configuration. [C842]

"Detecting moving targets in SAR via keystoning and multiple phase center interferometry"

Without motion compensation, synthetic aperture radar (SAR) images of the ground are generally blurred. In 1997, MITRE reported the development technique called the keystone process for removing the range migration caused by the radial velocity component of each pixel's movement within the scene, whether moving or stationary with respect to the ground. When applied to multiple phase center phased array radar data, this first pass process allows for automated detection of moving targets via phase thresholding. Once detected in phase space, the moving targets can be individually and automatically focused using the procedures previously reported. Although we can easily detect and accurately geo-locate bright (large radar cross-sections) moving targets using either phase or amplitude thresholding techniques, we have found that, for smaller targets, the phase differences between the cells containing the moving target are greatly distorted by the presence of strong ground clutter simultaneously present in those cells. Only after the ground clutter is cancelled will the phase difference be sufficiently dominated by the target response to allow correct geo-positioning. Here we report on a technique whereby the clutter may be cancelled by using multiple phase centers. [C843]

"Higher order clutter mitigation in bistatic space-based radar systems using a knowledge-aided STAP approach"

Bistatic space-based radar (SBR) systems offer several advantages for performing wide area ground moving target indication (GMTI) surveillance. However, in bistatic systems there is inherent non-stationarity of the clutter covariance matrix due to the bistatic geometry. This non-stationarity presents challenges for performing space-time adaptive processing (STAP) to separate ground targets from the clutter returns. Various approaches for mitigating the clutter non-stationarity in bistatic systems have been presented in the literature by different authors. In realistic bistatic SBR GMTI scenarios, there are higher order effects, in addition to the first order effect of ground clutter non-stationarity, that can present significant additional challenges for performing STAP. [C844]

"Performance enhancement of the FRACTA algorithm via dimensionality reduction: results from KASSPER I"

The recently developed FRACTA algorithm is a reiterative censoring and detection algorithm for space-time adaptive processing (STAP) which has been shown to provide excellent detection performance in non-homogeneous interference environments. In this paper, a partially adaptive implementation of the FRACTA algorithm is presented which significantly reduces the high computational complexity and large sample-support requirements of fully adaptive STAP. Prior to application of the FRACTA algorithm, the data is passed through a multi-window post-Doppler dimensionality reduction transformation. Two implementations of the multi-window post-Doppler dimensionality reduction methodology are considered: PRI-staggered and adjacent-bin. A detailed

analysis of the application of the partially adaptive FRACTA algorithm to the KASSPER I challenge datacube is presented. The PRI-staggered approach with D=6 filters per Doppler bin is found to provide the best detection performance, outperforming the fully adaptive case while simultaneously reducing the runtime by a factor of ten. Using this implementation, partially adaptive FRACTA detects 197 out of 268 targets with one false alarm (the clairvoyant processor detects 198 targets). In addition, the partially adaptive FRACTA algorithm is shown to be resilient to jamming, and performs well for reduced sample support situations. When compared to partially adaptive STAP using traditional sliding window processing (SWP), the runtime of partially adaptive FRACTA is 14 times faster, and the detection performance is significantly increased (SWP detects 46 out of 268 targets with one false alarm). [C845]

"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 [C846]

"MIMO Radar Space-Time Adaptive Processing for Multipath Clutter Mitigation"

This paper describes a multiple-input-multiple-output (MIMO) generalization of space-time adaptive processing (STAP) to mitigate radar clutter subject to multipath propagation between transmit and receive arrays. Multipath clutter can occur when surface returns are multiply scattered, causing significant Doppler frequency and wavenumber spreads. In the worst case, multipath propagation may cause Doppler spread clutter to return via the receiver mainlobe. In such situations, conventional STAP cannot mitigate Doppler spread mainlobe clutter without also suppressing the target. MIMO radar techniques using orthogonal waveforms have been proposed for increasing radar coverage rate often at the expense of employing significantly larger radar time-bandwidth products. In this paper, we consider a MIMO approach wherein conventional radar waveforms are phase-coded to be orthogonal after Doppler processing at the receiver, i.e. in "slow-time". Slow-time MIMO has the advantages of being bandwidth efficient and easily implemented without the need to modify the receiver before range pulse-compression. In this paper, the mathematical formulation of MIMO STAP is developed for both direct-path and multipath clutter scenarios. At each slant range, the MIMO STAP processor operates on a receive sensor, transmitted pulses, and slow-time phase code channel data cube. Coherent combination of the decoded slow-time channels at the receiver permits effective control of the transmit array pattern by receive post-processing as a function of slant range. Simulation results demonstrate SNR gains when a transmit null is steered in the outbound direction towards the multiply scattered clutter [C847]

"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%. [C848]

"Target Detection in Abruptly Non-Stationary Doppler-Spread Clutter"

This paper addresses the problem of target detection in the presence of Doppler spread clutter which is neither stationary during a coherent integration time (CIT) interval nor across different range bins. This phenomenology occurs, for example, in over-the-horizon skywave HF radar where propagation through moving ionospheric inhomogeneities spreads the surface clutter and the clutter statistics can change quite abruptly during a CIT and across range bins. In these cases, the performance of conventional adaptive techniques suffers from a lack of adequate training data. The method proposed here breaks the full CIT into smaller sub-CIT's which are then extrapolated using low order AR models. The Doppler spread clutter is thus effectively modeled as an abruptly time varying autoregressive (ATVAR) process. Subsequent Doppler processing and coherent combining of the extrapolated sub-CIT's is then performed with improved signal-to-clutter gain since only a small proportion of the sub-CIT's are corrupted by abrupt non-stationary behavior. Moreover, nearly full coherent signal gain against

noise is maintained. Initial processing on experimental radar clutter data with injection of a simulated target illustrates that this approach can provide an SCNR improvement of more than 5 dB compared to conventional Doppler processing [C849]

"A Monte-Carlo Method for Initializing Distributed Tracking Algorithms"

Distributed processing algorithms are attractive alternatives to centralized algorithms for target tracking applications in sensor networks. In this paper, we determine an initial probability distribution of multiple target states in a distributed manner to initialize distributed trackers. Our approach is based on Monte-Carlo methods, where the state distributions are represented as a weighted set of discrete state realizations. The filter state vector consists of the target positions and velocities on the 2D plane. Our approach can determine the state vector distribution even if the individual sensors alone are not capable of observing it. The only condition is that the network as a whole be able to observe the state vector. A robust weighting strategy is formulated to account for missed detections and clutter. To demonstrate the effectiveness of the algorithm, we simulate a network with direction-of-arrival nodes and range-Doppler nodes [C850]

"Development of a MATLAB Based Target Tracking Simulation Environment"

A simulation environment for tracking of maneuvering targets in clutter is developed in MATLAB. The simulation environment allows to generate 2-dimensional surveillance radar measurements and to run various target tracking algorithms on these measurements. As a first simulation example, IMM-NNJPDA algorithm, which incorporates NNJPDA data association and IMM filter structure, is implemented and the performance of this algorithm is investigated in an example scenario. By this simulator, in the future, it is aimed that statistical test and evaluation of different radar sensors, scenarios, target tracking methods and data fusion architectures will be performed [C851]

"An application of advanced spectrum estimation to multi-channel radar detection and location"

We explore the application of an advanced spectral estimation technique to target detection and localization in multi-channel space radar systems. Previous work had applied motion compensation and array calibration to produce SAR-like range-Doppler images for each channel, followed by a maximum likelihood angle of arrival (AOA) and alternating projections (AP) technique designed to optimally detect and locate targets in this representation. Moving targets in a given range-Doppler cell exhibit a channel-to-channel phase difference after the motion compensation and array calibration. This phase progression may also be detected and estimated using spectral estimation approaches. However, since the target and clutter phase ramps are very close, a super-resolution approach is needed. The reduced-rank linear predictor ROCKET is investigated in this role. It is shown that the original technique has a two-threshold capability that provides two opportunities to discard false alarms, whereas the pure ROCKET-based approach only has one. As a result, the two-threshold AOA+AP technique generally outperformed the ROCKET-based algorithm in Monte Carlo simulations. Furthermore, the two-threshold construct holds the promise for further performance improvements pending ongoing investigations [C852]

"Visual tracking with probabilistic data association filter based on the circular hough transform"

This paper proposes a robust visual tracking framework to track circle-like objects in cluttered environment. Instead of using the resulting positions after circle detection and tracking in the image domain, we directly perform the visual tracking task in the parameter space which describes the measurement features. The visual tracking technique is combined with targets generation closely. We utilize the probabilistic data association filter (PDAF) to filter the detected measurements with noise and disturbance. The likelihood ratio through the Hough transform is employed to modify the evaluation of the association probability and make the estimate more reliable. Furthermore, the joint probabilistic data association filter (JPDAF) is used to deal with the multiple circle-like objects tracking. The likelihood variation of each target is introduced with JPDAF as a basis of the predictions for different targets. The overall performance has been verified in several challenging experiments [C853]

"Detection of targets in bandlimited and spatially correlated clutter"

This paper describes the preliminary analysis of an unconventional approach for detecting targets in band limited clutter that exhibits some degree of spatial correlation from range bin to range bin. The receiver processing chain utilizes a lattice predictor (LP) filter to remove clutter at the output of a Doppler filter bank. Subsequently, an order-statistic (OS) constant false alarm rate (CFAR) processing stage is used to threshold the data and a binary integrator creates a binary image of threshold crossings accumulated over several coherent processing intervals (CPIs). A novel technique is applied for removing noise from the binary image using morphological

filters, thereby exposing tracks created by any moving targets. Once a track has been detected, the corresponding target is declared present. Test results based on measured clutter data will be presented that suggest the proposed processing techniques may improve detection performance in a clutter environment. [C854]

"Adaptive processor convergence improvement using reiterative projection statistics"

Adaptive radar processors form estimates of the statistics of the received interference (such as clutter and/or jamming) and receiver noise processes using measured samples (i.e., snapshots) of the signal environment. Snapshots that contain the signal of interest (i.e., targets) and/or other outliers are, in practice, frequently interspersed within a set of more homogeneous interference snapshots. This condition often results in poor convergence in terms of signal to interference-plus-noise ratio (SINR) and ultimately, probability of detection. In this paper, a previously developed projection statistics (PS)-based outlier detection technique is extended to a reiterative and prewhitened form, similar to a recent reiterative generalized inner product (GIP) technique. We compare SINR convergence performance of reiterative GIP and reiterative prewhitened PS, among other methods, in the presence of multiple outliers. The results show that reiterative prewhitened PS is superior to reiterative GIP and to the other methods in terms of SINR convergence criteria. [C855]

"Robust distributed detection fusion scheme under unknown time-variant signal-to-clutter ratio conditions"

A censored summation based weighted fusion scheme (CSWF) for multiradar distributed detection systems is presented to improve the detection probability of the fusion center where final decision is made by using the generalized sign test statistics (GSTS) formed and sent by every radar. It incorporates the direct summation fusion (DSF) and all kinds of the censored summation fusions (CSF) and regulates their relative importance by a weight vector. If any of them declares the presence of a target, the CSWF will accept it. The DSF fuses all the GSTSs by adding up them, while the CSF only adds up the remainder after discarding some of them. Under unknown time-variant signal-to-clutter ratio conditions, the result shows that the DSF and CSF can not always perform well and even have very poor detection performance; conversely, the CSWF has a quite good performance and behaves at least the second best among the three schemes. The CSWF is robust and high-performance. [C856]

"SBR waveform and processing parameters as a function of array distortion"

Structural distortions in large antennas have impact on antenna gain, sidelobe level and adaptive interference rejection. Partial compensation for the distortion of space-based radar (SBR) phased-array antennas and array-fed reflectors can be achieved by adjusting the phase-shifter settings to compensate for the distortion, if it can be accurately measured. This approach is effective in regaining the antenna gain and sidelobe levels, but the adaptive rejection of interference and clutter is much more complex. This paper addresses the ground moving target indication (GMTI) performance for a large active electronically scanned array (AESA) at a medium-earth orbit (MEO) altitude of 10,000 km, and a maximum sinusoidal mechanical distortion of 10 cm modeled across the horizontal aperture. To evaluate the impact of mechanical distortion on GMTI performance, the full-dimension space-time adaptive processing (STAP) matched filter (MF) and the reduced-dimension joint-domain localized (JDL) algorithms were evaluated using signal-to-interference-plus-noise ratio (SINR), SINR loss and minimum discernable velocity (MDV) as the GMTI performance metrics [C857]

"ISAR image segmentation by non linear diffusion equation"

This paper describes a non linear spatial filtering for the target radar segmentation of ISAR/SAR images. Since such images are usually corrupted by speckle noise and clutters, image processing technique are required in order to obtain a more clear image. We have implemented a spatial technique based on the non linear diffusion equation, also known as the Perona-Malik equation. Our model is based on an calculation of the spatial gradient on a 5Ч5 stencil in order to increase the merging of target corresponding regions. By suitably estimating a diffusion coefficient related parameter, the gradient threshold, target segmentation is done into few integration steps of the equivalent explicit scheme. The resulting images maintain most of the original details also visible in converting the filtered image in a binary format. The proposed method can be the first step of target classification by matching correlation of more advanced techniques. [C858]

"Cancellation of clutter and multipath in passive radar using a sequential approach"

The paper deals with the cancellation of direct signal, multipath and clutter echoes in passive radar, where the transmitted waveform is not under control of the radar designer and the sidelobes of the ambiguity function mask even targets largely displaced in range and Doppler from the disturbance. A sequential approach is presented for

disturbance cancellation and target detection based on projections of the received signals in a subspace orthogonal to both disturbance and previously detected targets. Modeling the clutter spread on few Doppler bins allows complete clutter cancellation. The approach is shown to be effective against typical scenarios with a limited number of iterations. [C859]

"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. [C860]

"Modeling sea clutter as a nonstationary and nonextensive random process"

Sea clutter is the backscattered returns from a patch of the sea surface illuminated by a radar pulse. It is of great importance to develop statistical models that properly characterize radar clutter returns. A lot of effort has been made to fit various distributions to the observed amplitude data of sea clutter. However, the fitting of those distributions to real sea clutter data is not excellent, and using parameters estimated from those distributions is not very effective for detecting targets within sea clutter. This may be due to the fact that sea clutter data is highly non-stationary. This non-stationarity motivates us to perform distributional analysis on the data obtained by differencing amplitude data of sea clutter. By systematically analyzing differenced data of 280 sea clutter time series measured under various sea and weather conditions, we show that differenced data of sea clutter are well fitted by the Tsallis distribution. The latter is obtained by maximizing the Tsallis entropy, a generalization of the Shannon (or Boltzman-Gibbs) entropy. Interestingly, we find that the nonextensitivity parameters estimated from the Tsallis distribution may be used to help detect low observable targets within sea clutter. [C861]

"Soil Moisture and Surface Roughness Effects in Ground Penetrating Radar Detection of Land Mines"

Nonmetallic mine detection with GPR is challenging because of poor target/soil contrast and clutter from the random rough ground surface. Greater soil moisture implies higher dielectric constant, which in turn increases contrast and scattering of radar waves, but also increases the contrast between the air and the soil, increasing clutter. The finite difference time domain method for modeling impulse radar is use to quantify the effects of clutter on the target signal for both ideal smooth ground surfaces and rough surfaces for uniformly dry, wet, and a profiled moisture distribution characteristic of short-time watering. Results indicate that each uniform moisture case offers detection features that allow for the distinct temporal and spatial separation of target and clutter signals, but that non-uniform soil moisture makes nonmetallic mine detection problematic [C862]

"Optimum target detection using illuminators of opportunity"

Unlike classical bistatic radars, passive radars make use of illuminators of opportunity to detect targets and to estimate target parameters. One existing radio transmission suitable for passive radar operation is the global system for mobile communication (GSM). For non-cooperative bistatic configurations, one of the major difficulties is the estimation of the reference signal which is required to perform detection. This reference signal, a priori unknown, can be extracted from the signal received at the antenna array provided the direction of arrival of the direct path signal is known. Conventional matched-filter based Doppler filtering offers the possibility of placing the target and interferences in a domain where they can be separated based on Doppler shift. However, slow moving targets residing near mainbeam clutter in the range-Doppler diagram, remain difficult to detect. Internal clutter motion (ICM) exacerbates this issue by spreading the clutter signal power in Doppler frequency. In this paper, we first present a method to estimate autonomously the direction of the illuminating GSM base station from measurements obtained with a two-element antenna array. We passively detect the azimuth of the transmitter without a priori knowledge of the environment. Spatial processing is then employed to attenuate the direct path signal and mitigate its influence on the target detection process. We then propose two methods able to cope with clutter echoes with non zero-Doppler components. We first propose an extension of a CLEAN-like algorithm. We also propose to extend adaptive matched filters to noise-like signals. The adapted matched filter can be used to suppress strictly static clutter but also clutter affected by ICM. These methods are validated by using actual clutter measurements obtained from a passive radar using a GSM base station as illuminator of

opportunity. [C863]

"A real-time multiple target tracking algorithm using merged probabilistic data association technique and smoothing particle filter"

In this paper, we present a tracking system that combines the merged probabilistic data association (MPDA) technique together with the smoothing particle filter to track multiple targets. The MPDA approach combines the probabilistic nearest-neighbor filter (PNNF) together with the probabilistic data association (PDA) approach, in the data association step, to track multiple targets in dense clutter environment. Due to the high uncertainty when applying a particle filter to track a maneuverable target, the smoothing particle filter is used. Results show that combining MPDA together with smoothing particle filter can achieve a robust and real-time tracking system for tracking multiple targets even in dense clutter environment. [C864]

"A waveform strategy for detection of targets in multiplicative clutter"

Conventional radar signal processing techniques approximate multipath as a linear process. Unfortunately, such an approach results in poor detection performance and because the model for the interference does not accurately represent the physical scattering process. We instead propose a method that uses the flexibility of waveform design for a given aperture to linearize the physical scattering phenomenon. This allows us to successfully detect targets using a Wiener matched filter approach in high multipath conditions. [C865]

"Linear prediction of range-dependent inverse covariance matrix"

In this paper, we study issues associated with applying linear prediction theory to the range-dependent inverse covariance matrix (PICM) in bistatic airborne radar systems. For bistatic ground moving target indication radar, the clutter Doppler frequency depends on range for all array geometries. This range dependency leads to problems in clutter suppression through STAP techniques. An analysis of a new technique, proposed to obtain an estimate of the inverse covariance matrix using least squares estimation, is provided in this paper. Simulation results show a significant improvement in processor performance, as compared to conventional STAP methods. [C866]

"Two-dimensional human tracking using a three-element Doppler and direction-of-arrival (DDOA) radar"

We investigate the use of a low-cost, three-element receiving array for two-dimensional direction-of-arrival (DOA) sensing of multiple movers. The concept entails resolving the Doppler frequencies of the returned signals from the moving targets, and then measuring the phase difference at each Doppler frequency component to calculate the DOA of the targets. The three-element receiving array is configured to provide simultaneous DOA measurements in both the azimuth and elevation planes. An experimental system is constructed to test the concept and measurement results of multiple movers are presented. [C867]

"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. [C868]

"Moving target location and imaging using dual-speed velocity SAR"

To improve the ability of suppressing clutter as well as locating the moving targets without any ambiguity, dual-speed velocity SAR (DS-VSAR) is proposed in this paper. In DS-VSAR system, the platform flies with two different specified speeds in the imaging time duration. Multiple complex images are formed by multiple receiving antennas and transmitted into velocity-images (V-images), where moving targets may be separated from strong stationary clutter in terms of their motion parameters. Furthermore, the locations of the moving targets may be estimated accurately by using the information in two V-images under two platform speeds and the Chinese remainder theorem (CRT). Therefore DS-VSAR has the ability of not only to suppress clutter but also to locate and image both slowly and fast moving targets accurately. Some numerical experiments are given to show the effectiveness of DS-VSAR [C869]

"Moving Target Localization for Indoor Imaging using Dual Frequency CW Radars"

In this paper, we propose a simple method, to determine the unambiguous range of a moving target, using dual frequency continuous wave (CW) radars. The carrier frequencies, and hence the wavelength, determine the maximum unambiguous range of the target. The technique is capable of determining range for an indoor moving target. It uses phase comparison of the Doppler signals to estimate the range, where as the target velocity is directly obtained from the Doppler shift. Simulation results are presented in the presence of noise to validate the technique. Experimental results are also provided showing the effectiveness of the proposed method for indoor range estimation. Specifically, we have performed two experiments, the first experiment is in an indoor laboratory setting with absorbers to mitigate multipath. In the second experiment, the target was behind a one foot thick concrete wall, in an indoor setting without absorbers. For both experiments, we were able to successfully detect the target and estimate its range [C870]

"Concurrent Detection and Tracking using Multiple, Flying, Sensors"

We develop a probabilistic technique for performing multiple target detection and tracking based on data from multiple, flying, sensors. Multiple sensors can facilitate detecting and discriminating low signal-to-clutter targets by allowing correlation between different sensor types and/or different aspect angles. However, the data association problem can cause the computational complexity of standard trackers to become prohibitively high when combining too much data-a problem which will be exacerbated when including data from multiple sensors. Dynamic logic (DL) is a probabilistic technique for performing data association, based upon maximum likelihood parameter estimation of mixture models, which does not suffer from a computational explosion with increasing amounts of data. Previously, a DL-based tracker was developed for the relatively simple case incorporating data from a stationary sensor platform. In this paper we expand the framework to incorporate multiple, moving, sensor platforms, which requires a revision in the parameter estimation equations. The framework is general enough to be valid for different sensor types, for example radar or electro-optical. Sample results from synthetic data are presented [C871]

"A New Radar Detector in Unknown Signal and Clutter Environment"

In this paper, we introduce a new detector in the absence of any statistical knowledge of the fluctuating signal; perhaps a weak signal, and clutter. We use a few sampled fractional moments (FM) to construct the maximum entropy (MAXENT) probability density function (PDF) estimation. These moments; i.e., their fractional orders, are obtained from the observed sample variates. Using the fractional moments instead of the integer moments the estimated PDF is quite close to the true PDF. The test statistics is a fractional polynomial of very low order of the received samples. We consider the following target fluctuating models, swerling, lognormal, and Rician. We also consider the clutter to follow low and heavy tail models; i.e. Rayleigh, and lognormal [C872]

"Cramer-Rao bounds for target Doppler and power in space based radar"

In this paper, the Cramer-Rao bound for target parameters from a space based radar platform is derived. In particular, the bounds for target Doppler and power are derived under a variety of conditions-target in white noise, target in clutter and noise case. In the later case, the performance is analyzed with range foldover and in the presence/absence of earth's rotation. When both these phenomena are present, the bound is shown to be inferior compared to other situations where only either effect is present. In the general case, methods such as waveform diversity should be considered for superior target detection. [C873]

"SBR sparse array performance with subarray orientation and timing errors"

Coherent multiple aperture radars have been proposed for ground moving target indication to improve tracking accuracy and for along-track interferometry for detecting slow moving objects. An alternate architecture is indicated for detection of very slow moving targets. The approach that promises the most effective detection of slow moving targets is along-track interferometry (ATI). The Air Force Research Laboratory's RLSTAP has been used to synthesize the clutter and target returns for a sparse space based radar array. This paper considers the limitations on along-track interferometry detection of moving targets, due to metrology on array orientation and coherency, and target motion. The effects of orientation between the two subarrays can be accommodated if accurate metrology and compensation are provided. [C874]

"Experimental results on single antenna target detection using time-reversal techniques"

In this paper, we describe a single antenna time-reversal based detection scheme that can be used to enhance the performance of a radar system in a multipath rich scattering environment. Using time-reversal, the response

from a cluttered medium is first nulled. When the target enters into the medium, the electromagnetic energy focuses around the target so that a stronger echo is obtained. The experimental results show that depending on the amount of clutter in the medium, the performance of a radar detection scheme can be improved up to 4.8 dB using time-reversal methods with a single antenna [C875]

"Performance analysis of meter band radar height-finding approach for low-angle tracking"

In this paper, a new meter band radar superresolution height-finding approach under clutter environments is presented in the presence of multipath, which cascades moving target indication (MTI) method and forward spatial smooth MUSIC (FSS-MUSIC) algorithm, the MTI$FSS-MUSIC approach for short. The numerical simulation analysis of the presented approach is performed and the root-mean-square-error (RMSE) of target height estimation is given. It is demonstrated that clutter suppression method i.e., MTI cascaded superresolution height-finding approach is available for VHF array radar low-angle tracking applications [C876]

"Forward-Looking Planar Array 3D-STAP using Space Time Illumination Patterns (STIP)"

Close-in sensing is needed for urban warfare operations, where ground moving target indication (GMTI) could be provided via forward or rear-facing multi-function array radars mounted on small highly-maneuverable airborne platforms. However, airborne radar arrays oriented any direction other than side-looking cause an elevation dependent angle-Doppler relationship in the clutter returns. This non-stationarity is acute in close-in sensing geometries where elevation diversity exists over the scene of interest. However, planar arrays have an inherent advantage over linear arrays due to their ability to observe clutter statistics as a function of elevation. This paper demonstrates the utility of elevation diversity by synthesizing a single 3D-STAP filter that exhibits an elevation dependent azimuth-Doppler response which is tailored to null the clutter "bowl" which characterizes the forward-looking clutter spectrum. Such a capability is particularly exploitable on transmit, where all elevation angles are simultaneously illuminated. To demonstrate potential benefits, this paper proposes the use of recently developed space time illumination patterns (STIP) from a planar AESA to invoke elevation diverse space-time illumination in a forward-looking clutter scenario. It is shown that 3D-STIP (azimuth-elevation-Doppler) facilitates elevation specific space-time beamforming which removes the clutter energy from a given Doppler frequency across all ranges, potentially simplifying processing on receive. Simulations using synthesized training data and clairvoyant covariance knowledge are conducted to demonstrate proof-of-concept [C877]

"Incorporating Pulse-to-Pulse Motion Effects into Side-Looking Array Radar Models"

A technique is presented for incorporating pulse-to-pulse (inter-pulse) motion effects into side-looking array radar data models yielding a motion-sensitive space-time snapshot. Low flying, highly-maneuverable unmanned aerial vehicles (UAV) represent a potential worst case application scenario given their roll, yaw, and pitch rates are primarily limited by structural integrity. High degrees of maneuverability during the coherent processing interval (CPI) allow clutter and target returns to change significantly. The technique presented uses M coordinate transformations to describe platform attitude variations throughout the CPI. Ward's model then is extended to incorporate maneuver-induced changes in spatial frequency and Doppler. The new motion-sensitive space-time snapshot is used to characterize space time adaptive processing (STAP) performance without motion-compensation applied. Results clearly show motion-induced clutter-null broadening with measurable degradation of STAP algorithm minimal discernable velocity [C878]

"Range-dependence Issues in Multistatic STAP-based Radar"

Multisatic radar systems offer the potential to overcome some of the limitations of the monostatic or bistatic systems. In particular, the ability to build larger apertures allows to increase spatial accuracy. Space-time adaptive processing (STAP) is a method of choice in the context of slow-moving target detection. However, the statistics of signals from multistatic radars are typically range-dependent. This range-dependence leads to major difficulties in estimating the interference plus noise covariance matrix required to perform STAP In this paper, we present a method able to compensate for the range-dependence of the signal statistics and we show that this method achieves near-optimal performance [C879]

"Detection, Location and Imaging of Fast Moving Targets Using Non-uniform Linear Antenna Array SAR"

In this paper, a new system called non-uniform linear antenna array SAR (NULA-SAR for short) is proposed. Using multiple complex images formed by multiple antennas with special configuration, NULA-SAR can not only suppress the stationary clutter, but also locate and image both slowly and fast moving targets accurately. Numerical experiments are presented to demonstrate the effectiveness of NULA-SAR [C880]

"Performance Analysis of Meter Band Radar Height-Finding Approach for Low-Angle Tracking"

In this paper, a new meter band radar superresolution height-finding approach under clutter environments is presented in the presence of multipath, which cascades moving target indication (MTI) method and forward backward spatial smooth MUSIC (FBSS-MUSIC) algorithm, the MTISFBSS-MUSIC approach for short. The numerical simulation analysis of the presented approach is performed and root-mean-square-error of the target height estimation is given. It is demonstrated that clutter suppression method i.e., MTI cascaded superresolution height-finding approach is available for VHF array radar low-angle tracking applications [C881]

"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. [C882]

"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. [C883]

"Adaptive Waveform Design for a Multi-Antenna Radar System"

We consider a radar system which uses an array of antennas, and is capable of adjusting the waveform transmitted through these antennas based on target and clutter statistics, on a pulse by pulse basis. A model for the radar returns which incorporates the transmit waveforms is developed. The target detection problem is formulated for that model. An algorithm is derived for designing the transmit waveform so as to optimize detection performance. [C884]

"Sequential Detection for a Target in Compound-Gaussian Clutter"

Sequential detection allows the analysis of an incoming data flow and the detection of changes in the distribution of these measurements. In this paper, we develop the sequential detection algorithm for a target under compound-Gaussian clutter. Both the target and clutter parameters are assumed unknown. We first derive estimates for these parameters, then discuss the sequential detection algorithm for two cases: target parameter is known and unknown. We consider detections for both the target appearance and disappearance. We examine the relationship between several performance measurements for the sequential detector, including the false-alarm rate and the average detection delay. In the numerical example part, we first illustrate the performance of our algorithms. Then we present an example of the optimal polarimetry design in the sequential detection. [C885]

"A Subspace-Based Approach to Sea Clutter Suppression for Improved Target Detection"

A key issue in detection of small targets on the ocean surface using active radar is low signal-to-clutter ratio (SCR), particularly in situations involving low grazing angle and high sea state. When sufficiently high pulse repetition rates are available, it is possible to obtain several samples of the clutter in a time interval short enough that key contributors to the clutter remain approximately stationary. This paper develops an approach to estimate the clutter subspace in such scenarios and exploit this estimate for clutter suppression and improved detection performance. [C886]

"Study of System Design Parameters for Space-Based Traffic Monitoring"

This paper addresses the ground moving target indication (GMTI) performance and the impact of system design parameters on space-based multi-channel synthetic aperture radar (MSAR) systems as they suffer from the high speed of the radar platform leading to a wide spread clutter spectrum. Opposite to classical GMTI systems near future space-based SAR systems offer only few simultaneous channels and relatively low pulse repetition frequency (PRF). The impact of PRF, antenna size, antenna separations and number of channels on detection performance is studied. The analysis is based on a post-Doppler approach of the optimal processor. [C887]

"CFAR Target Detection Based on Gumbel Distribution 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 and system capability. This paper considers a new approach to solve the target detection problem in a complex HF radar signal environment. It uses conventional constant false-alarm-rate (CFAR) detection procedure but based in this case on an untypical assumption of Gumbel distributed power spectrum values along range cells for thresholding. The CFAR detection test rule was combined with a local peak determination procedure. The proposed detection scheme was tested using real HF radar data and gave very promising results. [C888]

"Knowledge-aided Heterogeneity-compensation Algorithm for STAP Applicable to Bistatic Configurations and Conformal Antenna Arrays"

Space-time adaptive processing (STAP) is a well-suited technique to detect slow-moving targets in the presence of a strong interference background. We consider the application of STAP in a bistatic radar configuration when the radar returns are recorded by a conformal antenna array (CAA). The secondary data snapshots used to estimate the optimum weight vector are typically heterogeneous, i.e., not identically distributed with respect to range, thus preventing the STAP processor from achieving its optimum performance. We present a novel knowledge- aided (KA), registration-based pre-processor that mitigates the heterogeneity of the secondary data. When applied to simulated data for a bowl-shaped antenna, this pre-processor is shown to provide enhanced performance when used in conjunction either with the standard sample matrix inversion (SMI) algorithm or with the more computationally- and data-efficient joint domain localized (JDL) algorithm. [C889]

"Detection, Location and Imaging of Fast Moving Targets Using Non-uniform Linear Antenna Array SAR"

First Page of the Article [C890]

"Moving Target Detection based on Sub-aperture Image"

First Page of the Article [C891]

"Spaceborne Parasitic Multistatic SAR-GMTI by Along-Track Interferometry"

First Page of the Article [C892]

"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. [C893]

"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 [C894]

"Detection Performance Analysis of Distributed OSCA CFAR with Nonconherent Integration"

A novel distributed detector, called order statistic cell-averaging (OSCA) detector, are proposed in the case of noncoherent integration, In this detector, each sensor transmits its test cell sample and a designated order statistic (OS) of its reference observations surrounding test cell to the fusion center. At the fusion center, the global noise power level is obtained with cell-averaging (CA) processing. Under the assumption of chi-square family target model and exponential clutter for independent square-law detector, the exact formulas of probability of false alarm (Pfa) and probability of detection (Pd), are derived. Finally, the corresponding detection performance is calculated with numerical analysis [C895]

"Side-Lobe Blanking In Doppler-Domain For An Airborne Side-Looking Phased Array PD Radar"

For airborne PD radar, some strong side-lobe clutter would be detected as targets, because the Doppler shift of the side-lobe clutter is different from the Doppler shift of main-beam clutter when the angle between the side-lobe clutter scatter and the main-beam direction is over some value. However, when we filter the main-beam clutter with Doppler filter, the side-lobe clutter would be remained and then be detected as targets. These side-lobe false alarms shows an equal-range ring on radar display. This paper discusses a side-lobe blanking (SLB) method in Doppler-domain, which compares the Doppler filter output amplitude of Sigma channel with that of auxiliary channel, if Sigma channel is smaller, it's a side-lobe false alarm, blank it. Practical results shows effectiveness [C896]

"An S-band Direct Radar Frequency Source"

The overall high performance requirements for the modern radar system set higher and higher requirements for the radar frequency source, such as high spectrum purity, low phase noise and wide bandwidth, fast frequency switching speed, and complex signal generation capability, etc. and drive continuously the development of radar frequency source technique. This paper describes the design and implementation of an S-band direct radar frequency source for an ultra-low-altitude target acquisition radar and presents the result of development [C897]

"A Robust CFAR Detector Based on Ordered Statistic"

An improved version of VI-CFAR called OSVI-CFAR is presented. It is a combination of the ordered statistics (OS) CFAR, the smallest-of OS (SOOS) CFAR and the greatest-of OS (GOOS) CFAR. In homogeneous and clutter edge environments, the detection performance and false-alarm regulation properties for the OSVI-CFAR detector are almost consistent with the VI-CFAR based on mean level (called ML VI-CFAR). But in multiple target situations which the interfering targets are present in both the halves of the reference window, the detection performance for the OSVI-CFAR detector is improved greatly, so it is more robust than the MLVI-CFAR in practice. Finally, some important properties of the OSVI-CFAR detector are analyzed and discussed [C898]

"Analogue TV Signal-Based Passive Radar onboard Single Air-Platform"

An analogue TV signal-based passive radar onboard single air-platform can be considered as a bistatic CW radar. This implementation suffers, however, considerable range ambiguities due to the time-varying form of analogue TV video signal, when it detects and tracks the target by exploiting the AOA and TDOA information in echoes of targets from transmitter of opportunity. In this paper we describe the implementation of passive radar onboard single air-platform that measures the AOA information in the echoes of target using air-borne orthogonal interferometry array and obtains un-ambiguous TDOA information by exploiting both analogue TV video and audio signals [C899]

"Adaptive monopluse with STAP"

Monopulse is a well known technique for high accuracy estimation of target parameters such as azimuth and elevation as well as the radial velocity. In conjunction with an adaptive processor for cancellation of interference one obtains so called adaptive monopulse. Interference may be either jamming or clutter or both. In this contribution some properties of adaptive monopulse applied in a clutter environment is discussed. We focus on an airborne radar scenario so that the adaptive monopulse includes a space-time adaptive processor (STAP). Several different STAP architectures are compared with respect to their aptitude for target parameter estimation [C900]

"Combined Membership Functions in Fuzzy Signal Detection"

In this paper, we propose a model for a constant false alarm detection (CFAR) that uses fuzzy logic to describe the uncertainty on the decision about the presence or the absence of a target. The received signal is processed

and the membership function to three regions, namely; "signal present", "signal absent" and "uncertainty" is evaluated. The membership functions from different observations are combined according to some fuzzy fusion rules to obtain the global decision. The results obtained showed that the fusion rule defined by min(x+y, 1) gives better performance detection than the other rules [C901]

"Tracking Extended Moving Objects with a Mobile Robot"

Tracking moving objects is of central interest in mobile robotics. It is a prerequisite for providing a robot with cooperative behaviour. Most algorithms assume punctiform targets, which is not always suitable. In this work we extend the problem to extended objects and compare the algorithms that have been developed by our research group. These algorithms are capable of tracking extended objects [C902]

"A method for automatic spotting using water column"

This paper addresses the method for automatic measurement of projectile target deviation using water columns cause by underwater explosion. The detection and tracking of water column is operated according to the transformation of RCS of a water column. A model of water columns is described here, and a bi-parameter sea-clutter map was used as detection background in order to distinguish water columns from sea-spikes and low-velocity targets. Finally, the paper gives the actual experimental result that proves the correctness of the method [C903]

"Analysis of STAP on MDV for Spaceborne SAR-GMTI Applications"

Space-time adaptive processing (STAP) holds tremendous potential for the new generation spaceborne radar to get good performance of ground/sea moving target indicator (GMTI). A system scheme based on the fully adaptive space-time processing of spaceborne SAR-GMTI mode of operation is presented in this paper and the minimum detectable velocity (MDV) of target in GMTI mode is analyzed. Theoretical analysis and simulations demonstrate the effectiveness of the system scheme [C904]

"Novel Filter Design for detecting weak targets of slow speed out of multi-mode clutters"

The paper presents a novel stagger MTI filter design algorithm, which can detect weak targets of slow speed out of multi-mode clutters. The method is carried out by slipping pulses, and the best pulse repetitive frequencies selected by gradient-GA make the first notches of the filter banks as shallow as possible, so the weak targets in the first notch can be detected. Multi-model clutters can be suppressed by MTI filter, and blind-velocity can be appeared out of three times velocity of sound. Combined GA's the capability of the whole searching and not limited by selection of initial parameter with the gradient algorithm's advantage of fast searching, it can offer fewer initial population and low computation complexity. The simulation and performance analysis demonstrate the feasibility and validity of the algorithm [C905]

"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. [C906]

"Detection of Targets in Sea Clutter Using Adaptively Truncated Interleaved Spectral-Temporal Interferometry"

A new method is introduced to detect targets in the presence of sea clutter. Most previous analysis methods have worked almost exclusively in the spectral domain, but the new method uses a combination of band-pass spectral filtering, autocorrelative algorithms and time-series analysis for target detection. The procedure is well adapted to deal with scenarios involving accelerating targets and de-accelerating targets, and outperforms traditional methods in this area. impulsive RF noise can also be effectively ignored. The method is at least the equal of traditional methods for uniformly moving craft. The method also has some advantages in detection of

slowly moving targets in the presence of low frequency sea-clutter. The procedure is called Adaptively Truncated Interleaved Spectral-Temporal Interferometry (ATISTI). [C907]

"TDRSS: The System Simulation Software for Three-Dimensional Radar"

Based on the analysis of the principles of frequency-phase scanning 3-D (Three-Dimensional) radar and the scaattering mechanism of 3-D radar, the target and cllutter IF(intermediate frequency) signals model of frequency-phase scanning 3-D radar is brought forward in this paper, then TDRSS (Three-Dimensional Radar Simulation System), as one general radar system simulation software, is proposed in this paper. At last and its results obtained during tests are introduced as well. [C908]

"Estimation Of Target Movement Parameters In Synthetic Aperture Radar"

The publication presents a technique of detecting moving objects observed by a Synthetic Aperture Radar. Movement of the target introduces certain changes to the echo structure in SAR system. Those changes decrease SAR performance and in order to detect moving target correctly a two-dimensional Doppler filter should be applied. 2D Doppler techniques usually have high computational costs, which connected with large amount of data processed by SAR makes them difficult to implement it real-time systems. The authors propose to apply a simple 2D Doppler filter as a pre-processor and a source of an a priori information for further MTI processing. The technique of determining target's movement parameters based on a phenomenon of Range Migration is also presented. The authors show, that movement of the target changes the range migration curves and the shape of the curve can be used to estimate the target velocity. The estimates can be used to match SAR processing to a target echo. [C909]

"Analysis and Real Time Implementation of a Clutter Map CFAR Detector with Noncoherent Integration"

In this paper, we analysis a CMAP-CFAR (Clutter Map Constant False Alarm Rate) detector with noncoherent integration. The predetector statistics of the complex envelope are assumed Gaussian. A Swerling II target fluctuation model is considered and the incoming pulses are assumed independent. Closed form expressions of the probability of detection and the probability of false alarm are determined. On another hand, we propose a real time implementation of CMAP-CFAR detector with post integration using Texas Instrument DSP TMS320C4x. [C910]

"Performance Analysis of Permutation and Rank Tests under K-Distributed Clutter in Radar Detection"

In this paper, we analyze the performance of some nonparametric detectors (permutation and rank tests) against the parametric ones. The detector performance analysis was realized by Monte-Carlo simulations, having considered the ideal case of independent and identically distributed (IID) samples of K-distributed clutter, and nonfluctuating and Swerling II target models. The results are shown in curves of detection probability (Pj) versus signal-to-clutter ratio (SCR). Also, we have to point out that both permutation and rank detectors are constant false-alarm rate (CFAR) detectors under IID clutter samples. [C911]

"Radar Detection of Small Sailing Yachts"

Paper describes measurements in the real sea conditions of the maximum radar detection and tracking distances of small sailing yachts without radar reflectors and equipped with different types of radar corners by contemporaneous ship and shore based radar equipment. Researches were conducted on order of the Maritime Office in Gdynia. [C912]

"Subsurface Investigations by MARSIS in Mars Express Mission"

The analysis of the surface return echoes in the subsurface data extraction in North Mars Polar region has shown the possibility to utilize simplified surface models, at least, for the purpose of the evaluation of the penetration depth capability. The surface simulation, obtained starting from MOLA data, has been utilized during the planning activity in order to select the MARSIS operative sequence in order to optimize the amount of scientific data taking into account the data rate available and the scientific target to be investigated during the next part of the mission. Moreover a simulator, still in progress, utilizing the surface characteristics will perform the analysis of the real data in order to make available the required information expected, by the mission, in terms of detection and identification of dielectric constant on the surface and subsurface. [C913]

"Space-Time Adaptive Processing analysis for the moving target on the sea surface indication purpose"

Space-time adaptive processing (STAP) can improve target detectability in a presence of a ground clutter for airborne radar. Ground clutter echo has a wide spectrum as a result of the radar platform (airplane or satellite) motion. To reject clutter echo and preserve target echo, STAP employs antenna array. Simultaneous filtering in both spatial (angle) and frequency domain can improve performance. In this paper we propose a new application of STAP. Assuming an antenna array standing on a sea shore, the objective is to detect targets on the sea surface. Unfortunately sea clutter has different statistical properties compared to airborne clutter. As a consequence, basic STAP algorithm is not optimal in any sense. Future research will face the problem of evaluating performance of STAP applied to sea clutter. We hope to develop a new algorithm that can perform better in the presence of sea clutter. [C914]

"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. [C915]

"Application of STAP For Detection of Target In The Presence of Ground Clutter"

For Airborne radars it is necessary to suppress the levels of the interferers well below the weak desired signal. The problem is complicated due to the motion of the radar platform as the ground clutter received by airbornne radar is spread out in range, angle and over Doppler. Space-Time adaptive processing (STAP) is a technique, which helps to detect small signal of interest in such a noisy environment. This paper considers a generic clutter model. The simulations clearly bring out the 2-D nature of ground clutter and give an insight into the noisy environment in which the target is detected. [C916]

"The Joint Radar Targets Detecting and Communication System"

The combined radar system architecture for joint radar target detection and communication is considered. In this system we use complex quasi-continuous waveform of the big time-bandwidth product and duration with the combined modulation. This waveform is used in interrupted continuous wave radar technique. With reference to mariner radar [1] for a radar-location and communication it is offered complex coherent radar waveform with phase and linear frequency modulation. Problems of waveform synthesis, performance characteristic of the combined system are discussed. [C917]

"Adaptive Target Detection in Clutter Using MIMO Radar"

In this paper the problem of target detection using coherent pulse terrain was considered for MIMO radars. We have formulated this problem as a hypothesis test. Using the generalized likelihood ratio test (GLRT) two adaptive decision schemes have been developed for clutter with unknown statistics. The performance of the proposed detectors have been evaluated using Monte-Carlo simulations. The results show the superiority of the MIMO radaars with temporal coherent processing over the conventional phased arrays. [C918]

"Simple 3D Millimetre Clutter Scanner for Field Measurements"

In this paper, a simple clutter scanner for millimeter wave range is described. Our target was to design a device that can be used to measure background clutter characteristics of different kind of operating sceneries. Scanner presented in this article, is intended for automatic, true three dimensional clutter recordings through extended periods of time. The main components of our design are the millimetre wave unit, the mechatronic scanner and the data acquisition and control computer. Scanning sector is up to 40 degrees in azimuth and 20 degrees in elevation. Resolution is roughly 0.3 degrees, and dynamic range is 40 dB. [C919]

"Permutation Detectors under Nonhomogeneous K-Distributed Clutter in Radar Applications"

In this paper, we analyze the performance of some permutation tests (PTs) under a nonhomogeneous K-distributed clutter model, and nonfluctuating and Swerling II target models. Also, we compare the PTs results against their parametric counterparts under the same conditions. We shall analyze the detector performances in terms of detection probability versus signal-to-clutter ratio for different parameter values: the number of

integrated pulses, the clutter reference samples, the false alarm probability, the shape parameter of the K-distributed clutter and the power deviation of the clutter. [C920]

"The GPOF-based Ground Return Deembedding in Stepped Frequency Ground Penetrating Radar"

The work is devoted to a problem of detecting shallow underground objects like anti-personnel mines using ultra-wideband ground penetrating radar (GPR). In case of step-frequency radar, an inverse discrete Fourier transform (IDFT) is a standard data processing technique to convert the raw radar data into the range profile. The latter can be used for detecting buried targets and estimating their depth. Here, an advanced data processing algorithm based on a general-pencil-of-functions (GPOF) method is proposed to improve the radar performance. [C921]

"Rain Clutter Filtering from Radar Data with Discrete Wavelet Transform"

Moving weather systems will have a nonzero Doppler response at rate at which the rain droplets are approaching the radar system. The complete data the radar collects contain the returns of both the target and the clutter. The signal processing block in a radar system uses filtering operations to extract the target information while suppressing the clutter. Typically the filters are designed based on Doppler Frequency using a Fourier filter bank. Instead of the frequency domain, the wavelet analysis allows the time-scale domain in processing. The filter bank in this study utilizes Discrete Wavelet Transform (DWT), DWT coefficients represent the results of a multi-resolution analysis of the radar signal. We study the operation of a DWT filter bank and a Fourier filter bank (FFT). Our experiments indicate that the Fourier filter bank filter the rain clutter very well. However, a DWT filter bank has different time resolution for different frequency ranges. With very heavy rain clutter affecting to the target signatures, our experiments indicate that the wavelet filter bank performs better than the Fourier filter bank. The experiments were performed in MATLAB environment and data is real radar rain clutter data from Finnish Air Force medium range air surveillance radar (low PRF). The objectives of this study were to develop a DWT based filtering system and to test it's operation in one situation of rain clutter and then to compare it's results to those from the FFT method. [C922]

"Spatial-Temporal Differential Analysis for GMTD with Airborne Radars, Part 2: First Experimental Results"

We consider an application of the spatial-temporal differential analysis (STDA) technique to the ground-moving target detection (GMTD) using airborne radars with multiple receive channels. STDA is a new approach, suitable to processing multiple radar signals which utilizes spatial and temporal scintillations in the instantaneous signal power. To test the practical potential of STDA, we used multi-channel airborne radar measurements (MCARM) database, which was developed to test and improve space-time adaptive processing (STAP). In particular, we processed the MCARM file rd050575, obtained from flight 5, cycle d, and acquisition 575. The goal was to detect the Sabreliner airplane flying towards the radar-carrying airplane BAC 1-11 in the presence of urban, land, and sea clutter. Second-order structure functions for multiple radar signals were used for the processing. This simplified STDA technique applied in the time domain only provides a good performance by detecting the Sabreliner with a false alarm rate below 10' in the same range bin where it was previously detected using several STAP variants. [C923]

"Return loss reduction techniques for an ultra wide bandwidth phased array antenna in V/UHF band"

V/UHF indoor Radar Cross Section (RCS) measurements can still be performed when the anechoic chamber dimensions are not large enough compared to the wavelength and the wall absorbing material performances are relatively low. The main issue is that regular transmitting horns have large aperture angles. These radiation patterns do not eliminate the multi-path signals to and from the target after a reflection on the chamber walls. In order to drastically reduce unwanted signals from the chamber, a dual polarization ultra wide bandwidth (120 MHzГ‚Вї1875 MHz) phased array antenna has been designed and developed in 2004. The optimization consisted in lowering the phased array side-lobes in the angular direction of the chamber walls. Clutter signals from these walls were reduced by 40 dB. Among the received signals from the chamber, the return loss of the phased array antenna is now the most significant. After a brief presentation of CAMELIA indoor RCS measurement facility, the phased array antenna is detailed. Then a return loss reduction experimental study for this large phased array antenna is presented. The technical solutions are described and the measured return loss reduction performances are discussed. [C924]

"A Case Study on the design of a cluttermap based plot classification mechanism"

Many fielded state-of-the-art radars suffer occasionally from excessive false alarm rates. Various mechanisms have been devised in order to improve the signal-to-clutter ratio in general, but control of false alarms remains to be an issue of concern for the designers. This paper discusses a post-detection mechanism that splits the total offer of plots into four classes, such that each of these classes may be utilized by the tracking algorithm in order to have control over the false track rate. The mechanism has been developed for maritime sea-surveillance radar having a logarithmic receiver and a sliding window video extractor. It is basically a plot map performing a two-dimensional feature based classification. The features exploited are the signal-to-noise ratio and the target extent. The parameters in the algorithm are tuned based on a learning set from the radar operating in real life and tested using the same parameter values on a test set, also recorded during real life operation. The results suggest that a mechanism like proposed can be effective in controlling the false alarm rate', however sometimes at the expense of loosing some detections of real targets. [C925]

"Clutter Suppression in GPR Using Chaos Modulation"

In this paper, a chaotic radar is designed in which the transmitted signals are formed through modulating the amplitude of ultra wideband (UWB) signals using chaos. It is illustrated that the proposed radar has an excellent resolution performance as well as the capability of sidelobe suppression that is significant in ground penetrating radar (GPR) applications. Additionally, an expectation maximization (EM) based method is proposed to form a non-coherent receiver that conducts blind ground clutter equalization. The identification and equalization performance of the proposed EM receiver shows its robustness in blind equalization while achieving non-blind performance. Numerical electromagnetic simulations using finite difference time domain (FDTD) method under near ground penetrating situations with hidden targets are executed to illustrate the advantages of the proposed technique. [C926]

"Tracking of multiple ground targets with adaptive monopulse radar. Part I: The sensor"

In this contribution and in companion paper [1] aspects of ground target tracking by means of airborne radar are discussed. The radar sensor consists of a multichannel array antenna enabling space-time adaptive processing (STAP) for clutter rejection, and angle and Doppler monopulse estimation. Both the STAP and adaptive monopulse algorithms are described and the aptitude for monopulse estimation with different processor architectures is discussed. Results for a typical multiple-target scenario are presented. [C927]

"Tracking of multiple ground moving targets with adaptive monopulse radar-part II: the tracker"

For analysing dynamic scenarios with multiple ground moving vehicles, airborne GMTI radar is a well-suited sensor due to its wide area, all-weather, day/night, and real time capabilities (GMTI: ground moving target indication). The production of GMTI tracks from GMTI data is essential for producing a "recognised ground picture" as well as for analysing traffic flows. This contribution is the second out of two twin papers on ground target tracking. In part I the properties of the radar sensor used and a scenario with two crossing vehicles are discussed. In part II we describe aspects of the tracking algorithm used and present selected numerical results related to an improved sensor modelling aspects. [C928]

"PCL-Signal-Processing for Sidelobe Reduction in Case of Periodical Illuminator Signals"

Passive coherent location (PCL-) systems deal with illuminators of opportunity, whose signals are usually not adapted to radar applications. Especially in the case of signal inherent periodicities the target echoes are often covered by sidelobes of clutter. In order to reduce high correlation sidelobes and enable highly accurate range measurements, a signal adaptive filter processing is introduced. Its mathematical description explains that aiming at low sidelobes and highly accurate range estimation for arbitrary signals results in a filter method providing a phase correlation. The SNR obtained by this filter method turns out to be dependent on the amplitude variation of the signal frequency spectrum. The effectiveness of the side lobe reduction is demonstrated on experimental data of analogue TV-signals to verify that accurate unambiguous range estimation is possible, even for strongly periodical signals. [C929]

"Fast and High-Resolution PCL Radar Detection in Noisy Environment"

Multiple target detection in conventional PCL (Passive Coherent Location) radar systems by means of Ambiguity Function Processing and without any powerful algorithm is impossible. Presented Gradual Clean Algorithm (GCA) is a new and simple method, which could provide the perfect detection in noisy environment and heavy clutter condition up to SNR=-15 dB and SCR=-100 dB (clutter is assumed as a distributed target with large RCS). Determining the number of real targets and keeping the false alarm probability approximately constant are the presented algorithm capabilities. [C930]

"Simple Sea Clutter Canceller for Noise Radar"

In the last decade the noise radar technology is intensively investigated. The low transmitting power and nonspecific waveform makes that the noise radar has very god LPI properties. The simultaneous emission and reception of signals in such kind of radars make them sensitive to near-far problem. Strong echoes, originated from ground clutter can completely mask the weak target return. In case, when the radar is placed on a vessel, except of zero-Doppler ground returns the dominant part of return power consists of Doppler-spread sea cutter echoes. The papers present a simple adaptive sea clutter canceller, which can be used to mitigate near-far problem "on the sea". [C931]

"Receiving Signal Processing of Wideband MIMO Radar Based On Transmitting Diversity"

Multiple input multiple output (MIMO) radar is a new radar technique developed recently. This paper described the principle of wideband MIMO radar based on transmitting diversity and presented it's receive signal processing method, Simulation results show that the proposed wideband receive signal processing method can effectively accomplish matched filter and simultaneously form multiple receive beams and surveillance multiple targets [C932]

"Geometric Analysis on Moving Targets and First-order Sea Clutters in Bistatic Shipborne SWR"

The geometric relationship between a bistatic radar and targets is highly complicated when they are moving with different velocities and headings. Target motion equations, which are used to describe the complex dynamic system's characteristics, is derived based upon the Cartesian coordinate systems established both on the transmitter (CCST) platform and on the receiver (CCSR) platform of the bistatic radar system. The results show that the instantaneous ranges between a target and the transmitter platform (TP) and the receiver platform (RP) contain a time-variable tangential component and a time-variable radial component. The Doppler-broadening mechanism of first-order sea clutters in bistatic shipborne surface wave radar (SWR) is analyzed based on the results derived above, and the conclusion shows that there exists dynamic broadened component in the broadened Doppler spectrum resulted from the difference of the motion between TP and RP [C933]

"Fractal Features and Detection of Meteor Interference in OTHR"

Backscatter signal from OTHR receiver may contain strong noise and interference background, among which the meteor echo is a typical and strong Impulsive interference. This meteor echo may inject transient but great power into the receiver, arise the noise floor in the range-Doppler map and decrease SNR. So it must be suppressed before target tracking. Many solutions are presented for meteor echo excisions, among which the meteor position must be estimated firstly. Usually the ocean clutter is so strong that it may cover other signals such as target and meteor, so it must be suppressed before position estimation. Different from these approaches, this paper proposes a novel algorithm of meteor position estimation without depressing clutter. The main idea is focused on the different fractal dimension corresponding to the ocean clutter and the meteor echo. Accounting for the real-time processing requirements, an effective of directional fractal dimension based on the fractional Brownian motion model is also proposed. Experiments prove that it is an effective method [C934]

"Relative Speed Step Size in SAR processing for Moving Target Detection"

Ground moving target indication (GMTI) using synthetic aperture radar (SAR) is studied in this paper. For systems using long integration time relative speed between the target and the SAR platform has to be included in the detection algorithm. A separation between the true relative speed and the relative speed used in the SAR process will cause unfocused targets. Unfocused targets decrease the detectability. In the detection phase of SAR moving targets blind hypothesis on relative are used. The step size between the hypotheses or the quantization step in relative speed is a trade off between the number of hypotheses to test and detectability. A large number of tests will increase detectability but will also increase computation load and vice versa. The importance of relative speed increases as the azimuth integration time gets larger. Long integration time is associated with low signature moving targets detection in strong clutter environment and especially for SAR GMTI at low frequencies. In this paper we determine the optimum quantization of relative speed for moving target detection. The optimum quantization is derived from the moving target impulse response. By using the optimum quantization the computation burden in SAR GMTI is reduced and the detectability secured [C935]

"Comparison and Simulation of Linear/LOG CFAR Algorithms"

An intelligent CFAR (constant false alarm rate) circuit can effectively combine the advantages of linear and LOG CFAR circuits by switching from linear to LOG or vice-versa and also deciding the algorithm that suits a particular environment best based on various parameters such as clutter, distance, optimum number of range

cells etc automatically. This paper presents a comprehensive tabulation of results which can be used to implement the intelligent CFAR circuit The MATLAB simulations were performed for seven algorithms both LOG and linear for all possible environments (homogeneous/non-homogeneous). They were done for various sizes of range cells (16, 32 and 64). They were also simulated for different clutter environments such as Rayleigh, Weibull and log-normal. The results including the number of targets, no of false alarms, no of missed targets along with the multiplication factors were tabulated for 1000 iterations [C936]

"Prediction of Sea Clutter Based on Chaos Theory with RBF and K-mean Clustering"

Artificial neural network (ANN) has been widely applied in time series analysis, typically, it can give an effective method to solve complicated problems which are too complex to understand in physic and statistic method, or observation data varied statistically and the data generated in nonlinear mechanism. Based on the underlying dynamic mechanism of the sea clutter, to reconstruct the nonlinear model of dynamical phase space, correlation integral (also called C-C method) and Cao method are used to get time delay tau and embedding dimension min this paper. Furthermore, an algorithm of radial basis function (RBF) with k-mean clustering to adjust and modify the networks is also presented to predict the nonlinear characteristic sea clutter for the goal of detecting the weak target signals beneath the sea clutter. With the new algorithms, computation complexity can be deduced while its reliability can be greatly improved. It also can satisfy the real-time requirement in real application. More detailed calculates and test results are presented [C937]

"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 [C938]

"An Algorithm for Multitarget Tracking in Dense Clutter"

Due to some adverse factors, tracking multitarget in dense clutter becomes a difficult task. Therefore, a new algorithm is presented in this paper which consists of m-best 2-D assignment algorithm and generalized likelihood ratio test (GLRT). Simulated numerical examples are given, which demonstrate that this algorithm can solve the problem of "measurement-to-track" association efficiently, and discriminate the true or false track in short time which can reduce the need for storage and calculation enormously [C939]

"Novel Long-Term Coherent Integration Method For Moving-Target-Detection"

In radar signal processing, clutter suppressing and moving targets detection are basic problems. In order to detect the weak targets effectively, a novel method of long-term coherent integrated moving-target-detection based on the fractional Fourier transform is proposed in this paper. This method can compensate the Doppler migration and suppress the clutter effectively by using the discrete FRFT as the swept-frequency filter bank. The simulation results show that it has better performance of weak targets detection than the classical MTD and its computation burden is acceptable, which prove the validity of this method [C940]

"Two-Hierarchical Hough Transform for Sky-wave Over-the-Horizon Radar Track Initiation"

In this paper, a data preprocessing method for sky-wave over-the-horizon radar (OTHR) track initiation using two-hierarchical 2D Hough transform is proposed. We firstly use range-time data space to hierarchical I Hough transform and obtain rough candidate measurement sequences, where Doppler is used as an accumulation constraint; then we use the corresponding azimuth and time measurements to hierarchical II Hough transform to refine above sequences for track initiation. Simulation results show that the proposed method can eliminate clutters efficiently and make significant improvement in reducing false tracks [C941]

"Order Statistic and Algebraic Product CFAR Detector for Weibull Clutter"

A new radar constant false alarm rate (CFAR) detection algorithm operating in Weibull clutter is developed. In the proposed CFAR detector, that called order statistic and algebraic product (OSAP) CFAR detector, the output of OS processors on the both lagging and leading windows around the test cell are weighted by fuzzy weighting function (membership function) and are combined by algebraic product (AP) rule to get a better detection performance. The weighing function of this detector is obtained and the performance of the OSAP detector is evaluated and compared with the OSGO and OSSO-CFAR detectors. The results represent that the detection

performance of OSAP-CFAR detector is superior to than of OSGO and OSSO CFAR detectors in the homogenous background and in multiple interfering targets situations [C942]

"A method of hybrid ATI and DPCA technique to detect moving target"

The technique of moving target detection is more important in surveillance and detection. Both the along-track interferometry (ATI) and displaced phase center antenna (DPCA) techniques can estimate the position and radial velocity of moving target; however they are used in different circumstance. In the paper we compare the detection performance of slow ground moving target using ATI and DPCA technique for the new model of distributed space-borne SAR in detail. And provide a method of hybrid ATI and DPCA technique to detect moving target. Some typical computer simulation results are presented which illustrate the problem convincingly [C943]

"A New Approach to Improve Coherence in SAR/GMTI Processing of Distributed Micro-satellites Systems"

In order to improve the capability of clutter cancellation in bistatic SAR/GMTI processing, a new method to improve coherence between two sets of echoes from two receivers is developed based on the distributed micro-satellites system with the constellation of SAR-train. According to the idea of equivalent mono-static, the coherence improvement can be achieved by match filter to the spectra of equivalent squint angle, i.e. the bistatic bisector. In this way, the decorrelation component induced by the along-track baseline is removed. Because of Doppler equals to equivalent radial wave multiplied by equivalent squint angle spectra, this method can be realized in two steps, as the first step the compensation of equivalent radial wave number error is achieved through range spectra cut and shift of the narrow band echoes. As the second step, the Doppler spectra not overlapped should be removed, by which the bistatic bisector can be aligned. Simulation results show the decorrelation components introduced by the along-track baseline can be fully eliminated using this method [C944]

"Performance Analysis of Track Initiation Algorithm"

Su Feng presented the modified logical track initiation algorithm in his paper, however, the development of the algorithm has not been proved in theory. In this paper, the track detection probability and false track probability of the algorithm is deduced by statistics methods. The simulation test verifies the results [C945]

"Bistatic Radar DPCA Technique"

This article gives the spatial geometry model of bistatic radar displaced phase center antenna (DPCA) technique based on two-antenna. The bistatic radar DPCA technique requires that the distance between the two transmitting antenna phase centers (d), the pulse repetition interval (PRI) and the speed of the moving platform (Va) are strictly associated, just as the monostatic case. When the speed of the moving platform fluctuates, we can suppress clutter and detect moving target by interpolating and registering. The validity of the theoretic analysis is proved by simulation [C946]

"Clutter Reduction Based on Apex Shifted Radon Transform in Sub-surface Forward-Looking Ground Penetrating Radar"

In this paper a method is proposed to reduce none-apex hyperbola clutter due to target being located at the outside of imaging region and the inside of electromagnetic wave field in forward-looking ground penetrating radar (FLGPR) measurements. This clutter reduction method is based on apex shifted Radon transform which maps the none-apex hyperbola clutter in radargram to an energy congregate region in the tau-q domain. The none-apex hyperbola clutter is estimated by using a q band-pass filter and the inverse transform. Then the estimated clutter is removed by subtraction method. Finally, remainder surface clutter is reduced by scale and shift. The effectiveness of the approach is demonstrated with an experimental data set, and it increases the signal-to-clutter ratio of near-surface target [C947]

"Approaches of Single Channel SAR Combining ATI for GMTI"

This paper investigates a detector based on polynomial curve fit for slow ground moving target indication (GMTI) with a single channel synthetic aperture radar (SAR) multi-look along track interferometry (ATI). In addition to the steps of constructing multi-look using overlapped or unoverlapped windows, imaging, phase compensation and performing interferometric processing involved in common techniques of ATI used for single channel clutter suppression, the approach in this paper farther divides real parts of single channel ATI signals into numerous regions, calculates histograms of imagery parts of signals and adjudges threshold for special region by

predetermined probability of false alarm (Pfa), and finally the detector is obtained by higher order polynomial curve fit throughout the data area. Another new method of moving target validation via multi-look sample covariance matrix is also proposed. Simulation results show the effectiveness of these methods in the detection of moving targets submerged in strong clutter [C948]

"A Design Method of Parameters for Airborne Conical Scan Pulsed Doppler Radar Seeker"

The look-down mode of an airborne pulsed Doppler radar seeker is important for the detection of a moving ground target. The performances of airborne pulsed Doppler radar seeker operating in look-down mode are strongly influenced by the presence of ground clutter. In this paper the different clutter characteristics of airborne conical scan pulsed Doppler radar seeker in searching and tracking mode are analyzed, and a novel design method of parameters for the seeker is proposed. Then a design instance is given to validate the practicability of this method [C949]

"An Improved Target Detection Method on Wavelet-Based Fractal Scaling Analysis"

Wavelet-based fractal scaling analysis is a new method based on fractal geometry for detecting small targets within sea clutter. But the fractal dimension of sea clutter is affected by not only the presence of a target but also sea wave propagation directions, which will degrade accuracy of detection under various sea and weather conditions. An improved method using spatial Hurst parameter differences is provided to overcome the above drawback. Experiments with IPIX real-life radar data have shown that the novel method is more robust and accurate than wavelet-based fractal scaling analysis method [C950]

"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 [C951]

"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) [C952]

"Radar Track-Before-Detect Algorithm of Multitarget Based on the Dynamic Programming"

For detecting and tracking multitarget under the background of low SCR, a radar track-before-detect algorithm of multitarget based on the dynamic programming is presented. This algorithm can exactly estimate the number of targets in the observed region, and optimally separate the tracks of these targets. Therefore it can solve the problems of missed alarms and false alarms, which usually arise, when the pervious track-before-detect algorithm are used to detect multitarget with unknown number of targets [C953]

"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 [C954]

"Velocity Layover Solution in VSAR Image"

In the velocity synthetic aperture radar (VSAR), multiple moving targets in image domain may be superposed in the same range-azimuth cell and, therefore, may not be easily distinguished from each other. This phenomenon is named "velocity layover" of multiple moving targets in this paper. A super-resolution spectrum estimation

method, i.e., spatial projection processing, is used to solve this problem. It is shown that the superposed targets can be reconstructed in velocity images (V-images), and their motion parameters can be estimated respectively. Therefore, the superposed targets can be located respectively via the proposed method [C955]

"Research on Target Tracking Technology of OTHR based on MPDA"

Considering the problem of OTHR's target tracking, which estimates the state of a discrete-time, linear stochastic system whose observation process consists of a finite set of known, non-linear measurement models. MPDA (multipath probabilistic data association filter) is capable of exploiting multipath target signatures arising from discrete propagation modes that are resolvable by the radar. In this paper, numerical simulations are made under zero-clutter environment in planar measurement model and spherical measurement model of OTHR respectively. When tracking a single, non-maneuvering target in an environment where up to four possible measurements of state are received, the simulation results show that the performance under spherical model is superior to that under planar model [C956]

"A CFAR Based on Statistics of Cell Under Test"

Aiming at solving the problem of detection performance degradation of CA-CFAR and OS-CFAR in the circumstance of multi-targets and strong interference, a CFAR whose selection of reference samples is based on statistics of the CUT (cell-under-test) is presented. Simulation shows that this CFAR suffers a small CFAR loss compared to CA-CFAR in homogeneous environment, and performs robustly against interferers in a non-homogeneous environment [C957]

"Novel Ground Bounce Removal Algorithms Based on Non-homogeneous Detector"

In this paper, a non-homogeneous detector (NHD) is developed for ground penetrating radar (GPR) for the first time. The homogeneousness of ground bounce (GB) and the number and position of buried targets (or target-like objects) can be determined by the general likelihood based NHD. Combined with NHD, principal components analysis (PCA) based and blind source extraction (BSE) based methods are also presented for GB removal, which are referred to as NHD-PCA and NHD-BSE algorithm, respectively. For NHD-PCA algorithm, PCA is only taken on target areas to avoid leakage of target signals energy and descend of signal noise ratio (SNR) in target areas. For NHD- BSE algorithm, since the number of targets can be priorly determined by NHD, it has much less number of components to be extracted than that needed by independent component analysis (ICA), therefore less computational load is required. Meanwhile, all sources selection strategies needed by ICA are unnecessary for NHD-BSE because of the known number of extracted sources. The experimental results show the good performance of proposed methods [C958]

"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 [C959]

"Analysis of Squint Angle in Point Target Assessment"

This paper analyzes the characteristics of impulse response function in squinted geometry. Based on this analysis the expression of side-lobe's slant angle is deduced explicitly. In the course of point target assessment, the proposed method picks the declining one-dimensional profiles by this angle. The simulation results show that the method is highly effective and practical compared with the line-by-line searching method [C960]

"Simulation of Multi-channel SAR Raw Data Based on Real Single Channel SAR Data"

This paper presents a multi-channel SAR raw data simulation method that is used to develop, verify and evaluate the multi-channel SAR/GMTI technique. The simulated data are generated by superimposing multi-channel clutter data formed from real single SAR data and multi-channel moving targets data obtained through computer simulation. This is a compositing method, has cost benefits and greater fidelity. The compound data are tested with R-D imaging algorithm, DPCA technique and channel calibration technique proposed in reference. The results show the high quality of this multi-channel SAR raw data simulation method [C961]

"GLRT Detection for Range and Doppler Distributed Targets in non-Gaussian Clutter"

A generalized likelihood ratio test (GLRT) is derived for adaptive detection of range and Doppler distributed targets. The clutter is modelled as a spherically invariant random process (SIRP) and its texture component is range dependent (heterogeneous clutter). We suppose here that the speckle component covariance matrix is known or estimated thanks to a secondary data set. Thus, unknown parameters to be estimated are local texture values, the complex amplitudes and frequencies of all scattering centers. The proposed detector assumes a priori knowledge on the spatial distribution of the target and has the precious property of constant false alarm rate (CFAR) with the assumption of a known speckle covariance matrix or by the use of frequency agility [C962]

"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 [C963]

"A Kind of Dual-Channel GMTI Real-Time Processing Method Based on Frequency DPCA"

In this paper, current situation of GMTI technology would be discussed firstly. After that, a kind of dual-channel GMTI real-time processing method based on frequency DPCA would be presented. After analyzed the principle of clutter-suppression and the diagram of the algorithm, the processing result to both simulation data and real echo data from X-band dual-channel SAR system by the algorithm would be presented. The results proved this method is reasonable and reliable [C964]

"On Concept and SCR of PCL AEW Utilizing Illuminators of Opportunity"

In this paper, the concept of PCL AEW radar system utilizing illuminators of opportunity such as FM broadcast was proposed for the first time, followed by its system description and characteristics analysis. To analyze the critical factor of SCR for passive radar, the vertical radiation pattern for FM broadcast and the corresponding elevation angle for target or AEW were derived, with the aid of bistatic radar equation, the SCR for this novel passive radar system was obtained and simulated. Finally, it is come to a conclusion that a reasonable SCR lies in the range of-60~110 dB and constant SCR holds for an ovals of Cassini just as the SNR does for bistatic radar [C965]

"Target Detection in Long Duration Energy Integration by Time-Frequency Distribution and Morphological Filtering"

A new energy integration detection scheme is proposed to detect a nonlinear frequency modulate (FIM) embedded in strong complex additive white Gaussian noise (CAWGN). In this scheme, the optimal kernel of Cohen's time-frequency distribution (TFD) is designed to realize local coherent integration of a signal. Thresholding and morphological filtering are used to extract the time-frequency (TF) support region of the signal from the TFD of an observation. Simulated results show that in the strong noise background with low ratios of signal to noise (SNR) the proposed method is effective [C966]

"A Pre-Doppler Approach for Reduced Loss Bistatic STAP"

In this paper we investigate the effects of bistatic clutter spectral dispersion on STAP techniques. The use of reduced d.o.f. algorithms is considered since they enable localized training in the range dimension and thus limited effects of clutter non-stationarity. To this aim, the selection of appropriate adaptive degrees of freedom is demonstrated to be a crucial issue. Due to their intrinsic capability to yield reduced adaptivity loss and to their limited computational load, Pre-Doppler STAP techniques are shown to be a very appealing solution for clutter cancellation and slowly moving target detection in bistatic radar systems [C967]

"A New Method of Resolving Velocity Ambiguities in Multi-Channel Interferometric SAR/GMTI"

Along-track interferometry is an effective technique of the land clutter suppression for ground moving target indication (GMTI). Based on the principle of clutter cancellation in dual channels along-track interferometric

synthetic aperture radar (SAR), the performance of relocation and radial velocity estimation in the three channels SAR/GMTI is analyzed, and a set of analytical formulas is derived. To solve velocity ambiguities resulted from interferometeric phase, unequal separation four channels along-track interferometric SAR/GMTI scheme is proposed, and the method of resolving velocity ambiguities is presented in detail. In addition, irregular spacing of sub-aperture help to exclude blind velocities and improve detection probability. Theoretical analysis and simulation results show the validity of this scheme [C968]

"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 [C969]

"Small Target Detection in Sea Clutter Based on Doppler Spectrum Features"

Small target detection in sea clutter is a challenge problem in radar signal processing community. Based on the analysis of sea clutter Doppler spectrum characteristics, two target detection algorithms are proposed, namely, a Bayesian detection algorithm based on joint Rayleigh distribution model and a feature detection algorithm based on the entropy feature extracted from signal's Doppler spectrum. The detection performances of the proposed algorithms are evaluated based on the data collected by the McMaster IPIX radar at the east coast of Canada [C970]

"Rank CFAR Detector in Presence of Randomly Arriving Impulse Interference"

We have researched the rank detector in presence of clatter and randomly arriving impulse interference with Poison and binomial distributed flow with arbitrary average repetition frequency and magnitude, Raleigh amplitude distribution, and Swerling II target model. Our purpose is to obtain the limits when this detector is nonparametric and to compare it with post-detection integration (PI), binary integration (BI), excision (EXC) BI, and robust adaptive censoring post-detection integration (RACPI) CFAR processors. The results are obtained by Monte Carlo simulations and can be used in both, radar and communication receivers [C971]

"Research on 2-Channel Outdoor Instrumentation Radar"

To meet the requirements of the outdoor radar target scattering measurement, a 2-channel instrumentation radar based on pulse-to-pulse frequency shifting technique was designed and realized. The radar can perform radar-cross section (RCS) measurement simultaneously on two fixed frequency band, and test 2-dimension imaging cooperated with a rotation platform. The pulse-to-pulse frequency shifting technique avoids the problems causing by the nonlinear error of the linear frequency modulation. To farthest eliminate the errors causing by the outdoor phantom signals and the background clutters, a series of range gate pulses generated by FPGA were set and the high resolution imaging technique was used. The quadrature errors can be corrected by a real time calibration branch. The principles of the pulse-to-pulse frequency shifting are summarized, the design and realization are presented, the hardware in the loop simulation method is introduced and the test result is given and analyzed [C972]

"Approximate Invariance of the Inverse of the Covariance Matrix and Its Applications"

Space-time adaptive processing (STAP) normally requires knowledge of the inverse of the covariance matrix (ICM) of undesired signals for detecting desired target signals. The computation of the real-time ICM is impractical at current computer speeds. Presenting two theorems, this paper shows that the ICM is approximately invariant to clutter changes if radar and platform parameters remain unchanged. Potential applications of this approximate invariance are manifold. One of applications we suggest in the paper is a pre-built space-time non-adaptive processor (PSTAP). Both simulated data generated by the high fidelity simulation software, RLSTAP, and real data collected by the multi-channel airborne radar measurements (MCARM) system are tested. The results indicate that PSTAP performs virtually the same as STAP. A moving target has been detected from the MCARM data [C973]

"Averaging of Sorted Bigenvalues for STAP"

Optimum STAP requires knowledge of the true interference covariance matrix. In practice, this matrix is not known and must be estimated from training data, which must be target-free and statistically homogeneous with respect to the range gate under test. These conditions are often not satisfied, which degrades the detection performance. Particularly, for ground moving target indication radar, the clutter Doppler frequency depends on range for all array geometries, except linear side-looking. This range dependency leads to problems in clutter suppression through STAP techniques. In this paper, we study issues associated with a novel technique, which works on the eigenanalysis of homogeneous clutter, to address this clutter range dependency problem. Simulation results show a significant improvement in processor performance as compared to conventional STAP techniques [C974]

"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 [C975]

"Clutter Rank of Sparse Linear Array Radar"

Severe clutter existing in airborne and spaceborne radar systems makes the moving target indication (MTI) mission a big challenge. To suppress the clutter effectively, the rank of clutter covariance matrix (termed as clutter rank) should be well understood. In dense array radar systems, it is found that the clutter rank can be estimated by the bandwidth-aperture product. This methodology is also applicable to sparse array radars, as long as the effective length of the equivalent array is correctly computed. In this paper, a general formula is presented to estimate the clutter rank of the system using linear arrays, and sequentially, the sufficient condition of full-rank clutter is given. The simulation shows that the general formula is accurate in various circumstances [C976]

"Adaptive Filtering in Polarization Domain with the Criterion of LCMV"

The radar targets can be detected by polarization information when they are difficult to be distinguished from clutter or interference environment by information derived from time and frequency and spatial domains. The traditional methods of polarization filtering are not suitable for the detection of targets in an environment containing strong jams because the signal to interference ratio (SIR) is usually every small and the polarization state of the jam is unknown or distributed continuously. This paper proposes a novel algorithm of adaptive polarization filtering based on the principle of linear constraint minimum variance (LCMV), which achieves the optimal receive of signal by adopting the variable polarization of antenna. For the realization of algorithm and the adaptive fast varying interference, a recursion polarization filtering algorithm is given which can adapt the polarization states of the jam at sampling speed. Simulations are shown and results are in good agreement with theoretical analysis [C977]

"A method or radar targets position acquisition based on Possibilistic C_means algorithm"

Targets position acquisition is a key technique in radar data processing system. The existence of sea clutter result in the coupling of targets in radar video which lead to the distortion of targets position acquisition. A method for radar targets position acquisition based on possibilistic C_means algorithm is used to solve the problem. During marking different targets by the connectivity and combination algorithm, a method based on possibilistic C_means algorithm is presented to segment coupled targets. The result of the experiment showed that this method can use azimuth and range of radar video simultaneously to realize target position acquisition which can overcome the targets splitting caused by conventional method based on one-dimensional acquisition and can segment coupled targets caused by several factors effectively, thus improving the accuracy of targets position acquisition [C978]

"Detection and Location of Fast Moving Targets Using Minimum Redundancy Linear Array SAR"

In this paper, a new system called minimum redundancy linear array SAR (MRLA-SAR) is proposed. Using multiple complex images formed by multiple antennas with a special configuration, MRLA-SAR can not only suppress the stationary clutter, but also locate and image both slowly and fast moving targets accurately. Numerical experiments are also presented to demonstrate the effectiveness of MRLA-SAR [C979]

"A new method of improving the weak target detection performance based on the MIMO radar"

Based on the spatial diversity of the multiple input multiple output (MIMO) radar, a new method is presented to improve the detection performance of weak targets in clutter in this paper. First, the general spatial diversity condition is deduced. Accordingly, by selecting suitable MIMO radar spatial configuration, the target and clutter in a detection unit may be regarded as the non-fluctuating and the fluctuating components, respectively. Therefore, an effective method to exploit the spatial diversity to increase the signal-to-clutter-plus-noise ratio of the receiver is proposed. Compared to the conventional radar, it is shown that superior detection performance may be obtained with the proposed method, especially for the weak target in clutter. Finally, detailed numerical experiments are also provided to demonstrate the effectiveness of the proposed method [C980]

"Applying Fractional Processing to Radar Satellite Constellations"

This paper introduces a new distributed SAR processing based on fractional Fourier transform for ground moving targets imaging. According to the analysis of the minimum mean-squared error, the distributed SAR representation is given. The multi-channel Doppler imaging used adapting coefficient to handle azimuth domain processing. Compared with the traditional approaches, it can achieve a better result of clutter cancellation by using optimal beamforming in the fractional Fourier domain. The effectiveness of this method has been tested through simulation [C981]

"Method of Resolving the Range Ambiguity for High PRF Stepped-Frequency Radar"

High PRF stepped-frequency radar can achieve simultaneously the advantages of pulse Doppler (PD) and high range resolution (HRR) radar, but it's difficult to resolve the range ambiguity brought about by high PRF. In this paper, a novel method based on the phase difference out of the FFT between two adjacent range cells is proposed to solve the problem. This method firstly solves the range/Doppler coupling in the FFT by iterative reckoning between the range and the Doppler of a target and the accuracy of both reach 5 high resolution bins respectively. Secondly, it eliminates the effects of the target motion to the phase difference, consequently the accuracy of resolving the range ambiguity is reasonably high. Simulation verifies its validity [C982]

"Multiplicative multifractal modeling of sea clutter"

Sea clutter refers to the radar returns from a patch of ocean surface. Accurate modeling of sea clutter and robust detection of low observable targets within sea clutter are important problems in remote sensing and radar signal processing applications. In this paper, we introduce a multiplicative multifractal process for modeling the sea clutter. Through analysis of 392 amplitude time series of 14 sea clutter datasets measured under various sea and weather conditions, we show that the data are consistent with multifractals over certain time scale range, and that the generalized dimension spectrum Dqaccurately detects low observable targets within sea clutter. The method is computationally very fast and practically easily implemented. These attributes strongly suggest that the method may be developed into an automated target detector within sea clutter. [C983]

"Power-law sensitivity to initial conditions in sea clutter"

Understanding the nature of sea clutter is crucial to the successful modeling of sea clutter as well as to facilitate target detection within sea clutter. To this end, an important question to ask is whether sea clutter is stochastic or deterministic. In the past decade, Haykin et al. have carried out analysis of some sea clutter data using chaos theory, and concluded that sea clutter was generated by an underlying chaotic process. Recently, their conclusion has been questioned by a number of researchers. To reconcile ever growing evidence of stochasticity in sea clutter with their chaos hypothesis, Haykin et al. have further suggested that the non-chaotic feature of sea clutter could be due to many types of noise sources in the data. To test this possibility, McDonald and Damini have tried a series of low-pass filters to remove noise; but again they have failed to find any chaotic features. While most of these studies are conducted by comparing measured sea clutter data with simulated stochastic processes, we use the direct dynamical test for deterministic chaos developed by Gao and Zheng to analyze 280 sea clutter data measured under various sea and weather conditions. The method offers a more stringent criterion for detecting low-dimensional chaos, and can simultaneously monitor motions in phase space at different scales. However, no chaotic feature is observed from any of these scales. But more interestingly, we find that sea clutter can be conveniently characterized by the new concept of power-law sensitivity to initial conditions (PSiC), which generalizes the defining property for chaotic dynamics, the exponential sensitivity to initial conditions (ESIC). We show that PSIC offers a powerful method for detecting targets within sea clutter. [C984]

"Tracking of multiple maneuvering targets in clutter with possibly unresolved measurements using IMM and JPDAM coupled filtering"

We present a (suboptimal) filtering algorithm for tracking multiple highly maneuvering targets in a cluttered environment using multiple sensors. We concentrate on the case of two targets which may temporarily move in close formation, giving rise to a single detection due to the resolution limitations of the sensor. The proposed filtering algorithm is developed by applying the basic interacting multiple model (IMM) approach and the joint probabilistic data association with merged measurements (JPDAM) technique and coupled target state estimation to a Markovian switching system. The algorithm is illustrated via a simulation example. [C985]

"Complex spatial/temporal CFAR"

The conventional cell averaging constant false alarm rate (CFAR) criterion and its variations work well only in strictly spatially stationary environments. In non-homogeneous environments, clutter map (scan-by-scan) processing is deployed. The performance of this method degrades in the presence of slow targets. In this paper, a hybrid procedure for CFAR is proposed, which combines the advantages of both spatial and time averaging. The detection probability is derived and the related plots are given for different values of L, the number of persistence scans. A method is presented to choose the parameter of the hybrid CFAR to have the lowest self-masking effect. [C986]

"Clutter mitigation in weather radar systems filter design & analysis"

One of the factors limiting the performance of weather radar systems is the presence of "clutter" in the received signal. Clutter is the group of signal components caused by reflections from objects other than weather targets; it is undesirable because it can obscure meteorologically interesting signals from actual weather targets. Objects that cause clutter are usually stationary, so the signal components with zero and near-zero Doppler shifts are usually clutter. Most weather radar systems use digital high-pass filters to reduce clutter by severely attenuating the zero and near-zero frequency components of the received signal. An alternative and relatively new technique for reducing clutter is frequency-domain filtering, where the Doppler velocity spectrum of the received signal is calculated and manually altered below a certain velocity. The frequency-domain filter performs the same task as the high-pass digital filter but never removes too much of the signal, as the digital filter sometimes does, because an appropriate cutoff frequency is calculated for each spectrum. The performance of a frequency-domain filter is compared with a digital high-pass clutter filter, and the frequency-domain filter is shown to remove more clutter from the radar signal. [C987]

"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. [C988]

"Computationally-efficient range-dependence compensation method for bistatic radar STAP"

We address the problem of detecting slow-moving targets using space-time adaptive processing (STAP). The construction of the optimum weights at each range implies the estimation of the interference-plus-noise covariance matrix. This is typically done by straight averaging of snapshots at neighboring ranges. However, in most bistatic configurations, snapshot statistics are range dependent. Straight averaging results thus in poor performance. In an earlier paper, we proposed a range-dependence compensation method that provides optimum performance. However, this implies a large computational cost. In this paper, we adapt the method to provide optimum performance at low computational cost. [C989]

"Pre-filtering for clutter rejection in beamspace STAP"

Several space-time adaptive processing algorithms have been proposed to detect weak targets in the presence of strong interference, especially clutter and jamming. Except for displaced phase center array (DPCA) processing, radar signal processing algorithms ignore the fact that the location of the clutter ridge in angle-Doppler space is known, given the platform speed and direction. This paper introduces our attempt to exploit this a priori knowledge in conjunction with the joint domain localized processing algorithm. Using a two-dimensional filter, clutter is rejected in a first, non-adaptive stage, followed by adaptive processing in the angle-Doppler

domain. [C990]

"MTD detector using convolutional neural networks"

A detector based on joint time-frequency signal analysis and convolutional neural networks is proposed for radar detection in highly complex and nonstationary cluttered environments. This detector is coherent and monocell, i.e. it works with the complex envelope of the echoes from the same range cell, and exhibits joint CFAR and MTD characteristics. It includes a pre-processing time-frequency block which provides a constant false alarm rate (CFAR) behaviour regarding the clutter power when normalization is utilized. Multiple targets can be also resolved in the same resolution cell (MTD) if the neural network presents multiple outputs. [C991]

"Modified JDL with Doppler compensation for airborne bistatic radar"

In this paper, we study issues associated with applying space-time adaptive processing (STAP) techniques in bistatic airborne applications. For ground moving target indication (MTI) radar, the clutter Doppler frequency depends on range for all array geometries other than linear sidelooking. This range dependency leads to problems in clutter suppression through STAP techniques. One aspect is that the STAP filter becomes range dependent. This paper proposes Doppler compensation using interpolation, in the angle-Doppler domain, for the modified joint domain localized (JDL) processor. Simulation results show that a significant improvement in processor performance is obtained throughout the whole frequency spectrum. [C992]

"Signal processing for automotive radar"

With rising accident rates, researchers are looking for solutions to reduce fatalities. Some enhance car designs to protect drivers more adequately. Some propose improvements to the traffic and road systems to reduce the chances of accidents. Still others propose the installation of special gadgets to improve the situational awareness of drivers and to alert them to dangerous circumstances. A motor vehicle may be equipped with a radar sensor that checks the spatial environment around the vehicle. The radar is the most commonly adopted sensor for this purpose due to its all-weather capability. In this paper, a 77-GHz FMCW automotive radar signal processor is developed and implemented using the Renesas (previously Hitachi) SH7615 solutions engine development board. The project includes building additional required hardware, the DSP algorithm and a data simulator program to generate test data for testing. The main purpose of the automotive radar signal processor is to detect legitimate targets from unwanted clutter (e.g. road surfaces), and to extract target information from the radar returns. In this paper, the application of the new AND-OR CFAR is also introduced. The simple mathematical fusion models of the AND-OR CFAR are provided and explained here as well. This manuscript is divided into sections. The first section will delve into the basics and the building blocks of the automotive radar. The signal processing portion of this work will be presented in the second section. The data simulator built to simulate testing data is explained in the third section. Results from testing are put forward in section four. Conclusions drawn from the experience are presented in the last section. [C993]

"Clutter effects on ground moving targets' interferometric phase"

{no data available} [C994]

"Radar antenna architectures and sampling strategies for space based moving target recognition"

{no data available} [C995]

"Moving targets detection and velocity estimation via multi-channel along-track interferometry"

{no data available} [C996]

"A novel prescreening method for UWB SAR target detection using adaptive nonlinear filters"

{no data available} [C997]

"Signal processing method for detection of subsurface objects by ultra-wideband SAR"

The problem of subsurface target detection has been studied. Modifications of a damped exponential model has been applied for reducing the clutter due to a rough boundary. Utilizing numerical simulations, a sensitivity analysis is performed to investigate the features of detection of low-contrast targets. The dependence of the received signal on the properties of an inhomogeneous medium, rough surface and the locations of the objects has been studied. The calculations have been performed for randomly buried objects. It has been found that it is

possible to significantly improve the ratio between the scattered signal from subsurface objects and the scattering from a rough boundary. [C998]

"Polarimetric calibration of space SAR data subject to faraday rotation -a three-target approach"

{no data available} [C999]

"A sensor management protocol for tracking with diverse sensors"

We develop a sensor management protocol that a vehicle may use to track other vehicles and objects in its neighborhood using a sensor-suite, an individual element of which gives either periodic cluttered updates or a periodic uncluttered updates. We outline how to combine the joint probabilistic data association filter with stochastic Kalman filters for the state estimation process. However, since such an algorithm is sensitive to modeling errors, we discuss the use of data-driven optimization algorithms to increase robustness. Finally, we discuss extensions of previously developed covariance control sensor management algorithms. [C1000]

"Multisensor tracking of multiple maneuvering targets using multiscan JPDA and IMM filtering"

We present a novel suboptimal filtering algorithm developed by applying a multiscan joint probabilistic data association (Mscan-JPDA) technique and interacting multiple model (IMM) filtering approach. In the past this algorithm has been restricted to single sensor tracking which we now extend to a multiple sensor tracking scenario. Multiscan JPDA addresses the problem of measurement-to-track data association for multiple targets and clutter. An IMM approach is exploited to consider the tracking of highly maneuvering targets. The proposed algorithm is illustrated via a simulation example involving tracking of two maneuvering targets by two sensors (radar and infrared) and a multiscan data window of length two. [C1001]

"On adaptive sampling for multisensor tracking of a maneuvering target using IMM/PDA filtering"

We present a novel adaptive sampling scheme for tracking a highly maneuvering target. During the maneuvering mode of a target, estimation accuracy of the tracker is typically worse than that during the constant velocity (benign motion) mode. Hence it is desired to have higher sampling rate during the maneuvering mode and relatively lower sampling rate for the benign motion mode. In the proposed adaptive sampling policy, we predict an expected cost function for a candidate sampling interval selected from a predefined set of sampling intervals. We then choose the largest sampling interval for which an expected performance metric is satisfied. We use a random sampling approach coupled-with switching multiple kinematic models for target motion, to generate future (pseudo-)measurements which allows computation of the relevant performance metric. The algorithm is illustrated via a simulation example involving tracking of a maneuvering target in presence of clutter and two sensors (radar and sonar). Multisensor tracking is achieved by a suboptimal filtering algorithm developed by the interacting multiple model (IMM) filtering approach combined with the probabilistic data association (PDA) technique and with the proposed adaptive sampling scheme. [C1002]

"Naval radar in a littoral environment"

The changed political situation in the world forces navies to reconsider their roles and missions. As a consequence, the naval operation areas shift from warfare on the open sea to littoral warfare. In modern scenarios full scale, multiple engagements attack on a naval convoy is less likely. Instead, the threat is more likely to come from weapons launched from the land or small, high-speed ships. Additionally, detection and tracking of surface targets becomes a more important sensor function. This paper discusses the impact of littoral warfare on the design of naval radar. The main aspects discussed in this paper are the benefit of accurate Doppler information, high radar stability, use of Doppler-polarimetry and sensor flexibility. [C1003]

"Multidimensional superresolution ISAR reconstruction techniques in sea-cluttered environnement"

For high-resolution radars (as the ones used for radar imagery tasks are), sea clutter is difficult to characterize, especially for low grazing angles. According to the physical model of sea surface, the echo signal is best described as the product of a Gaussian process, with rapid variation (the speckle component), and of a slow varying component (the underlying component). The K-compound distribution is used for the statistical characterization of the clutter echo. Standard target complex signature simulations techniques (based on the well-known scattering center model or using geometric primitives) are combined with synthetic sea clutter, allowing us to generate realistic signals. The MUSIC 2D super-resolution reconstruction method, presented in the paper, is used to generate ISAR target images. A comparative study of robustness of MUSIC and Fourier type images is then performed. The obtained results show the validity of both clutter simulation engine and super-resolution reconstruction methods. The problem of naval targets, subject to particular simulation conditions, is

also discussed in detail. [C1004]

"Estimating weak sinusoidal frequencies embedded in radar clutter using generalized chaos synchronization"

In this paper, a novel approach for estimating sinusoidal frequencies embedded in radar clutter spectrum based on generalized chaos synchronization is proposed. The proposed method is shown to be able to extract the weak sinusoidal signal even when the target frequencies are located inside the clutter spectrum. The unbiasedness of proposed approach is also analyzed. Using real radar clutter data, it is shown that the proposed method is superior to the standard estimation methods. [C1005]

"Improving STAP performance in bistatic space-based radar systems using an efficient expectation-maximization technique"

In this paper, we describe a space-time adaptive clutter processing (STAP) approach for bistatic space-based radar (SBR) systems. A candidate SBR system employing a transmitter at medium Earth orbit (MEO) and an airborne receiver is defined. A STAP configuration for performing wide area ground moving target indication (GMTI) is also specified. STAP performance is analyzed using simulated data in two different bistatic SBR geometries. Standard STAP performance degradation is shown to be a function of the system, relative seventy of clutter non-stationarity in the two scenarios. To provide enhanced estimation of the clutter statistics, we apply an approach based on an efficient form of an expectation-maximization (EM) algorithm for estimating covariance matrices in non-stationary interference. The STAP performance of the EM technique is compared to that of standard STAP processing and higher order Doppler warping. The EM approach is seen to produce a usable Doppler space fraction (USDF) that is significantly improved over the other techniques. It has several powerful features, including the ability to align non-linear angle-Doppler contours, adaptivity to interference without applying a fixed range-dependent transformation, and the ability to simultaneously compensate for different range dependencies in higher range and Doppler ambiguities. The EM STAP approach also naturally accommodates knowledge-aided STAP techniques that improve understanding of clutter reflectivity variations. [C1006]

"Two new approaches for detecting a maneuvering air target in strong sea-clutter"

Two new approaches for detecting a maneuvering air target in strong sea-clutter are proposed in this paper. One is based on the adaptive chirplet decomposition, and the other is inspired by the spectral subtraction. Experiments with real-world data samples show that both methods presented in this paper can effectively enhance the Doppler radar signals from maneuvering air targets though each has different strength and weakness. [C1007]

"Maximum likelihood estimator approach to determine the target angular co-ordinates in presence of main beam interference: application to live data acquired with a microwave phased array radar"

This paper illustrates the application of the maximum likelihood estimation (MLE) technique to determine the target direction of arrival (TDoA) in presence of main beam directional interference (MBI). Application to target plus noise-like interference live data are also considered. MLE technique, which is the best in terms of achievable performance, is a possible candidate as an alternative to the more conventional monopulse usually implemented in multifunctional and surveillance radar. Multifunctional radars are required to detect, locate and track targets in presence of natural (clutter) and intentional RF directional interference. The interference might impinge on the side lobes as well as on the main beam of the antenna pattern. A possible definition of side lobes (SLI) and main beam (MBI) or skirt (SKI) interference is given. Concerning the location capabilities of the radar, the requirements can be summarized as follows: (1) the estimation of the Target Direction of Arrival (TDoA) has to be unbiased; and (2) the accuracy of the angular co-ordinates has to be a suitable fraction of the -3 dB beamwidth depending on the target and the interference conditions. The paper contains the derivation of an algorithm to estimate the TDoA, via the MLE technique, against side lobes as well as MBI. To test the validity of the MLE approach, data have been recorded in the recent years with a ground based microwave phased array test-bed radar equipped with the conventional three high gain beams: the sum, the difference in azimuth and the difference in elevation. The experimental set-up is described and the achieved TDoA estimation in presence of a MBI is presented; in addition to this, the estimation of the target power and Doppler frequency is also presented. [C1008]

"Non-cooperative target identification of battlefield targets-classification results based on SAR images"

Non-cooperative target identification (NCTI) has become more and more important during the last years. So it is essential to develop robust classification schemes, which can be applied reliably in military operations. The major problems are the clutter (which is not present in air), the unknown target orientation (aspect and elevation angle), the high variability of the target scatterers and the possible multiple variants of the target. In this paper we concentrate on analysis and comparison of classification rates for target identification, the former detection process of the targets in the observed SAR scene will not be discussed. We focus on SAR images of single separated stationary and moving ground targets. To be able to compare our classification results with results published in literature we start our evaluation with the public MSTAR dataset, which is used since many years for ATR evaluation and identification. In addition to this we worked with a second dataset from another field measurement campaign which was performed by QinetiQ, UK. We quantify the influence of some fundamental key aspects on the classification rate. These subjects are target centering (using center of mass algorithms), image segmentation (target, clutter, target shadow), different applied classifiers (nearest neighbour classifier, support vector machines, SVM), the image resolution and the target orientation (knowledge of the aspect angle). Additionally we analyse the influence of clutter and target shadow on the classification rate when using again the MSTAR and QinetiQ datasets. For this purpose the data were segmented in a part containing the target (or target shadow) and another part containing only the surrounding clutter. For the QinetiQ dataset the classification rates drop from 79% to 70% when only the target (separated from the clutter) was used as a feature. The MSTAR dataset shows similar results. Thus obviously the identical background of each of the targets in the test and reference database contributed a lot to the reported high classification rates. That again shows that realistic expressions on the capabilities of target classification can only be based on independent test and training data. By introducing the image clutter content, ICC, we quantify the influence-of the separated clutter on the classification rate. Furthermore the target shadow can be used for additional information dependent on the depression angle. Finally we come to the conclusion that the main work is not only choosing and applying the classifier, but concentrate on the data collection (that means good data quality), preprocessing and feature extraction processes. [C1009]

"Geometrical considerations for terrain mapping in SBR applications"

Knowledge aided signal processing calls for the use of existing information such as digitized image maps to further suppress clutter in a typical radar detection operation. In the context of space based radar (SBR) applications, given the SBR parameters and the look angles the first problem is to translate these parameters into a data point on a map. This is realized by converting these parameters into conventional latitude and longitude and then using the corresponding image intensity to estimate the clutter covariance matrix. Using this approach, it is possible to pre-compute the desired weight vector for a location of interest on earth that the SBR is assigned to visit. As a result, using the measured data together with the weight vector, it is possible to test for target detection hypothesis accurately at the time of visit by the SBR. [C1010]

"An improvement of the SNR during MTI-tracking at low elevations"

In order to maintain a stable track during low-altitude tracking Saab has developed a signal processing method. The stability of this method requires the signal-to-noise ratio (SNR) to be above a certain level. By utilizing the knowledge of the speed of the tracked target the moving target indication (MTI) filter response can be optimised and, hence, the SNR can be increased. [C1011]

"Imaging of subsurface targets using a 3D quadtree algorithm"

The imaging of subsurface targets using ground penetrating radar (GPR) is becoming an increasingly important area of research. Conventional image formation techniques expend large amounts of computation to resolve a region fully, even a region of clutter. However, by using multi-resolution techniques, e.g, quadtree algorithms, potential targets and clutter can be discriminated in a computationally efficient way. Prior work has focused on the development of 2D quadtree algorithms for surface targets. For mine detection, target depth adds another dimension; thus, we have developed a 3D quadtree algorithm, and applied a multi-stage detector that uses the energy change between quadtree stages to discriminate target and clutter regions. This algorithm is then tested on computer-generated data, as well as experimental data collected from a model mine field. Results show that target location information can be obtained even under near field and small aperture conditions. [C1012]

"Cramer'r-Rao bounds for compound-Gaussian clutter and target parameters"

We compute Cramer'r-Rao bounds (CRBs) for the target and compound-Gaussian clutter parameters using radar array measurements. In particular, we compute CRBs for (i) complex target amplitudes, (ii) the spatial covariance matrix of the speckle component, (iii) texture distribution parameters. We first derive general CRB expressions under an arbitrary texture model and simplify them for gamma and inverse gamma texture distributions. We use

the generalized Gauss-Laguerre quadrature to compute the CRBs for gamma texture, whereas the CRBs for inverse-gamma texture do not require numerical integration. We use numerical simulations to validate our results. [C1013]

"Scheduling multiple sensors for tracking a highly maneuvering target in clutter"

The problem of multiple sensor scheduling for tracking a highly maneuvering target in clutter is considered. The objective is to schedule the sensors one or multiple time steps ahead so that the overall tracking performance of the system can be improved while minimizing the cost of resources. In the proposed scheduling algorithm, under the constraint that only one sensor may be used at any time step, we predict the expected cost one or multiple time steps ahead as a function of the candidate sensor scheduling sequences, and pick the sequence that minimizes an expected performance metric. We use a random sampling approach coupled with switching multiple kinematic models for target motion, to generate future (pseudo-)states and (pseudo-) measurements which allows computation of the relevant performance metric. Tracking of highly maneuvering target is achieved by an effective suboptimal filtering algorithm based on an interacting multiple model (IMM) filtering approach combined with probabilistic data association (PDA) technique and the proposed sensor scheduling scheme. The proposed algorithm is illustrated via a simulation example involving two geographically distributed radar sensors. [C1014]

"Multi step ahead beam and waveform scheduling for tracking of manoeuvering targets in clutter"

Modern radar systems have considerable flexibility in their modes of operation. In particular, it is possible to modify the waveform on a pulse to pulse basis, and electronically steered phased arrays can quickly point the radar beam in any feasible direction. Such flexibility calls for new methods of scheduling, both of the waveform and the beam direction so as to optimize the radar performance. We consider a radar system capable of rapid beam steering and of waveform switching. The transmit waveform is chosen from a small library. The operational requirement of the radar is to track a number of manoeuvring targets while performing surveillance for new potential targets. Tracking is accomplished by means of an LMIPDA (linear multitarget integrated probabilistic data association) tracker. An interacting multiple models (IMM) method is used to model manoeuvering targets in the tracker. LMIPDA provides a probability of track existence, permitting adoption of a "track-before-detect" technique. "False alarm" tracks are maintained until the probability of track existence falls below a threshold. Our aim is to maintain the tracks of the existing targets to within a specified accuracy as determined by the absolute value of the track error covariance matrix. However, this has to be done within the time available, given that a full scan has to be performed within a prescribed interval. We give an algorithm for scheduling revisits to measure the targets while maintaining surveillance. [C1015]

"Detection of low observable targets within sea clutter by structure function based multifractal analysis"

Sea clutter is the backscattered returns from a patch of the sea surface illuminated by a radar pulse. Robust detection of targets within sea clutter is of significant importance to our coastal and national security, to navigation safety, and to environmental monitoring. However, no simple and reliable methods for detecting targets within sea clutter have been proposed. We apply the structure function based multifractal theory to analyze 392 sea clutter datasets measured under various sea conditions. The method developed is mathematically rigorous, conceptually elegant, computationally fast, and, practically, easily implementable. Our results demonstrate that the method can robustly detect low observable objects within sea clutter. [C1016]

"Clutter scattering function estimation and ground moving target detection from multiple STAP datacubes"

Methods for estimating the clutter scattering function and detecting ground moving targets, using pulse-Doppler surveillance radar data, are described. The imaging problem is cast as one of structured covariance estimation with time-varying measurement models and illumination patterns. An expectation-maximization (EM) algorithm is derived and the computational issues arising from its use are discussed. The detection algorithm uses the estimated clutter statistics and a time-varying target model in a standard generalized likelihood ratio test (GLRT). [C1017]

"Bistatic ultra-wideband SAR for imaging of ground targets under foliage"

Bistatic SAR is compared with monostatic SAR concerning, e.g. coherent integration time and spatial resolution. We also suggest that bistatic SAR may be used to suppress background clutter, e.g. when the clutter scattering is dominated by dihedral or trihedral scattering mechanisms. This idea is applied to the problem of detecting

concealed vehicles in foliage using VHF-band SAR. Electromagnetic simulations show that the vehicle-to-clutter ratio can dramatically increase by choosing different incidence angles for the transmitter and receiver in a bistatic SAR. [C1018]

"Performance comparison of three recent STAP methods"

In this paper, we present a comparison of target detection performance for normalized adaptive matched filter (NAMF), normalized parametric adaptive matched filter (NPAMF), and normalized low-rank adaptive matched filter (LRNAMF) for space-time adaptive processing. Test statistics for these algorithms as functions of range bins and filter outputs as functions of Doppler beam position (DBF) and azimuth angle (AZ) are computed for the KASSPER L-band datacube, which is simulated for the airborne linear phased array radar application. First, we illustrate that when the signal-to-noise ratio is used as a target-detection parameter, LRNAMF outperforms NAMF and NPAMF under weak conditions of training data contamination. Next, we demonstrate the target cancellation effect when the training data are contaminated by competing targets (outliers). Finally, we present a scenario for target detection in heterogeneous radar clutter when there is spatio-temporal steering vector uncertainty. In this scenario, we show that there is substantial broadening in the filter outputs as functions of DBP and AZ for these algorithms. [C1019]

"Site-specific modeling tools for predicting the impact of corrupting mainbeam targets on STAP"

This paper provides details about modeling tools being developed under the Defense Advanced Research Projects Agency's (DARPA) knowledge-based sensor signal processing and expert reasoning (KASSPER) program to efficiently predict the performance of GMTS sensors operating in real-world environments. Specifically this paper addresses model to compute losses due to targets corrupting the training data (W.L. Melvin and J.R. Guerci, May 2001) (J.S. Bergin et al., April 2002) for airborne radars that employ space-time adaptive processing (STAP) (J. Ward, December 1994). The modeling tools can be used to predict losses in a computationally efficient manner and therefore allow analysis of GMTI performance for realistic simulation scenarios that span very long time periods. [C1020]

"Theoretical aspects on a method for terrain scattered interference mitigation in radar"

Hot clutter (terrain-scattered interference (TSI), terrain-scattered jamming (TSJ) or jammer multipath) are signals from jammers which are reflected on the ground or sea before they are received by a radar. In the mainbeam an often weak target signal has to compete with hot clutter. Hot clutter is a significant problem today to military airborne radar systems and should be suppressed. This paper is a theoretical analysis of a hot clutter suppression method which consists of 1) estimating the direct jammer signal, 2) estimating the linear system created by the multipath (the "reflection system") and 3) removing an estimate of the reflected jammer signal from the main received radar signal. The paper can give a better understanding of the method and guidance on how to design the method for the best result. The results of the work in this paper are: both with white and colored noise, we can state and solve optimal estimation problems for the reflection system and give expressions for the bias and covariance. We can also see how the model order, the number of data etc. influences the estimation quality. [C1021]

"A novel characteristic detection method for radar target"

In this paper, a novel method of radar target detection based on 2-dimensional (2-D) fractal dimension is proposed. The proposed approach exploits both range information and azimuth information to estimate fractal dimension. Moreover, the approach can increase the number of the data points. The above two merits result in the fractal dimension estimated by this method is more accurate and robust than the previous method. The detection performance is also better than the previous one, which only makes use of 1-dimensional (1-D) information to estimate fractal dimension. Theoretical analysis and experimental result show that the proposed method performs well in strong clutter background. The proposed method is also validated by real-life radar data, and the better result has been achieved. [C1022]

"Estimation of range-dependent clutter covariance by configuration system parameter estimation"

The range-dependent nature of the surface clutter power spectrum observed in monostatic or bistatic airborne radar systems results in a mismatch of the clutter covariance matrix (computed from a secondary set of range-cell data) relative to that of a possible target test cell, with attendant degradation of space-time adaptive processing (STAP) performance. In this paper, we develop a new method for predicting the test cell clutter covariance matrix by estimating the configuration system parameters that directly influence the clutter power spectrum. The method uses a multiple complex sinusoid model whose parameters are related to the configuration system parameters, which are then optimized to match the radar return pulse-train data in a least-

squares sense. The estimated configuration parameters are then used to predict the clutter covariance matrix in the test cell, which is then used with traditional STAP methods. Computer simulation results are presented that demonstrate the significantly improved STAP performance obtained by the method developed here compared to the conventional method of using the sample covariance matrix estimated from secondary data. [C1023]

"Range-Doppler and clutter considerations in designing a bistatic space based GMTI radar system"

The theoretical application of bistatic radar concept to the ground moving target indicator mode from space based platforms present some intriguing possibilities, along with several intrinsic difficulties that must be surmounted in order to design an effective system. Key among these difficulties is the extraction of slowly moving ground target velocities from the significant background clutter spread introduced by relative Earth-satellite motion. The difficulty in characterizing the clutter is significantly compounded by the extreme variability in the bistatic footprint as a function of Earth/satellite geometry. In order to explore the theoretical nature of the motion induced clutter spread, a simple MATLAB model was constructed to simulate the clutter characteristics of a hypothetical medium Earth orbit (MEO) transmitter, and a low Earth orbit (LEO) receiver. Various receiver and transmitter satellite geometries have been discussed in the literature; placing the transmitter at MEO allows for a larger transmitter footprint, and moves it to a higher and presumably 'safer' orbit, but then generally requires a somewhat larger antenna aperture. The more numerous LEO receiver platforms needed do not then require the additional expense of radiation hardening and are also less expensive to place in orbit. [C1024]

"Radar signal detection in non-Gaussian distributed clutter by Bayesian predictive densities"

We present a coherent radar signal detection scheme in non-Gaussian distributed clutter and its simulation results. In this scheme the clutter is modeled by compound Gaussian distribution and unknown parameters, i.e. target amplitude and clutter, are estimated based on a posteriori distribution with a noninformative prior. Also a technique called Bayesian predictive densities is employed. In order to investigate the performance, we carried out the Monte Carlo simulation and its results are also compared with conventional detection schemes such as maximum likelihood and maximum a posteriori estimator. The simulation results show its usefulness. [C1025]

"Nonparametric permutation tests versus parametric tests in radar detection under k-distributed clutter"

Permutation detectors (tests) are nonparametric CFAR (constant false-alarm rate) detectors if clutter samples are independent and identically distributed (IID). The optimum statistic for the parametric detector is also optimum for the permutation detector. In this paper, we analyze the performance of some permutation tests (PTs) under an ideal k-distributed clutter model and nonfluctuating (NF) and Swerling II (SW-II) target models. Also, we compare the PTs results against their parametric counterparts under the same conditions. We analyze the detector performances in terms of detection probability (Pd) versus signal-to-clutter ratio (SCR) for different parameter values: the number of integrated pulses (N), the clutter reference samples (M), the false alarm probability (Pfa) and the shape parameter (v) of the k-distributed clutter. The conclusions obtained from the analysis of the different results are discussed. [C1026]

"Design and analysis of a knowledge-based radar detector"

In this paper we introduce and assess a knowledge-based (KB) radar detector composed of three elements: a geographical information system-based (GIS-based) data selector, which eliminates static outliers from the secondary data exploiting the a-priori information concerning the topography of the observed scene, a data-adaptive training selector which removes dynamic outliers from the training data, and an adaptive radar detector which performs the final decision about the target presence. The performance of the new algorithm is analyzed on real radar data collected by the McMaster University IPIX radar. The results show that the new KB system achieves a satisfactory performance level and can outperform some previously proposed adaptive detection schemes. [C1027]

"Geometrical and signal processing aspects using a bistatic hitchhiking radar system"

Bistatic hitchhiking radar system concepts have been object for extensive research both for military and civilian applications. Hitchhiking systems are in principle easy to construct and can be used without introducing any interference, or being seen by a possible enemy. This paper addresses how to handle the geometry such systems are faced together with using proper signal analysis strategies for obtaining optimum target detection. The main motivation for doing bistatic measurements is to be able to see signals from the target that are scattered in other directions than backwards, due to target shape. For large bistatic angles the target forward scattering region can give serious enhancement due to the Babinet principle. Experimental results from bistatic hitchhiking radar are shown for the purpose of aircraft detection. The data presented has been processed non-

coherently. For suppression of device noise and scan-to-scan stationary clutter a signal analysis method called "target back propagation technique" has been used. 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" for suppression of device noise and stationary clutter, even if just three scans are integrated. [C1028]

"An analysis of phase array radar system on a moving platform"

In this paper, we derive a time-varying model for the steering vector of a phased array pulse Doppler radar system installed on a moving platform. Six oscillating motions are included in the derived model as well as the forward motion of the platform. We also present the sensitivity analysis of the derived model and analyze the effect of the perturbation between the true and measured array manifold on the accuracy of the motion compensation algorithm. From the simulation, it can be shown that the platform motions have no prominent effects on the target's power spectrum in moderate sea states (up to 3). However the barge's forward motion is a problem if the targets fall in the spreading spectral region of the sea clutter. [C1029]

"Manoeuvring target tracking with the IMM-VDA algorithm"

This paper describes an algorithm for tracking a manoeuvring target in heavy clutter and/or with a low probability of detection. It is known that when tracking under such adverse conditions multi-scan tracking algorithms, such as the multi-hypothesis tracker (MHT), provide improved performance over single-scan trackers. This paper uses a computationally efficient algorithm for multi-scan target tracking based on the Viterbi algorithm, known as the Viterbi data association (VDA) algorithm. In this paper it is shown how the VDA algorithm can be combined with the well-known interacting multiple model (IMM) method to create an effective multi-scan manoeuvring target tracker. The performance of the IMM-VDA algorithm is shown by simulation. It is compared to another manoeuvring target algorithm based on the VDA approach which uses a hard decision manoeuvre detection scheme. In addition, it is compared to a single-scan tracking algorithm based on the probabilistic data association method. [C1030]

"VS-IMM using road map information for a ground target tracking"

Tracking a ground target, based on GMTI radar measurements, is a challenging problem. This is due particularly to the environment with a high density road traffic, terrain masks... etc, and to the high manoeuverability of ground targets. In this paper, the tracking of a manoeuvring ground target on a road in a cluttered environment is studied using map information to enhance the tracking quality. Based on road segments positions, dynamic models under road constraints are built and an optimized projection technique of the estimated state is proposed in order to keep the target position and heading on the road. Using this projection approach, a multiple model tracking algorithm is derived and its performances are studied. The derived filter is an IMM (interacting multiple model) filter with a variable structure (VS-IMM) where the models set adapts sequentially according to the target position and to the road network configuration. [C1031]

"Target Existence Based MHT"

In a cluttered environment, measurements originate not only from the objects being tracked, but also from spurious sources. The number of existing objects (targets) to be tracked is also unknown. The Multi-Hypotheses Tracking (MHT) filter is generally considered to be the "optimal" n-scan target tracking filter in such a multi-target cluttered environment. This paper introduces a new MHT filter based on the target existence. The probability that a target exists is estimated, and the estimate of the target kinematic state is subsequently conditioned on target existence. False track discrimination uses the probability of target existence as the track quality measure. This approach simplifies the structure of the algorithm and reduces complexity. A simplified version of the algorithm, which decouples new track hypotheses from the measurement-to-existing-track allocations is also presented. A simulation study shows the effectiveness of this approach in an environment of heavy and non-uniform clutter, with multiple maneuvering targets with crossing trajectories. [C1032]

"Joint Integrated PDA Avoiding Track Coalescence"

Joint PDA approach is very effective in tracking multiple targets in data association environment, with clutter measurements and missed detections. Joint IPDA has built upon this by including the probability of target existence as a track quality measure to enable automatic tracking and track maintenance in data association environment. Both JPDA and JIPDA suffer from the problem of track coalescence, where tracks following targets whose trajectories don't separate for extended time start following "center" of these targets. JPDA*is an extension of JPDA which combats coalescence by pruning possible measurement to track allocation hypotheses.

Following JPDA*derivation, this paper derives JIPDA*, an extension of JIPDA which also combats track coalescence. JIPDA*updates the probability of target existence as the track quality measure. A simulation study verifies the effectiveness of this approach and compares JIPDA*with JIPDA and IPDA when tracking crossing targets in an environment of heavy clutter. [C1033]

"Clutter map and target tracking"

Target tracking algorithms have to operate in an environment of uncertain measurement origin, in the presence of possibly non-detected target measurements as well as clutter measurements from unwanted scatterers. Integral part of expressions for data association probabilities is the estimate of clutter density. A priori knowledge of the clutter density may be derived in the form of the closed expression, whilst in the case of environmentally caused clutter; clutter measurement density has to be estimated using measurements from a number of scans, using a clutter map. This paper presents, as well as compares, three different clutter map estimators. The first is the classic clutter map estimator, which averages the number of measurements over a number of scans. This is a biased estimator of the inverse of clutter density. The second clutter map estimator uses spatial characteristics of the multi-dimensional Poisson process, and is termed spatial clutter map estimator. The third clutter map estimator uses temporal characteristics of the Poisson process, thus this estimator is termed temporal clutter map estimator. Both spatial and temporal clutter map produce an unbiased estimate of the inverse of clutter measurement density. [C1034]

"The shifted Rayleigh filter for bearings only tracking"

The recently introduced shifted Rayleigh filter is a moment matching algorithm that exploits the essential structure of the nonlinearities present in bearings-only tracking. The algorithm can befitted to a wide range of scenarios and places no restrictions on model dimensionality. The key feature is that it generates the exact updated conditional distribution of target motion, given a normal approximation to the prior. In this paper, two versions of the algorithm are applied to the problem of tracking a moving object from multiple, independently drifting sonobuoys that supply noisy bearings only measurements, corrupted by clutter. A separate moving sensor provides noisy bearings only measurements of sonobuoy motion. The shifted Rayleigh filter adapts well to this scenario. Simulations indicate that it give good estimates, even in adverse circumstances when the clutter probability is 67% and the standard deviation of sensor noise is 16°. [C1035]

"Multiple model tracker based on Gaussian mixture reduction for maneuvering targets in clutter"

The problem of tracking targets in clutter naturally leads to a Gaussian mixture representation of the probability density function of the target state vector. Research reported previously reveals that a tracker using an integral square error (ISE) based mixture reduction algorithm can provide performance which is significantly better than any other known techniques using similar numbers of mixture components. One useful algorithm architecture for targets exhibiting very different trajectory characteristics over time would replace each Kalman filter within a conventional MMAE or IMM with an ISE-based algorithm that assumes the adequacy of the same particular dynamics model and discretized parameter choice ("mode"). The performance of such algorithms is evaluated, and compared to that of the corresponding MMAE or IMM based on Kalman filters in the same scenario except for being clutter-free. [C1036]

"Non parametric target tracking in non uniform clutter"

Target tracking algorithms have to operate in an environment of uncertain measurement origin, in the presence of randomly detected target measurements as well as clutter measurements from unwanted random scatterers. Most data association target tracking algorithms incorporate a measure of clutter density. Quite often the clutter density is non-uniform, especially in ground target tracking, or when the radar beam "touches" the ground. Non-parametric target tracking assume a priori unknown clutter density, however the assumption is that it is uniform within the selection gate. Complex selection gates, which are created for a number of multi-scan and/or multi target tracking algorithms, can encompass a large volume where the clutter density will vary widely. We propose an alternative clutter density estimation scheme for non-parametric target tracking, which does not assume uniform clutter within the selection gate. Instead, clutter density is estimated on a measurement by measurement basis, prior to a posteriori target track update. The scheme is adaptive and has no bias in estimated inverse of clutter density at the measurements coordinates. A simulation study shows the benefits of adaptive clutter estimation based on single target tracking algorithms in an environment of heavy and non-uniform clutter. [C1037]

"Waveform based detection of anti-personnel mines with an UWB radar"

The present paper deals with feature-based landmine detection by means of UWB ground penetrating radar

(GPR). A waveform of target response is used as a discriminative feature for two feature-based detection schemes. The output of each DPS is a confidence map obtained by means of energy projection of a 3D distributed feature onto a 2D surface. An automated detection is made over the obtained confidence maps and mines detectability is analyzed on the basis of the receiver operation characteristic curves. Performances of the feature- and energy-based data processing schemes (DPS) applied to the experimental data are compared. It is shown that suggested waveform based detection is stable to the change of the environment. [C1038]

"Array deformation performance impacts on a LEO L-band GMTI SBR"

Space based radar (SBR) has been investigated for decades and has once again made an appearance as a viable method for performing the moving target indication (MTI) mission. Large arrays are needed for this application in order to provide adequate energy on target for detection and to minimize the observed ground clutter Doppler spread. Large phased arrays in space are likely to experience mechanical deformation both at the sub-array panel level and across the structure as a whole. The impact of antenna deformations on antenna pattern, peak directive gain, and signal to interference plus noise ratio loss (SINRL), which shows impact on minimum discernable velocity (MDV), is demonstrated. This paper address the deformations when applied to a low earth orbit (LEO) based L-band radar concept of interest to the US Air Force (USAF) and NASA [C1039]

"Orthogonal pulsing schemes for improved target detection in space based radar"

Two phenomena that degrade the performance of ground moving target detection (GMTI) capabilities of space based radars (SBR) are (i) range foldover effects associated with multiple data points originating from different range bins due to the radar pulse stream and (ii) Earth's rotational effect on clutter Doppler frequency. The degradation in performance due to these phenomena is quantified in this paper and methods to minimize their effect are discussed. In this context, transmit pulsing schemes involving waveform diversity is proposed for improved target detection capabilities [C1040]

"New versions of MCDA/ICMDA algorithms applied in a nonlinear context"

Over-the-horizon (OTH) radars provide a survey of wide areas, using ionospheric reflections of the electromagnetic waves. Most of the time they have to face multipath problems: state estimation has to be done with measurements involving different observation models. To tackle this measurement-to-observation-model association problem, the Monte Carlo data association (MCDA) algorithm, and a derivative one, the iterated conditional mode data association (ICMDA) have been developed. They only apply in a linear context. We propose new versions of these algorithms, well adapted to nonlinear problems. Our two algorithms are applied, through numerical simulations, to a concrete case: target tracking with the French OTH radar Nostradamus, in clutter environment [C1041]

"Effect of antenna peak sidelobe levels on L-band space-based GMTI radar performance"

In this paper, we present simulation results that show the effect of the two-way peak sidelobe levels on the signal-to-interference-plus-noise ratio (SINR) loss curve, as a function of clutter-to-noise ratio, for a monostatic space-based ground moving target indicator (GMTI) radar operating at L-band in a low earth orbit. We perform space-time adaptive processing (STAP) using the joint domain localized (JDL) algorithm presented in H. Wang and L. Cai (1994) and examine the effect of two receive antenna weighting functions on the SINR loss curve: a) uniform weights, and b) Taylor array factor weights. When STAP is performed using the JDL algorithm, the number of required spatial degrees-of-freedom determine the number of beams that are formed. The large aperture antennas used in space-based radar (SBR) are often partitioned into subarrays, and JDL auxiliary beams are formed by steering the receive array factor. Steering the receive array factor gives a different peak sidelobe level for each beam. We show that when the transmit antenna is uniformly weighted, the two-way peak sidelobes which affect the SINR loss curve are due to the first few sidelobes of the transmit pattern. A uniformly weighted receives antenna results in a narrower mainlobe and, therefore, a narrower SINR loss notch. However, this comes at the expense of increased sidelobe clutter levels when operating in a strong clutter-to-noise environment. Simulations are used to show that the best receive antenna weighting scheme depends on the clutter environment in which the radar operates [C1042]

"An alternative approach to multichannel radar detection and location"

Space based radar (SBR) surveillance concepts have been investigated for decades and have once again made an appearance as a viable means of performing the ground moving target indication (GMTI) mission. From the signal processing perspective, a number of unique technical challenges must be addressed. These include a larger Doppler clutter spread, which will cause moving targets to be more likely in the endoclutter region, larger target densities, and nonhomogeneity and/or nonstationarity of the collected data. These and other

phenomenology impact the ability of algorithms implemented by the system to perform target detection and parameter estimation. Various adaptations of space-time adaptive processing (STAP) have been put forward as the primary, if not only, solution to detect and locate ground moving targets (GMTI) in complex clutter environments from airborne and/or space based radar platforms. Most, if not all, of the proposed variations can be optimized to work in specific environments but suffer degradation when called upon to perform in a different setting. The reason for this appears to be inherent to the process itself. In order to overcome the difficulties described above, an alternative approach to the current STAP paradigm has been developed and studied for target detection and location in multichannel radar systems. The new technique is based on an adaptation of a previously developed technique, used in passive arrays for angle of arrival (AOA) estimation, in conjunction with a knowledge based array calibration technique. When combined together, these two algorithms provide a powerful new tool for the detection and location of moving targets in complex clutter environments [C1043]

"Imaging of subsurface targets using a 3dDquadtree algorithm"

{no data available} [C1044]

"Reduced-rank signal-dependent classification of training data for space-time adaptive processing"

Nonhomogeneous and nonstationary training data are two of the key technical challenges facing space-time adaptive processing (STAP) for target detection using space-based radar. We describe a technique for training data selection that seeks to classify the available data in a reduced-rank subspace based on the multistage Wiener filter (MWF). The method builds on previous work by allowing each data sample to associate with multiple covariance classes within the separate subspaces defined by the signal and the class, thereby enabling larger sample support for each class. Performance of the new method is assessed using simulated data based on a monostatic space-based radar scenario. Comparison is made with conventional training data selection techniques [C1045]

"Robust cascaded canceller using projection statistics for adaptive radar"

Adaptive radar requires independent and identically distributed (i.i.d.) training data, or snapshots, in order to obtain fast SINR convergence performance in the presence of correlated interference such as jamming and/or clutter returns. Targets, clutter discretes, and impulsive jamming are examples of non i.i.d., real-world data components that corrupt interference training data. Such data are considered to be statistical outliers. Recent outlier detection work for space time adaptive processing (STAP) training data selection has involved use of the generalized inner product (GIP) test statistic. In this paper, we use a prewhitening method followed by a robust projection statistics (PS) algorithm for 2D outlier removal prior to each building block in a reiterative adaptive cascaded canceller. SINR performance is shown to be superior using 2D PS compared to 2D GIP to excise multiple outliers [C1046]

"Detection of slow moving targets in SAR images using STAP processing with two-channel sigma-delta antenna"

To obtain moving target detection in SAR images, strong signals from nonmoving objects (ground clutter) have to be removed. In the classical approach for single channel SAR data, simple FIR filtering or frequency-domain filtering is used. The disadvantage of this approach is significant weakening or masking of moving target echo (by either wide transition band or limited attenuation in stopband), which makes the detection possible only for targets that are strong and well separated in frequency domain. This can be overcome by STAP technique for multi channel SAR data. In this paper, the analysis of channel mismatch influence on slow moving target detection is performed for the case of two channel sigma-delta antenna [C1047]

"A 94 GHz imaging radar system for an experimental multisensor target tracking system"

In this paper, we present a 94 GHz imaging radar system that has been developed for use in an experimental multisensor target tracking system. By updating the tracker with measurement data from both the 94 GHz radar, an IR camera and optionally a video camera, advantages such as robustness against countermeasures and clutter are obtained. Simultaneous real-time tracking of several targets has been demonstrated experimentally. [C1048]

"The modelling and exploitation of spatial correlation in spiky sea clutter"

A physically based sea clutter model is used to calculate the statistics of sea clutter. The mean radar cross section (RCS) is found to match experimental results and the second moment is found to be consistent with the resolution dependence of the clutter shape parameter. The correlation structure predicted by the model is found,

on average, to be consistent with real data, but the latter also shows significant transient coherence. This property may be exploited for sea spike suppression and target detection improvement [C1049]

"Coherent change detection with SAR"

In the context of investigating coherent SAR data for battle damage assessment, we examine the ability to detect changes in objects using synthetic-aperture radar (SAR) observations. The emphasis is on targets which are a few resolution cells in extent. Both coherent and non-coherent methods are studied. Coherent methods are effective when clutter coherence is high. The correlation between intensity images may also be used to detect changes. Practical performance limits are set by sources of phase noise, such as the temporal coherence of clutter, and the spatial resolution of the sensor compared with the target/change dimensions [C1050]

"Software Model of the Signal Processing Unit in the Conventional Radar"

Some results of research project related to software model of the signal processing unit in the conventional radar was presented in this paper. Also, the concept of estimation of Doppler frequency for real targets on the basis of FFT and MUSIC is proposed [C1051]

"A novel distributed CMLWLC CFAR detector"

In the past applications, the centralized CFAR, which used in the multi-sensor information fusion system, brings an overload communication burden, therefore the distributed CFAR detector becomes a developing and important field. In current distributed CFAR detectors, most of them assume that every sensor in the detector have same signal to noise ratio (SNR). In this paper, we study the case that every sensor in the detector have different SNR. Corresponding to this case, a novel distributed adaptive CFAR detector termed as CMLWLC is presented. In the scheme, a local test statistic, which is the ratio of its test sample level and a designated censored mean level (CML) of its reference samples, is calculated by distributed sensors, and then each sensor transmits its local test statistic to the fusion center. At the fusion center, the global decision is made based on weighted linear combining (WLC). Since the weights are adjusted according to different SNR, adaptively, the proposed detector can available in the case that the target echo and noise/clutter have different level for every sensor. Meanwhile, for a Swerling II fluctuating target in Gaussian noise of unknown level, its closed-form expressions of false alarm probability and detection probability are derived. Comparison numerical results show that the CMLWLC detector has good detection performance in both homogeneous and multi-target backgrounds. [C1052]

"Polarization target detection algorithm based on instantaneous Stokes sub-vector"

Firstly, the statistics of random polarized wave's instantaneous Stokes sub-vector is analyzed and its probability density function (PDF) is obtained. Secondly, the target detection problem is skillfully translated into the detection problem of three equivalent polarization signals. Thereby, a novel fusion detection algorithm is presented based on the difference statistical distribution of Stokes sub-vector between targets and clutters. Experimental results show that no matter the target is random polarization or invariable polarization, the algorithm is effective. Its performance can be comparative to that of the optimal polarization detector (OPD) and better than that of the polarization white filtering detector (PWF). Considering variable conditions of polarimetric measurements, it can be used more widely than the optimal polarization detector [C1053]

"Some simulation results of 3D imaging based on chirp stepped-frequency signal"

In this paper, some simulation results of 3D imaging of ground moving target are presented. Chirp stepped-frequency signal is transmitted in the interferometric inverse synthetic aperture radar system. Before the processing of 3D imaging, the strong ground clutter has been removed by using a new chirp stepped-frequency signal format. Then the 3D images of the ground moving targets can be achieved according to the principle of the interferometric 3D imaging. [C1054]

"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. [C1055]

"Differential Geometry Measures of Nonlinearity for Ground Moving Target Indicator (GMTI) Filtering"

The ground moving target indicator (GMTI) radar is widely used to detect, geolocate, track, and classify ground-moving targets in all weather, day-night, and cluttered conditions. The measurements of a GMTI radar are slant range, azimuth, and range-rate or Doppler. These measurements are nonlinear functions of the target state. Until recently, a quantitative measure of the degree of nonlinearity (DoN) for nonlinear filtering problems was lacking. Recently, the DoN of a filtering problem with a nonlinear measurement model has been quantified using the differential geometry based measures of nonlinearity such as the parameter-effects curvature and intrinsic curvature. We calculate three types of parameter-effects curvature and intrinsic curvature for the nonlinear GMTI filtering problem for a variety of scenarios. We vary the distance between the target and the GMTI sensor in these scenarios using simulated data. We demonstrate that the state estimation mean square error (MSE) increases with increase in the DoN [C1056]

"The impact of tropospheric propagation on data fusion from multiple radars"

Data fusion from spatially separated radars is increasingly being considered within network centric warfare to mitigate complex threats. Propagation of signals from spatially separated radars through differing atmospheric environments, however, can introduce significant errors in target positioning and ranging. For example, simulations illustrate that two radars separated by 100 km viewing the same single target through different tropospheres could place the single target in positions separated by over 200 m. Attempts at fusing the data and resolving the information into a single object could result in operational deficiencies due to classification and discrimination errors. Additionally, anomalous propagation conditions such as tropospheric ducting can lead to radar coverage holes and hence the perception of faulty radars and system level fusion errors. These errors must be characterized and, as far as possible, eliminated if the operational effectiveness of cooperative radar engagements and capabilities are to be optimized. This paper illustrates the type and magnitude of these errors, and their likely impact on system level fusion. The architecture of a potential correction system is outlined. [C1057]

"Online multitarget detection and tracking using sequential Monte Carlo methods"

In this paper, we present a new sequential Monte Carlo (SMC) algorithm for online joint multitarget tracking (MTT) and detection in the presence of spurious objects, e.g., clutter. The proposed method provides an efficient solution to deal with two major challenges in MIT problems: 1) time-varying number of targets, and 2) measurement-to-target association. By detecting regions of interest within the surveillance region and monitoring their appearance and disappearance, we are able to estimate the number of targets, even when the environment is hostile with low target detection probability and high clutter density. Adopting an efficient 2-D data assignment algorithm that computes all feasible assignments subject to certain constraints, we are able to efficiently and effectively marginalize the association hypotheses from the likelihood junction. Subsequently, we utilize SMC methods, also known as particle filters, to recursively and jointly estimate the multitarget states. Computer simulations and performance evaluation demonstrate the robustness of the proposed method for multitarget detection and tracking within a hostile environment in terms of high clutter density and low target detection probability. [C1058]

"Limits of linear multitarget tracking"

Multitarget tracking in clutter has two levels of complexity. One is caused by the exponential increase of number of measurement histories in time, and the other is caused by complexity in allocating measurements to tracks in each scan, which is also exponential in the number of tracks and the number of measurements involved. Linear multitarget tracking is a Bayessian method for multi target tracking which dispenses with measurement to track allocation completely. This results in complexity which is linear in the number of tracks and the number of measurements. Linear multitarget tracking is a recent development, with published results in a limited environment of just two targets in heavy clutter. This paper presents a simulation study which investigates the limits of linear multitarget tracking, both in the number of targets and the clutter measurement density. False track discrimination and target retention statistics are presented and compared with other single target and multi target tracking algorithms. [C1059]

"New detection algorithm of extended targets for radar and electro optical sensors"

This paper presents a new technique able to detect extended targets (small ones and big ones) (Ostrovityanov and Basalov, 1985), under very low signal to noise ratios (SNR) and signal to clutter ratios (SCR) with a high probability of detection and a low probability of false alarm. The method is based on the calculation of some

modified statistical descriptors (Gonzalez and Woods, 2002), and the peak plots (Rihaczek and Hershkowitz, 2000) from raw sensor image. The peak plots are extracted by means of the shift-and-convolution technique (Perez Martinez et al., 2001). Experimental results are also presented demonstrating the quality of this technique. Experimental results have been obtained with ARIES radar (Perez et al., 2002), a surface marine and coast surveillance LFM-CW high resolution radar (HRR) (Wehner, 1995) developed by INDRA SISTEMAS S.A. in collaboration with the Technical University of Madrid. The Spanish Ministry of Defence has founded this research. [C1060]

"Tracking a Maneuvering Target in Clutter by a New Smoothing Particle Filter"

Tracking maneuvering target in cluttered environment is a problem of great theoretical and application interest. In this paper a new smoothing particle filter algorithm is proposed which combines the particle filter with a Gibbs sampler to perform the smoothing of the estimation of the target maneuvering and measurement origin. This algorithm is used to estimate states of a maneuvering target from its cluttered measurements, and the simulation results show its powerful ability to solve the problem [C1061]

"The modified Riccati equation in target tracking: some recent results"

Some recent results on the modified Riccati equation are studied in this paper. This modified Riccati equation has already been associated with tracking a target under measurement uncertainty. We consider the special case of tracking a target without clutter, but with a probability of detection of less than one. This special case has received quite some attention recently, especially in relationship with Cramer Rao bounds, or equivalently expected performance. Furthermore, in some other recent works, new theoretical results on the modified Riccati equation have been derived. We will compare these results and point out their importance for performance assessment and prediction in a target tracking context. [C1062]

"Fusion center with neural network for target detection in background clutter"

Analysis of radar signals for target detection in background clutter involves the use of different algorithms. These algorithms provide different levels of detection probability and false alarms as a function of the clutter present. This paper provides a solution to the problem of selecting the appropriate algorithm for target detection in background clutter with high probability of detection and low false alarms. The approach is based in parallel execution of CA-CFAR (cell averaging constant false alarm rate), GO-CFAR (greatest off) and SO-CFAR (smallest off) algorithms and a fusion center based on a neural network with different fusion rules. Results with simulated and real data are presented and discussed. [C1063]

"A hybrid approach for online joint detection and tracking for multiple targets"

In this paper, we present a new approach for online joint detection and tracking for multiple targets. We combine a deterministic clustering algorithm for target detection with a sequential Monte Carlo method for multiple target tracking. The proposed approach continuously monitors the appearance and disappearance of a set of regions of interest for target detection within the surveillance region. No computational effort for target tracking is expended unless these regions of interest are persistently detected. In addition, we also integrate a very efficient 2D data assignment algorithm into the sampling method for the data association problem. The proposed approach is applicable to nonlinear and nonGaussian models for the target dynamics and measurement likelihood. Computer simulations demonstrate that the proposed hybrid approach is robust in performing joint detection and tracking for multiple targets even though the environment is hostile in terms of high clutter density and low target detection probability [C1064]

"A multiple intelligent software agent based technique for improving radar detection of low observable small craft in sea clutter"

The current method of detection of a radar target is based on the setting of a threshold determined by the average of the background returns in the region of interest. Problems arise with this method when attempting to detect small targets in littoral waters since in designing the detector it is necessary to make assumptions concerning the statistical behaviour of the background clutter. Since only long term data is available and short term prediction is required there is an inevitable missed detection/false alarm problem. The problems associated with detecting low observable targets using track-before-detect systems based on Hough transform or dynamic programming techniques are reviewed. An alternative self-adaptive spatio-temporal CFAR system and a multiple hypothesis tracker based on multiple intelligent software agents are described. The process is not perfect but, by assuming that there will be too few data measurements to establish the clutter statistics accurately, a robust sub-optimal solution is formed. The process reported is not restricted to radar returns but has potential applications in infra-red and electro-optical systems, and for processing images in particle physics and astronomy. [C1065]

"Estimating Target State Distributions In a Distributed Sensor Network Using a Monte-Carlo Approach"

Distributed processing algorithms are attractive alternatives to centralized algorithms for target tracking applications in sensor networks. In this paper, we address the issue of determining a initial probability distribution of multiple target states in a distributed manner to initialize distributed trackers. Our approach is based on Monte-Carlo methods, where the state distributions are represented as a discrete set of weighted particles. The target state vector is the target positions and velocities in the 2D plane. Our approach can determine the state vector distribution even if the individual sensors are not capable of observing it. The only condition is that the network as a whole can observe the state vector. A robust weighting strategy is formulated to account for misdetections and clutter. To demonstrate the effectiveness of the algorithm, we use direction-of-arrival nodes and range-Doppler nodes [C1066]

"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. [C1067]

"Optimum polarization for foliage camouflaged target discrimination using a genetic algorithm"

The coherent scattering model can be ran for many realizations of foliage around a hard target to obtain the statistical variations of foliage and target response in a Monte Carlo simulation. Foliage camouflaged target detection at low microwave frequencies is investigated, using a powerful foliage and hard target simulation tool which accounts for near-field interactions between the hard target and foliage. Based on fully polarimetric simulation results of a foliage camouflaged metallic target a polarization synthesis optimization method for improving signal to clutter is examined. A genetic algorithm is implemented for finding an optimal set of radar transmit and receive polarizations that maximizes target backscatter to clutter ratio [C1068]

"Numerical study of wide-band low-grazing HF clutter from ocean-like surfaces"

Backscattering of a vertically polarized, ultra-wide band HF pulse (3-30 MHz) from one-dimensional Pierson-Moskowitz impedance surfaces is studied using method of moments (MoM)-based numerical simulations. With the field source located near the surface, low-gazing regime is realized for the most of the illuminated region. The direct numerical solution is compared to approximate calculations based on the small perturbation method (SPM). Once the Norton surface wave effects are included in the SPM scattering coefficient, average clutter levels as well as waveform shapes generally show good agreement. As the sea state increases, backscatter returns from farther ranges exhibit larger discrepancies. In such a situation, using the "effective surface impedance" (that accounts for surface roughness) brings SPM-based average clutter levels in agreement with their MoM counterparts: however, the differences in waveform shapes persist. Future studies will use the simulation capability described in this paper to investigate the ability of a short-pulse, ultrawideband HF radar to image ocean waves, measure surface currents and surface current shear, and detect targets. [C1069]

"Detection of Targets in Foliage Clutter, Based on Multiresolutional Denoising"

We address here the problem of detection of targets obscured by foliage clutter using X-band portable continuous wave radar. The weak signal, backscattered from the target and the impulsiveness nature of the foliage clutter are the two problems which make the reliable detection not so easy task. The impulsive foliage clutter is more accurately modeled with the symmetric alpha stable distribution, compared to the most used distributions in the radar community. With this more accurate model and giving an account that the Doppler statistic can not be considered as simple stationary system, we investigate here the applicability of new multiresolutional approach recently proposed from Donoho and Yu (2000), namely a kind of pyramid transform based on median interpolation. We also derive computational effective approximation for the computation of the optimal thresholds for the last approach [C1070]

"Segmentation and aspect estimation in SAR image of target chip"

{no data available} [C1071]

"Polarization discrimination for improving foliage-camouflaged target detection"

{no data available} [C1072]

"Automatic detection of targets using fractal dimension"

{no data available} [C1073]

"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. [C1074]

"GPR clutter reduction and buried target detection by improved Kalman filter technique"

The reduction of background signal, or clutter, from ground penetrating radar (GPR) measurements is an area of active research. The weak reflection signal obtained from subsurface targets is usually blurred by such strong clutter, which mainly comes from flat or rough ground surfaces, underground inhomogeneities, and coupling between the transmitting and receiving antennae. In this paper, the improved Kalman filter techniques have been studied and applied to reduce the background interference signals and detect the buried targets in GPR dataset. The effectiveness and validities of the proposed improvement methods in this paper for processing GPR detection data are studied. The processed results prove that the proposed methods are effective and adaptive for reducing clutter and detecting subsurface targets. [C1075]

"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. [C1076]

"Low-angle reflectivity modeling of sea clutter using LS method"

Radar sea clutter (SC) reflectivity is important for predicting the performance of radar engaged against a low-angle target at sea. Existing techniques to resolve the reflectivity estimate are mainly based on radar clutter theory and the LS approximation method. A more practical reflectivity model for SC is presented through data (Nathanson, F.E. et al., "Radar design principles: signal processing and the environment", McGraw-Hill, 1991). Throughout the reflectivity modeling, the idea of inductive reasoning is used. By using it, the functional relations between radar parameters and radar surface clutter backscattering are analyzed. In calculating the unknown parameters in the presented models, simplification of limit conditions are used so properly that the LS method can be employed. From the comparisons analysis, we can obtain that, generally, the presented SC model approximates that of Nathanson et al. better than others. Considering the accuracy and complexity for a more complex prediction of radar performance, the presented SC reflectivity model is preferable. [C1077]

"Sequential Monte Carlo filtering for multi-aspect detection/tracking"

We propose in this paper a mixed-state sequential Monte Carlo (SMC) filter for joint multiframe detection and tracking of multiaspect targets in cluttered image sequences. The proposed detector/tracker is a sampling/importance resampling (SIR) particle filter that uses resampling according to the weights to combat particle degeneracy and also includes an additional Metropolis-Hastings (MH) move step to avoid particle impoverishment. The dynamic models for target motion and target aspect and the statistical model for the spatially correlated background clutter are assumed as prior knowledge in the design of the filter. The

performance of the algorithm is investigated using simulated image sequences generated from real infrared airborne radar (IRAR) data [C1078]

"Experimental results on target detection in cluttered medium using electromagnetic time-reversal techniques"

We describe an experimental technique that can be used to improve the detection performance of a radar system in cluttered environments. The detection algorithm depends on time-reversal techniques. By using time-reversal, the response from cluttered medium is first nulled. When the target enters into the medium, the electromagnetic energy focuses around the target so that a stronger echo is obtained. The initial experimental results show that using time-reversal techniques, we can improve the signal-to-noise ratio of the return-echo due to the target compared to conventional change-detection radar. [C1079]

"On the use of energy density spectra for discriminating between landmines and clutter objects"

The paper studies the use of energy density spectra (EDS) derived from ground penetrating radar (GPR) measurements on a sub-surface target to discriminate between landmines and clutter objects. The GPR used to collect the data is frequency swept and has a bandwidth of 1.4 GHz. Our investigation indicates that the EDS reveals distinct characteristics between landmine targets and many clutter objects, and hence can be exploited for their discrimination. Experimental results based on data measured at a government test site corroborate the effectiveness of the proposed approach. [C1080]

"Weak target detection by multiscale space-time adaptive processing"

STAP is a recent popular research field in which a multichannel and multipulse radar system is utilized to enhance the performance of radar detection under severe clutter and jammer conditions. Real-time STAP requires an intelligent lower dimensional processor realizable from a computational point of view. Several "reduced-dimension (or partially adaptive) STAP" techniques have been introduced to represent the noise sub-space and reduce the dimension of the weight vector. Beside these approaches, we introduce a new technique which is based on modeling the radar clutter as a multiscale stochastic process. Our approach is shown to be capable of outperforming the popular partially adaptive STAP algorithms although the computational complexity is significantly reduced. [C1081]

"Terrain height estimation using GMTI radar"

We simulate the performance of existing and planned tactical GMTI (ground moving target indicator) systems using data cubes derived from high-fidelity interferometric SAR measurements, to assess the utility of these GMTI systems for an auxiliary terrain height estimation function. The two systems are current and next generation GMTI radars with linear and planar arrays, respectively, that could be mounted on a manned aircraft or a large UAV. In order to achieve the vertical element separation required for interferometric terrain height estimation, the antenna array in the first case must be pitched up relative to the horizontal position that is ordinarily used for DPCA or STAP clutter suppression. The purpose of the study is to determine whether useable terrain elevation maps can be generated by interferometric techniques within the operational constraints of these systems. Such elevation map data, obtained using a GMTI radar, would be valuable to knowledge-aided algorithms which rely on precise three-dimensional registration of radar data with terrain or road databases. [C1082]

"Modelling of sea clutter with Gaussian mixtures and estimation of the clutter parameter"

In order to model sea clutter, we propose to use a generalized distribution which is valid for different background statistics, like low and high sea states. The envelope detector's input statistics are assumed to be a Gaussian-mixture (GM). A new background probability density function (pdf) resembles Rician mixtures. In order to detect targets using adaptive techniques, clutter background statistics should be known a priori. In practice, however, background statistics are typically not known a priori. Thus, a joint estimation and detection process is employed whereby the background statistics are estimated before target detection. We estimate the parameters using a maximum likelihood (ML) based method from the output of the envelope detector. Performance analysis is presented using real sea clutter data. [C1083]

"Target Tracking 2004: Algorithms and Applications"

First Page of the Article [C1084]

"Phase noise reduction technique for pulsed TWT"

Summary form only given. Reduction of the phase noise and intrapulse phase modulation of TWTA in radar transmitters becomes imperative because strongly reflected stationary clutter can mask signal of moving target. As Doppler radar is, in general, operated in fully saturated power, causing the phase noise to govern overall noise behavior. The phase non-linearity has it roots on beam velocity variation with time domain voltage jitter of HVPS (High Voltage Power Supply), which disturbs synchronism between beam and RF. The disrupted electrical phase length, in turn, induces spurious ripples and raise noise floor in phase noise spectral density plot. In this paper, we propose two novel methods that can be complementary to further reduce the phase noise. First method is phase locking loop phase noise reduction in that the proportional phase difference between input and output signal is detected and converted into dc control voltage by a double balanced mixer. This dc voltage is used to control an electronic phase shifter set to TWTA input, compensating the respective phase fluctuation. Second strategy focuses on reduction for HVPS voltage jitter. Throughout the high voltage divider, low power signal clippers, integrator and comparator, the only jitter signal is discriminated and utilized as a control signal in an electronic phase shifter. This method is superior to the present complicating noise filtering devices because of its simplicity and independence of RF circuitry. The system implementation of both methods is less expensive and more compact than conventional filtering devices for phase noise reduction. [C1085]

"TWT phase noise reduction techniques"

The traveling wave tube amplifier (TWTA) is widely utilized in RF amplification for radar transmitters. This application requires very low phase noise in order to distinguish a moving target from strongly reflected clutter. This paper provides better understanding of the phase noise behavior of a TWTA and discusses new methods to substantially suppress this noise. [C1086]

"Regularized Doppler radar imaging for target identification in atmospheric clutter"

We develop a method for the formation of Doppler radar images with enhanced features. This problem, when studied as an adaptive spectral estimation problem, is particularly ill-posed because of the small number of data. Our approach is based on a regularized estimation of depth-frequency images which combines a high-resolution Fourier model of the observations with prior information about the nature of the features of interest. We first derive an appropriate model and a regularized criterion for meteorological clutter restoration before addressing the extension to the identification of spot-like targets superimposed on this clutter. We also adapt quasi-Newton algorithms, based on half-quadratic regularization, for the computation of the solution. The practical interest of our approach is validated on simulated and real data. [C1087]

"Tracking of multiple maneuvering targets using multiscan JPDA and IMM smoothing [Cradar sensor example]"

We consider the problem of tracking multiple maneuvering targets in the presence of clutter using switching multiple target motion models. A novel suboptimal fixed-lag smoothing algorithm is developed by applying the basic interacting multiple model (IMM) approach and joint probabilistic data association (JPDA) technique to a state augmented system. But unlike the standard single scan JPDA approach, we exploit a multiscan JPDA (Mscan-JPDA) approach to solve the data association problem. The algorithm is illustrated via a simulation example. [C1088]

"Low rank adaptive signal processing for radar applications"

This paper addresses the problem of radar target detection in heterogeneous clutter environments. We present the performance of the low rank normalized matched filter (LRNMF) test and the low rank normalized adaptive matched filter (LRNAMF) in a background of disturbance consisting of clutter having a covariance matrix with known structure and unknown scaling plus background white Gaussian noise with unknown variance. It is shown that the LRNMF test retains invariance with respect to the unknown scaling as well as the background noise level and is approximately CFAR. Analytical expressions for calculating the false alarm and detection probabilities are presented. Performance analysis of the LRNAMF test using simulated data from the KASSPER program is presented. Issues of sample support for subspace estimation, constant false alarm rate (CFAR) and detection performance are presented. [C1089]

"A novel spread clutter suppression algorithm based on multiple-dimension matched field processing technique [Cover-the-horizon radar]"

High-frequency skywave over-the-horizon radar (OTHR) can provide a wide coverage over the horizon by means of the refraction within the ionosphere. However due to the complex propagation conditions of

electromagnetic waves in the HF band, many disadvantageous effects, such as phase path contamination and multimode propagation, cause the target to be submerged by the neighboring spread clutter. In this paper, the spread effect of identical clutter, backscattered from the adjacent dwell illumination region (DIR), has been discussed. On the basis of the existing matched field processing (MFP) method developed for this problem, the multiple-dimension cross-relation method, using the multiple channel signals, has been proposed and used for the temporal data directly. Experimental simulations are given to demonstrate that the improved method is effective in suppressing the spread clutter. [C1090]

"Feature based registration of range images for mapping of natural outdoor environments"

Challenges related to viewpoint registration in rough forest terrain can be quite different compared to those faced in structured environments. Maneuvring the sensor between measurement positions introduces large error into the a priori estimates of the registration coordinates. As a consequence, locally optimal registration methods may not work properly. Moreover, due to the clutter, the scene contents can change substantially even due to a relative small displacement of the sensor. Often, the sensor has to be moved to the other side of the target object, such as a group of trees, to get a good coverage of its geometry. In both cases, overlap between the two 3D data sets will be minimal ruling out conventional registration methods. In this paper, a feature-based method for registering 3D range scans for mapping natural outdoor environments is proposed. The method utilizes cylindrical, rotation symmetric features extracted from the 3D measurement data for viewpoint registration. The method is tested on real range images. [C1091]

"Through-the-wall wideband synthetic aperture beamformer"

A coarray-based aperture synthesis scheme using subarrays and post-data acquisition beamforming is presented for through-the-wall wideband microwave imaging applications. The wall causes wave refraction and a change in the propagation speed; both effects alter the travel time between the transmitter, the target, and the receiver. Coherent combining of the pulse waveforms emitted by the different transmitters and incident at the receivers through reflections from targets and clutter requires incorporation of wall effects into the beamformer design. Simulation results verifying the proposed synthetic aperture technique for a TWI system are presented. [C1092]

"Reduction of clutter contamination in radar cross section measurements using independent components analysis"

Residual clutter contamination can limit the accuracy of low-level target scattering measurements. The idea of separating the desired target measurement from the clutter, on the assumption that the target and clutter have different statistical properties over the observed data, is considered. Specifically, the independent component analysis (ICA) technique is applied to the measurement problem. The ICA approach does have limitations due to underlying model assumptions and solution ambiguities that must be considered in the measurement context. However, simulations suggest that the technique can potentially improve measurements in certain challenging scenarios. [C1093]

"The target IF signals simulation of three-dimensional radar"

To provide a test platform for EW systems, the TDRSS (three-dimensional radar simulation system) was developed. The paper discusses the target signal simulation in TDRSS; simulation results prove that the algorithm could accurately represent the target IF return of three-dimensional radar. [C1094]

"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. [C1095]

"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. [C1096]

"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. [C1097]

"A switching constant false alarm rate technique for high frequency surface wave radar"

A novel constant false alarm rate (CFAR) technique is proposed as a near optimal solution for detection in mixed homogeneous and nonhomogeneous environments. This CFAR technique explores both the advantages of cell averaging CFAR and order statistics CFAR detectors. We introduce a criterion to derive a near-optimal target detector for high frequency surface wave radar. The effectiveness of the new technique is demonstrated by comparing its performance with traditional CFAR technique using data collected from the HFSWR network on the east coast of Canada. [C1098]

"A novel method for clutter reduction in the FLGPR measurements"

A new method of removing rough-surface clutter in forward looking ground penetrating radar (FLGPR) is proposed based on the physical optics model. The Wigner-Ville distribution (WVD) is proposed to perform a time-frequency analysis. The instantaneous power is worked out to do further processing. By imaging the instantaneous power, we can detect a target more accurately. The treatment comparisons of the experimental data show that the clutter-reduction method presented is better than the conventional method. [C1099]

"Multitarget tracking in clutter: two algorithms for data association"

In this paper two algorithms for data association in the context of multiple target tracking on non-manoeuvering aircrafts using back-propagation neural network (BPNN) and learning vector quantization neural network (LVQNN) are presented. The performances of the algorithms are compared with those of the standard method for data association based to the nearest-neighbour rule by Monte Carlo experiment and by using real radar data records. [C1100]

"The knowledge aided sensor signal processing and expert reasoning (KASSPER) real-time signal processing architecture [Cradar signal processing]"

The KASSPER project is a Defense Advanced Research Projects Agency (DARPA) program which has the goal of improving the performance of ground moving target indicator (GMTI) radar systems by incorporating external sources of knowledge into the signal processing chain. The KASSPER real-time signal processing architecture is a radar system scheduling and signal processing framework that is being developed at Massachusetts Institute of Technology Lincoln Laboratory (MIT LL). This paper discusses the design of the architecture, knowledge handling issues. resource scheduling issues, the current state of the prototype implementation of the framework, and the current state of the project's real-time processor testbed. [C1101]

"Control of false track rate using multiple hypothesis confirmation"

A modem surveillance radar system is likely to return several hundred plot detections per radar scan, especially if the system is searching for targets of low radar cross section such as sea skimming missiles against a background of sea clutter. The track extractor must take this plot data and present a track picture that is sufficiently clean of false and clutter tracks that it can be readily understood. Techniques based upon "tentative tracks" are shown to have limitations in their ability to confirm tracks in clutter, and multiple hypothesis techniques are demonstrated that overcome these problems. [C1102]

"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. [C1103]

"Discrimination of subsurface targets with a plane of symmetry using polarimetric bistatic radar"

First Page of the Article [C1104]

"Bearings-only multiple maneuvering target tracking using sensor-array based on MHEKF, PDA/JPDA"

"Fake points" come into being in the bearings-only multitarget-tracking system. The method of multihypothesis extended Kalman filter (MHEKF) can only partly eliminate them. To solve it more completely, a new method of sensor array is proposed. First, we used a pre-processing technique to avoid the nonlinearization in the observation function. Secondly, based on the fake points' property and geometry, we eliminated them nearly complete using sensor-array. Thirdly, track initialization implemented the idea of the MHEKF and track maintenance using the PDAF or JPDAF algorithm subsectionally. At last, a simulation of two interfering targets tracking in clutter using sensor-array was simulated, the result demonstrates for the effectiveness of this method. [C1105]

"A hybrid approach for target detection using CFAR algorithm and image processing"

In ship detection, a key aspect is to keep a low level constant false alarm rate combined with a high detection probability in presence of clutter background, caused by reflections from wave tops on the sea, rain, snow or fog. Generally, the constant false alarm rate (CFAR) algorithm is applied, which is based on the assumption that clutter background can be modeled using a Gaussian distribution, generating a high level of false alarms in presence of non Gaussian clutter. This problem has been addressed under two independent approaches: modeling the environment noise (sea clutter) with independent non Gaussian models or using variations of CFAR detection algorithm. Both approaches provide good results only for specific characteristics of clutter. We discuss a hybrid approach for target detection that use three probabilistic models of clutter associated to sea state (Gauss, Weibull and K distributions), detection algorithms with adaptive threshold for CFAR, classification algorithms that associate a noise model with a specific CFAR algorithm according to the sea state, and low level morphological operations to generate an image of targets. The goal of this approach is provide an automatic mechanism to associate a clutter model with a specific CFAR algorithm according to sea state in order to obtain radar images without clutter. The proposed detection approach is evaluated by high level simulation. Results are presented and discussed. [C1106]

"Physics-based airborne GMTI radar signal processing"

The Knowledge-Aided Sensor Signal Processing and Expert Reasoning (KASSPER) program aims to improve airborne ground moving target indicator (GMTI) radar performance by taking into account all available prior knowledge. One powerful piece of information is that the radar return signal is a superposition of near-ideal plane-waves. A plane-wave signal and clutter model or sampled GMTI radar data can be used to calibrate the receive array, suppress clutter, and detect moving targets. Each range gate is processed independently. Sample covariance matrices are unnecessary. The synthetic KASSPER challenge datacube is processed to demonstrate performance. [C1107]

"Radar applications of low rank signal processing methods"

This paper addresses the problem of radar target detection in severely heterogeneous clutter environments. Specifically we present the performance of the normalized matched filter (NMF) test in a background of disturbance consisting of clutter having a covariance matrix with known structure and unknown scaling plus background white Gaussian noise. It is shown that when the clutter covariance matrix is low rank, the NMF test retains invariance with respect to the unknown scaling as well as the background noise level and is CFAR. Performance of the test depends only upon the number of elements, number of pulses processed in a coherent processing interval and the rank of the clutter covariance matrix. Analytical expressions for calculating the false alarm and detection probabilities are presented. Performance of the method is shown to degrade with increasing

clutter rank especially for low false alarm rates. An adaptive version of the test is developed and its performance is studied with simulated data from the KASSPER program. Issues of sample support for subspace estimation, constant false alarm rate (CFAR) and detection performance are presented. [C1108]

"Application of beam domain STAP techniques to space-based radars"

This paper deals with beam-based space-time adaptive processing (STAP) algorithms for a low-earth-orbit (LEO) space-based radar (SBR). The performance of a subarray-based joint-domain-localized (JDL) algorithm is first examined for different parameters. Then, a combined beam-domain STAP algorithm approach that combines JDL with difference (Δ) beams is presented. It is shown that the combined JDL-Δ algorithms offer less system complexity and provide performance similar to that of the JDL with higher degrees of freedom. It is also shown that the earth's rotation induces a crab angle, which makes the clutter range-Doppler spectrum range dependent. This paper shows that this crab angle severely degrades STAP performance. [C1109]

"Analysis of terrain scattered interference-mitigation"

Terrain scattered interference mitigation methods for airborne radar have been studied and deconvolution methods for interference suppression have been proposed. This paper describes an analysis of the terrain scattered interference mitigation performance for different conditions and limitations. The direct path signal must be accurately estimated without strong multipath errors. A time-limited impulse response is required to avoid too much suppression of target signals. Small relative Doppler shift errors are required between the direct path and the terrain scattered paths. Several strong jamming signal sources cannot be resolved and suppressed. Receiver blocking gives errors in the impulse response estimate. Clutter signals must be suppressed for accurate impulse responses. Numerical stability must be ensured in the inverse filtering and deconvolution operations. [C1110]

"Efficient tapering methods for STAP"

The sample support problem in space-time adaptive processing (STAP) arises from the requirement to adapt to a changing interference environment where the available wide-sense-stationary sample support is severely limited for direct implementation of adaptive algorithms. In this paper we outline several approaches to address the sample support problem by utilizing efficient covariance matrix tapering (CMT) methods to retain the a-priori known structure of the covariance matrix. By combining efficient tapering approaches along with terrain knowledge based STAP and other preprocessing schemes such as subarray-subpulse, relaxed projection method, it is possible to reduce the data samples required in a nonstationary environment and consequently achieve superior target detection. In addition, the application of Khatri-Rao product to the data domain implementation of CMT is also introduced thus expanding the class of robust algorithms for real-time STAP implementation. [C1111]

"New implementation of the Billingsley clutter model for GMTI data cube generation"

Internal clutter motion (ICM) places significant limits on the effectiveness of STAP clutter suppression techniques, for example in achieving the smallest minimum detectable velocity in GMTI radar surveillance applications. To simulate this effect with maximum fidelity, the required correlation must be impressed on the returns from individual scatterers during the construction of the data cube. Doing so can represent a substantial computational burden on the simulation process when a clutter scene is characterized by many millions of individual pixels. Such numbers are typical when using high fidelity SAR maps as the basis of the clutter model. The paper reports on a fast computational technique for wind-blown clutter simulation that works within a flexible data-generation system employing real high-fidelity IFSAR maps with co-registered elevation data as ground truth. [C1112]

"Sparse, random array processing for space-based radar"

We investigate moving target detection with a space-based cluster of radar satellites, modeled as a random sparse array. Results show that improvement in signal to interference is a sensitive function of the pulse repetition frequency and varies over a large dynamic range. Achievable improvement factor maxima are moderately degraded by array pitch (satellite cluster rotation) and strongly degraded with increasing position errors. In general, with increased randomness, fewer elements contribute to form DPCA pairs so that satellite usage efficiency and SNR are degraded. [C1113]

"ADC spurious signal mitigation in radar by modifying the LO"

Analog-to-digital converters (ADCs) used in MTI or pulse Doppler radars generate spurious signals from large clutter echoes because of the non-linear ADCs. These spurious signals can appear as real moving targets in the

Doppler passband of a radar. The paper shows mathematically how these spurious signals are mitigated and a means of implementing the process is provided. [C1114]

"Adaptive beam-domain processing for space-based radars"

This paper discusses beam-domain space-time adaptive processing (STAP) algorithms for a low-Earth-orbit (LEO) space-based radar (SBR). The performance of the subarray-based joint-domain-localized (JDL) algorithm is first examined for various processor parameters. Then, a combined beam-domain STAP algorithm approach that combines JDL with difference (Δ) beams is presented. It is shown that the combined JDL-Δ algorithms offer less system complexity and yield performance similar to that of JDL that uses higher degrees of freedom. It is also shown that the Earth's rotation induces a crab angle to the platform, which makes the clutter range-Doppler spectrum vary with range. Illustrative examples show that this crab angle severely degrades the signal-to-interference-plus-noise ratio (SINR), thereby reducing the minimum detectable velocity (MDV) of STAP systems. [C1115]

"Multi-resolution signal processing techniques for airborne radar"

Synthetic aperture radar (SAR) exploits very high spatial resolution via temporal integration and own-ship motion to reduce the background clutter power in a given resolution cell to allow detection of non-moving targets. Ground moving target indicator (GMTI) radar, on the other hand, employs much lower resolution processing, but exploits the physical aperture and relative differences in the space-time response between moving targets and clutter for detection. Therefore, SAR and GMTI represent two different temporal processing resolution scales which have typically been optimized and demonstrated independently to work well for detecting either stationary (in the case of SAR) or exo-clutter (in the case of GMTI) targets. Based on this multi-resolution interpretation of airborne radar data processing, there appears to be an opportunity to develop detection techniques that attempt to optimize the signal processing resolution scale (e.g., length of temporal integration) to match the dynamics of a target of interest. The paper investigates signal processing techniques that exploit long CPIs (coherent processing intervals) to improve the detection performance of GMTI radar. [C1116]

"Phase noise reduction techniques of radar's TWTA"

The reduction of phase noise of TWTAs in radar transmitters is imperative because strongly reflected clutter can mask the signal of a moving target. This paper provides better understanding of the phase noise behavior of a TWTA and proposes two new methods to substantially suppress this noise. Multi-PSK digital communication and modern radar transmitters have stringent requirements on their power amplifier amplitude and phase stability response. The TWTA in radar systems is operating at fully saturated power, causing the phase noise to be the dominant noise component. We propose two novel methods that can be complementary to further reduce the overall phase noise. These methods are superior to the present complicated noise filtering devices because of their simple implementation, lightness and inexpensiveness. [C1117]

"The Earth rotation effect on a LEO L-band GMTI SBR and mitigation strategies"

Space based radars (SBR) have been used to accomplish a number of civilian and military missions. Most recently, SBR concepts have been considered to perform ground moving target indication (GMTI) radar modes. Unlike airborne surveillance platforms, SBR clutter returns are affected by the high satellite velocity and Earth rotation. The phenomenology of the Earth's rotation, and its impact on clutter Doppler returns, are discussed for a Low Earth Orbit (LEO) L-band radar concept. The USA Air Force's Research Laboratory Space Time Adaptive Processing Tool (RLSTAP) high fidelity radar modeling tool is used to provide simulated data in order to demonstrate the Earth rotation effects, and resulting clutter rejection impact on slow moving target detection. [C1118]

"Performance assessment of along-track interferometry for detecting ground moving targets"

Along-track interferometry (ATI) is an interferometric synthetic aperture radar technique that can be used to measure Earth-surface velocities. As such, the ATI technique holds promise for the detection of slowly moving ground targets. However, the models often used to characterize ATI performance were developed mainly in the context of mapping ocean currents, and they do not necessarily apply to the case of discrete, moving ground targets amidst clutter. We provide expressions for more accurately modeling the behavior of an ATI system in the context of ground moving target indication. Analysis and design equations are given for topics including target defocus, signal-to-noise and signal-to-clutter ratios, interferometric correlation, interferometric phase bias, target detection, geolocation accuracy, and area coverage rate. [C1119]

"Range sidelobes suppression for wideband randomly discontinuous spectra OTH-HF radar signal"

Over-the-horizon (OTH) HF radars work in a heavily congested HF band. It is quite difficult to find broad clear frequency bands for system requirements. The randomly discontinuous spectra (RDS) signal is employed to combat spectrum congestion since it can evade the external interferences in the frequency domain. However, the spectra discontinuity of the signal gives rise to high range sidelobes when matching the reflected echo, which is much more difficult for target detection. So it is indispensable to investigate the technique for sidelobes suppression of the range profile when an RDS signal is utilized. In this paper, we introduce a new signal processing technique, that is radically different from the conventional technique, to lower range sidelobes based on suppressing the self-clutter of the radar range ambiguity function (AF) by mismatch filtering. Simulation results show that the peak sidelobe level can be reduced to -30 dB while the frequency bands span up to 400 kHz. [C1120]

"Efficient robust AMF using the enhanced FRACTA algorithm: results from KASSPER I & II [Ctarget detection]"

This paper presents further developments and results of the FRACTA algorithm which has been shown to be robust to nonhomogeneous environments containing outliers. The main focus here is upon the detection of targets in the KASSPER I challenge data cube which possesses dense clusters of targets and the highly nonhomogeneous KASSPER II data in which severe clutter is present over all ranges and Dopplers thereby hindering the identification of a dominant clutter ridge. The KASSPER II dataset is further exacerbated by dense clusters of targets as well as the presence of several deep shadow regions that not only prevent target detection but may also skew covariance matrix estimation. A doppler-dependent thresholding technique is developed which is then incorporated into the FRACTA.E framework and then applied to the KASSPER II dataset. Simulation results are compared with the standard sliding window scheme as well as when clairvoyant knowledge of the covariance matrices is employed. Results verify the improved performance of the FRACTA.E algorithm. [C1121]

"Space-time adaptive processing (STAP) with limited sample support"

A particularly active area of research in space-time adaptive processing (STAP) involves scenarios in which the sample support available for training the adaptive processor is limited. Several of these scenarios are of significant current interest. One of those scenarios is an environment in which targets are potentially so dense (relative to the sample support requirements) that they bias the weight training, thereby causing significant performance degradation of the STAP processor. Such environments include those containing roads and highways, for example. Other related problems include scenarios in which the clutter itself is not homogeneous over significant ranges, e.g. conditions where the terrain type is highly variable, urban environments, etc. One technique that addresses the low-sample support conditions described above is the parametric adaptive matched filter (PAMF). Performance of this technique and several contending. STAP approaches are demonstrated using the KASSPER challenge dataset only. [C1122]

"Estimation of radar target reflectivity in ultrawideband regime-a group theoretic approach"

The paper presents a fundamentally new mathematical framework based on group representation theory for the modeling and processing of signals in the ultrawideband (UWB) regime. A group theoretical approach is motivated by the fact that in the UWB regime, the underlying mathematical structure of the inverse scattering is governed by the affine group. In particular, a received echo can be viewed as the affine Fourier transform of the range-Doppler image evaluated at the transmitted waveform. Based on group representation theory and a novel Wiener filtering method over the affine group, we derive a regularized closed form analytical estimate of the range-Doppler target reflectivity density in the presence of nonstationary noise and clutter in the UWB regime. This estimate also leads to a method of data fusion to form synthetic UWB high resolution images from multiple radars with narrowband transmission. [C1123]

"3-dimensional STAP performance analysis using the cross-spectral metric"

Research done in recent years has clearly demonstrated large improvements in clutter suppression and target detection by including elevation adaptivity, otherwise described as 3-dimensional (3D) STAP. The paper further quantifies the performance gains garnered by 3D STAP by fixing the degrees of freedom (DOF) and varying the array dimensions to include the equivalently sized linear array. The focus is placed on performance bounds established by matched filter and 3D cross-spectral metric (CSM) SINR curves generated with known covariances. The mathematical extension of the CSM from 2D to 3D is shown to be straightforward, thus allowing the CSM to serve as a partially adaptive performance bound for eigenvalue-selection based 3D STAP algorithms. [C1124]

"A novel two frequency MTI radar"

A new design for two-frequency MTI radar is introduced. The suggested system can change its frequency in each pulse. Therefore, the system is very resistant to electronic warfare. The analytical results of our calculation show that the system has a very high blind speed and in realistic situations it increases signal-to-noise ratio, although it widens clutter bandwidth and detects some spurious targets. [C1125]

"A CFAR thresholding approach based on test cell statistics"

A new constant false alarm rate (CFAR) detection algorithm, that takes into account the statistics of the sample in the test cell for reference sample selection, is proposed and analysed. The new CFAR algorithm, designated as switching CFAR (S-CFAR), is designed to operate in a homogeneous environment and multiple targets with clutter transition situations. Mathematical analysis in an homogeneous environment shows that the S-CFAR processor has very small CFAR loss compared to the conventional cell-averaging CFAR processor. Monte-Carlo simulations in a non-homogeneous environment demonstrate that the S-CFAR processor has improved robustness against interference targets and clutter power transitions. The S-CFAR processor is also simple to design and implement, since no sample ordering is required. [C1126]

"Adaptive conformal array radar"

This paper considers the novel application of space-time adaptive processing (STAP) to conformal array radar. Using numerical simulation, we characterize the performance potential of two candidate conformal array designs: a tapered, belly-mounted canoe and a conformal array taking the shape of a chined radome. We find the nonlinear nature of the conformal array design induces clutter angle-Doppler nonstationarity. This nonstationarity leads to covariance matrix estimation errors and a consequent degradation in STAP performance potential. We find these additional losses reside in the range of 4-10 dB for the two array designs under consideration. Finally, we briefly investigate several ameliorating solutions based on localized processing and time-varying weights, achieving performance gains on the order of several decibels to fully mitigating nonstationary behavior over regions of the detection space. [C1127]

"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. [C1128]

"An alternating transmit approach for STAP with short antenna arrays"

The approach of alternating the transmission between a leading and a trailing antenna sub-aperture from pulse to pulse (ALTX) is presented for radar systems equipped with digital beamforming. ALTX is shown to improve detection and DOA estimation performance with respect to standard transmission with the whole antenna aperture for systems with a short antenna array and a limited number of receiving channels. [C1129]

"Non-coherent detection of slow-moving targets in high-resolution sea clutter"

The radar detection of targets in the presence of sea clutter has historically relied heavily upon the radial velocity of targets with respect to the radar platform, either by estimating the relative target Dopplers (such as for STAP) or by examining the path which targets traverse from scan to scan. However, for targets with little or no radial velocity component, it can become quite difficult to differentiate targets from the surrounding sea clutter. The paper addresses the detection of slow-moving targets in sea clutter and develops an approach for the non-coherent detection of such targets when high range resolution is available. [C1130]

"A knowledge-aided GMTI detection architecture [Cradar signal processing]"

Space-time adaptive processing (STAP) plays an important role in ground moving target indication (GMTI). Heterogeneous clutter environments prevent STAP from achieving its theoretical performance bounds. The incorporation of a priori knowledge into the signal processing architecture holds the potential to greatly enhance detection performance by mitigating heterogeneous clutter effects. In this paper we propose one possible knowledge-aided STAP approach comprised of the following elements: a knowledge-aided prediction/estimation filter, a discrete matched filter, and a partially adaptive STAP applied to the clutter residual, assisted by knowledge-aided training. We focus our discussion on justifying the aforementioned elements and independently characterizing their performance potential. Using both measured and simulated data, we find the potential for substantial performance improvement. [C1131]

"Improving knowledge-aided STAP performance using past CPI data [Cradar signal processing]"

A technique for incorporating past coherent processing interval (CPI) radar data into knowledge-aided space-time adaptive processing (KASTAP) is described. The technique forms Earth-based clutter reflectivity maps to provide improved knowledge of clutter statistics in nonhomogeneous terrain environments. The maps are utilized to calculate predicted clutter covariance matrices as a function of range. Using a data set provided under the DARPA knowledge-aided sensor signal processing and expert reasoning (KASSPER) program, predicted clutter statistics are compared to measured statistics to verify the accuracy of the approach. Robust STAP weight vectors are calculated using a technique that combines covariance tapering, adaptive estimation of gain and phase corrections, knowledge-aided pre-whitening, and eigenvalue rescaling. Several performance metrics are calculated, including signal-to-interference plus noise (SINR) loss, target detections and false alarms, receiver operating characteristic (ROC) curves, and tracking performance. The results show a significant benefit to using knowledge-aided processing based on multiple CPI clutter reflectivity maps. [C1132]

"Distributed adaptive OSWCA CFAR detector"

In the sense of likelihood ratio test (LRT), a weighted adaptive OSWCA CFAR detector using distributed sensors is proposed in this paper. In the scheme, a local test statistic, which is the ratio of its test sample level and a designated order statistic (OS) of its reference samples, is calculated by each sensor, and then each sensor transmits its local test statistic to the fusion center. At the fusion center, the final decision is made based on weighted cell averaging algorithm (WCA). Since the weights are adjusted according to different signal-to-noise/clutter ratio (SNR), adaptively, the proposed detector can be available in the case of that the target echo and noise/clutter that have different level for each sensor. Unlike many current distributed CFAR detectors, which assuming that all noise/clutter samples satisfy independent identical distributed (IID) and have same SNR for each sensor. Meanwhile, for a Rayleigh fluctuating target in Gaussian noise of unknown level, we obtain its closed-form expressions for the false alarm probability and the detection probability. The numerical analysis results indicate that the proposed OSWCA scheme can be available. [C1133]

"Modeling and simulation of video target echo and clutter for HLA-based radar system"

In this paper, we investigate the modeling and simulation of the target echo and K-distributed clutter echo for radar. In output of the simulator, velocity and distance of a moving target are simulated by delaying the video waveform and linearly shifting the phase of carrier wave, angle of a moving target is simulated by the angle gain of the antenna. Clutter is used as disturbance. [C1134]

"Multi-target tracking in clutter without measurement assignment"

This paper presents a new approach for multitarget tracking in a cluttered environment. Optimal all neighbour multi-target tracking (MTT) in clutter enumerates all possible joint measurement-to-target assignments and calculates the a posteriori probabilities of each of these joint assignments, e.g. J(I)PDA and MHT. The numerical complexity of this process is exponential in the number of tracks and the number of measurements involved. Our approach starts with an all-neighbour single-target tracking (STT) filter which provides the a priori probabilities of measurement origin; e.g. IPDA, IMM-PDA, ITS. These probabilities are used to modify the clutter density at the location of the selected measurements. In effect, the STT filter is transformed into a MTT filter with a numerical complexity which is linear in the number of tracks and the number of measurements. Measurement features, such as amplitude, can also be incorporated. Simulations are used to verify the approach when tracking crossing targets in an environment of heavy and non-uniform clutter. [C1135]

"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. [C1136]

"HF ground wave radar sea clutter cancellation based on chaotic prediction"

In the background of signal detection for HF radar, the sea clutter is quite significant and can mask some weak target signals. This paper reports a chaotic local prediction based sea clutter cancellation method to improve the SNR of the target. Recent observation shows that HF sea clutter may be modeled as a nonlinear deterministic dynamical system. Then it can be assumed that the chaotic prediction error of target echo is greater than the prediction error of sea clutter. A local chaotic predictor is used to construct a sea clutter cancellation technique. Real sea clutter, simulated target data and real target data were used to show that a chaotic prediction based clutter cancellation method is a promising technique to suppress sea clutter and enhance target detection. [C1137]

"Performance analysis of multidimensional clutter map CFAR"

It is difficult for radar to detect targets moving slowly on the ground or flying slowly with low altitude. In order to increase the detection probability of weak targets among strong clutter, it is useful to accumulate the echo signal of the target using Doppler information, and to adopt an effective CFAR procedures. Here a novel multidimensional clutter map CFAR (MDCM-CFAR) algorithm is proposed, compared with the traditional clutter map CFAR (CM-CFAR) and mean level CFAR algorithms. MDCM-CFAR has better detection performance. [C1138]

"Performance analysis of NNF-class target tracking algorithms applied to benchmark problem"

In target tracking system, accurate target state estimation is required to accomplish efficient radar beam pointing control even in a cluttered environment. State estimation accuracy is degraded by false alarms due to clutters and jamming by intelligent targets. The NNF (nearest neighbor filter) is widely used for tracking a target in a cluttered environment for its computational simplicity. One drawback of the NNF stems from the fact that the selected NN is a false measurement. To improve the performance of the NNF, the PNNF is suggested to consider the probability of the event that the selected NN is the target-originated measurement. The PNNF-m is a new data association with the NN by incorporating the number of validated measurements into design of the PNNF. In this paper, tracking filter algorithms combined with nearest neighbor data association have been applied to the benchmark problem of target tracking algorithms for MPAR (monopulse phased array radar) to compare the tracking performance in the realistic situation where the spatial density of false measurements in the validation region is unknown. Also the performance comparison of the NNF-class filters and the PDAF is included. [C1139]

"A CFAR algorithm for radar detection under severe interference"

A new radar constant false alarm rate (CFAR) detection algorithm operating under severe interference is developed in this paper. The new CFAR algorithm, designated as switching CFAR (S-CFAR), is presented and analysed in closed-form based on Swerling I nonhomogeneous clutter and target model. Mathematical analysis demonstrates that the S-CFAR is robust when up to half of the search region is occupied by interfering samples. The S-CFAR algorithm is useful in applications where a radar performs detection in a clear region of its range and/or Doppler profile with an unknown number of interfering target (and possibly jamming) samples. S-CFAR implementation is also simple since no sample ordering is required. [C1140]

"Detection and estimation of target on using polarization signal processing"

It is very important to find an effective method for measuring the target range and estimating the target's power in the environment where the signal/clutter ratio (SCR) is small. In order to solve this problem, some new methods such as 'position by polarized angle' (PPA) and 'probability estimate polarization (PEP) filter are proposed based on the estimation of the polarization state of the clutter in this paper. The principle of these new kinds of polarization processing and their performance evaluation with experimentally derived data are discussed. The results from computer simulation indicate that the SCR can be improved above 20dB and the correct probability of tracking target can be increased from less than 10% to more than 97%. [C1141]

"The effect of spaceborne spotlight SAR antenna beam pointing steered on image quality"

In the condition of beam pointing steered spaceborne spotlight synthetic aperture radar (SAR) antenna model and imaging model are found. The math analysis confirms that beam pointing steered results in echo amplitude being modulated and causes infinite pairs of echoes. So beam pointing steered may deteriorate image quality. Besides, based on the analyses of tradeoff relation of beam pointing steered ratio, spot area azimuth width and image dynamic extension, the fundamental principle of designing beam pointing steered ratio is presented. Finally, point target simulation is given and simulation result tests the validity of theoretical analysis. [C1142]

"Ocean clutter suppression using one-class SVM"

This paper presents a new algorithm based on pattern classification technique to suppress ocean clutter of high frequency ground wave radar (HFGWR). We first decompose radar returns as weighted sum of several chirp-like signals and then extract chirp rates and initial frequencies of these chirps to construct the feature space. The support region of ocean clutter in this feature space is calculated by one-class support vector machine (OCSVM). New data that falls inside this support region are labelled as ocean clutter and are discarded. We validate our method by conducting experiments on real radar data. The result shows that the selected features can discriminate between ocean clutter and target echo effectively and our classifier can suppress ocean clutter successfully by defining a fine support region of ocean clutter in that feature space [C1143]

"The united detection of the stationary or slow-moving-speed targets in the clutter based on the high range resolution (HRR) and Doppler beam sharpening (DBS) technique"

During air-to-ground guided missile scanning of the area of interest and detection of targets, mass ground clutter enters the radar receiver with the target echoes, so that the radar cannot distinguish targets from the clutter. Therefore, the radar's detection capability is seriously influenced by the clutter. Because the ground clutter has a space-time two-dimensional property, traditional detection techniques cannot be used. The paper presents a united detection technique based on high range resolution (HRR) and Doppler beam sharpening (DBS) to fulfill the detection. The united detection technique uses simplified range-Doppler arithmetic to get the signal-to-clutter ratio gain and get the two-dimensional multiple scatterer image, thereby improving the radar's detection capability in clutter. A computer simulation has been done and the results demonstrate that the united detection technique achieves good results, and the technique is valid and easy to perform. [C1144]

"Radar target echo signal and clutter simulator based on HLA"

We investigate the modeling and simulation of the target echo and the K-distributed clutter echo for each radar member. The radar members are then synchronized as a radar net by HLA. From the output of the simulator, we can get each radar member's target information (distance, velocity, angle) in its reference frame. Clutter is used as disturbance. [C1145]

"Fusion of radar and AIS data"

The AIS system that will be brought into effect can improve shipping security for its more accurate information of target position and target identification. On applying AIS making use of the fusion of radar and AIS data should be attached important to. A method of fusion of radar and AIS data is proposed in this paper. The membership degree, on which the adaptive correlation-detecting function is constructed, is calculated by fuzzy C-mean clustering algorithm. It has been shown by simulations that reliable associations of track-to-track could be achieved. [C1146]

"Target detection improvement using blind channel equalization OTHR communication"

In this paper, we introduce a blind channel equalization method for over-the-horizon-radar (OTHR) system based on the sea clutter signal. First, we establish that the radar signal, at different time recurrences, can be represented by a MIMO model taking into consideration the propagation parameters (Doppler, delay and attenuation) of the multipath channel. Then, we show that thanks to the Doppler diversity, one can separate the two components of the sea clutter (referred to as Bragg lines) which allows us to reduce the problem to a SIMO one. A CMA-like blind equalization algorithm is then applied to invert the system and combine coherently the channel multipaths. The channel and Doppler information are finally used to mitigate the sea clutter interference and the multipath effect and hence improve the detection and Doppler estimation of the desired target signal. [C1147]

"Detecting multiple slow-moving targets in SAR images"

Ground moving target indication (GMTI) radars can detect slow-moving targets if their velocities are high enough to produce Doppler frequencies distinguishable from the surrounding stationary clutter. However, no reliable technique is currently available to detect targets that fall below the minimum detectable velocity (MDV) of GMTI radars. Detecting slow moving targets in synthetic aperture radar (SAR) images has also not ceded a reliable solution. Reflected energy from the target is spread over many pixels in the image due to its motion, degenerating the detection process. The addition of clutter from surrounding stationary objects or ground features further complicates detection. Several techniques for SAR imaging of moving targets have been attempted. These techniques require pre-detection, which, in turn, requires sufficient signal-to-stationary ground clutter ratio (SCR). Other attempts such as adaptive, model-based approaches face exponential combinatorial complexity. Exponential computational cost results from having to consider a large number of combinations between multiple target models and the data. The dynamic logic algorithm (DLA) presented below detects multiple slow-moving targets simultaneously in SAR images with low signal-to-clutter ratio, no minimum velocity requirement, and without combinatorial complexity. The mathematics underlying the algorithm is based on biologically inspired signal processing concepts. [C1148]

"The enhanced FRACTA algorithm with knowledge-aided covariance estimation"

The enhanced FRACTA (FRACTA.E) algorithm has been shown to be an effective space-time adaptive processing (STAP) methodology for the airborne radar configuration in which there exists non-homogeneous clutter, jamming, and dense target clusters. In this paper, the FRACTA.E algorithm is supplemented with knowledge-aided covariance estimation (KACE) in order to reduce the required sample support, which may be necessary in severely non-homogeneous environments. The resulting algorithm is applied to the KASSPER I challenge data cube where it is shown via simulation that KACE enables FRACTA.E to achieve essentially the same level of detection performance with considerably less training data. [C1149]

"A new approach to wideband space-time adaptive processing (W-STAP)"

This paper presents a new methodology for airborne wideband space-time adaptive processing (W-STAP) radar systems. In W-STAP, the wideband target signal is first decomposed into a series of narrowband signals. This is referred to as a sub-banding process. The different signals are then combined into a single reference sub-band (usually the center). STAP processing is then performed at this reference band. The combination process is done through a transformation from the different sub-bands into the reference one using the focusing approach H. Wang et al., (1985). In this method, non-singular transformation matrices are used. Compared to the conventional approach proposed in Hoffman et al., (2000), the focusing technique provides greater computational efficiency in wideband STAP systems. [C1150]

"A first bistatic airborne SAR interferometry experiment-preliminary results"

Here are described the first successes in obtaining bistatic cross-platform interferograms from a two aircraft SAR acquisition campaign performed in February 2003 by the DLR and ONERA using their E-SAR and RAMSES facilities. The main challenging issues in the signal processing involved are the estimation and compensation of phase drift between the two radars master oscillators (bistatic receive signal is demodulated with a local oscillator which is not coherent with the transmitter one) and the determination of the relative aircraft trajectories -i.e. interferometric baseline-accurate to the millimetre (X-band wavelength is 3 cm, hence 1 mm error in relative position shifts the phase by about 10°). The high phase quality of the first interferograms obtained is encouraging, but also shows that full endo-clutter moving target indication capability in multistatic environment requires at least two passive SAR receivers in the vicinity of the transmitting active SAR system. [C1151]

"Estimation of geometric radar configuration parameters for range-dependent compensation in STAP in the presence of targets, jammers, and decorrelation effects"

We propose a new method for extracting the geometric radar configuration parameters required to perform range-dependence compensation of clutter statistics in space-time adaptive processing (STAP). The performance of the method is evaluated in the presence of targets, jammers, and decorrelation effects, such as due to internal clutter motion. [C1152]

"Performance analysis of optimum nonparametric rank tests for radar detection under K-distributed clutter"

This paper deals with a comparative analysis of optimum rank tests versus optimum parametric tests for radar detection, under K-distributed clutter, and nonfluctuating and Swerling II target models. The performance analysis is carried out under independent and identically distributed clutter samples. Some results of detection probability

(Pd) versus signal-to-clutter ratio (SCR) are presented in curves for different detector parameter values. Also, a detailed discussion of the simulation results is provided and some conclusions are summarized at the end of the paper. [C1153]

"Joint detection and tracking of multiple maneuvering targets in clutter using random finite sets"

Joint multi-target detection and tracking is a challenging problem due to several factors such as the number of targets being an unknown time-varying random parameter, and the target generated measurements being obscured by clutter. The theory of random finite sets permits an elegant formulation of the joint multi-target detection and tracking problem in a Bayesian framework, in particular, the random finite set formalism leads to the probability hypothesis density (PHD) filtering method, which realizes Bayesian joint detection and tracking in a suboptimal but numerically tractable manner. In this paper the PHD filter is applied to jointly detect and track multiple maneuvering targets. The tracking performance fidelity of the PHD filter is demonstrated by numerical results. [C1154]

"Preliminary research on target detection in first-order peaks with adaptive cancellation"

HFSW radar can detect oceanographic parameters based on electromagnetic waves diffracting along the sea surface. A difficulty arises in detecting slowly-moving targets because of the strong ocean clutter. For wide-beam HF radar, broadened first-order peaks complicate target detection further, so no effective detection algorithm in first-order peaks has yet been put forward. The paper examines the Bragg peaks of wide-beam HF radar. The reason why the first-order Bragg peaks are broadened is analyzed, and then the conclusion that the two first-order peaks from a distant sea cell with unitary current are profile-correlative is drawn. Based on the conclusion, a new method is presented for target detection in first-order peaks. The method performs well both on simulated data and on real data with the HF system OSMAR2000. [C1155]

"Automatic target detection using a dynamic learning neural network"

Automatic detection of targets in a radar image is an important problem with many applications. The radar echoes from a target have to compete with the echoes from the clutter. A clutter signal can be modeled by a nonlinear deterministic dynamical system. A dynamic learning neural network is used to approximate the nonlinear system in terms of the polynomial basis function. As an example, the neural network is applied to a SAR image from the MSTAR public release data set for target detection. The results suggest that the proposed approach provides better detection evaluation measures, including detection rate, false detection rate, and lose detection rate than those of the conventional CFAR detector. [C1156]

"Optimal detectors for nonfluctuating targets under spiky K-distributed clutter in radar applications"

The optimum parametric detector structure for nonfluctuating target models in spiky K-distributed clutter is proposed and analyzed by computer simulations. The performance of this new detector (the clipping detector) is considerably better than the performance of the linear and quadratic detectors. Monte Carlo simulations have been used for the estimation of false alarm and detection probabilities, nevertheless importance sampling technique has been used for the estimation of very low false alarm probabilities (e.g., less than 10-5). Also, a detailed discussion of the simulation results will be provided and some conclusions compiled at the end of the paper. Furthermore, results for Swerling II target model are presented. [C1157]

"System on reconfigurable chip for automatic detection and tracking radar"

Using a mixed system of digital signal processor (DSP) and reprogrammable field programmable gate arrays (FPGA) with efficient hardware design techniques, we propose the implementation of automatic detection and tracking radar in a system on a reconfigurable chip (SoRC) for providing the trajectory and predicting the future position of multiple moving targets. Combining the functionality of a pulsed Doppler radar for target detection and tracking radar for future position prediction and tracking in an SoRC our system implementation revolves around automatic detection of targets for the removal of clutter and interference, track initiation, track association, track smoothing using Kalman gain components and track termination. [C1158]

"M3 filter with adaptive mode probabilities control for low sampling rate tracking"

This paper proposes the Multiple Maneuver Model (M3) filter with recalculation of residual covariance in mode probabilities calculation. The conventional M3filter had a problem that mode probabilities oscillate in the long range radar with long sampling period. The oscillation is caused by extremely low likelihood functions of target models at the measurement in mode probabilities calculation. For controlling the oscillation under clutter and frequent miss detection environment, the M3filter that calculates the residual covariance in mode probabilities

calculation is proposed. The residual covariance is calculated in advance using the overlap coefficient that indicates how error ellipses are overlapped. It is shown that the proposed M3filter has capability of controlling the oscillation without residual information and improving the tracking quality for maneuvering target. [C1159]

"The parameters design method of recursive MTI filter based on pole-zero analyses"

Shaping for pass band is a kind of feature of the recursive MTI filter, and design of second order recursive MTI filter for the recursive MTI filter possesses of typical significance. This paper analyzes the effect of filter parameters on second order recursive MTI filter characteristic by pole-zero analyses method, and discusses the relation between filter parameters and improvement factor, or flatness in pass band, or filter notch, or normalized clutter spectrum width. A method for the design of feedforward and feedback parameters is given. The computer simulations show that the frequency response characteristic is extremely good and the clutter can be effectively suppressed. [C1160]

"The best linear unbiased with greatest of selection (BLUGO) CFAR algorithms"

This work presents a new CFAR detector with greatest of selection based on best linear unbiased method (BLUGO-CFAR). This CFAR detector has the ability of CFAR algorithms with greatest of selection to control the rise of false alarm rate at clutter edge, it also has the advantage of CFAR algorithms based on order statistics in multiple targets situation. The analytic results show that the performance of BLUGO is evidently superior to that of OSGO both in homogeneous background and in multiple targets situations, resulting by an increase in the number of order statistics to estimate the noise power level. Since the reference window is split into two sub-windows, the sample sorting time is reduced as half as that of OS. If Ml=M2=0, Nl=N2=0, BLUGO reduces to GO, if M1=N1=O, BLUGO reduces to MX-CMLD. [C1161]

"Radar clutter suppression using adaptive algorithms"

Radar clutter is the extraneous return waveform from the radar background environment. Because the clutter has a large cross-section, radar clutter can seriously degrade target detection. Conventional radar systems assume the clutter is stationary with its energy concentrated at low frequencies. Thus, a fixed high pass filter (HPF) is used to filter out the clutter. This approach has two major problems: (1) it degrades detection of a slow moving target, and (2) it cannot filter out the high frequency clutter. To overcome the difficulties of conventional radar clutter suppression algorithms, This work proposed two adaptive clutter suppression schemes to enhance the target detection probability. Computer simulations are used to evaluate the performance of the proposed clutter suppression algorithms. [C1162]

"Space-time adaptive processing for space based radar"

Spaced-based radar space-time adaptive processing (STAP) in a heterogeneous clutter environment is addressed. An efficient Kalman Filter implementation of the normalized form of the parametric adaptive matched filter (NPAMF) is introduced and shown to perform well against a detailed, ground moving target indication (GMTI) simulation. The number of secondary data range cells required by NPAMF is much smaller than the product of spatial channels and pulses and, thus, NPAMF is attractive for low sample support applications. Results indicate that the same minimum detectable velocity can be realized with about half the SBR aperture if conventional Doppler processing is replaced with STAP, in particular, NPAMF. [C1163]

"The improvement of the conventional GMTI method with single-channel SAR"

SAR/GMTI (synthetic aperture radar/ground moving target indicator) can detect targets with low velocities and provide images of the area covered by a scanning antenna with high revisit rates. By the conventional GMTI method, the estimated velocity of the moving target is not accurate. The authors improve it by a new idea which uses a series of moving windows. This paper shows the new method's results by processing raw radar data and analyzes its performance finally. A conclusion is drawn that the improved method is more effective and accurate for GMTI. [C1164]

"Multi-channel along track interferometry"

In this paper we introduce an algorithm for velocity estimation of a ground moving point target using a multi-channel along-track interferometry (MC-ATI) system. The presented results are relative to a multi frequency system, but the algorithm can be used also for a multi-baseline one. The performance of the system is evaluated by presenting also the probabilities of detection. [C1165]

"Iceberg and ship discrimination with ENVISAT multipolarization ASAR"

Spaceborne synthetic aperture radar (SAR) can provide wide area and all-weather surveillance for iceberg and ship targets. However, the discrimination between icebergs and ships in SAR imagery, especially in the single polarization imagery that has been available over the past decade, is not always reliable. This is especially true when vessel and iceberg size are on the order of the pixel spacing. Present requirements for ocean surveillance with SAR data include a high detection and classification accuracy due to the necessity of comparable performance with other reconnaissance methods, such as aerial. ENVISAT advanced SAR (ASAR) data offers a potential solution to the iceberg-ship discrimination problem. ASAR data has comparable swath and resolution to other operational SAR systems and in addition offers an alternating polarization (AP) mode. AP targets offer more information than single polarization with respect to radar scattering mechanisms. The AP ship and iceberg targets in this study were observed to have considerably different polarization responses. In particular, ship targets in the HH and HV channels were comparable. In contrast, iceberg targets had at best, weak HV responses compared to the HH channel. Two methods for target discrimination were investigated: a multipolarized area ratio and HV signal-to-clutter ratio (SCR). [C1166]

"Beam-space signal processing and analysis of a LEO L-band GMTI SBR"

Space based radar (SBR) has been investigated for decades and has once again made an appearance as a viable method for performing the moving target indication (MTI) mission. This work address a low earth orbit (LEO) based L-band radar concept. This work emphasize beam-space adaptive signal processing for improved clutter mitigation for an SBR employing multiple phase centers and a digital beamformer. A beam-space processing technique is considered for clutter mitigation; and, a parametric study of the number and spacing of beams are performed for a candidate scenario. Beam-space clutter mitigation techniques are much less computationally stressing than 'full joint domain' space time adaptive processing (STAP). Beam-space processing can take advantage of the simultaneous beams formed by digital beamformers. This work defines a SBR system of interest to both USAF and NASA. Application of the beam-space clutter cancellation approach are discussed and sized for this application. [C1167]

"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. [C1168]

"Moving target indication"

The function of the moving target indication is to suppress the radar returns from static or slow-moving unwanted objects and to pass, for further processing, the echoes from the aerial or sea surface moving objects or targets. The moving target indication adaptability facilitates the radar sensor to adjust its operational capabilities to the current weather conditions in the area swept by radar surveillance envelope. [C1169]

"Analysis of clutter distribution in bistatic high frequency surface wave radar"

In high frequency surface wave radar (HFSWR), surface target detection is mainly limited by ocean clutter and ionospheric clutter. In order to investigate further the nature of both clutters and to develop potential strategies to enhance target detection, an experiment was conducted to operate a radar simultaneously in both monostatic (transmitter and receiver are co-located) and bistatic (transmitter and receiver are far from each other) modes. Experimental results from bistatic HFSWR are compared to those from monostatic HFSWR. It is shown that the ionospheric clutter has different distributions for the two modes. This difference may potentially be exploited to enhance the performance of the radar. A comparison between the predicted Bragg frequency and measured Bragg frequencies has been undertaken and it is shown that the Bragg frequency has a curvature along the range due to the side scattering experienced in bistatic operation. [C1170]

"Extended object tracking using particle techniques"

In This work we consider the problem of extended object tracking. An extended object is modelled as a set of point features in a target reference frame. The dynamics of the extended object is formulated in terms of the translation and rotation of the target reference frame relative to a fixed reference frame. This leads to realistic, yet simple, models for the object motion. We assume that the measurements of the point features are unlabelled,

and contaminated with a high level of clutter, leading to measurement association uncertainty. Marginalising over all the association hypotheses may be computationally prohibitive for realistic numbers of point features and clutter measurements. We present an alternative approach within the context of particle filtering, where we augment the state with the unknown association hypothesis, and sample candidate values from an efficiently designed proposal distribution. This proposal elegantly captures the notion of a soft gating function. We demonstrate the performance of the algorithm on a challenging synthetic tracking problem, where the ground truth is known. [C1171]

"Beamforming and signal processing with sparse, random arrays for space based radar"

We investigate moving target detection with a space-based cluster of radar satellites, modeled as a random sparse array. For a linear array which moves along its axis, the optimum space-time processing leads to a DPCA-like solution. We analyze the performance degradation with array pitch (satellite cluster rotation) and yaw (Earth rotation) and known random element position errors. Results show that the signal/clutter improvement factor is an extremely sensitive function of the pulse repetition frequency and that it varies over a large dynamic range. Achievable improvement factor maxima are moderately degraded by array pitch and strongly degraded with increasing position errors. Yaw effects appear to be negligible. In general, with increased randomness, fewer elements contribute to form DPCA pairs so that satellite usage efficiency (and SNR) is degraded. [C1172]

"Anomaly subspace detection based on a multi-scale Markov random field model"

We introduce a multi-scale Gaussian Markov random field (GMRF) model and a corresponding anomaly subspace detection algorithm. The proposed model is based on a multiscale wavelet representation of the image, independent components analysis (ICA), and modeling each independent component as a GMRF. The anomaly detection is subsequently carried out by applying a matched subspace detector (MSD) to the innovations process of the GMRF, incorporating a priori information about the targets. The robustness of the proposed approach is demonstrated with application to automatic detection of airplanes on synthetic cloudy sky backgrounds. [C1173]

"Signatures of vessels in ENVISAT AP-mode imagery"

A series of ENVISAT AP mode data has been collected over the Nome field off the coast of central Norway. An oil production vessel has been imaged with different ASAR beams and polarisations to study how its signature changes with varying imaging parameters. Cross-polarised data gives better contrast for automated detection compared to co-polarised data, when the incidence angle is small. [C1174]

"Two-parameter power-variable-training STAP"

Airborne ground moving target indicator (GMTI) radars must employ a method of radar clutter mitigation to separate moving objects from stationary ground clutter. Two-parameter, power variable training STAP effectively combines two distinct STAP methods to improve clutter suppression, target detection, and angle estimation. Power variable training STAP utilizes a clutter covariance scaling factor to prevent clutter overing and undering that can degrade radar performance. Two-parameter STAP augments power variable training STAP by implementing an adaptive clutter projection for the highest power clutter, thus limiting breakthrough clutter discretes while preserving MDV. Results are illustrated with radar data collected from the Tuxedo airborne radar. [C1175]

"Multiple-input multiple-output (MIMO) radar: performance issues"

The application of multiple-input multiple-output (MIMO) techniques to multistage radar offers a number of advantages, including improved resolution and sensitivity. Depending upon the radar's mode of operation, the array design and the environment, these advantages may or may not be significant. In this paper, a simple analytic model for ground moving target indicator (GMTI) radar detection is presented and its predictions are compared with simulation. Conventional single-input multiple output (SIMO) and MIMO GMTI radars are compared in terms of minimum detectable velocity, area-search rates and array sidelobes. Optimal waveform cross-correlation matrices are identified for MIMO radars, given different performance criteria. Finally, bounds are developed for MIMO arrays with uniformly sampled virtual apertures. [C1176]

"MIMO radar theory and experimental results"

The continuing progress of Moore's law has enabled the development of radar systems that simultaneously transmit and receive multiple coded waveforms from multiple phase centers and to process them in ways that have been unavailable in the past. The signals available for processing from these multiple-input multiple-output

(MIMO) radar systems appear as spatial samples corresponding to the convolution of the transmit and receive aperture phase centers. The samples provide the ability to excite and measure the channel that consists of the transmit/receive propagation paths, the target and incidental scattering or clutter. These signals may be processed and combined to form an adaptive coherent transmit beam, or to search an extended area with high resolution in a single dwell. Adaptively combining the received data provides the effect of adaptively controlling the transmit beamshape and the spatial extent provides improved track-while-scan accuracy. This paper describes the theory behind the improved surveillance radar performance and illustrates this with measurements from experimental MIMO radars. [C1177]

"Angle glint suppression for millimeter-wave radar based on polarization filtering"

For the millimeter wave radar, angle glint of extended targets is the main angle error. A new kind of dual polarization wide band millimeter wave radar is proposed and a glint suppression technology based on polarization filtering is studied in this paper. Firstly the echo-signal is processed into one dimension range profile based on high range resolution of millimeter wave radar and the effective strong scattering centers are detected, secondly the polarization filtering is used to the signals in the range cell where the scattering centers exist in order to suppress clutter and increase the angle measurement precision of single scattering center, finally the angle of each scattering center is measured by amplitude sum/difference and the target average angle is obtained by weighting all the scattering centers, which can realize the correct track on the target. Theoretical analysis and simulation results indicate that the technology can obviously increase the angle measurement precision of the whole target. [C1178]

"Naval radar in a littoral environment"

First Page of the Article [C1179]

"A concept for hip prosthesis identification using ultra wideband radar"

Ultra wideband (UWB) radar has been extensively investigated both theoretically and practically for the identification buried artifacts. Ground probe radar (GPR) concentrates on the identification of lightly buried land mines, unexploded ordnance (UXO) and archeological targets. The same technology is proposed in a similar context for the rapid identification of in vivo implanted metallic prostheses. The technique is based on resonance based target identification and the paper investigates UWB scattering from a metallic hip prosthesis in free space as a first step in the identification process. [C1180]

"Naval radar in a littoral environment"

First Page of the Article [C1181]

"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. [C1182]

"Application of texture feature classification methods to landmine/clutter discrimination in off-lane GPR data"

Recent advances in ground penetrating radar (GPR) fabrication and algorithm development have yielded significant performance improvements for anti-tank landmine detection in government sponsored blind tests. However, these blind tests are typically conducted over well-maintained homogeneous testing lanes specifically designed to test landmine detection performance in low-clutter population situations. New GPR data collections over targets emplaced in un-maintained off-lane soils have much higher GPR anomaly populations and provide more stringent tests of landmine detection algorithms. In this work, we focus on the application of feature-based class separation techniques to lower false alarm rates in heterogeneous off-road soils. In particular, we explore

the application of texture feature coding methods (TFCM), which have previously shown promise in fields like tumor detection [C1183]

"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 [C1184]

"Multisensor tracking of a maneuvering target in clutter with asynchronous measurements using IMMPDA filtering and parallel detection fusion"

We present a (suboptimal) filtering algorithm for tracking a highly maneuvering target in a cluttered environment using multiple sensors dealing with possibly asynchronous (time delayed) measurements. The filtering algorithm is developed by applying the basic interacting multiple model (IMM) approach, the probabilistic data association (PDA) technique, and asynchronous measurement updating to a state-augmented system for the target motion. A state augmentation approach is developed to estimate the time delay between local and remote sensors. A multisensor probabilistic data association filter is developed for parallel sensor processing for target tracking under clutter. The algorithm is illustrated via a highly maneuvering target tracking simulation example where two sensors, radar and an infrared sensor, are used. Compared with an existing IMMPDA filtering algorithm designed for synchronous (no delay) sensor measurements processing, the proposed algorithm achieves considerable improvement in the accuracy of track estimation. [C1185]

"Multiple-target tracking and identity management in clutter, with application to aircraft tracking"

In this paper, the problem of tracking and managing the identity of multiple targets in a cluttered environment is discussed and applied to passive radar tracking of aircraft. The targets are assumed to be hybrid systems. We propose a filter based on joint probabilistic data association for target-measurement correlation combined with an identity management algorithm and an algorithm that we have developed in earlier work for hybrid state estimation. The multiple-target tracking and identity management algorithm, also incorporates suitable local information, when available, in a manner that decreases the uncertainty, as measured by system entropy. In situations in which local information is not explicitly available, a version of local information incorporation based on multiple hypothesis testing is included to improve identity management. The algorithm allows us to track multiple targets, each capable of multiple modes of operation, in the presence of interference which could be both noise in the continuous processes as well as in the form of spurious measurements. [C1186]

"Improved ship detection using polarimetric SAR data"

The improvements in ship detection performance that can be obtained by using polarimetric synthetic aperture radar (SAR) data as compared to single-channel SAR data are investigated. Statistical decision theory is used to define decision variables that quantify the trade-off between the probability of missed detection and the probability of false alarm; performance is characterized by calculating receiver operating characteristics from single-channel and polarimetric SAR data by using likelihood ratio tests with the Neyman-Pearson criterion. It is shown that improvements in detection performance can be obtained with polarimetric SAR data as compared to single channel SAR data. We evaluate the results of these algorithms applied to single channel, dual channel amplitude only, dual channel with amplitude and phase, and fully polarimetric SAR data of known ships. In this way, the relative improvement in ship detection performance that is realized by introducing polarimetric information is quantified [C1187]

"Target number detection based on a order Choi-Willams distribution"

A new method is proposed to obtain accurate detection of moving targets in the synthetic aperture radar (SAR) imaging. The proposed algorithm is based on the a-order Choi-Willams-distribution -Hough (a -CWDH) transform introduced in this work. The a -CWDH transform avoids the usual trade-off between the auto-term concentration and cross-term interference for linear, chirp-like auto-components due to time-frequency distribution in the fractional Fourier domain. We can still get the clear image of targets even in the case of low SNR (-12dB). The method avoids a long time of coherent processing and sophisticated motion compensation by performing on the echo within one burst of step frequency signal. Simulation results indicate that the method can

precisely detect the target number of a group. [C1188]

"Time-frequency analysis for maneuvering target detection in over-the-horizon radars"

A novel linear time-frequency representation method is proposed for source detection and classification in over-the-horizon radar (OTHR) systems. Of particular interest is the estimation and identification of the multipaths of maneuvering targets described as multicomponent time-Doppler signatures in the presence of strong clutter. By approximating the time-Doppler signatures as chirp signals in each block of time period, chirp signal analysis is used to estimate the chirp parameters (chirp rates and center frequencies) of the clutter and target signal components. Clutter components, which are localized around the low chirp rates and frequencies, are effectively suppressed through subspace projections. The target signals are then dechirped, which is followed by either conventional DFT transform or high-resolution spectrum estimation methods for center frequency estimation. [C1189]

"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. [C1190]

"Multi-target linear converter-mlc"

First Page of the Article [C1191]

"A new method for detectability of signals in K-distributed clutter"

In this paper, we introduce a new method to analyze the detection performance of radar systems, operating in K-distributed clutter and thermal noise. A parametric approximation of cumulative distribution function (CDF), and probability density function (PDF) in terms of weighted sum of exponentials for detection probabilities are obtained, using a finite amount of sample random variables in the environment. The method proposed here is based on approximating CDF of the sample variates by a linear combinations of complex weighted exponentials. This method simplifies the detection problem and is directly applicable to many problems in the simulation of communication systems to determine density functions. [C1192]

"A new adaptive polarization-space-time domain radar target detection algorithm for nonhomogeneous clutter environments"

A new adaptive radar target detection algorithm, called the polarization-space-time localized generalized likelihood ratio (PSTL-GLR) test shall be exploited, which is of significant use in nonhomogeneous clutter environments. The key idea of the PSTL-GLR algorithm is that the degree of freedom (DOF) is controlled to avoid a serious detection loss due to limited secondary data vectors by transforming the data from space-time domain to angle-Doppler domain, while maintaining high performance of the joint polarization-space-time processing. The detection performance of the proposed algorithm is derived analytically in terms of the probabilities of detection and false alarm, along with numerical evaluation to illustrate its efficiency in limited secondary data environments. [C1193]

"Generalized optimization of polarimetric contrast enhancement"

The optimization of polarimetric contrast enhancement (OPCE) is one of important problems in radar polarimetry. The traditional OPCE is to choose optimal polarization states for enhancing a desired target versus an undesired target/clutter. The contrast enhancement enables us to discriminate or distinguish the desired target from background or from the undesired target. We propose a generalized OPCE (GOPCE). For the GOPCE problem, we need to find not only three coefficients such that the ratio of two factors associated with the desired target and clutter is maximal, but also optimal polarization states such that the received power ratio of the target and clutter is maximal. Both the factors consist of three parameters, i.e., the Cloude entropy (Cloude, S.R. and Pottier, E., IEEE Trans. Geosci. Remote Sensing, vol.35, p.68-78, 1997) and two special similarity parameters (Yang, J. et al., Electron. Lett., vol.37, p.193-4, 2001). The optimal coefficients of the GOPCE are obtained by solving an eigenvalue problem. Using an example, we demonstrate that the GOPCE can be employed for detecting roads in a forest area by using polarimetric SAR data. [C1194]

"Stepped frequency continuous wave radar-data preprocessing"

Radar systems have been paid a lot of attention since the end of WWII. Along with performances improvement one has witnessed a diversification of their applications, which range from target detection and parameter measuring to navigation systems, anti-collision systems and subsurface sensing. The last application has had a great importance for humanitarian demining purposes taken into account the number of landmines spread across the world and the danger they pose to humans. Both, continuous wave and pulse radar have been employed for landmine detection. This paper deals with stepped frequency continuous wave (SFCW) radar that operates from 400 MHz to 4845 MHz, in steps of 35 MHz. The novelty of the system, built at International Research Center for Telecommunication-transmission and Radar (IRCTR), consists in the fact that 8 frequencies are transmitted simultaneously, which drastically decreases the data acquisition time. Because of the strong reflection from the air-ground interface one may face some difficulties to "see" the landmines, which are lying on, or just below of the surface. If the antenna system footprint is much more larger than the size of the mine, this is even more difficult as the signal from the mine will be buried in the clutter signal. In order to remove the clutter signal and to improve signal to clutter ratio, average clutter subtraction and synthetic aperture radar have been investigated. [C1195]

"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. [C1196]

"Detection of targets above rough surfaces using millimeter-wave bistatic radars"

In this paper, we report on a new set of indoor measurements aimed at characterizing the bistatic radar return from rough surfaces at Ka-band. The polarimetric response over the entire upper hemisphere, at both low and high incidence and scattering angles, and at near forward and backward directions are reported. This first of a kind data reveals the angular dependence of various polarimetric quantities such as the copolarization ratio, the crossto copolarization ratio, and the correlation between various polarized radar returns. It can be used to validate existing or new surface scattering models and to identify and evaluate bistatic configurations for radar operation. The potential of bistatic radars in detecting the presence of targets embedded in clutter is also demonstrated experimentally using a simple target above a rough surface. [C1197]

"Harmonic radar tag measurement and characterization"

Conventional radar systems transmit and receive at a single, fundamental frequency. It is sometimes challenging to identify a small object against a large background with these radars due to the relatively large return from the background. In effect, the background represents a clutter environment. Harmonic radar tags can be attached to an item, such as insects, and then used to track that item against the background. To do so, the radar must transmit a signal at the fundamental frequency but receive at twice that frequency. Since the clutter return is at the fundamental frequency, the radar is able to discriminate the return from the tag. This paper describes equipment constructed at Michigan State University to conduct research on harmonic tags. [C1198]

"Investigation of side looking EM field scattering from a buried metallic object to support UXO discrimination"

Detection and identification of buried unexploded ordinance (UXO) remains a challenging problem. Despite limitations due to clutter and ground coupling, ground penetrating radar has shown considerable virtues for UXO discrimination. Recent UWB field tests between 10's of MHz and 100's of MHz have demonstrated that certain of the target's dimensions can be estimated from analysis of complex natural resonances in the signal. The problem becomes much more complicated when objects are placed in layered ground and oriented vertical to the antenna, so the incident field cannot excite currents along the major axes and the scattered field from the object cannot easily be separated from the layer interface response. To investigate this, we pursue simulations here designed to test side looking EM field scattering from a buried object placed in layered ground. The numerical calculation is done using the finite difference time domain (FDTD) method in conjunction with the generalized perfectly matched layer GPML. The results are analyzed for a cylinder placed in a uniform and layered earth.

[C1199]

"Automatic target recognition of slow moving ground targets using stap"

First Page of the Article [C1200]

"ISAT-innovative space-based-radar antenna technology"

ISAT is the innovative space-based-radar antenna technology program of the Defense Advanced Research Projects Agency (DARPA). The goal of the ISAT program is to develop antenna technology to enable tactical grade space-based GMTI (ground moving target indicator) radar-particularly from higher (-10,000 km) orbits which facilitate constellations with fewer satellites. [C1201]

"A probabilistic nearest neighbor filter for m validated measurements."

First Page of the Article [C1202]

"Integrated track splitting suite of target tracking filters"

First Page of the Article [C1203]

"Constrained tracking filters for A-SMGCS"

First Page of the Article [C1204]

"A new data association algorithm for multi-target tracking in a cluttered environment"

First Page of the Article [C1205]

"Experiences using DOA methods with a small digital beamforming antenna"

Results and performance obtained when using direction of arrival estimation techniques on measured data from a small S-band digital beamforming antenna is discussed. The antenna is a receiving array with 12 digital channels in a horizontal linear array. To obtain high angular resolution, model based algorithms, which are more or less sensitive to array calibration errors, is used. Data has been obtained both at measurements in an anechoic chamber, where the experimental set up can be controlled, and outdoor by illuminating a test area with radar pulses from a separate wide coverage antenna, where the conditions are less ideal with clutter and many ground targets present. [C1206]

"Adaptive radar signal processing-the problem of exponential computational cost"

We provide a survey of space-time adaptive processing for radar target detection. Specifically, early work on adaptive array processing from the point of view of maximum signal-to-noise-ratio and minimum mean squared error perspectives are briefly reviewed for motivation. The sample matrix inversion method of Reed, Mallet and Brennan is discussed with attention devoted to its convergence properties. Variants of this approach such as the Kelly GLRT, adaptive matched filter and ACE tests are considered. Extensions to handle the case of nonGaussian clutter statistics are presented. Current challenges of limited training data support, computational cost, and severely heterogeneous clutter backgrounds are outlined. Implementation and performance issues pertaining to reduced rank and model-based parametric approaches are presented. [C1207]

"The perspective directions of the technical modernization of inter-period signal processing systems of pulse ATC radars"

The engineering solutions improving detection of air targets against the clutter background in pulse radars of ATC are substantiated and analyzed. [C1208]

"The optimization of a signal processing in radar with scanning antenna array"

It is shown that the scanning radar antenna is an instrument of a selection of echoes from target with intended range and an instrument of a suppression of intensive close clutter. The obtained result is useful to a case of a continuous or quasi-continuous transmitted signal. [C1209]

"Multiple scale correlation of chirp signal by discrete wavelet transform"

Chirp signal, a finite duration pulse with linear frequency modulation (LFM) is the signal waveform widely used for coherent image formation. Coherent imagery is derived essentially as a 2-dimensional correlation of received, delayed chirp waveform with a 2-dimensional matched filter. There is wide and active research interest in analyzing coherent imagery at multiple scales for multiresolution speckle reduction, clutter separation from desired targets and other low level vision requirements such as multiple scale segmentation, etc. This paper attempts to address these requirements during the image formation process; i.e., obtaining multiple resolution imagery by signal correlation at multiple scales. We derive a shift and scale invariant DWT algorithm, which functions as the cornerstone for such multiple scale correlation. We also briefly discuss implications of this image formation algorithm with particular attention to speckle reduction. [C1210]

"Temporal impulsive noise excision in the range-Doppler map of HF radar"

In this paper we present an effective scheme to excise impulsive noise pixels from a range-Doppler image or map. The temporal impulses in high frequency ocean surveillance radar (HFOSR) Doppler spectrum image arise due to local lightning discharges or man-made sources. Previous work focused on locating the noise position (detection) and applying a simple blanking technique, thereby burying targets in the noise spectrum. Built on these prior approaches, our current work develops an additional key step that uses weighted or block prediction method to estimate the possible true values of the destroyed ones. A range-Doppler image with much higher signal to clutter and noise ratio (SCNR) results. Another direct advantage over the former scheme is the improved robustness. Experimental images verify both the effectiveness and advantage of our method. [C1211]

"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. [C1212]

"Phased array technology for GPR antenna design for near subsurface exploration"

The geophysical explorations for near surface investigations for buried objects are carried out by ground penetrating radar (GPR) using sensors operating at radio and microwave frequencies. It is well realized that focused beaming from an antenna into subsurface yields high resolution (with improved illumination of the target area) and results in better delineation of the subsurface targets. ASTRON (the radio astronomy research center of the Netherlands) has been engaged in developing a new generation of all-sky, full sensitive, multibeam radio telescopes for astronomical research at radio frequencies. Using a highly sensitive tapered slot THEA antenna, measurement beams on the sky are electronically formed and steered as desired. Experimental data show great promise in detecting moving objects in the sky. The existing know-how of focused beaming using phased array technology developed at ASTRON could be extended for better illumination of non-moving subsurface objects for GPR investigations. Stacking (adding) of the data gathered using both the beam-forming transmitting and receiving GPR antennas would result in reduced surface clutter effects and in enhanced detection of the near surface targets. In this paper, the concept of phased array technology in a bistatic mode of operation for GPR application is described. [C1213]

"Non-linear STAP filters based on adaptive 2D-FIR filters"

This paper presents a non-linear adaptive approach to the cancellation of clutter echoes in modern AEW radar systems equipped with digital beamforming. Two new STAP schemes are conceived by using different non-linear functions that are applied to the output of a bank of adaptive 2D FIR filters. The STAP schemes are shown to yield better detection performance than previously known schemes when operating in a non-stationary clutter background containing interfering targets. Since they require a limited increase of the computational load, compared to the single 2D-FIR filters, the proposed schemes can be regarded as practical solutions for robust and effective STAP of radar data. [C1214]

"Mitigating the effects of chaff in ballistic missile defense"

In this paper, an algorithmic (schema) approach for detecting and tracking targets in highly cluttered environments is presented. The approach is to accurately track the centroid of the chaff cloud using a combination of medium band (MB) and wide band (WB) range resolution radar waveforms. At moderate pulse

repetition frequencies (PRFs), differential target velocities (about the centroid of the chaff cloud) are detected and tracked via Doppler banks of transversal filters that are tuned to detect the target velocity differences. Through sensitivity analysis using Matlab models, the theoretical lower bound on detectable differential target velocity as a function of the chaff cloud composition (e.g., clutter cross section, clutter spectral width, number of dipoles, and clutter velocity standard deviation) and radar related parameters (e.g., waveform frequency, bandwidth, integration times, PRFs, and signal-to-clutter ratio) is presented. [C1215]

"Proceedings of the 2003 IEEE Radar Conference (Cat. No. 03CH37474)"

First Page of the Article [C1216]

"Operations of an airborne bistatic adjunct to space based radar"

Space to air bistatic concept of operations for area surveillance has renewed potential to extend the capability of space-based radars. However, design considerations of antenna size, number of simultaneous receive beams, and bistatic geometries must be analyzed in terms of area coverage rate and target signal to noise ratio. The clutter spectrum, observed from a space bourne transmitter to airborne receiver depends on both bistatic range and receiver look geometries, and changes rapidly due to the satellite velocity. Bistatic space-time adaptive processing (STAP) is required to cancel the severe clutter, and is characterized by the required degrees of freedom (DOF) to obtain target detection probability and minimum detectable velocity (MDV). Demands on the receiver's digital beamforming and STAP are presented, including the characteristics of digital signal processing. Finally, an estimate is made of the throughput requirements on a real-time processor. [C1217]

"Detection improvements with CFARs having expanded amplitude inputs"

This paper addresses some differences in performance of cell averaging, constant false alarm rate (CA-CFAR) processors as a function of whether the input signal has linear, square-law, or a higher order response relative to the output of a linear receiver. For brevity, these CFAR inputs are herein referred to as A, A2, A4, etc., signals. Specifically, the CFAR input voltage is assumed to be of amplitude AN, where A is the amplitude of a linearly received signal. When using conventional in-phase (I) and quadrature (Q) channels, A = (I2+ Q2)12/. Emphasis is on CA-CFAR performance when the threshold is set for rejecting very spiky clutter which, for this study, is defined as having Weibull statistics with the parameter a = 5. Under these conditions, analyses indicate that for detecting a target in noise, a square-law (N=2)CA-CFAR input signal may provide 9.3 dB better detection sensitivity than does a linear (N=1) CFAR input. Also for targets in noise and a Weibull a = 5 clutter threshold setting, it appears that fourth order (N = 4) CFAR input may yield nearly 20 dB improvement over linear input. [C1218]

"Performance evaluation of two polarimetric STAP architectures"

Space-time adaptive processing (STAP) is a powerful technique for detecting slowly moving targets in strong clutter. However, STAP performance is limited when used on radars with small apertures. Past research suggests polarization's potential to effectively discriminate between targets and clutter, thereby improving detection performance. We evaluate two methods of incorporating polarization into STAP, modeled after the polarimetric matched filter (PMF) and the polarimetric whitening filter (PWF). Our analysis serves to unify various proposed approaches to combining STAP and polarization, and benchmarks the benefits of polarization to GMTI detection. Using measured clutter and target characteristics from published sources as a baseline, we found that the PMF technique offers up to 6-dB improvement over STAP. This significant advantage is realized in the center of the clutter spectrum, and the impact on minimum detectable velocity (MDV) is modest. However, the PWF offers increased performance over the entire Doppler spectrum, and can be easily implemented as a STAP post-processor. [C1219]

"Space-time interpolation for adaptive arrays with limited training data"

This paper describes a method for improving the small sample support space-time adaptive processing (STAP) performance of distorted linear arrays. Receive arrays which deviate from a straight line may occur, for example, in conformal radar and towed sonar array applications. With limited training data, distorted linear arrays suffer greater signal to interference plus noise (SINR) loss due to inflation of the clutter covariance matrix rank. In this paper, Brennan's rule for the clutter covariance matrix rank is extended to 2D arrays and used to motivate the development of a space-time interpolation (STINT) method for clutter rank reduction. By using a space-time transformation that minimizes the constrained mean-square-error between clutter at the distorted array and a virtual uniform line array, STINT processing lowers the clutter covariance rank and hence improves output SINR when training data is limited. Simulation results also indicate that STINT processing reduces the minimum detectable target velocity (MDV) achievable by finite sample support STAP. [C1220]

"Mixed-state particle filters for multiaspect target tracking in image sequences"

We introduce in this paper new mixed-state particle filter algorithms for direct target tracking in image sequences in a scenario where the true target template is unknown and changes randomly from frame to frame. We present two versions of the mixed-state particle filter tracker using respectively the sampling/importance resampling (SIR) technique and the alternative auxiliary particle filter (APF) method. Monte Carlo simulation results with heavily cluttered image sequences generated from real infrared airborne radar (IRAR) data show that the proposed algorithms have good performance and compare favorably to an alternative grid-based HMM filter by yielding similar steady-state root mean-square error (RMSE) at a much lower computational cost. [C1221]

"New methods for handling the range dependence of the clutter spectrum in non-sidelooking monostatic STAP radars"

We address the problem of detecting slow-moving targets using a non-sidelooking monostatic space-time adaptive processing (STAP) radar. The construction of optimum weights at each range implies the estimation of the clutter covariance matrix. This is typically done by straight averaging of neighboring data snapshots. The range-dependence of these snapshots generally results in poor performance. We present two new methods that handle the range-dependence by exploiting the geometry of the direction-Doppler curves. [C1222]

"Biparametric clutter-map CFAR processor independent of original clutter distribution"

The traditional CFAR processors are based on the sliding-window concept, which have substantial performance degradation under nonhomogeneity. Owing to temporal processing and the exploitation of the local homogeneity of the map cell, the clutter-map procedure acquires enhanced robustness with little CFAR losses. In this paper, a Gaussian biparametric clutter-map constant false alarm rate (GBCM-CFAR) processor is proposed which merges the clutter-map technique and noncoherent integration together. It can approximately achieve CFAR independent of the original clutter distribution. The performance in the presence of fast point targets is assessed, in the examples of Weibull and lognormal clutter, in order to elicit the effect of the system parameters. Its performance is close to that of the optimum Neyman-Pearson detector with little CFAR losses in homogeneous environments. It is also suitable to deal with the nonhomogeneous situation. [C1223]

"Detection and imaging of slowly moving target of airborne SAR based on the GMCWD-Hough transform"

In this paper, the features of airborne SAR moving target echoes are analysed, the Generalized-marginal Choi-Williams Distribution-Hough transform (GMCWD-HT) is also introduced. According to the echoes model of airborne SAR, a new method of detecting and imaging the slowly moving target of airborne SAR based on the (GMCWD-HT) is proposed. Computer simulation results show that this method can be used to perform the slowly moving target detection and imaging of airborne SAR in the low signal to clutter ratio; its detecting performance is better than the common method based on Wigner-Ville distribution. [C1224]

"Maneuvering target detection in over-the-horizon radar by using adaptive chirplet transform and subspace clutter rejection"

In over-the-horizon radar (OTHR) target detection, the signal-to-clutter ratio (SCR) is very low, typically from -50 dB to -60 dB. Furthermore, for maneuvering targets, such as aircraft and missiles, Doppler frequencies of their radar return signals may be time-varying. In this case, the Fourier transform based techniques and super resolution spectrum estimation techniques may not work well since they use sinusoidal signal models. We propose a signal subspace clutter rejection algorithm combined with an adaptive chirplet transform technique for maneuvering target detection with OTHR. Simulation results of adding simulated maneuvering targets into raw OTHR clutter data are presented to illustrate the effectiveness of the proposed algorithm. The simulation results show that moving targets with -53.5 dB SCR can be detected. [C1225]

"Configuring a sparse aperture antenna for spaceborne MTI radar"

Sparse arrays provide potential for improving the minimum detectable velocity (over 3 m/s improvement for sidelooking radar) of spaceborne moving target indication radar for a given physical aperture. This paper examines the benefits and some of the challenges resulting from employing sparse arrays: grating lobes introduce ambiguities that may create Doppler blind zones; area coverage rate may reduce due to a narrower antenna main beam for coherent transmission; and intrinsic clutter motion may reduce the usable fraction of the Doppler space. We consider the application of orthogonal transmit waveforms to increase area coverage rate, as well as frequency diversity and aperiodic subarray spacings to mitigate Doppler blind zones. [C1226]

"Sensor staggering in multi-sensor target tracking systems"

For a multi-sensor target tracking system in a cluttered environment, the effects of temporally staggered sensors on system performance are investigated and compared with those of synchronous sensors. A probabilistic data association filter (PDAF) is used to track the target. Measurements from local sensors are fused in a centralized manner for the system with synchronous sensors. The system performances are compared both in terms of track life and in-track percentage. For a wide variety of scenarios, simulation results show the superiority of temporally staggered sensors over synchronous sensors. [C1227]

"Maximum likelihood angle extractor in the presence of sea-surface multipath"

In the presence of sea-surface multipath, the standard monopulse ratio technique to extract elevation angle of target produces large bias. In this paper we propose a maximum likelihood (ML) angle extraction technique for low elevation targets above the sea surface, of known average signal strength having a Rayleigh fluctuation. The procedure is then modified for targets having unknown average signal strength. The resulting modified angle extractor has only a small performance degradation compared with the known average signal strength case, but it performs much better than the monopulse ratio based estimator. This angle extractor reduces the root mean square error (RMSE) by more than 50% in the signal processing stage when used for low flying target tracking scenarios. Further improvement is achieved by using the predicted average target signal power in dynamic scenarios where a significant reduction in the tracker RMSE performance can be achieved, as shown in the simulations presented. [C1228]

"Target detection in sea clutter using convolutional neural networks"

A detector based on convolutional neural networks is proposed for radar detection of floating targets in highly complex and nonstationary cluttered environments. This detector is coherent and monocell, i.e. it works with the complex envelope of the echoes from the same range cell. It includes a pre-processing time-frequency block implemented by the Wigner-Ville distribution, which provides a constant false alarm rate (CFAR) behavior regarding the clutter power when normalization is utilized. Simple theoretical models for the clutter and targets were allowed to study the impact of the correlation and Doppler of both target and clutter on its performance. This detector has also been tested with real-life sea clutter with an improved performance compared to classic detectors. [C1229]

"Proceedings of the 2nd International Workshop on Advanced Ground Penetrating Radar (IEEE Cat. No.03EX680)"

First Page of the Article [C1230]

"New solutions to the problem of range dependence in bistatic STAP radars"

We address the problem of detecting slow-moving targets using a space-time adaptive processing (STAP) radar. The construction of optimum weights at each range implies the estimation of the clutter covariance matrix. This is typically done by straight averaging of neighboring data snapshots. However, in bistatic configurations, these snapshots are range-dependent. As a result, straight averaging results in poor performance. After reviewing existing methods exploiting the precise shape of the bistatic direction-Doppler curves. [C1231]

"Feasibility analysis of GSM signal for passive radar"

Passive radar makes use of an 'illuminator of opportunity' already present in the environment for other purposes (TV transmission, broadcast systems, etc) to detect targets as well as estimating target parameters. This radar has the merit of being a completely covert radar system, which does not advertise the presence of either the receivers or transmitting stations. One such existing radio transmission that may be utilize for this purpose is that of the GSM system. This paper is intended to access the feasibility and suitability of using the GSM downlink signals from the GSM base station as the 'transmissions of opportunity' in an experimental passive radar system. The analysis of the GSM signal as a radar waveform for the passive radar systems design and its associate signal processing scheme is investigated. Simulations and preliminary experimental results demonstrate that the detection of ground moving targets can be indeed be achieved, affirming that this system is indeed viable and for certain does offer a novel and unique kind of passive detection that is outside the scope of other current approaches. [C1232]

"A novel method for improving the real-time of multitarget-multisensor tracking system"

Since multitarget-multisensor tracking system can effectively fuse all kinds of information came from all kinds of sensors, this tracking system can more correctly track targets and widely interpret their state than any single tracking system does. But the real-time the multitarget-multisensor tracking system is not very good. In this paper, a novel method is presented, which is to improve the real-time of the multitarget-multisensor tracking system by optimizing the performance of the tracking gate method. Finally, the simulation shows that this method can effectively improve the real-time of multitarget-multisensor tracking system, especially in a heavy clutter and/or false alarm environment. [C1233]

"High fidelity modeling of space-based radar"

Space based radar design are becoming more affordable given new technologies of solid state active apertures and advanced digital signal processing. However, it is important to be able to synthesize the design of the system with sufficient detail to anticipate the radar system's operation and interference effects expected in a space environment. This includes simulation of site specific clutter with realistic Earth rotation and statistical variation, wideband propagation of the signal from multiple phase center aperture, and impact of channel match and errors on adaptive processing for detecting targets. The research laboratory space time adaptive processing (RLSTAP) has been developed as a variable fidelity radar simulation tool to captures these effects. The paper will describe results of modeling an L-band multimode space based radar, including effective of ambiguities from antenna subarrays, and range and Doppler waveforms on adaptive processing. [C1234]

"A moving target detection filter for an ultra-wideband radar"

A time modulated ultra-wideband (TM-UWB) through-wall impulse radar currently has been developed at Time Domain Corporation, Huntsville, AL, which detects the motion of people in range and azimuth through non-metallic walls. The radar operates in real-time with 3Hz update rate. In order to detect the motion of people moving with different velocities, a digital moving target detection (MTD) filter has been developed which is implemented in the software of the radar. The MTD filter is an IIR high-pass filter and it helps reject the stationary (time history invariant) clutter. Results on the time vs. slow-frequency (Fourier transform of slow-time response) distribution for targets moving at different velocities are presented for a given update rate. The transfer function of the MTD filter as a function of a target velocity is also presented for a given update rate. [C1235]

"Blind adaptive detection of distributed targets in compound-Gaussian clutter"

This paper considers the problem of detecting distributed targets in the presence of compound-Gaussian noise with unknown statistics. At the design stage, in order to cope with the a priori uncertainty, we model clutter returns as Gaussian vectors with the same structure of the covariance matrix, but possibly different power levels. Hence, resorting to the method of sieves, we devise a fully blind detector, which ensures the constant false alarm rate (CFAR) property with respect to the disturbance power levels. Moreover the performance analysis confirms the capability of the novel receiver to operate in scenarios of practical interest for radar systems. Finally the comparison with the plain modified generalized likelihood ratio test (MGLRT), devised assuming Gaussian disturbance, and shows that even in the presence of Gaussian clutter, the newly proposed detector achieves satisfactory performance. [C1236]

"Robust adaptive signal processing methods for heterogeneous radar clutter scenarios"

This paper addresses the problem of radar target detection in severely heterogeneous clutter environments. Specifically we present the performance of the normalized matched filter (NMF) test in a background of disturbance consisting of clutter having a covariance matrix with known structure and unknown scaling plus background white Gaussian noise. It is shown that when the clutter covariance matrix is low rank, the NMF test retains invariance with respect to the unknown scaling as well as the background noise level and is approximately CFAR. Performance of the test depends only upon the number of elements, number of pulses processed in a coherent processing interval and the rank of the clutter covariance matrix. Analytical expressions for calculating the false alarm and detection probabilities are presented. Performance of the method is shown to degrade with increasing clutter rank especially for low false alarm rates. An adaptive version of the test is developed and its performance is studied with simulated data. A technique known as self censoring reiterative fast maximum likelihood/adaptive power residue (SCRFML/APR) is presented to overcome the problem of outliers in training data for heterogeneous clutter scenarios. [C1237]

"Robust STAP using reiterative censoring"

Effective methods are developed for selecting sample snapshots for the training data used to compute the adaptive weights for an adaptive match filter; specifically a space/time adaptive processing (STAP) airborne radar configuration is considered. Several new robust adaptive algorithms are presented and evaluated against

interference scenarios consisting of jamming, nonhomogeneous airborne clutter (generated by the RLSTAP model), internal system noise, and outliers (which could take the form of targets themselves). These algorithms use either the generalized inner product (GIP) or the adaptive power residue (APR) metrics in reiterative fashion for culling the training data. [C1238]

"Improving on the monostatic radar cross section of targets by employing sea clutter to emulate a bistatic radar"

Aircraft that employs radar cross-section reduction techniques typically have a significantly larger bistatic radar cross-section. This paper discusses the possibility of utilising an airborne monostatic radar configuration over an oceanic region to emulate a bistatic radar. This is achieved by employing the reflective nature of the ever-present sea clutter to effectively create a "pseudo-transmitter" on the sea's surface. In addition to improving the radar cross-section of targets, this emulated bistatic radar system reduces the target's capability to locate the airborne receiver. The reflection and scattering characteristics of the sea's surface are also discussed and rudimentary models reflecting these characteristics with regard to the forward scatter region are developed. [C1239]

"Parallel detection fusion for multisensor tracking of a maneuvering target in clutter using IMMPDA filtering"

We present a (suboptimal) filtering algorithm for tracking a highly maneuvering target in a cluttered environment using multiple sensors. The filtering algorithm is developed by applying the basic interacting multiple model (IMM) approach and the probabilistic data association (PDA) technique to a two sensor (radar and infrared, for instance) problem for state estimation for the target. A detection fusion approach is followed where the raw sensor measurements are passed to a fusion node and fed directly to the target tracker. A multisensor probabilistic data association filter is developed for parallel sensor processing for target tracking under clutter. A past approach using parallel sensor processing has ignored certain data association probabilities leading to an erroneous derivation. Another existing approach applies only to non-maneuvering targets. The algorithm is illustrated via a highly maneuvering target tracking simulation example where two sensors, a radar and an infrared sensor, are used. Compared with an existing IMM-PDA filtering algorithm with sequential sensor processing, the proposed algorithm achieves significant improvement in the accuracy of track estimation. [C1240]

"Ubiquitous MIMO multifunction digital array radar"

Radar equipment specifications are often driven by the need to detect small targets in clutter. Relevant specifications include dynamic range, phase noise, system stability, isolation and spurs. Furthermore, the desire for low probability of intercept radar operation also influences the radar hardware design. This paper describes how digital array radars can be used to manage radar time and energy, thereby simplifying radar equipment design. Digital arrays enable both highly focused transmit beams (e.g., for track) and broad transmit illumination (e.g., for search). Regarding the latter, multi-input multi-output (MIMO) techniques, which allow wide angular coverage, are described. [C1241]

"Impact of ground clutter on buried object detection by ground pentertaing radar [Cpentertaing read penetrating]"

We performed careful analysis of the measure data to determine the clutter level and responses of different targets in different types of soils under different environmental conditions. We found that even in a dry sand ground clutter level is higher than responses of many types of antipersonnel mines. As a result, the signal-to-clutter ratio for GPR targets becomes nonsufficient for reliable detection by widely used detection procedures. A new detection algorithm, which should partly overcome this problem, has been developed. The performance of the algorithm on real GPR data is encouraging. [C1242]

"Ultra wideband endfire synthetic aperture radar for landmine detection"

The detection of landmines is an important and challenging application for remote sensing technologies. The use of ground penetrating radar is an established technique but requires close coupling between the antennae and the ground and generally suffers from a poor area coverage rate. In order to clear mines rapidly along a route using a vehicle mounted system, a forward looking sensor is required that can operate effectively in a stand off configuration and detect surface laid, flush and buried mines. Reliable detection is required against a background of vegetation and other, surface and buried mines. Reliable detection is required against a background of vegetation and other, surface and buried, clutter. The Remote Minefield Detection System (REMIDS) is a

technology demonstration programme funded by the UK Ministry of Defence designed to use an Ultra Wideband Synthetic Aperture Radar (UWBSAR) and a polarimetric infrared camera. The UWBSAR is a 3GHz bandwidth impulse radar with onboard data collection and offline image processing. The UWBSAR has been successfully trialled against landmines. Previous trials have mounted the radar on an airship and employed a conventional side-looking imaging geometry. In contrast, for the trials reported in this paper, the radar was amounted on a trolley to simulate a ground vehicle and operated in a forward-looking mode. The resulting use of an endfire synthetic aperture radar rather than the more conventional broadside aperture is the principal development reported in this paper. This coarsens the resolution and introduces a left-right ambiguity into the data. Previous trials have also highlighted the lack of a comprehensive data set containing controlled targets and a range of clutter conditions. The current trials were therefore conducted on a purpose built 80m test track which contained five different soil types, a range of surface conditions and over 200 targets of varying types and burial depth. The trials campaign collected over 500 data sets by varying the conditions of data collection in terms of polarisation, antenna height, antenna separation, incidence angle, power levels and pulse repetition frequency. The experimental configuration allowed the track of the platform to be repeated to sufficient accuracy to allo- w the synthesis of multiple baselines in the vertical and horizontal. The principal conclusions from the trials analysis are 1) that the data set collected is of good quality and comprehensive in terms of targets and background; 2) the endfire synthetic aperture configuration worked as anticipated; and 3) the left-right ambiguity can be resolved if a suitable antenna configuration is used. [C1243]

"Polarimetric optimisation applied to permanent scatterers identification"

In this work, the potential of full-polarimetric SAR data to enhance the performance of permanent scatterers candidates (PSC) detection is investigated. In particular, the problem of finding the polarisation states that maximise the signal amplitude inverse coefficient of variation (ICV) is analyzed. Under the hypotheses of Rice statistics and high signal to clutter ratio (SCR), the problem can be cast into a form equivalent to the optimisation of the ratio between PS (target) and clutter backscatter. Then, solution can be derived for the optimal transmit and receive polarisation states. In the paper, selected typologies of PS and clutter are investigated. The approach is validated through Monte Carlo simulation of the multitemporal polarimetric response of PS-like SAR pixels. Results indicate that optimal ICV values of polarimetrically complex PSC pixels are higher than in the ERS case of the single VV channel, thus leading to increased stability of the subsequent parameter retrieval. Moreover, simulation of ICV vs. SCR suggest that a higher number of PSC may be detected by using optimal polarisation states than in the conventional VV channel alone. [C1244]

"A performance evaluation of autoregressive clutter mitigation methods for over-the-horizon radar"

Wide-area surveillance over-the-horizon radar (OTHR) requires minimizing the dwell time in each search region without compromising Doppler resolution of targets from clutter. Low-order autoregressive (AR) modeling of the clutter spectrum has been proposed to unmask targets from clutter using shorter coherent integration times (CITs). We compare the performance of three methods using AR parameters to maximize signal-to-clutter-to-noise ratio (SCNR) with shorter CITs. In particular, we consider AR-based data extrapolation (DATEX), minimum variance clutter pre-whitening (MV-CPW), and a method called HOPPLER, which consists of pre-whitening, conventional Doppler processing, and re-insertion of the clutter spectrum. We compare the methods using real data from a mid-latitude OTHR with a target beacon embedded in sea-clutter. [C1245]

"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. [C1246]

"Detection of small targets in ocean wave clutter using panchromatic time series imagery"

Visual detection of small objects on or near the ocean surface from an aircraft is important for search and rescue, and detection of stealthy boats and other militarily important targets. This is made difficult by a combination of the rapidly moving sensor platform and the typically high level of modulations in scattered light at the surface. To achieve reasonable search rates, the observer must scan through modest grazing angles (i.e., look towards the horizon) where the ocean clutter that limits detection performance is varying light from wave facets and white caps. This paper describes a technique for significantly improving the signal-to-clutter ratio. A time series of images is mapped to a common reference frame at the level of the mean ocean surface,

separating time and space variations, and the temporal dwell is utilized. For moored targets, the signal may be simply integrated up in time, while for drifting and powered targets, it must be integrated along the appropriate target velocity vector. Specific examples are provided for navigation buoys, small surface floats and slowly moving boats, most of which are difficult if not impossible to find in any single image frame. Achieved gain using panchromatic images is shown to approach 20 dB in cases where the velocity vector is known or can be calculated from the data. [C1247]

"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. [C1248]

"Radar applications of low rank signal processing methods"

This paper addresses the problem of radar target detection in severely heterogeneous clutter environments. Specifically we present the performance of the normalized matched filter (NMF) test in a background of disturbance consisting of clutter having a covariance matrix with known structure and unknown scaling plus background white Gaussian noise. It is shown that when the clutter covariance matrix is low rank, the NMF test retains invariance with respect to the unknown scaling as well as the background noise level and is approximately CFAR. Performance of the test depends only upon the number of elements, number of pulses processed in a coherent processing interval and the rank of the clutter covariance matrix. Analytical expressions for calculating the false alarm and detection probabilities are presented. Performance of the method is shown to degrade with increasing clutter rank especially for low false alarm rates. An adaptive version of the test is developed and its performance is studied with simulated data from the KASSPER program. Issues of sample support for subspace estimation, constant false alarm rate (CFAR) and detection performance are presented. [C1249]

"Multiresolution GMTI radar"

The detection and tracking of ground moving vehicles from airborne radar can be challenging at slow target velocities due to the close space-time (angle-Doppler) proximity of strong competing mainbeam clutter. Moreover, in complex non-stationary clutter environments, conventional space-time adaptive processing (STAP) cannot be relied upon to provide precision ing. In this paper, we re-examine GMTI radar from a multiresolution perspective resulting in a hybrid radar mode combining elements of synthetic aperture radar (SAR) with STAP GMTI. In particular, acute sources of clutter interference are resolved via quasi-SAR processing, and then combined with STAP GMTI to significantly reduce minimum detectable velocities, reduce the required DOFs, increase available training set size, and lower SINR loss and false alarms. [C1250]

"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. [C1251]

"Landmine detection by a broadband GPR system"

Most of the landmine detection techniques by GPR use a monostatic type radar system, which is suitable for detecting landmines buried in shallow soil, which is normally less than 10 cm. The shallow target is difficult to detect by conventional GPR due to its low range resolution. We developed a broadband Vivaldi type antenna, which operates at 1GHz-10GHz. Using this antenna, we made a prototype of a GPR system, which operates at 2GHz-5GHz. By scanning the antenna on a 2D plane, we could obtain clear 3-D images of mine-like targets buried in dry sand. We proposed an array signal processing technique using CMP method, and found it is effective for rejection of the ground surface clutter, even if the ground surface has roughness. [C1252]

"An adaptive clutter rejection scheme for atmospheric radars"

Clutter rejection is among the most important issues in radar signal processing, for which adaptive antenna technique is a powerful means. Compared to other applications of the adaptive antenna, however, atmospheric radars require strict conditions; The main antenna beam pattern should not be altered since the target region is defined by its shape. Especially, the loss of the antenna gain should be kept to no more than about 0.5 dB in order to maintain the high sensitivity of the system. Also, clutter from surrounding mountains is often stronger than the desired weak scattering from atmospheric turbulence. We propose a new algorithm which satisfies the above conditions, and confirm its capability by applying to actual radar data. Despite the fact that no information is given on the spectral features of the desired and undesired signals, only the clutter echoes from surrounding mountains were effectively cancelled without affecting the desired echoes from atmospheric turbulence. [C1253]

"Analysis of GPR scattering by multiple subsurface metallic objects to improve UXO discrimination"

Detection and identification of buried unexploded ordinance (UXO) is an emerging problem worldwide. Recent ultra wideband (UWB) field tests between 10s of MHz and 100s of MHz have demonstrated that certain of the target's dimensions can be estimated from analysis of complex natural resonances in the scattered signal. However, the problem becomes much more complicated at highly contaminated UXO sites where clutter items, from which subsurface UXO must be distinguished, appear simultaneously within the field of view of the sensor. This often occurs in realistic field conditions, where GPR discrimination capabilities are typically limited by ground clutter, coupling between antenna and ground, and limited view of the target due to innocuous items. Under extreme shielding by clutter, the incident field cannot excite strong currents on the target and in turn the scattered field from the object cannot easily be separated from the responses of the clutter. To investigate this, we pursue simulations here designed to test subsurface side-looking EM field scattering from multiple buried objects placed in a uniform ground. The numerical calculation is performed using the finite difference time domain (FDTD) method in conjunction with generalized perfectly matched layer GPML. The results are analyzed for a cylinder and plate placed in a uniform ground. [C1254]

"Combining GPR and EMI data for discrimination of multiple subsurface metallic objects"

Cleanup of subsurface metallic objects such as unexploded ordnance (UXO) constitutes an urgent problem worldwide. The heart of the problem is discrimination, as opposed to detection. Ultra-wideband electromagnetic induction sensors (UWB EMI), operating from a few Hz up to 100s of kHz, have shown considerable promise in subsurface discrimination of metallic objects. Unfortunately, a great many objects, including widespread clutter items, produce very broad, smooth EMI signal patterns, over a number of decades of frequency. Shape identification is complicated by the sensitivity of EMI fields to metal type. UWB ground penetrating radar (GPR) has also shown definite discrimination capability for characterizing subsurface metallic targets. Uninfluenced by metal type, GPR is capable of registering complex natural resonances from which target length can be estimated. Further, examination of the spatial patterns of GPR signals can indicate the (X,Y,Z) locations of targets, even of multiple targets present simultaneously in the incident beam. In this paper we consider potential collaborative roles of UWB GPR and UWB EMI for discrimination of multiple subsurface metallic objects. Rigorous 3-D FDTD models demonstrate GPR's ability to estimate target positions, orientations, and length even when reflections overlap. These data can then be used to constrain inversion of UWB EMI patterns. Processing of EMI measurements based on prior estimates of object location and orientation successfully extracts distinct frequency response signatures for two very closely spaced objects. [C1255]

"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. [C1256]

"Adaptive detection algorithm of the moving pin-point targets on the clutter background with high period-to-period correlation factor"

In the paper, the adaptive optimal detection algorithm of the moving targets on the clutter background has been carried out. Some results of modeling were described. The offered adaptive algorithm is more effective than the standard method of target selection. [C1257]

"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. [C1258]

"A novel multi-channel SAR moving targets detection and image method"

Provides a novel multi-channel SAR moving targets detection and image (MTDI) method. After clutter is cancelled by using three apertures, two ways of signals through which moving targets can be detected are gained. Then Doppler centroid and Doppler frequency rate can be estimated, so both the real positions and velocities of moving targets will be acquired. Finally some typical computer simulation results are presented which illustrate the method's validity. [C1259]

"GPR for archaeological investigations: real performance assessment for different surface and subsurface conditions"

This paper assesses GPR (Ground Penetrating Radar) performance for archaeological investigations. We exploit extensive data acquisition campaigns to characterize the instrument behavior in different operative conditions and we select ad hoc processing techniques to optimally extract target signatures from the collected data. The extensive analysis demonstrates the real effectiveness of GPR surveys in archaeological investigations. [C1260]

"Clutter effects on ground moving target velocity estimation with SAR along-track interferometry"

The SAR interferogram, defined as the product of the first channel and the complex conjugate of the second, is one way of comparing two SAR channels. When the two sub-apertures are aligned along the flight path, targets with non-zero radial velocities can be detected by exploiting the phase information of the interferogram. This paper examines the effect of clutter interference on the interferometric phase and provides a simple method for mitigating the clutter contamination by using time-frequency (TF) analysis techniques and a velocity-offset matched filter (VOMF). Both simulated and airborne results are presented. [C1261]

"Effective clutter removal for detecting non-metallic mines in various soil fields"

In this paper, an effective method for removing the clutter effects from the data collected using a stand-off impulse GPR with a small electromagnetic probe is presented. The method requires no a priori knowledge about the target and/or ground characteristics. Essentially, it combines successive processing and spatial variable moving averaging (SVMA) to eliminate the clutter and to enhance the detection of small land mines shallowly buried in different soils. In addition, this method can use measured GPR data to infer the effective soil permittivity. [C1262]

"Applying fractional Fourier transform to radar imaging of moving targets"

A fractional Fourier transform based method for radar imaging of moving targets is presented in this paper. Compared with the traditional joint time-frequency approaches, it can achieve a better result of clutter cancellation by using optimal filtering in the fractional Fourier domain due to linear and rotational properties of this transform. By using this method, we can carry out moving targets detection, LFM signal parameters estimation as well as clutter cancellation at the same time under the time-frequency analysis. The effectiveness

of this method has been tested through simulation. [C1263]

"A philosophical discussion of the physical limits of radar"

Any radar setup is limited by the physical properties of the electromagnetic radiation used to gather information about a target. Some of the limits on accuracy are due to the quantum nature of the photons, others due to the limitations of the electronic equipment used to perform the modulations. The techniques used to record the characteristics of the radiation are as important as the method by which that information is analyzed and interpreted. In each stage of the travels of the radiation, from creation and propagation to recording and analysis, the physical properties of the photons involved play a key role in the behavior of the radiation. The techniques by which these properties are modulated, monitored and recorded are also important. In this paper, these topics are discussed and weighed in detail. From this understanding of the flow of information a theoretical apparatus will be constructed that will be capable of recovering a maximum of that information for later use. [C1264]

"Dim target detection in IR maritime surveillance systems"

In this paper we present an automatic procedure for the detection of long-range airborne targets in maritime naval surveillance systems. The algorithm performance is investigated via simulation and compared to the one of the classical moving window detection algorithm. [C1265]

"Integer coded genetic algorithm design of staggered sampling MTI"

The stagger time-variant algorithm is an effective method to reject clutter and alleviate the blind speed problem. Selecting the suitable stagger-code to make the first notch shallow can avoid the lost of target. This paper presents a novel integer coded genetic algorithm (GA) to select the best stagger-code. By compared with other traditional algorithm, GA is a global stochastic searching method and can converge quickly. The simulation and performance analysis demonstrate the feasibility and validity of this algorithm. [C1266]

"Low elevation sea-surface target tracking using IPDA type filters"

The integrated probabilistic data association (IPDA) type filters provide estimates of the underlying target probability of existence/perceivability/visibility, apart from track state maintenance. These quantities are conveniently used as a track quality measure and can be used for track confirmation and termination. The sea-surface induced multipath fading reduces the detection probability of the target at certain ranges, which can lead to track loss. In this paper, we use IPDA type filters for tracking a target in such a scenario. The primary results presented in this paper are encouraging for a further study in the future. [C1267]

"Metrics for SAR-GMTI based on eigen-decomposition of the sample covariance matrix"

This paper investigates different metrics for indication of ground moving targets in multi-channel SAR data (SAR-GMTI). These metrics have in common that they are all based on the eigen-decomposition of the sample covariance matrix. Their statistical properties are analytically compared and their detection capabilities, demonstrated on measured two-channel airborne data. [C1268]

"Performance analysis of an airborne high PRF phased array radar in a jamming environment"

This study focuses on algorithms currently available for a high PRF airborne phased array radar, where the system is designed to unambiguously detect fast targets, such as fighters, under intense jamming. It is shown that under the constrained conditions, the best processing option is not the well known space time adaptive processor (STAP), but a dual processor which provides the optimal solution at lowest possible computational cost maintaining the overall optimal performance. [C1269]

"Progress in HFSWR research at Harbin Institute of Technology"

The Experimental HF Surface Over-The-Horizon Radar set up in the late of 80s has been updated by installation of multi-channel receivers with digitization at the second IF stage, new designed transmitting and receiving antennas, wideband solid-state power amplifiers, frequency synthesizer with low phase noise and flexible signal generator, a new radar controller added to allow the automatic and manual control of the radar, a new designed signal and data processor built mainly with 16bit A/D converters and several multiprocessor boards with Share chip processors added in, and a electromagnetic spectrum monitor equipped in the updated radar system to be able to automatically survey HF spectrum occupancy for providing so called clear frequency channel suitable for radar operation. The purpose of the setting up of the updated radar system is to demonstrate some of new functions of the radar system, and to prove some new techniques to be possibly used in a near future. In the

paper, some latest developments of countering measures with radio frequency interferences are presented, too. [C1270]

"Use of STAP techniques to enhance the detection of slow targets in shipborne HFSWR"

This paper addresses the detection of low velocity targets from a shipborne HFSWR (high frequency surface waves radar). In a shipborne configuration, as a consequence of the ship motion, the first order of Bragg lines is spread in the useful Doppler interval where detections of a ship target are expected to appear. Space time techniques like STAP, usually studied for airborne radar purposes, are candidates to reduce the effect of ship motion. The influence of pitch and roll components is also discussed. Simulations of STAP techniques are given, based on a conventional architecture of processing. Estimation of the clutter covariance matrix is studied with respect to the characteristics of the radar waveform. Interleaving between the classical HFSWR waveform and a wide band learning waveform is proposed, to enable the covariance estimation. [C1271]

"Augmented state IMM-PDA for OOSM solution to maneuvering target tracking in clutter"

The out-of-sequence measurement (OOSM) problem is one of the most important issues for target tracking in a multisensor fusion network. The optimal solution is to augment the state vector to include the past states which correspond to those delayed measurements in the filtering process. In this paper, maneuvering target tracking in clutter with the OOSM problem is considered. An AS-IMM-PDA algorithm that uses OOSM to improve tracking performance is presented. The benefit of the AS-IMM-PDA is demonstrated via a maneuvering target tracking example. [C1272]

"Millimetre-wave radars in targeting and data linking operations"

Millimetre-wave (W-band=75-110 GHz) radars are poised to form an important component of autonomous vehicle operations because high frequency systems are able to provide the conformal miniaturized solutions necessary for many robotic applications. A serial programmable integrated radar threat simulator (SPIRTS) that transmits 95 GHz centred emissions for investigating air-to-surface target threats has been developed and the performance of this unit in a targeting role is projected. Targeting operations at W-band are compared with those at lower Kaand X band frequencies. The upsides and downsides of W-band operation in clutter generation and in multi-path signal fading, important for future high frequency communication links, are highlighted. Clear air propagation effects for datalinking operations are also discussed for W band emissions. [C1273]

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First Page of the Article [C1274]

"CFAR techniques for over-the-horizon radar"

Since the OTHR background noise is too strong, the target echoes would be embedded in sea clutter and environment noise. In order to detect targets such as ships or aircrafts from radar returns, a range Doppler CFAR schemes is presented, the identical Doppler frequency resolution cells over adjacent range or azimuth resolution cells are used to form a sliding window for targets detection. Since the OTHR range resolution cells is very large and so do the azimuth resolution cells, the total number of range Doppler resolution cells that forms sliding window is limited in order to guarantee stationary. Some CFAR algorithms such as CA, CM, TM, BLU and QBW methods that are suitable for OTHR are compared and analyzed versus different total range or azimuth resolution cells number. If the total range Doppler resolution cells number is small (less than 12), CA-CFAR is preferred in order to get the good detection performance. In multiple targets situation, CM-CFAR or TM-CFAR are suggested which trims the largest samples that possibly be interfering targets. [C1275]

"Multi-scan parametric target tracking in clutter"

This paper presents a new single-target tracking filter. Similar in structure to track-oriented MHT, the Integrated track splitting (ITS) filter is a multi-scan tracking algorithm that, like IPDA, integrates target state estimation with the estimation of target existence. The ITS filter models each track as a set of components, where each component is defined with a unique measurement history which consists of zero or one measurement received each scan. For each component the state estimate and the a-posteriori probability of component existence are computed recursively. After each scan, a new component is formed from each pair of "existing component, associated measurement". The probability of the new component existence is the probability that the parent component exists and that the measurement used to create the new component is the target measurement. The probability of target existence, mean and covariance of the state estimate for the track are then calculated and used for track maintenance and track output. ITS-MAP filter uses a-priori clutter density information provided by

a clutter map, analytically or by some other means to better discriminate clutter from target measurements. Simulations are be used to verify the performance of the ITS-MAP algorithm and to compare its performance with that of other target tracking algorithms in a dense and non-homogeneous clutter environment. [C1276]

"Ship and shipwake enhancement in coastal surveillance radar systems using target back propagation technique"

Rotating incoherent radar systems are usually used for coastal surveillance of vessels. Signal to clutter/noise enhancement is obtained by averaging a number of scans. Because the vessels move and thus migrate out of the radar resolution cells, the number of scans that can be averaged is limited by this effect. This paper exploits a target back propagation technique to overcome this problem. Measurements show that a significant enhancement of the ship image quality is achieved using this technique. Also the ship wake is made clearly visible and is subject for further study in the wavenumber domain and Radon transform domain for detection and feature extraction. [C1277]

"Efficient reiterative censoring of robust STAP using the FRACTA algorithm"

This paper presents further developments of the FRACTA algorithm (S.D. Blunt et al, NRL Tech. Rep. 10.059), which has been shown to be robust to nonhomogeneous environments containing outliers. The focus here is on the efficient implementation of the FRACTA algorithm. The key development is a censoring stopping mechanism whereby the number of reiterative steps can be minimized and computation is reduced. We introduce a data-dependent stopping rule that demonstrates excellent results as evidenced by the detection of targets in the KASSPER challenge data cube. We also present some other enhancements to the FRACTA algorithm that further improve both efficiency and performance. [C1278]

"An overview of space-time adaptive processing for radar"

The paper provides a survey of space-time adaptive processing for radar target detection. Specifically, early work on adaptive array processing from the point of view of maximum signal-to-noise-ratio and minimum mean squared error perspectives are briefly reviewed for motivation. The sample matrix inversion method of I.S. Reed et al. (see IEEE Trans. on Aerospace and Electronic Systems, vol.10, p.853-63, 1974) is discussed with attention devoted to its convergence properties. Variants of this approach, such as E.J. Kelly's GLRT (see IEEE Trans. on Aerospace and Electronic Systems, vol.22, p.115-27, 1986), adaptive matched filters and ACE tests, are considered. Extensions to handle the case of non-Gaussian clutter statistics are presented. Current challenges of limited training data support, computational cost, and severely heterogeneous clutter backgrounds are outlined. Implementation and performance issues pertaining to reduced rank and model-based parametric approaches are presented. [C1279]

"Bistatic synthetic aperture radar with application to moving target detection"

Bistatic radar involves the use of a physically separated transmitter and receiver. This paper describes a bistatic radar system which uses the combination of a spaceborne synthetic aperture radar transmitter on board the European Space Agency's Envisat satellite, and a low-cost, stationary, groundbased receiver. The advantages of this variant of the bistatic configuration involve the passive and therefore undetectable nature of the receiver, in addition to standard bistatic considerations such as forward scatter. Experimental results obtained using the receiver, and an analysis into the utility of the system for moving target detection in the presence of clutter, based on a simulation in Matlab of the electronic Displaced Phase Centre Antenna technique are both presented. It is found that the DPCA method considered has a possible signal-to-clutter-and-noise ratio after cancellation and processing of approximately 10dB although this is with the assumption of adequate received pulses and so integration gain, to offset the signal-to-noise ratio degradation caused by the canceller. A discussion of future experimental work, including the possible use of two such receivers for an investigation into interferometry concludes. [C1280]

"Clutter simulation in maritime environments"

Knowledge of clutter characteristics are an important factor in determining radar system performance, especially for target detection. Clutter may be modelled as a random process, with the clutter characteristics embodied in the statistics of the process. Most modern pulsed-Doppler radars utilize range-Doppler maps in their detection schemes, and so it is crucial to understand the statistical properties of clutter in these maps in order to develop effective target detection algorithms. In this paper, we discuss the simulation of the sea clutter seen on the range-Doppler map or an X-band pulse-Doppler radar operating in a maritime environment. We shall implement the compound K-distribution model for maritime clutter returns and incorporate temporal and spatial correlations in clutter map realizations. [C1281]

"Adaptive modelling of sea clutter and detection of small targets in heavy clutter"

This paper describes and compares three methods for detection of low RCS radar targets in heavy sea clutter using a high PRF radar. Two methods are based on auto-regressive processes, one on Karhunen-Loeve decomposition. Experiments have been performed on DSTO sea clutter dataset using these methods and the results are presented in this paper. [C1282]

"Stochastic modeling and simulation studies for the surface wave high frequency radars: problems and challenges"

Modeling and simulation strategies for the Surface Wave High Frequency Radars (SWHFR) are discussed in this tutorial paper. Their potential application areas are summarized, together with problems related to ground wave propagation, radar cross section (RCS) prediction, clutter elimination, noise and interference cancellation, etc. Challenges in SWHFR system design, antenna requirements, signal processing techniques as well as detection and tracking approaches are reviewed. [C1283]

"Investigations with SECAR-a bistatic HF surface wave radar"

This paper describes a bistatic HF surface wave radar, designated SECAR, which was deployed near Darwin, Australia, and used to conduct a variety of scientific investigations related to radar design, siting and target detection, as well as providing a test-bed for evaluating the operational utility of HFSWR as an element of a national surveillance network. The scientific results are significant because of their implications for improved radar design and effective deployment. [C1284]

"A multiple-sweep-frequencies scheme based on eigen-decomposition to compensate ionospheric phase contamination"

This paper presents an improved scheme to compensate nonlinear phase path contamination when the backscattered signal propagates through the ionosphere in high-frequency skywave radar systems. The ionospheric variation often causes the spread of the ocean clutter spectrum in the frequency domain. The energy of the first-order component of ocean clutter dominates in Doppler spectrum, and thus its spreading may submerge the neighboring low-velocity target easily. The instantaneous frequency (IF) estimating algorithm based-on eigen-decomposition has been introduced to estimate the frequency fluctuation due to ionospheric phase path variation and the compensation is carried out before the coherent integration. In the proposed multiple-sweep-frequencies scheme we construct a new "sweep-frequency" dimension by using different transmitting frequencies, and because of the different variation of Doppler frequencies for the target echo and ocean clutter first-order Bragg lines with the varying transmitting frequencies, that can be considered as different "sweep-frequency angles", the full-rank autocorrelation matrix used in eigen-decomposition can be formed. Better estimation accuracy is achieved and significant spectral sharpening can be observed in the resultant spectrum. To avoid the additional systemic complexity due to the multiple frequencies sweep operation, a segmenting range transform in an assistant channel is proposed to obtain the "sweep-frequencies" dimension data and estimate the ionospheric contamination. Experiments show that the proposed scheme is effective and its performance is discussed. [C1285]

"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. [C1286]

"HF surface wave radar operation in adverse conditions"

For the past 12 years the Canadian Department of National Defence and Raytheon Canada Limited have collaborated on a cost-shared programme to develop an Integrated Maritime Surveillance (IMS) system based on HF Surface Wave Radar (HFSWR). The primary objective behind the programme was to demonstrate the capability of HFSWR to continuously detect and track surface targets (ships and icebergs) as well as airborne

targets, at all altitudes, to ranges in excess of 200 nautical miles, reliably and consistently in real time and in all weathers. A secondary objective was to demonstrate the concept of IMS, involving the fusing of data from HFSWR radars and other sensors. This paper reviews techniques and methods used in the processing of HFSWR data to ensure that performance is maintained, even under adverse operating conditions. [C1287]

"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. [C1288]

"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. [C1289]

"Transient ultra wide band measurement applications: radar cross section, synthetic aperture radar, electromagnetic compatibility"

The Electronic Armament Centre (CELAR: Centre d'Electronique de L'Armement) and the Research Institute of Microwave and Optical Communications (IRCOM: Institut de Recherches en Communications Optiques et Micro-ondes) has evaluated the use of ultra-wide-band (UWB) short pulse measurement facilities to characterize target electromagnetic signatures. A first device is capable of determining the radar cross section (RCS) within a 200 MHz to 1.2 GHz frequency band. A second device, an UWB synthetic aperture radar (SAR), is dedicated to pulse measurements on outdoor targets (buried mines) and low frequency clutter. These transient techniques are soon used for EM coupling applications on various systems. [C1290]

"Multifunction radar resource management using tracking optimisation"

In this paper we report on the relationship between track update intervals and track accuracy in a multifunction phased array radar system. Strategies for selecting the update rate are highlighted and the degradation of performance as update rate reduces is demonstrated. It is shown that using suitable techniques, considerable radar resources can be liberated for non-tracking tasks. [C1291]

"PDAF versus PMHT performance on OTHR data"

Over the Horizon Radar (OTHR) is the primary Australian wide area surveillance sensor. The radar tracking system currently used for OTHR is based on the Probabilistic Data Association Filter (PDAF). Research and development(R&D)has continued to improve tracking performance. R&D has been extended to include the Probabilistic Multiple Hypothesis Tracker (PMHT). This paper deals with the comparison of the PDAF and the PMHT for tracking targets in experimentally recorded OTHR data. The data has been selected over a range of conditions and every effort has been made to ensure that both trackers have been optimised. The comparison uses a Tracker Assessment Tool (TAT) which measures performance against a total of 15 metrics. This report presents a quantitative performance comparison of the current tracking algorithm and these new tracker developments. [C1292]

"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. [C1293]

"Single versus tandem radar sensor target tracking in the adaptive cruise control environment"

The multiple target tracking performance of a multiple model technique is investigated. The performance when using a single radar sensor is compared to that when a tandem radar set is employed and the technique implemented is a combination of the interactive multiple model algorithm and the probabilistic data association filter. The investigation shows that the inclusion of a second redundant radar sensor significantly improves the tracking performance of the multiple model technique with only a slight increase in the computation cost. The ability to initiate, maintain, and terminate the tracks of multiple targets in a cluttered adaptive cruise control environment is improved a) by reducing the chances of wrongfully terminating tracks when targets are not "picked up" during a small number of consecutive radar scans and b) by reducing the state estimate covariances. A method for showing this latter improvement involves calculating the spectrum of the relative covariance matrix. These benefits of the redundant sensor counter those of a complementary sensor where a greater field of view is afforded. [C1294]

"Network-centric MFA tracking architectures"

Multiple frame association (MFA) based on multiple dimensional assignment problems has been developed for a centralized communication and tracking architecture, but such an architecture suffers from communication overloading, single-point failure, and data latency over the network of platforms. Thus, one must turn to decentralized architectures with the objectives being to affordably preserve the quality of MFA attained on a centralized architecture while managing communication loading and achieving a consistent air picture across the multiple tracking platforms. Such objectives present some of the most challenging tracking research problems. Thus, the goal of this work is to develop and test some initial architectures developed for network centric (decentralized) multiple frame association (Network MFA), namely, MFA Centralized, Replicated MFA Centralized, Network MFA on Local Data and Network Tracks, and Network MFA on All Data and Network Tracks. Based on well-established performance metrics, the relative merits of the architectures are also discussed. [C1295]

"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. [C1296]

"Power budget study for passive target detection and imaging using secondary applications of GPS signals in bistatic radar systems"

Signals from satellite systems like GPS, IRIDUM and Globalstar that are reflected from moving or stationary objects are utilised for their detection in a synthetic aperture bistatic radar system (SAR). The movements of the satellite and its position at different coordinates with respect to time can serve as a base for a synthetic aperture. This paper focuses on the development of a system based on the analysis of indirect signals, in particular GPS signals. The main concern in this study is the low power of the GPS signal at the earth's surface (typically about -160 dB). Due to the nature of the reflector/target, some power will be absorbed, and hence result in a further reduction in signal strength reflected by the target. However, the other equally important concern here is the ground and sea clutter, which is 18-22 dB stronger than the direct signal level. Here we present theoretical results of both the maximum detection range and land clutter contributions of the air target detection by bistatic SAR that utilizes the existing GPS satellite as the transmitting signal source. [C1297]

"Characterization of symmetric scattering using polarimetric SARs"

Cameron's coherent target decomposition (CTD) and classification are discussed in the context of SAR, and the limitations of Cameron's classification are examined. It is shown that these methods may lead to a coarse and misleading scattering segmentation because of the large radiometric dispersion tolerated in each of the elemental scatterer classes, as well as the implicit assumption on the coherence nature of target scattering. A new method, named the symmetric scattering characterization method (SSCM), is introduced to better exploit the information provided by the largest target symmetric scattering component, under coherent conditions. The SSCM, which expressed the symmetric scattering in term of the Poincare sphere angles, permits a better characterization of target symmetric scattering and the generation of coherent scattering segmentation of much higher resolution, in comparison with Cameron's segmentation. [C1298]

"Multi-sensor multi-target tracking using out-of-sequence measurements"

Out-of-sequence measurements (OOSMS) arise in a multi-sensor central-tracking system due to communication network delays and varying preprocessing times at the sensor platforms. During the last few years a great deal of research has focussed attention on the OOSM filtering problem. However, research in the multi-sensor multi-target OOSM tracking involving data association, filtering, and hypothesis management is still lacking. Some previous efforts have used buffering and measurement reprocessing to handle the OOSMs. In this paper, we present single-model multiple-lag OOSM algorithms for data association, likelihood computation, and hypothesis management for a dwell-based multi-sensor multi-target multi-hypothesis tracking (MHT) system that handles missed detections and clutter. We present numerical results using simulated multi-sensor ground moving target indicator (GMTI) radar measurements. [C1299]

"Joint Integrated Probabilistic Data Association-JIPDA"

This paper presents a new algorithm for multi-target tracking. In multi-target situations, multiple tracks may share the same measurement(s). Joint events are formed by creating all possible combinations of track-measurement assignments. The probabilities for these joint events are calculated The expressions for the joint events incorporate the probabilities of track existence of individual tracks, as well as an efficient approximation for the cluster volume and an a-priori probability of the number of clutter measurements in each cluster. From these probabilities the data association and track existence probabilities of individual tracks are obtained These probabilities will allow track update in the classic PDA fashion, as well as automatic track initiation, maintenance and termination. The JIPDA algorithm is recursive and integrates seamlessly with the IPDA algorithm. Simulations are used to verify the performance of the algorithm and compare it with the per performance of the IPDA, IPDA-DLL and IJPDA algorithms in a dense and non-homogenous clutter environment, in crossing target situations. [C1300]

"TWS tracking techniques based on adaptive Gaussian mixture model in phased array radar"

In this paper, an on-line real-time tracking algorithm for radar image sequences is proposed. First, a GMM (Gaussian mixture model) is used to approximate values of a particular pixel of the radar image sequences, parameters of the GMM are updated each time. Then, we use a simple heuristic to hypothesize which Gaussian of the mixture is most likely to be part of the adaptive background model. After the background model is established, pixel values that don't match the pixel "background" Gaussians are grouped using connected components. Features of the targets such as center position, size, radial and angular velocities are also computed in the mean time. Finally, the connected components are tracked across frames using a Kalman filter-based tracker. The experimental result shows that the algorithm is robust in clutter and easy to implement on-line. [C1301]

"Radar detection improvement by integration of multi-object tracking"

This paper presents a new and simple approach to the problem of multiple sensor data fusion. We introduce an efficient algorithm that can fuse multiple sensor measurements to track an arbitrary number of objects in a cluttered environment. The algorithm combines conventional Kalman filtering techniques with probabilistic data association methods. A Gauss Markov process model is assumed to handle sensor outputs at various sampling frequencies and random nonequidistant time intervals. We applied the algorithm to post-process the digital range returns of radar sensors to improve their quality. Since the static noise returns have near-zero velocity, the algorithm associates a certain track with each digital return, and estimates the track velocity, thereby allowing for removal of false returns originating from static pattern noise. [C1302]

"ALMA: a new approach to data initial association"

An adaptive limited memory approach (ALMA) is proposed to deal with the data initial association problem in tracking-while-scanning systems in high clutter environments. By using measurements in the window limited memory and exploiting the target detection probability and receiver noise sampling information, the initial track number is estimated. It in turn can be adopted to adjust the initial correlation region and the normalized residual square threshold adaptively; many false initial trajectories are therefore restrained. Computer simulation demonstrates that the real time data initial association problem can be settled by a combination of radar's dynamic characteristics and limited window measurements. [C1303]

"Comparison of plot and track fusion for naval sensor integration"

This paper compares plot and track fusion or a generic suite of sensors that might be available on a future warship, with an emphasis on their relative ability to maintain track continuity in the event of missed measurements/plots. Using plot fusion measurement level data are formed into tracks at a central location, whereas with track fusion state estimate (i.e. track) level data are combined from separate sensors into a single track state estimate. An extensive amount of literature discusses the two methods from an architectural standpoint although few quantitative results exist on the advantages and disadvantages of the two approaches for practical sensor integration applications. Results are presented for parametric modelling of track continuity and track completeness based on analysis of naval radar data characteristics. [C1304]

"Multi-resolution analysis of polarimetric SAR data using wavelets"

An analysis technique is presented for quantifying statistically and under a unified framework non-stationarity in polarimetric SAR imagery. The unified framework is provided by a multi-resolution analysis (MRA) based on a particular wavelet frame that works like a differential operator. The wavelet MRA provides local estimates of a statistics called structure function, that in turn can characterize two types of non-stationary behavior: smoothed singularities (e.g. edges, point targets); self-similar processes with stationary increments (e.g. fractional Brownian motion). In the polarimetric case we are interested in the combined dependencies on scale and polarization state. To the purpose an extension of the wavelet MRA is introduced for deriving wavelet representations of an intensity image synthesized at any polarization state (pol-MRA). A novel formalism called the polarimetric structure signature condenses in graphical form the properties of points of discontinuity with respect to scale and polarization transformations. A test case illustrates the application of the pol-MRA technique to the analysis of weak but polarimetrically diverse linear features embedded in clutter. [C1305]

"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. [C1306]

"Multiple target tracking using Hough transform PMHT algorithm"

The problem of estimating the parameters that determine a mixture density has been subject of extraordinary interest in the last years. Such a mixture density estimation problem is multi-target tracking. One of the new data association/tracking algorithms used for multi-target tracking is the Probabilistic Multi-Hypothesis Tracker. This paper considers a modification of the Probabilistic Multi-Hypothesis Tracker. The implementation of the Hough transform is proposed to generate a good start point to the main PMHT algorithm. The suggested modification improves estimation accuracy and correctness of the PMHT algorithm and overcomes its main drawback of low convergence. [C1307]

"Radar 2002 (IEE Conf. Publ. No.490)"

First Page of the Article [C1308]

"Modelling of the littoral environment for real-time radar performance assessment"

The role of the Royal Navy has changed dramatically since the end of the Cold War. Ships and personnel are now expected to fulfil a wider range of possible missions in theatres all over the world. Consequently ship's radar systems are now expected to give a high level of performance in regions that include the Middle East and the Eastern Mediterranean, despite being originally designed to operate predominately in the North Atlantic. The problem is that the local scenario and environmental conditions can dramatically affect radar system performance in two important ways. Firstly the environment can change the way that energy propagates outwards from the radar leading to large variations in target and clutter strength between different locations. Secondly these variations are often hidden by automatic threshold changes that reduce sensitivity to prevent the radar picture from becoming cluttered. This can give the false impression that the radar is operating optimally and could prevent ship's personnel from adapting their tactics to fit to the local situation. This paper outlines an updated model that is compared to real data in ducting conditions. The model is used to examine radar performance in littoral scenarios and to estimate sea state and duct strength from real radar data. The ultimate aim is to combine information collected by the ship's surveillance radar with modelling to allow ship's personnel to monitor the effect of the local environment on radar performance. [C1309]

"Bistatic radar denial by spatial waveform diversity"

The purpose of this paper is to introduce and evaluate a number of techniques to prevent a radar being used by an adversary as a bistatic illuminator of opportunity. These are all based on the idea of radiating a so-called "masking signal" which is arranged to be orthogonal, both in a spatial sense and in a coding sense, to the radar signal, and of a level sufficient to mask the radar signal to an adversary, and hence to deny a reference for bistatic operation. The overall performance of the scheme is quantified in terms of two parameters: (i) the degree of masking of the radar signal by the masking signal, and (ii) the degree of suppression of echoes (from targets or from clutter) of the masking signal in the channels of the radar receiver. The choice of waveforms is considered, followed by a description of two approaches to the choice of radiation patterns, and then the results of some simulations of the overall performance are presented. [C1310]

"Multiple model estimation scheme for map-matching"

A map-matching method using a multiple model (MM) estimation scheme is presented in this paper. A vehicle travelling on the road network is subject to often changes in the movement direction as the vehicle turns onto another road at an intersection or negotiates a road bend. Hence, the estimation of the successive locations of the vehicle on the road network from a sequence of noisy position measurements can be accomplished by a MM filter with a time-varying set of switching models. Each model describes a rectilinear movement along a road which is likely to be used by the vehicle at the current instant. As underlying MM estimation technique, the proposed method applies a variable structure variant of the latest change moment testing algorithm (VS-LCMT) whereby hypotheses about the moment of the last sudden change of the road model are successively generated. The current road is identified by finding the road model which has associated the most probable hypotheses and the estimate of the vehicle state is obtained by probabilistically combining the partial estimates provided by a bank of filters matched to these hypotheses. The imminence of a road model change is quantified on the basis of the state-dependent probability of the vehicle being outside the current road. This imparts flexibility to the algorithm. The algorithm allows the reduction of the computational effort by utilizing 1D state estimates. [C1311]

"A new maximum likelihood generalized gamma CFAR detector"

The Generalized Gamma Model has as special cases the Rayleigh, Weibull and Lognormal models. It also closely approximates the K-pdf model. Radar Clutter is often approximated in one of these forms. It is therefore quite useful to develop CFAR (Constant False Alarm Rate) detectors that perform well under this clutter model. In this paper, a Maximum Likelihood Generalized Gamma (MLGG) CFAR detector has been developed. This MLGG detector uses the Maximum Likelihood Equations, both locally and globally, in order to estimate the parameters of the Generalized Gamma clutter. These estimated parameters are then used to estimate the local mean of the detector. The mean of the local CFAR window is then taken as the first moment of the Generalized Gamma distribution evaluated with the estimated parameters. In the examples it is shown that in homogeneous Generalized Gamma clutter, with point targets, the MLGG detector outperforms our standard test detectors, Cell Averager, Ordered Statistic and Optimized Weibull. [C1312]

"ISAR imaging in strong ground clutter by using a new stepped-frequency signal mode"

In this paper we have presented a new mode of stepped-frequency signal. By using this signal, which transmits two pulses of the same earner frequency at each burst and with this carrier frequency stepped up a Δf in each subsequent burst, the ground clutter can be cancelled by using simple first-order cancellation. A computer

simulation is given to illustrate the effectiveness cif the proposed method. [C1313]

"An efficient adaptive sequential procedure for detecting targets"

Wald's sequential probability ratio test (SPRT) is known to be optimal for simple hypotheses. However, the hypotheses in target detection applications are usually composite, because, as a rule, the models are only partially known. A major method traditionally used for testing composite hypotheses is based on a generalized likelihood ratio. However, the generalized SPRT suffers from a crucial drawback-it is very difficult to select thresholds in order to guarantee prescribed levels of false alarms and missed detections. We consider an adaptive approach that allows us to overcome this problem. At each stage, unknown parameters are replaced with an estimator which is based on previous observations, but not on the current observation. It is shown that the adaptive test is uniformly asymptotically optimal in the sense that it minimizes the average sample size for all parameter values when probabilities of errors are small. The general results are applied to the problem of detecting a target with unknown intensity in clutter with unknown variance. [C1314]

"Bayesian smoothing and filtering for multiframe, multiaspect target detection and tracking"

We introduce a new Bayesian algorithm for joint multiframe detection and tracking of multiaspect targets that move randomly in cluttered digital image sequences. Two versions of the algorithm are derived: a batch Bayes smoother and an on-line Bayes filter. Performance results with a simulated image sequence generated from real infrared airborne radar (IRAR) data show an improvement over the association of a bank of correlation detectors and a Kalman-Bucy tracker in a scenario with a heavily cluttered multiaspect target. [C1315]

"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. [C1316]

"Short CPI STAP for airborne radar"

Circular, electronically scanned antenna arrays are currently being considered for use in airborne surveillance systems. These arrays are capable of pointing a beam in any direction at any time. This allows the radar to perform both 360° search and high update rate track modes simultaneously. To manage the radar's resources efficiently, shorter coherent processing intervals (CPIs) should be used for nearby or large targets. However, shortening the CPI effects STAP performance by increasing the amount of Doppler space that is lost to the clutter . This paper analyzes the useable Doppler space performance of short CPI STAP. It is shown that CPIs as short as 6 pulses can be used to track high velocity targets. Short CPI STAP performance is analyzed theoretically and by simulation. [C1317]

"Application of fast projection techniques without eigenanalysis to STAP"

In ground surveillance from an airborne or space-based radar it is desirable to be able to detect small and slowly moving targets, within severe ground clutter. For operational moving target indication (MTI) systems the clutter filter coefficients have to be updated frequently due to rapidly changing interference environment. This paper examines the small sample size performance of different fast fully adaptive space-time processors (STAP) and compares it to the optimum-detector performance. These previously proposed techniques, named matrix transformation based projection (MTP) and lean matrix inversion (LMI), were originally developed to provide fast jammer suppression in phased array radars with many elements. For this application they have been proven to operate with near-optimum performance, yet with a computational expense extremely reduced from that of the

optimum detector in most practical cases. The investigation herein focuses on the performance achieved when only a very few data samples are available to adapt (update) the clutter filter coefficient. [C1318]

"Block Toeplitz with Toeplitz block covariance matrix for space-time adaptive processing"

Interference covariance matrix estimations and computational complexity are two main concerns in space-time adaptive processing (STAP). This paper deals with the two problems by exploring a structured covariance matrix. First, a conjugate gradient iterative algorithm (CGIA) with reduced computational complexity is presented, which is based on FFT by using a block Toeplitz with Toeplitz block (BTTB) structure of the interference covariance matrix. To ensure the convergence of CGIA, an iterative BTTB (IBTTB) covariance matrix approximation is also proposed. Based on the approximated BTTB matrix, the corresponding STAP algorithm provides superior and robust performance both in limited sample support and in the presence of system errors. [C1319]

"STAP with angle-Doppler compensation for bistatic airborne radars"

We study issues associated with applying space-time adaptive processing (STAP) techniques in bistatic airborne applications. We consider the performance of several STAP approaches in different scenarios. Specific consideration is given to the effects of bistatic clutter spectral dispersion on covariance estimation and the algorithm's resulting clutter rejection capability. Our prime focus emphasizes adaptive processing methods capable of high performance with efficient utilization of training data. A deterministic two-dimensional spectral compensation is used to align the clutter spectral centers and thus enhance the performance of the proposed approaches. Algorithm performance is assessed using the output signal-to-interference-plus-noise ratio (SINR) compared to that of the matched filter with known covariance. [C1320]

"Maritime target and sea clutter measurements with a coherent Doppler polarimetric surveillance radar"

Doppler polarimetry in a surveillance radar for the maritime surface picture is considered. This radar must be able to detect low-RCS targets in littoral environments. Measurements on such targets have been conducted with a coherent polarimetric measurement radar in March 2001 and preliminary results from that campaign are presented. The system provides estimates of the scattering matrix per range-Doppler bin. Several physical quantities that can be exploited to discriminate target echoes from sea clutter responses are discussed and an impression is given on their effectiveness. [C1321]

"GMTI STAP in target-rich environments: site-specific analysis"

We address the problem of training data corruption in space-time adaptive processing (STAP) for ground moving target indication (GMTI) radar scenarios characterized by high densities of ground targets. A site-specific clutter simulation is used to demonstrate the impact that target signals in the training data have on STAP performance. Measured MCARM data results are presented that reveal similar performance trends as those observed in the simulations. A strategy for mitigating the deleterious effects of targets in the training data using a priori knowledge of the radar environment (e.g., locations of roads) to edit the training data is presented. [C1322]

"Multifractal features of sea clutter"

Sea clutter refers to the backscattered returns from a patch of the sea surface illuminated by a transmitted radar pulse. Since the complicated sea clutter signals depend on the complex wave motions an the sea surface, it is reasonable to study sea clutter from nonlinear dynamics, especially chaos, point of view, instead of simply based on random processes. In the past decade, Dr. Simon Haykin's (1997) group at the McMaster University of Canada carried out analysis of some sea clutter data using chaos theory, based on the the assumption that a chaotic attractor is fully characterized by a non-integer fractal dimension and a positive Lyapunov exponent. Thus, they concluded that sea clutter signals are chaotic. In other words, the complicated sea clutter waveforms are generated by nonlinear deterministic interactions of a few modes (i.e., number of degrees of freedom). However, a numerically estimated non-integral fractal dimension and a positive Lyapunov exponent may not be sufficient indication of chaos. Cowper and Mulgrew (see Proc. UCNN, vol.4, p.2633, July 1999), Noga (see Ph.D thesis, Cambridge University, 1998), and Davies (1994) separately have questioned the chaoticness of the radar sea clutter. We show, using the direct dynamical test for deterministic chaos developed by Gao and Zheng, which is one of the more stringent criteria for low-dimensional chaos, a two minute duration sea clutter data is not chaotic. We also carry out a multifractal analysis of this sea clutter data set, and find that the original sea clutter amplitude signal is approximately multifractal, while the envelope signal, formed by picking up the successive local maxima of the amplitude signal, thus measuring the energy of successive waves on the sea surface, is well modeled as multifractals. These behaviors determine that the amplitude signal follows

approximately log-normal distribution while the envelope signal, and thus the energy of the successive waves of the sea surface, is log-normally distributed. Approximate log-normal distributions for the amplitude signal has been observed earlier. However, by using the multiplicative multifractal theory, there is theoretical justification for the log-normal distribution of sea clutter, as discussed. The implications of the multifracta- l nature of sea clutter may have relevance for the detection of point targets on the sea surface. [C1323]

"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 [C1324]

"A polarimetric adaptive detector in non-Gaussian noise"

We address polarimetric adaptive detection of targets embedded in compound-Gaussian clutter with unknown covariance matrix. To this end we assume that a set of secondary data, free of signal components and with the same covariance structure of the cell under test, is available. We resort to a design procedure based upon the generalized likelihood ratio test (GLRT): first we derive the GLRT assuming that the textures are known, then we plug into the derived test suitable estimates of these parameters. Remarkably, the newly proposed detector has the constant false alarm rate (CFAR) property with respect to the texture statistical characterization. Moreover, even though it does not ensure the CFAR property with respect to the clutter covariance matrix, a sensitivity analysis shows that the probability of false alarm is only slightly affected by variations in the clutter correlation properties. Finally, the performance assessment, conducted via Monte Carlo simulations, confirms the capability of the receiver to operate in real radar scenarios. [C1325]

"Projection approach for STAP"

The sample support problem in space-time adaptive processing (STAP) applications arises from the requirement to adapt many spatial and temporal degrees-of-freedom (DOF) to a changing interference environment that includes clutter and jammers. Often, in heterogeneous overland strong clutter environments, the available wide sense stationary sample support is severely limited to preclude the direct implementation of the sample matrix inverse (SMI) approach. We outline an approach to address the sample support problem by utilizing projection methods-alternating projections or relaxed projection operators onto desired convex sets-to retain the a-priori known structure of the covariance matrix. Our initial analysis shows that by combining these approaches with eigen-based techniques, it is possible to reduce significantly the data samples required in non-stationary environment and consequently achieve superior target detection. In fact, multiplicative improvement in data reduction compared to direct eigen-based methods can be obtained at the expense of negligible loss in space-time aperture. [C1326]

"A new constrained joint-domain localized approach for airborne radars"

Critical issues associated with the application of multi-dimensional adaptive filtering including space-time adaptive processing (STAP) to real-world radar systems are considered. In particular, the design of transform domain localized techniques are examined from the perspective of receiver beam position and Doppler filter selection relative to mainlobe clutter as well as target returns. In particular, asymmetry in the selection of auxiliary beams and the effects of spatial tapering are shown to offer dramatic improvements in signal to interference ratio for targets with low Doppler. [C1327]

"Performance characterization of space-time adaptive processing algorithms for distributed target detection in non-ideal environments"

The use of adaptive algorithms to mitigate the detrimental effects of noise on receivers employing antenna arrays is instrumental in modern day radar systems applications. In most of these algorithms, the target is assumed to be confined to only one range cell. Under practical operating conditions, the target can actually be distributed across several range cells. This signal contamination causes the performance of the adaptive algorithm to degrade. Also, a covariance matrix is used for clutter-plus-noise in the design of the adaptive algorithm. This quantity is usually characterized by using samples taken from range cells surrounding the test cell. Performance suffers if the underlying test cell covariance matrix is different from the average covariance matrix of the surrounding range cells. We analyze a space-time adaptive processing (STAP) algorithm designed to utilize signal contamination to the advantage of the receiver. Expressions for performance, incorporating the possibility

of covariance matrix mismatch, are developed for such distributed target scenarios. Numerical analysis illustrates that the presented algorithm functions significantly better than traditional STAP algorithms in signal contaminated environments. This investigation also shows how variations in the parameters that describe covariance matrix mismatch affect performance. [C1328]

"Track-level registration for networked trackers"

The paper presents a recursive algorithm for joint registration and track-to-track fusion based on equivalent measurements generated by geographically separated multitarget radar trackers. The input data for the algorithm are clutter-free decorrelated equivalent measurements and associated covariances that have been extracted from sensor-level track estimates. Simulation results show that the proposed algorithm adequately estimates sensor biases, and the resulting central-level track estimates are free of registration errors. Furthermore, equivalent measurements generated for this algorithm are also suitable for processing by existing batch-processing registration algorithms. [C1329]

"A comparison of track initiation methods with the PMHT"

An important problem in multi-target tracking in clutter is that of track initiation and termination. When targets enter or leave the field of view of a sensor, the tracking algorithm must start new tracks or terminate existing tracks accordingly. One approach used to solve this problem is the addition of a visibility attribute to tracks. The visibility attribute provides a degree of filtering over the prior probability of measurement association and can be used as a statistic for track decisions. Standard model order estimation techniques suggest an alternative approach based on the log likelihood of the measurements. These approaches are used to derive initiation schemes for the probabilistic multi-hypothesis tracker (PMHT). The performance of these two approaches is compared with an intuitive ad hoc system through the use of receiver operating characteristic type curves. [C1330]

"Quasi-ray Gaussian beam algorithms for subsurface sensing in the presence of a moderately rough air-soil interface"

A major source of variability in ground penetrating radar (GPR) interrogating signals is related to reflection from, and (double) transmission through, the rough unknown air-soil interface which obscures the useful target-scattered signals. These considerations motivated our recent investigations toward a more robust, physics-based, adaptive approach to subsurface imaging in the presence of a moderately (both in height and slope) rough air-soil interface. The proposed approach entails prior estimation of the deterministic gross features of the rough interface and subsequent exploitation of this information to enhance underground target imaging. So far, this approach has been applied to two-dimensional (2D) frequency-stepped and pulsed GPR configurations, for slightly lossy soils and low-contrast mine-like targets, yielding encouraging results. In this paper, we briefly review the proposed framework and discuss some representative results. [C1331]

"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. [C1332]

"Use of a wideband radar to track large moving ground vehicles"

First Page of the Article [C1333]

"Track decoupling: linear joint IPDA (LJIPDA) and multi-target linear IPDA (MLIPDA)"

This paper presents a new approach to multi-target tracking. Rather than forming complex hypotheses based on all possible combinations of measurement origins, we attempt to decouple individual tracks based on the probabilities of measurement origins. Two such algorithms, both based on the IPDA algorithm, are presented in this paper. One, which we call linear joint IPDA (LJIPDA), recalculates IPDA using the probabilities of measurement origin. The other, which we call multitarget linear IPDA (MLIPDA), uses the probabilities of measurement origin to modify IPDA results. Both algorithms are recursive and yield formulae for both data association and probability of track existence. Simulations were carried out to compare these algorithms with IPDA in a dense and non-homogenous clutter situation. [C1334]

"Bistatic reflectivity measurements on various terrains at X, Ku, Ka and W-band frequencies"

Data that realistically represent the phenomenology of bistatic reflectivity are essential to the design of radar systems intended to sense land based targets and low flying aircraft. A need exists to further characterize clutter phenomenology in order to design and project the performance of current and future systems. This paper provides an overview of X, Ku, Ka and W-band bistatic measurements made at the Research, Development and Engineering Center at Redstone Arsenal. The data collection includes both on-axis (zero degrees) and off-axis (10 and 30 degrees) measurements of the bistatic reflectivity response of sand, gravel, sod and flat plates. The reflectivity results from gravel, grassy sod, smooth sand and flat plates are presented. Modeling and statistical analysis of the data are discussed. This work has application to tactical missile systems that must complete their engagements at low altitudes in a clutter environment. [C1335]

"Efficient determination of thresholds via importance sampling for Monte Carlo evaluation of radar performance in non-Gaussian clutter"

An efficient importance sampling simulation method is presented for estimating the thresholds to achieve very low probabilities of false alarm for radar receivers in clutter modeled as a non-Gaussian, spherically invariant random vector. Thresholds at false alarm probabilities of 10-6and lower are estimated with only 10,000 trials for both known and unknown clutter covariance matrix cases. [C1336]

"FOPEN SAR imaging of ground moving targets using rotational time-frequency-radon transforms"

In this paper, we introduce the basic concept of the rotational Fourier transform, the bilinear rotational time-frequency transforms, and the Radon transform. Based on a certain model of radar returns from moving targets, we propose a method using a rotational time-frequency-Radon transform for synthetic aperture radar imaging of moving targets in foliage. [C1337]

"Moving target detection in over-the-horizon radar using adaptive chirplet transform"

In over-the-horizon radar (OTHR) moving target detection, the signal to clutter ratio (SCR) is low. One method to detect a moving target is to first reject the clutter and improve the SCR before the detection, such as the adaptive Fourier transform developed by Root (see SPIE Conference, San Diego, p.19-24, July 1998) when a target moves uniformly. When a target does not move uniformly, the Fourier based techniques for the target detection including super resolution techniques may not work well. We replace the Fourier transform by the adaptive chirplet transform in the Doppler processing in OTHR when a target moves non-uniformly. [C1338]

"ARIES: a high-resolution shipboard radar"

This paper introduces the new ARIES radar, a high-resolution surveillance system designed for operation at sea. Its main characteristics are described, together with some remarkable experimental results regarding high-resolution observation of sea clutter and real targets. [C1339]

"A comparison of two non-homogeneity detection methods for space-time adaptive processing"

The paper undertakes a comparison of two non-homogeneity detection (NHD) methods and addresses their impact on the performance of the adaptive matched filter (AMF) method and the normalized adaptive matched filter (NAME) method in severely non-homogeneous clutter scenarios. Performance analysis is carried out using simulated data as well as measured data from the US Air Force Research Laboratory's MCARM (multi-channel airborne radar measurement) program. Specific consideration is given to the computational cost of the NHD method and the sample support requirements. The paper presents a technique for speeding up the computations in the NHD. Performance is reported in terms of the probability of detection versus signal-to-noise ratio (SNR) for simulated data analyses. [C1340]

"Secondary data partitioning via maximum likelihood estimation: extensions"

Adaptive beamforming based on sample matrix inversion requires the availability of a secondary data set for "training" (i.e., estimating the sample covariance matrix). For each snapshot processed, near-optimal detection performance can be achieved as long as the training data is independent, identically distributed, and free of target-like signals. Oftentimes, however, the available set of secondary data is contaminated by an unknown heterogeneous mixture of clutter, jamming, electromagnetic interference, and strong targets. Previously, the author and his colleagues applied maximum likelihood estimation (MLE) to pre-screen the available secondary data, identifying subsets having similar clutter and jamming statistics, and using these subsets for adaptive beamformer training. This paper extends the basic MLE approach to cases where the secondary data may

contain electromagnetic interference and/or strong targets. [C1341]

"Joint optimal Tx-Rx design for multiple target identification problem"

A design methodology for jointly optimizing the transmit waveform and receiver filter for multiple target identification is presented. The methodology is applied and illustrated for various multi- 'target' ID problems. The resulting probability of correct classification is significantly better than that achieved by a conventional chirp or any other waveform. Unlike the classical radar case, the choice of transmit pulse shape can be critically important for the identification of extended targets in presence of additive channel noise. [C1342]

"Doppler compensation for JDL for airborne bistatic radar"

In airborne bistatic radar the clutter Doppler is range dependent. STAP processor using training data from other range gate will experience widening of clutter notch. Widening of the clutter notch causes a major problem in detecting slow moving target. In this paper, Doppler compensation using interpolation in the angle-Doppler domain, for joint domain localised processor (JDL) is proposed. Comparison is made with Doppler compensated processor proposed by Kreyenkamp and Klemm (see IEE Proceedings: Radar, Sonar and Navigation, vol.148, no.5, p.253-58, 2001). Significant improvement in processor performance is observed across the whole frequency spectrum. [C1343]

"Small ship detection with high frequency radar using an adaptive ocean clutter pre-whitened subspace method"

We propose a novel scheme for using high frequency ocean surveillance radar (HFOSR) to detect slow weak target echoes embedded in temporally correlated sea clutter having a continuous spectrum. General Doppler processing CFAR detection of ships in ocean surveillance radar is usually inhibited by the continuous high order sea clutter. Conventional subspace methods can be utilized to enhance the detection, but they deteriorate dramatically in the presence of correlated sea clutter. In our paper an adaptive sea clutter filtering is introduced which improves the threshold and accuracy of the subspace detection method. Both simulated and real ship targets are used to verify the effectiveness of our proposed method. [C1344]

"Joint estimation of target number and DOA using reversible jump MCMC in sea clutter"

We address the problem of detection of a small target in high frequency ocean surveillance radar using the method of reversible jump Monte Carlo Markov chain. The number and the directions of arrival of targets are estimated simultaneously. However, the existence of sea clutter makes the traditional RJMCMC inefficient, and an adaptive preprocessing is preferred in combination with the original RJMCMC to achieve better detection. The performance of the proposed method is analyzed through several experiments with real data. [C1345]

"The Shannon channel capacity of a radar system"

A radar system can be used in conjunction with a coherent transponder as a communications system. A coherent transponder ("RF tag") received a stream of radar pulses, modifies these and transmits them back to the radar. This enables the RF tag to embed information in the radar data stream. We derive capacity formulas for this radar channel and then calculate these capacities for a specific SAR radar system and the RF tag configuration. We characterize the dependence of capacity on pulse repetition frequency, standoff range, and resolution. [C1346]

"ARES: radar data generator for systems design and development"

The Airborne Radar Environment Simulator (ARES) is a radar data generator tool capable of simulating returns from airborne and surface targets, ECM and also includes surface and volume clutter and atmospheric effects. The data output is time series signals at baseband IQ level. This data can be used for various purposes in support of the design and development life cycle of a radar system: theoretical studies of radar phenomena, design of signal processing algorithms and in providing test vectors for software development, The GEDAE software development tool allows the import of the data generated by ARES to provide test vectors representative of real radar data for use in signal processor software design and implementation. [C1347]

"Testing of MMW radar performance in adverse weather conditions and clutter backgrounds"

The US Army's Armament Research, Development and Engineering Center is constructing a Precision Armaments Laboratory (PAL) at Picatinny Arsenal, New Jersey, USA, specifically dedicated to the testing of sensors under adverse weather conditions. The laboratory consists of a base building and a 61 m tower with two

external elevators capable of serving as test beds for the radars, electro-optic, or other sensors under test and associated instrumentation. The tower will overlook three instrumented target site areas as well as a mid-range meteorological instrumentation site. The Georgia Institute of Technology has been assisting Picatinny Arsenal with the development of the instrumentation of the laboratory, and the planning and conduct of the testing. This paper examines the fully automated instrumentation being installed in the Army's PAL that is necessary to accurately determine and characterize meteorological conditions, measure the propagation path attenuation, perform the required measurements, and characterize the clutter background and target effects. [C1348]

"Improvement of high frequency ocean surveillance radar using subspace methods based on sea clutter suppression"

We present a new direction finding scheme for slow targets embedded in sea clutter that combines subspace methods (MUSIC and Root-MUSIC) and time domain sea clutter and noise suppression. The ocean surface behaves as a distributed source in contrast to ships that are point sources. By mapping data to eigenspaces, the sea clutter level decreases due to its non-deterministic behavior while point targets' levels remain unchanged while enhancing estimation performance. Since subspace methods have a higher threshold and are degraded heavily by the correlated sea clutter, clutter and noise suppression is introduced to enhance algorithm performance. Both simulated and real ship targets are used to show the lower threshold and higher estimation performance of the proposed algorithm. [C1349]

"An analysis of tracking gate for maneuvering targets"

It is important for a maneuvering target tracking to decide an proper gatesize parameter d in clutter environment. There are 2 problems to set gatesize parameter. One of the problems is that d set for a target in cluttered environment, the other is that d set for a maneuvering target. By the way, assume that a maneuvering target tracking in long-range radar, has been given, the gate radius of range direction and that of cross-range direction are unbalanced. Therefore if the conventional gating is applied to the maneuvering target tracking in long-ranged radar, it is impossible to control the gate radiuses of range direction and cross-range direction in the conventional gating. That is the reason the conventional gating has only one gatesize parameter which influences the gate radiuses of range direction and cross-range direction. To solve this problem, we propose a new gating which can set the gatesize parameter of range direction and that of cross-range direction independently. The computer simulations show an effectiveness of our idea by comparing our method with conventional method. [C1350]

"A suboptimization method of multitarget tracking algorithm M3 JPDA"

The M3JPDA algorithm has been reported to be suitable for tracking highly maneuvering targets in dense environment. This paper presents a suboptimization method of the M3JPDA algorithm for the reduction of the calculation time. Our method simplifies the probability calculations so that the probabilities of motion models and observation-to-track data association can be computed independently. [C1351]

"The MIT Lincoln Laboratory KASSPER algorithm testbed and baseline algorithm suite"

MIT Lincoln Laboratory is investigating how to use a-priori information in an adaptive MTI radar under the DARPA-funded knowledge-aided sensor signal processing and expert reasoning (KASSPER) program. Our objective is to demonstrate an embedded processor and some algorithms capable of real-time space-time adaptive processing (STAP) enhanced by a-priori knowledge of terrain types, locations of clutter discretes and road layouts. The immediate goal is to realize a baseline system, which is a conventional STAP chain making no use of a-priori information. It is designed to allow the entire KASSPER community to insert new algorithm features that exploit a-priori knowledge. The paper describes both the hardware and the algorithms that are being coded to realize the baseline system. This baseline algorithm suite is intended to provide a reasonable starting point for adding a-priori knowledge in the form of new training schemes or new STAP algorithms to improve target detectability near the mainbeam clutter ridge. [C1352]

"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. [C1353]

"Radar weak target detection and location based on Hough transform"

The Hough transform (HT) is analyzed and applied to radar weak target detection and location in this paper. The literature, in which only search radar is used, is extended to more general radar system. The theoretical analysis and experimental results used real-life radar data show that the presented method performs well in the strong clutter background, and robust to the clutter distribution. [C1354]

"Performance of order statistic clutter map CFAR"

Cell average clutter map CFAR (CACM-CFAR) is analyzed at first. CACM-CFAR has better performance in the inhomogeneous clutter environment, but is affected by interference and self-masking which will cause the low probability of detection. To solve these problems, a novel algorithm named order statistic clutter map CFAR (OSCM-CFAR) is proposed, in which the clutter map is updated by the k-th ranked cell in the clutter map cell. The performance analysis shows that the probability of detection for slow moving targets is increased by using the OSCM-CFAR algorithm. And the same case occurs in the multi-target environment when the new method is used. [C1355]

"Study on mechanism of dynamic programming algorithm for dim target"

An important problem in the field of radar signal processing, and a sequence of infrared images detection which arouses people's attention widely is the detection and tracking of dim moving targets in very low signal-to-noise ratio (SNR) or signal-to-clutter ratio environment. Track-before-detect (TBD) is especially useful for detecting and tracking moving targets in the condition of low SNR. In fact, dynamic programming is a problem of multi-stage decisions, and the dynamic programming algorithm (DPA) is an effective approach, which was adopted during the process of TBD. In the current work, the mechanism of the dynamic programming algorithm is analyzed, and a number of technical innovations that improve the performance of DPA are presented. Simulation results show this approach has high ability of detection for dim moving targets, and achieve 3 5 dB SNR gains comparable to those from other detection algorithms. [C1356]

"Passive coherent detection via exploiting illuminator of opportunity"

An experimental passive coherent target detecting system via exploiting illuminator of opportunity (also can be considered as external illuminator, such as broadcast, television etc.) is constructed, based on this experimental system, the principle of coherent receiving is analyzed and its power coverage is estimated, also, an applicable signal processing scheme is described. With the help of real data collection and processing, researches on the influence of direct signal rejection, channel properties and multi-path clutter rejection on the performance in passive coherent detection are investigated, results show the effectiveness of such system can be implemented by employing elaborated system allocation and advanced signal processing. [C1357]

"On motion compensation for weak radar reflected signal detection"

Detection of a weak radar reflected signal is to enhance the target echo against background noise or clutter using a long-term integration technique. During the integration duration, the target echo may migrate from one cell to another across the radar's resolution cells, e.g., range cell migration and Doppler cell migration; thus motion compensation must be considered to achieve better detection performance. If the radar can work in a long dwelling mode of the antenna pattern or have a slowly scanned antenna pattern, a new framework for detecting radar returned signals can be proposed. The method presented employs motion compensation based on range stretching and joint time frequency processing in the case of both range and Doppler cell migration. A practical realization of such a detector is suggested and performance analysis is given. Demonstrations on a real data set confirm its effectiveness. [C1358]

"Adaptive ground clutter cancellation of slowly moving targets with the multi-channel airborne SAR"

The detection of slowly moving targets and the estimation of their position and velocity are difficult problems for conventional airborne SAR systems with a single antenna, due to the spread of the clutter Doppler spectrum caused by the platform motion and the ambiguity between the cross motion and azimuth position. These problems can be solved via the use of multi-channel SAR and the space-time adaptive processing technique (STAP). In this paper, the clutter model and moving targets model suitable for airborne multi-channel SAR are presented and an efficient algorithm is proposed. Simulation results are illustrated, applying data produced by the proposed clutter model and moving targets model. [C1359]

"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. [C1360]

"Vision-based vehicle detection and tracking method for forward collision warning in automobiles"

We describe a vision-based vehicle detection and tracking method for forward collision warning in automobiles. The approach is based on a set of edge-based constraint filters that assist in the segmentation of vehicles from background clutter. The detected vehicles are then tracked using a combination of distance based matching, sum-of-square-of-difference in intensity (SSD) and edge density of detected vehicle regions. The computational load for tracking is minimized using a vehicle-clustering algorithm. Experimental results are presented to illustrate the performance of the algorithm. [C1361]

"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. [C1362]

"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. [C1363]

"Linear joint integrated probabilistic data association-LJIPDA"

Presents an approach for multi-target tracking. In multi-target situations, multiple tracks may share the same measurement(s). Rather than forming joint events by creating all possible combinations of track-measurement assignments, only a single track is processed at a time. Therefore, the number of operations is linear in the number of tracks. The a-priori probabilities of measurement origin are the conduit for inter-track information transfer. The LJIPDA algorithm follows three steps. In the first step, the a-priori probabilities of measurement origin are established for all tracks and all measurements. The next step is measurement oriented and corrects these probabilities. The final step is a modified IPDA algorithm, which uses visibility of measurements to the tracks to calculate the probability of target existence and the data-association probabilities. These probabilities allow track update in the classic PDA fashion, as well as automatic track initiation, maintenance and termination. Simulations are used to verify the performance of the LJIPDA algorithm and compare it with the performance of the IPDA and JIPDA algorithms in a dense and non-homogenous clutter environment, in crossing target situations. [C1364]

"Ultra wide band synthetic aperture radar for the detection of mined areas"

This article begins with a presentation of the concept of the ultra wide band (UWB) low frequency short pulse radar, its potential applications, advantages and limitations. To illustrate this, the article describes the work undertaken by the Centre Electronique de l'Armement (Defence Electronics Centre-CELAR) on the experimental UWB PULSAR radar for the detection of targets masked by vegetation and the measurement of clutter at low frequencies. Results of detection of mined areas are presented. [C1365]

"Accounting for array effects in joint-domain localized STAP processing"

We study critical issues associated with the application of multi-dimensional adaptive. filtering, including space-time adaptive processing (STAP), to real-world radar systems. In particular, transform domain localized techniques are examined from the perspective of receiver beam position and Doppler filter selection relative to mainlobe clutter as well as target returns. It is shown that the selection of asymmetric auxiliary beams offers

dramatic improvements in signal-to-interference ratio for targets with low Doppler. [C1366]

"A comparison of partially adaptive STAP techniques for airborne element digitised phased array radar"

In future there will be a growing requirement to use high levels of spatial and temporal sampling to enable the use of space time adaptive processing (STAP) to improve target detection in complex interference environments. However, in practice, the processing power and training data requirements will restrict the degrees of freedom (DOF) that can be used. A number of algorithms have been developed to take advantage of phased array architectures employing many DOF without suffering from slow processing, poor beam pattern control or inadequate training data. This can be achieved using either adaptive or non-adaptive DOF reduction techniques. We evaluate a number of partially adaptive techniques via simulations with airborne element digitised array radar (EDAR). [C1367]

"A planar antenna for omnidirectional GMTI radar"

For airborne surveillance and early warning radars 360° coverage is a desirable feature. Future military airborne radars will have omnidirectional coverage combined with ground moving target indication (GMTI) capability, for instance by using STAP (space-time adaptive processing) for detection of slow moving targets. In this contribution a randomly thinned array antenna for use with STAP is proposed. For achieving 360° azimuthal coverage subarrays including dipoles with rotational symmetry are used. Real-time STAP processing is achieved by using an overlapping subarray concept. It can be shown also that range ambiguous clutter returns are cancelled through vertical ing. The slow target detection performance is analysed, and the directivity patterns are shown. [C1368]

"UWB multi-static SAR with image stackng for land mine detection"

We investigate techniques for improving the signal to clutter ratio of an ultra wide-band SAR designed to detect small mine-like objects in the surface of the ground. In particular we collected images using different bistatic antenna configurations in an attempt to decorrelate the clutter with respect to the targets. The images were converted to a reference depression angle, summed, and then converted to ground coordinates. The resulting target strengths were then compared with the amplitude distribution of the ground clutter to show the improvement obtained. Use of the bipolar response to further enhance target to clutter ratios was also considered. Whilst some improvement was demonstrated, this was for the relatively easy scenario of targets on the surface partially obscured by grass. [C1369]

"Localized three-dimensional adaptive spatial-temporal processing for airborne radar"

Radar space-time adaptive processing (STAP) techniques have classically focused on azimuth-Doppler adaptivity while placing minimal emphasis on elevation. Elevation adaptivity offers significant clutter suppression improvement, allowing further suppression of interference sources having identical Doppler and azimuth as the expected target. This work incorporates elevation adaptivity using two approaches: (1) a factored approach and (2) a joint domain approach, both greatly improving clutter suppression performance. The proposed concepts are validated using results based on simulated range ambiguous airborne radar data. Target detection improvements on the order of 8 dB and 10 dB (as compared to standard 2D-JDL processing) are demonstrated for the factored and joint domain approaches, respectively, using an 8 Ч 8 non-uniform rectangular array. [C1370]

"2002 7th International Conference on Control, Automation, Robotics and Vision (IEEE Cat. No.02EX649)"

First Page of the Article [C1371]

"Simulation modelling and research of TBM trajectory detection"

Detection of TBM (tactical ballistic missile) type targets by typical long-range search radars is very difficult and is sometimes impossible to carry out. It results from the fact that such radars are usually projected and constructed in order to detect targets of fighter class. Difficulties concerning TBM detections result from their higher than a fighter radial speed and their lower than a fighter radar cross section (RCS) value that fluctuations are very complicated. Signal processing algorithms relating radar echoes from TBMs in a radar with stacked beams for receiving are described in the paper. Moreover a simulation model of such echoes is considered here too. The presented research results should be treated as introductory. Among others they give information about their future optimisation possibilities. [C1372]

"Surface modelling using 2D FFENN"

This paper is concerned with the development of a two-dimensional feed-forward functionally expanded neural network (2D FFENN) surface modeller. New nonlinear surface basis functions are proposed for the network's functional expansion. A network optimization technique based on an iterative function selection strategy is also described. Comparative simulation results for surface mappings generated by the 2D FFENN, multi-layered perceptron (MLP) and radial basis function (RBF) architectures are presented. The main purpose of this work is the development of a two-dimensional system, able to produce surface data mappings. The main application area of interest for the proposed system is sea surface modelling and target detection by sea clutter suppression. [C1373]

"Some aspects of design and environmental management in HF surface wave radar"

With the current emphasis on the surveillance of coastal waters, particularly for economic exclusion zone (EEZ) applications, there has been an increased interest in the capability of HF surface wave radar (HFSWR) to detect targets beyond the conventional radar horizon. The surface wave mode is generated where a vertically polarised high frequency electromagnetic wave is launched over a saline water surface; this then behaves in a manner such that there is significant propagation of the field around the curvature of the Earth. As this propagation mode relies on the surface currents in the conducting media of the sea, the resulting additional propagation loss has a dependence on the water salinity, surface roughness and frequency. A comparison of two-way HFSW loss with frequency over a smooth surface is shown. As the operating frequency increases, the additional propagation losses increase; however many other system constraints ease as the wavelength grows smaller (e.g. antenna size and target Doppler shift). This paper highlighted and provided some analysis for the frequency management and impulse suppression techniques that should be implemented in an effective HFSWR. [C1374]

"A peak detector that picks more than peaks"

The sensor measurement data supplied to an automatic tracking system is often provided by a peak detector or peak picker. Here it is assumed that digital processing is used for all steps from signal processing onwards. The peak detector follows the signal processing step and converts the received signals into radar measurements. It does this by interpolating the position about local peaks which are above a detection threshold. The peak detector output gives target and clutter measurements which are described by different probability density functions (PDFs). The probabilistic data association filter (PDAF) uses a priori models for the target and clutter distributions. The PDAF has since been extended to include a nonuniform clutter distribution. This paper outlines this extension and also describes another peak detector derived parameter, namely the curvature of a peak. It shows the difference between the peak curvature PDFs for targets and clutter from experimental over-the-horizon radar (OTHR) data. The extension of the PDAF to effectively use peak curvature is then outlined. The examples of performance show the impact of including these extra parameters from a peak detector. These results are based on data recorded from Australia's OTHR, Jindalee. [C1375]

"Effect of Doppler ambiguities on GMTI tracking"

We focus on the effect of Doppler ambiguities on target tracking with airborne GMTI radar. Even after platform motion compensation by STAP techniques, GMTI tracking proves to be a challenging task. Unless appropriately handled, Doppler blindness can cause serious problems, which seem to be even more difficult in the presence of Doppler ambiguities producing multiple clutter notches. We develop an appropriately modified GMTI sensor model and evaluate its impact on the GMTI tracking process. By this approach the minimum detectable velocity (MDV) and the pulse-repetition frequency (PRF) explicitly enter into the GMTI tracking algorithms. [C1376]

"Effect of ambiguities on GMTI radar"

We focus on the effect of range and Doppler ambiguities on the ability to detect slow moving targets by STAP radar. This work has been conducted in the context of international projects such as SOSTAR and AMSAR.The detection of moving targets by a moving radar (air- or spaceborne) is seriously degraded by strong clutter returns. Space-time adaptive processing (STAP) techniques can implicitly compensate for the motion induced Doppler shift and thereby improves the capability of slow target detection. The effect of ambiguities on the target tracking capability of a STAP radar is discussed in conjunction with a companion paper by Koch (see Radar 2002, Edinburgh, Scotland, October 2002). [C1377]

"Comparison of Doppler clutter cancellation techniques for naval multi-function radars"

We describe a comparison of fixed and adaptive clutter cancellation processes applied to measured multi-function radar (MFR) data in a littoral environment. The adaptive filters require estimates of the clutter

covariance and comparisons of different strategies for obtaining this are made. The results for the adaptive filters generally show substantially improved target detection over the non-adaptive filters. [C1378]

"Pattern synthesis for moving target detection with TechSat21-a distributed space-based radar system"

We have explored a novel approach for pattern synthesis in angle-frequency space, which is applicable for highly thinned arrays. It exploits the double periodicities of the grating lobes in the angular domain and the radar pulses in the frequency domain and allows substantial clutter suppression. Gains from 7 to 17 dB relative to a randomly, thinned array appear feasible. Further improvements in signal/clutter ratio can be achieved by joint array and filter weight optimization and by narrow-band Doppler filtering. [C1379]

"A comparison of track initiation with PDAF and PMHT"

A problem with many algorithms for target tracking is that they are designed to update tracks under the assumption that the tracks correspond to real targets, and that the initial conditions of the targets are known. In practice, this is not the case, and practical algorithms must be capable of track initiation and termination. One method of solving these problems is to introduce a Markov model to estimate the validity of each track. This approach has been referred to as target visibility. This paper compares the single target track initiation performance of the probabilistic data association filter (PDAF) with the probabilistic multi-hypothesis tracker (PMHT) when each uses the visibility target model. [C1380]

"Adaptive spatial filtering with data-dependent training for improved radar signal detection and localisation in structured interference"

Adaptive spatial filtering is applied in modern surveillance radar systems to improve the detection and localisation of desired signals embedded in severe and dynamic interference from clutter as well as jamming. In practical situations of interest, the interference can only be cancelled to sufficiently low levels by significantly compromising the sidelobe response of the adapted pattern. Attempts to effectively stabilise the sidelobes, by means of diagonal loading or rank-reduction for example, gives rise to suboptimal patterns which potentially lead to intolerable degradations in interference suppression. On the other hand, the application of an adaptive pattern with unregularised sidelobes to a test cell containing a signal that is not incident from the system steer direction may cause an unwanted detection or false alarm. This paper proposes a data-dependent training strategy for adaptive spatial filters which provide enhanced interference rejection with a reduced likelihood of false alarms while simultaneously avoiding target self-ing when the beam is pointed in the signal direction. [C1381]

"Analysis of spectrum variability in sea clutter"

Naval radar systems commonly employ Doppler processing to separate targets from clutter. A widely used system is the moving target detector or MTD system (Skolnik 1981) which performs a frequency analysis of a sequence of returns in each range gate. A threshold is then determined by some form of constant false alarm rate (CFAR) algorithm for the contents of each Doppler channel based on the returns in neighbouring range gates. It is normally assumed that the clutter spectrum is the same in each range gate; however, if this is not the case, it will clearly affect the threshold-setting process. It has been shown previously by Miller (2000) that there may be considerable variation in spectra for sea clutter observed at low grazing angles. In the above paper, an initial attempt was made to model this variability. The current paper applies this model to data collected by QinetiQ, Portsdown West and discusses enhancements to the original model. [C1382]

"A comparison of radar sea clutter models"

Radar performance prediction has always been an important part of the design and development of radar systems. Performance prediction offers a way of extending limited trials results obtained for the environmental conditions on the day to the full envelope of desired operation. The analysis of radar performance in free space is well documented and understood but the modelling of the radar target in a clutter environment is still an area of active research. This paper concentrates on airborne maritime radar. The key to obtaining realistic predictions of the probability of detecting a target on the sea surface is governed by the spatial and temporal statistics and correlation properties of the sea clutter. Radar detection is governed by the combination of the mean radar cross-section of the clutter and the temporal fluctuations of the pulse-by-pulse radar returns about the mean. Here, two models for the mean radar cross-section of the clutter are compared. [C1383]

"The use of track-before-detect in pulse-Doppler radar"

This paper describes the theory and a new method for using the track-before-detect (TBD) process in a pulse-

Doppler radar. The approach uses dynamic processing techniques via a modified Viterbi algorithm. The process has been applied to a number of real and modelled scenarios using a variety of radars, threats and environmental conditions. The process has been shown to give an increase in detection range equivalent to a signal-to-noise (S/N) gain of up to 10 dB. The process has also been shown to vastly reduce the workload of a tracker, and therefore increase its effectiveness, by reducing the occurrence of false alarms caused by clutter breakthrough. [C1384]

"Target detection in ground clutter with W-band stepped frequency polarimetric radar system"

This paper presents a constant false alarm rate (CFAR) target detection scheme in ground clutter at W-band (94 GHz), making use of clutter decorrelation bandwidth and co- and cross-polarized received data. The scheme, based on the concept of a CFAR matched subspace detector, yields a CFAR with respect to clutter amplitude distribution. In order to investigate the detection performance, we carried out a Monte Carlo simulation and experiments using the W-band stepped-frequency polarimetric radar system. The results are also compared with the conventional CFAR detector. [C1385]

"Wavelet detection of low observable targets within sea clutter"

We observe scattering events in the Doppler domain via a continuous wavelet transform (CWT). By minimising the uncertainty in velocity and time, the dominant event in the non-stationary instantaneous Doppler spectrum can be isolated. Considering the returns to be discrete in nature leads to a physically motivated detection statistic termed 'persistence' that measures the observed lifetime of the scatterers. A Doppler detection scheme is formulated at low velocities within the clutter spectrum, an area neglected by current Doppler filtering. When operated on real data containing an oil drum target, results appear to be complementary to simple intensity thresholding; this suggests detection is made on secondary effects such as wake disturbance. [C1386]

"Wide swathe multi-channel GPR systems for mine detection"

Many national and international programmes are underway to develop more effective detection and clearance system for buried mines. Results from the US national programmes on mine detection suggest that radar can outperform conventional metal detectors, which only respond to the metal content of a mine and hence are insensitive to minimum metal mines. Radar, and in particular ground penetrating radar, used in conjunction with other sensor arrays can result in a improved fused performance in terms of reduced false alarm rate. This paper reviews some key aspects of the performance of radar as a wide swathe sensor, in particular the system design, antenna characteristics, signal and image processing as well as detection performance. Examples of the radar images of mines and the factors that influence the image quality are presented. Current demonstrator radar systems can detect buried AT mines with some confidence, but the reliable detection of AP mines will require further development of antennas, clutter rejection algorithms and target detection methods. [C1387]

"GMTI performance estimation for airborne E-scan radar employing DPCA motion compensation"

Ground-moving target indication (GMTI) clutter rejection performance is conveniently represented by the signal-to-interference-ratio improvement factor. The effects which limit the SIR improvement factor, including clutter spectral width, platform motion and radar instability are reviewed and quantified. Calculation of the SIR improvement factor and consequent detection performance are described and illustrated for an E-scan radar employing DPCA for clutter motion compensation. [C1388]

"Results of flight tests of a two-channel radar system with real-time MTI processing"

In synthetic aperture radar (SAR), only fixed targets are mapped on their correct positions. Moving targets are displaced in azimuthal direction due to the Doppler frequency shift caused by target velocities. The detection and correct positioning of moving targets within SAR images is a problem that can be solved by using multiple antennas and multi-channel receivers. For the detection of slow moving targets or moving targets that are backfolded into the clutter spectrum, a good suppression of fixed target echoes is necessary to gain subclutter visibility. Space-time adaptive processing (STAP) shows good performance in clutter suppression and is state of the art. However, the main disadvantage of conventional STAP techniques is the very high computational load. Therefore, performing STAP in real-time for the purpose of on-board subclutter moving target indication (MTI) requires special techniques. To estimate the true azimuthal positions of moving targets, phase differences between receiver channels can be evaluated e.g. by using the well-known monopulse method. Alternatively, STAP can be applied to solve this problem as well. STAP in real-time is discussed for two applications. First, STAP can be used for suppressing clutter and jammers. Moreover, clutter filter coefficients gained by STAP can be used for the purpose of correct positioning of moving targets within SAR images. Results of this real-time STAP technique as well as results of the moving target repositioning technique are presented: the clutter

suppression quality and the moving target repositioning accuracy are demonstrated with real SAR data and moving targets recorded during a measurement campaign. [C1389]

"A powerful practical coherent adaptive radar detector"

An adaptive detector for the case of a radar target with unknown Doppler and unknown complex amplitude in AR (autoregressive) noise of unknown parameters has been derived. The secondary data is also used to improve the detection performance. The proposed detector has the form of a detector bank. The computational load of efficient realization of this detector bank is also presented. Finally the performance of the proposed detector is evaluated using both simulated and real clutter data [C1390]

"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 [C1391]

"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 [C1392]

"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 [C1393]

"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 [C1394]

"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 [C1395]

"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 [C1396]

"A real-time effective method for infrared point-target detection in spatially varying clutter"

This paper presents an algorithm of designing an effective image sequence processing scheme, which based on analyzing the targets and background model correctly. This algorithm will successfully detect very small (point) target in spatially varying clutter background when both the target and clutter are moving through the image scene. This method focuses on reducing the cost of computation, tracking the target in real-time, enhancing the SNR, and suppressing the clutter [C1397]

"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 [C1398]

"Novel method of decreasing influence of phase noise on FMCW radar"

In the last decade, the frequency-modulated continues wave (FMCW) radar has been widely used both in military and civil (automotive) applications. Using low peak power it is possible to build reliable, low cost radar, which can measure target position, radial velocity and also the target radial acceleration. The radar sensitivity, accuracy and sub-clutter visibility (SCV) are limited by the transmitted power and the presence of phase noise in a transmitted signal. The influence of transmitter phase noise on FMCW radar performance has been investigated. The low-frequency 1/f type phase noise of FMCW radar free running oscillator degrades significantly the target velocity spectrum estimated by the 2-dimensional FFT of the video signal and thus limits the radar ability to detect moving targets against heavy ground clutter. To improve the radar performance the new method of low frequency phase noise compensation, based on the polynomial phase modeling concept has been worked out. On the basis of the received signal, assuming that ground clutter echoes are present in the signal, the low frequency phase noise polynomial model parameters are estimated. The estimated parameters are further used for digital correction of the video signal phase, which leads to a sharpened echo velocity spectrum and increased SCV and accuracy of velocity estimation. The presented concept can also be used for attenuation of synchronous interference in FMCW radar [C1399]

"The modification of intelligent target detection in nonstationary clutter"

In non-stationary background, like sea clutter, the intelligent detection method independent of the statistical model, has the obvious advantages. Based on the strategy by Haykin (1997), a new intelligent detection scheme is proposed to improve the detection performance, in which the Kohonen neural network (NN) and the modified fuzzy NN are used. A variety of comparison experiments have been done with both the simulated data and the real sea clutter data between our proposed scheme and Haykin's scheme, which show clearly our method has a higher detection ability and a lower false-alarm rate [C1400]

"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 [C1401]

"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 [C1402]

"Two generalized greatest of selection CFAR algorithms"

The conventional cell-averaging (CA) CFAR detector gives a minimum loss of detection power in homogeneous background, but it exhibits intolerable rise in false alarm probability during abrupt transitions of clutter power levels and significant degradation in detection probability in the presence of interfering targets. The ordered statistics (OS) CFAR processor may resolve multiple targets quite well, but it lacks effectiveness in preventing excessive false alarms during clutter power transitions and its sample sorting time is too long. Therefore, some algorithms such as OSGO and GOSGO are proposed. The advantage of applying greatest of selection logic lies in controlling the rise of false alarms at clutter edges. If several ordered samples are linearly combined to give the noise power estimation for the leading or lagging sub-window, better detection performance can be made than with a single ordered sample as considered in OSGO. In this paper, two new greatest of CFAR schemes (TMGO and QBWGO) are proposed. They split the reference window into two sub-windows and uses TM or QBW methods to create two local noise power level estimations, the greatest value of them is used to set an adaptive threshold. It is shown that the detection performance of TMGO and QBWGO is superior to that of OSGO both in homogeneous background and multiple targets situations [C1403]

"Target detection in ground clutter with stepped frequency CFAR detector at millimeter-wave"

This paper presents a constant false alarm rate (CFAR) stationary target detection scheme in ground clutter at millimeter-wave frequencies. The proposed scheme makes use of the clutter decorrelation bandwidth considered in the stepped-frequency radar system and the concept of a CFAR matched filter for the received data projection onto the signal and clutter subspace. Therefore, the scheme achieves the CFAR, where the knowledge of the clutter covariance matrix is not needed preliminarily. In order to investigate the detection performance, we carried out experiments with a W-band stepped-frequency polarimetric radar system at 94 GHz with a bandwidth of about 300 MHz. The results are discussed and compared with conventional CFAR detectors [C1404]

"A new method for small target detection over chaotic background"

Based on the chaos of sea clutter, a nonlinear prediction method is used to transform the classic binary decision problem to the analysis of prediction error in radar target detection, and a fuzzy min-max neural network-based detection scheme is proposed. The simulation experiment results show that this method is effective even in very low signal to clutter ratio background [C1405]

"2D-OS-CFAR detector for cloud clutter suppression"

The problems of CFAR processing are investigated by means of real cloud clutter data. Based on FFT processing techniques, a comparison of cloud clutter suppressing performance is made between CAGO-CFAR detectors, 3D-CLUTTER MAP-CFAR detectors and MX-OS-CFAR detectors. A new robust 2D-OS-CFAR detector is developed to resolve existent problems, with CFAR processing on a two-dimensional R-Fd (range-Doppler frequency) plane in place of the conventional one-dimensional range. Order statistics are used to estimate clutter amplitude at the same time. The processing results of real cloud clutter and target simulation signals have verified excellent performances of the 2D-OS-CFAR detector [C1406]

"The application of wavelet packet to signal analysis of battle reconnaissance radar"

A method of using wavelet packet for signal analysis of battle reconnaissance radar is proposed. The advantage of this method over conventional radar signal processing technology is mentioned. Simulation results and analysis shows that the purpose of clutter suppression and target extraction can be effectively obtained by using wavelet packet in the battle reconnaissance radar [C1407]

"An approach to the spectral line tracking based on fast Fourier transform"

An approach to spectral line tracking based on the fast Fourier transform (FFT) under low pulse repetition frequency (PRF) is discussed in this paper. Compared with the conventional method of spectral line tracking, it is achieved by modification of pulse repetition interval (PRI) rather than the frequency of the coherent oscillator. Our method can be expressed as center filter tracking and filter center tracking [C1408]

"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 [C1409]

"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 [C1410]

"The radar clutter processor with wavelet floating threshold"

According to the theory of wavelet multiscale analysis, we have done some research on how to construct a radar clutter processor by means of a floating threshold. We provide some results of radar signal processing, which demonstrate the method's effectiveness [C1411]

"Adaptive power-managed FMCW emitter detection performance against low-RCS ships"

The design of a modern 9.3 GHz homodyne triangular-FMCW emitter for detection of low radar cross section (RCS) ships is described. Both searchand track-mode processing are described including a description of transmit and receive waveforms. Tradeoffs in emitter design are examined as a function of the modulation bandwidth. To predict target detection capability, clutter and target models are developed as the emitter is flown at 300 m/s in a scenario that starts at a range of 15 nmi from the target. To evaluate the feasibility of detecting low RCS ships at the horizon, a low-RCS ship design is examined. Each sea state (0-4) is characterized by using a second-order polynomial that describes the normalized mean sea backscatter coefficient as a function of the grazing angle. The emitter transmit power is adapted in time to measure the target characteristics. The emitter transmit power level is consistent with the RCS and range to the target while keeping a target-to-clutter power ratio at 20 dB. For detection analysis, 50, 100 and 500 m2 RCS values are considered [C1412]

"Radar Technology for Mine Detection"

Much attention is being given to the challenge of detecting buried non-metallic mines and National and International programmes are underway to develop more effective detection and clearance systems. Reported results from the US national programmes on mine detection suggest that radar can outperform conventional metal detectors, which only respond to the metal content of a mine and hence are insensitive to minimum metal mines. Radar, and in particular ground penetrating radar, used in conjunction with other sensor arrays can result in an improved fused performance in terms of reduced false alarm rate. This paper reviews key aspects of the performance of radar as a sensor, in particular the system design, antenna characteristics, signal and image processing as well as detection performance. Examples of the radar images of mines and the factors that influence image quality are presented. Current demonstrator radar systems can detect buried AT mines with some confidence, but the reliable detection of AP mines will require further development of antennas, clutter rejection algorithms and target detection methods. [C1413]

"STAP adaptive weight training using phase and power selection criteria"

This paper addresses the issue of adaptive weight training in space-time adaptive processing (STAP) algorithms for airborne radar in non-homogeneous clutter environments, while avoiding the inclusion of target signals in the training. A common method of ensuring STAP clutter cancellation performance in the presence of strong clutter discretes is to train the STAP adaptive weights using the returns with the largest power for a given Doppler bin. The presumption is that the strongest returns are from the strongest clutter. Many times, however, targets are also present whose inclusion in the STAP weight training results in significant target self-nulling as well as a degradation in clutter mitigation performance. A new STAP training method is presented that excises targets from the training set based on an interferometric measurement of phase for each potential STAP training sample. The resulting training method based on both phase and power selection criteria is shown to offer significant performance gains on experimental data [C1414]

"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 [C1415]

"Ground short range slowly moving target detection of airborne fire-control radar"

In the short range slowly moving target detection of airborne fire-control radar, the space-time trajectory of clutter varies with range due to the variation of elevation angle and show high non-homogeneity. In such cases, good detection performance can not be obtained by using either conventional or STAP processing. In this paper, a compensating method of clutter trajectory is proposed. Transforming data of different range with different frequency-shift, it can weaken the non-homogeneity effectively and make the clutter energy shrink to a very small area in the space-time plane. The computer simulation results show good performance and high improvement factor can be obtained when it is used as the pre-processor of STAP and it has the advantages of low complexity and ease of application [C1416]

"A distributed track correlation algorithm based on multi-elements fuzzy synthetic decision"

A distributed track correlation algorithm based on multi-element fuzzy synthetic decision, and its correlation criteria are presented. The algorithm is also compared with the two classic algorithms through simulations. The results of simulations show that the performance of the algorithm presented in this paper is more perfect than the classic ones, especially under dense targets, track crossing and target maneuvering environments, and the rate of correct correlation improves about 37 percent [C1417]

"Space time adaptive processing for domain factorised element-digitised array radar"

Due to limitations of current radar system hardware, digitisation and adaptive beamforming are usually performed at the subarray level of large phased array radar. In the long term, technology will permit development of element digitised array radar (EDAR), although this may not necessarily lead to adaptive processing being performed at the element level. The large computational requirements for adaptive processing, which vary with the cubed power of the number of digital channels, and the large data training set required, will restrict the number of digital channels employed. However, with element digitisation we are free to choose arbitrary degrees of freedom (DOF) reduction schemes to maximise adaptive beamformer performance. It has already been shown that DOF reduction schemes using domain factorisation (DF) give performance advantages in high clutter airborne intercept (AI) environments. We extend the DF technique described by Paine (see IEE Proceedings Radar, Sonar & Navigation, vol.148, no.2, p.81-88, 2001) to space-time adaptive processing (STAP) and demonstrate the detection of slow moving targets that are ambiguous with main beam and strong nadir clutter [C1418]

"Moving target detection in wide band SAR"

A likelihood ratio test is proposed for moving target detection in a ultra wide frequency band and wide antenna beam (wide band) SAR systems. The developed method combines time domain fast backprojection SAR processing methods with moving target detection. It saves the computational load when all relative speeds can be tested using the same clutter suppressed sub-aperture beams. The proposed method is tested on narrow band radar data [C1419]

"Imaging of moving target in strong ground clutter"

The imaging method of a low-altitude target in strong ground clutter is presented. The identical amount of stretching time-delay with the adjoined echoes is applied in the signal stretching process, and then the ground clutter is filtered through the one-order canceller. Furthermore the target's motion parameters can be accurately estimated by the narrow pulse signals on the constant carrier, so that motion compensation can be achieved. After the theoretical analysis, the validity is proven by simulation results [C1420]

"Modified joint domain localized reduced-rank STAP"

Among reduced-rank STAP methods, the joint domain localized (JDL) method is a relatively effective beam-Doppler domain method. However, there are two restrictions placed on this method which circumscribe its performance. One is that the transformation is equivalent to the 2D DFT, the other is that the target steering vector must be one column of the transformation. This paper points out that these two restrictions are not necessarily optimal cases, and presents a modified JDL method via changing the relative locations of each angle and Doppler in the transformation matrix. Simulation results demonstrate that these new structures are more data-efficient as well as more computationally efficient, and 4 channels can achieve similar performance to 9 channels in the original JDL method. Moreover, they are more tolerant to the non-ideal real environment [C1421]

"Realization of an airborne radar parallel signal processing system"

In order to fulfil real time signal processing tasks such as clutter rejection, moving target detection (MTD) and constant false alarm rate (CFAR) control in airborne radar, an airborne radar parallel signal processing system (ARPS2) is proposed with DSP chips as its kernel processing nodes. The DSP chips are used with parallel architecture. Each node has its private input and output memory. It adopts several parallel techniques, such as parallel storage, parallel processing, parallel code loading and parallel data organization to achieve high efficiency. It has a simple structure, excellent flexibility and easiness in developing. ARPS2 is going to be applied to an airborne radar. It can also be applied to perform high-speed real time signal processing algorithms in other kinds of radar [C1422]

"Frequency bandpass disparity of space-time adaptive array system"

The problem of inevitable frequency bandpass disparity (FBD) for an adaptive array system in an actual non-uniformity circumstance is researched in this paper. From different forms of characteristic analysis, the frames of the eigenvalue and power spectrum are developed, expressions of the adaptive filter characteristics and system improvement factor are also obtained. Such works are confirmed by computer simulation and have provided several feasible references in performance improvement for adaptive array system in circumstances of nonuniformity [C1423]

"Direct data domain STAP algorithm for airborne radar applications"

STAP has been widely studied for airborne radar as an approach to adaptively detect small target competing with ground clutter. Non-homogeneous interference is currently an important aspect of STAP. The discrete non-homogenates due to strong interference or target separating from the clutter ridge accounts for much of the degradation in urban and spiky clutter scenarios. The use of adaptive weights with the hybrid algorithm is widely applicable to discrete non-homogeneity problems, which is a hybridization of a two-dimensional non-statistical method with statistically based methods. This paper presents a new direct data domain processor with a prefilter attenuating clutter to strengthen suppression for discrete non-homogeneous interference. The desirable performance of STAP to discrete non-homogeneous interference is observed [C1424]

"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 [C1425]

"PEOD: Pade estimated optimum (radar) detector"

An expression for the optimum non-Gaussian radar detector is derived from the non-Gaussian SIRP model (spherically invariant random process) clutter and a Pade approximation of the characteristic function of the SIRP. The SIRP model is used to perform coherent detection and to modelize the non-Gaussian clutter as a complex Gaussian process whose variance is itself a positive random variable (r.v.). The probability density function (PDF) of the variance characterizes the statistics of the STEP and after performing a Pade approximation of this PDF from reference clutter cells we derive the so-railed Pade estimated optimum (radar) detector (PEOD) without any knowledge about the statistics of the clutter. We evaluate PEOD performance for an unknown target signal embedded in K-distributed clutter and compare it with optimum detector performance (optimum in particular clutter statistics such as Optimum K Detector-OKD-in K-distributed clutter) [C1426]

"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 [C1427]

"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 [C1428]

"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 [C1429]

"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 [C1430]

"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 [C1431]

"Experimental results for adaptive radar imaging in a wide angular sector"

We investigate experimentally an adaptive imaging approach, namely that of a synthetic wideband, stepped CW transmitter and a multichannel adaptive array for receiving backscattered energy from short range objects in a full +/-90 degree field of view. The method is a hybrid one, using conventional Fourier processing for range and is adaptive in angle. The 12-element linear array that was constructed is able to form an image in range and angle without Doppler information, and was tested with targets embedded in natural background clutter. The results show how background clutter affects the angular resolution of the array due to the increase in rank of the signal-plus-clutter covariance matrix, whereas at the same time the rank of this matrix is reduced for closely spaced scatterers due to signal coherence. In addition to investigating some known angular enhancement methods, we propose a method to enhance angular resolution in the presence of clutter by a projection, which seeks to reduce the received signal to a lower rank approximation, without using eigendecomposition, thus having an implementation advantage. This method allows more control over the angular resolution and the

background clutter level. Computer simulations as well as the experimental results are presented [C1432]

"Radar imaging of ground moving targets"

We analyze the effect of target motion on synthetic aperture radar images and discuss how a multi-aperture radar can detect, focus and relocate moving targets in clutter. AN/APY-6 radar data is used for analyzing the radar imaging of ground moving targets. Some applications of the time-frequency transform to detect and focus moving targets are also discussed [C1433]

"Filters for polarimetric calibration of UWB SAR imagery"

Polarimetric synthetic aperture radar (SAR) imagery is susceptible to degradation due to non-ideal responses in antennas and other hardware. Image corruption is especially serious in SAR operating over ultra-wide bandwidths (UWB) and imaging over wide angles, as the system response becomes a complicated function of angle and frequency. The usual approach to removing the system response from measured UWB SAR images involves operations in the two-dimensional spatial frequency domain of the imagery. We show that correction can also be performed by convolving the polarimetric images with two-dimensional polarimetric calibration filters (PCF). When compared to the frequency domain procedure, filtering offers improved calibration on extended-area targets, lower sidelobe noise, and computational savings. PCF can be synthesized from knowledge of the system response, or by an adaptive equalization technique that uses clutter returns to generate filters to correct for leakage, or crosstalk, between channels [C1434]

"Clutter suppression in radar by quasi-continuous complex signal and processing algorithm structure optimization"

The synthesis algorithm of a pair of signal-linked filters for navigational radars with one antenna using a complex amplitude-phase modulated waveform of long duration with coherent processing in the receiver is considered. A harmful influence of the ambiguity function (AF) sidelobes on target detection and parameter measurement is a significant obstacle to using the long pulse duration complex modulated waveform in marine radars. We discuss waveforms and linked processing for clutter suppression by means of AF sidelobe reduction. Some relationships for the quasi-continuous complex signal synthesis of amplitude-phase modulated waveform (APW) are given. The received signals are processed by a mismatch filter. The synthesis criterion of the mismatch filter structure was a root mean square minimization of the output signal sidelobe level. The computer synthesis software of the quasi-optimum mismatch processing structure has been developed. We give some examples of the waveform and mismatch algorithms of their professing which could be used in marine and coastal radars for surveillance of surface targets and navigation [C1435]

"Best management of FM waveform by a missile-borne pulsed Doppler radar during high-manoeuvring target tracking in strong clutter environment"

Referring to the application of missile-borne pulsed Doppler radars, the use of a radiofrequency HPRF-FM seeker, having a monopulse tracking processing, is considered in scenarios with a low altitude flying high-manoeuvring target. During target tracking the seeker has to solve the situations when the clutter signal occupies the target frequency positions and tracking can be lost. The algorithm that is presented shows how to dynamically choose an optimum FM factor, so to reduce clutter disturbing effects and to maintain a stable target tracking [C1436]

"Statistics of monopulse measurements of Rayleigh targets in the presence of specular and diffuse multipath"

In tracking of low-elevation targets with a monopulse radar, the presence of reflections from the sea surface causes severe errors in the direction-of-arrival (DOA) measurements of the target. Since the target echoes that are received directly and via the sea surface are unresolved in time and frequency, tracking targets in the presence of sea-surface induced multipath is a special case of tracking unresolved targets. The sea-surface reflection is modeled by a specular (coherent) component and a diffuse (noncoherent) component. The probability density function (pdf) of the measured amplitude of the sum signal and the amplitude-conditioned pdf of the in-phase and quadrature monopulse ratios are given for low-elevation, Rayleigh targets in the presence of sea-surface induced multipath. The means and variances of the monopulse ratios are used to illustrate the effects of diffuse multipath for a notional S-band radar [C1437]

"Bistatic reflectivity measurements at X, Ku, Ka and W-band frequencies"

Data that realistically represents the phenomenology of bistatic reflectivity is essential to the design of radar

systems intended to sense land based targets and low flying aircraft. A large database exists describing the response of X-band monostatic reflectivity, and limited data is available for X-band bistatic reflectivity. However, there is little data in the literature describing bistatic reflectivity at Ku-band or at millimeter wave bands. Radar designers often resort to either scaling, or using directly, the bistatic reflectivity of X-band to model this environment at the other frequencies. A need exists to further characterize clutter phenomenology in order to design and project the performance of current and future systems. This paper provides an overview of X, Ku, Ka and W-Band bistatic measurements made at the Research Development and Engineering Center at Redstone Arsenal. The data collection includes both on-axis (zero degrees) and off-axis (10 and 30 degrees) measurements of the bistatic reflectivity response. The radar instrumentation design for the data collection is briefly described. A summary of the reflectivity results from smooth sand terrain is presented, along with preliminary modeling and statistical analysis. This work has application to tactical missile systems that must complete their engagements at low altitudes in a clutter environment [C1438]

"Integration of Bayes detection and target tracking in real clutter image sequences"

We present an optimal Bayesian algorithm for integrated, multiframe detection and tracking of dim targets that move randomly in spatially correlated, cluttered image sequences. The algorithm consists of a multiframe minimum probability of error Bayes detector integrated with a multiframe maximum a posteriori (MAP) position estimator. The design of the detector/tracker incorporates the models for target signature, target motion, and clutter; it uses recursive spatio-temporal processing across all available frames to make detection decisions and to generate position estimates. A simulation with an artificial target template added to a real clutter background shows that the proposed algorithm outperforms the association of a standard single frame image correlator and a linearized Kalman-Bucy filter in a scenario of heavy clutter [C1439]

"Test results from the AN/APY-6 SAR/GMTI surveillance, tracking and targeting radar"

The AN/APY-6 is an X-band radar developed by Northrop Grumman under ONR (Office of Naval Research) sponsorship. It was developed to provide all-speed target detection, location, tracking, imaging and exploitation. It was installed in a USA Navy NP-3 aircraft in July 1999 and continues to undergo testing and demonstration in the NP-3. This paper presents test results in the form of SAR, GMTI and tracking imagery obtained from programs in which the NP-3 has participated. These include the DARPA Affordable Moving & Stationary Target Exploitation (AMSTE) GMTI precision location program and a number of USN fleet battle exercises (FBE) and the NATO Clean Hunter 2000 exercises [C1440]

"A spectral approach to image-enhanced moving target radar detection"

A difficult problem with ground moving target radar (GMTI) detection is how to consistently 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 change in vegetation, roads, buildings, and seasonal variation. We propose to use synthetic aperture radar (SAR) 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 accurately match GMTI clutter with the geographically registered SAR imagery for consistent moving target detection through clutter boundary areas [C1441]

"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 [C1442]

"Adaptation to the clutter environment by airborne maritime surveillance radars"

Airborne maritime surveillance radars must detect small targets against a background of sea clutter whilst maintaining surveillance over a large area of sea. This task is very demanding and requires the radar to dynamically adapt to the local environment in order to obtain the best possible detection sensitivity. An aircraft flying at, say 3000 ft would be able to observe an area of sea of about 49,000 km, with a range to the horizon of about 124 km. Over this area, the clutter characteristics observed the radar will be continuously changing as a function of range and look direction. These characteristics will vary in a manner dependent on the prevailing

conditions, the radar characteristics and the viewing geometry. In practice, the radar must cope with a very wide dynamic range of signal amplitude, with amplitude statistics varying from those of thermal noise to very spiky sea clutter and land. Continuous adaptation to this environment is required as a function of range and bearing. The dynamic behaviour of the radar as it adapts in this way is often a much more relevant measure of performance than more traditional static measures such as detection range. Methods used to adapt to the environment are surveyed in this paper, together with indications of how their dynamic behaviour can influence performance. [C1443]

"Fractal dimension as an indicator of track seduction"

A modern scanning radar is designed with sufficient sensitivity to detect small targets, and as a consequence will produce plot returns from many clutter objects. Much of the clutter, such as land clutter returns from large fixed objects, will produce a plot on almost every scan and algorithms may be designed to track and remove such clutter. However, many clutter sources such as sea or rain clutter produce plots having little or no correlation in position from scan to scan. If a track is seduced by such clutter plots, or if a false track starts within such an area of clutter, then the track may be maintained using random plots for some considerable time before failing to associate for sufficient scans to cause deletion. Indeed, the instability of the track will reduce the level of track smoothing, increase prediction error and open up association gates to make track maintenance more likely with each update. It is required to identify tracks that are maintained by random clutter; this paper shows that a measure of fractal dimension provides a suitable mechanism for identification. [C1444]

"Estimating the length of a radar shadow in shadow-feature-enhanced detection using a fuzzy system"

Shadow-feature-enhanced radar detection algorithms potentially allow the probability of target detection to be substantially increased when a target casts a radar shadow across a region of clutter beyond it. However, when the length of the radar shadow is not correctly known, much of the potential performance gain may be lost. We demonstrate a method for estimating the length of the radar shadow using a simple fuzzy system. We apply the shadow length estimation to the shadow-feature-enhanced maximum-likelihood constant false alarm rate (ML-CFAR) detector, showing that its performance can be greatly improved when the shadow length is not known a priori [C1445]

"Clutter tuning for bistatic clutter control"

A radar modeling and simulation tool known as RLSTAP is used to model a bistatic clutter tuning scenario. The transmit system and the receive system “circle” the ground patch where the target lies in opposite senses so the Doppler shift due to the motion of the transmit (Tx) system is cancelled by an equal and opposite Doppler shift due to the motion of the receive (Rx) system. Key results are presented for this case, as well as for various imperfect clutter tuning cases and a monostatic case [C1446]

"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 [C1447]

"Development of a digital array radar (DAR)"

Twenty-first century littoral and open-sea missions present USA Navy (USN) shipboard-radar systems with the challenge of detecting small targets in severe clutter and against multiple sources of interference. In fiscal year 2000 (FY00), the Office of Naval Research (ONR) sponsored a program to develop an active array radar that includes a digital beamforming (DBF) architecture. The DBF radar system has the potential for improved time-energy management, improved signal-to-clutter (S/C) ratios, improved reliability and reduced life-cycle costs. This paper summarizes the latest developments of the program during FY00 [C1448]

"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 [C1449]

"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 [C1450]

"New techniques for radar coherent range ambiguity resolution"

A new method of target coherent range ambiguity resolution is presented which is substantially different from previously proposed methods. The new target ranging eliminates the generation of target ghosts associated with most conventional techniques. A range-ambiguous radar with a medium to high pulse repetition frequency is assumed. Clutter is assumed to be present in multiple range intervals. The method utilizes constant frequency pulses that change phase pseudo-randomly from pulse to pulse. The phase progression of the received pulses are correlated with a bank of matched filters constructed using phase progressions representative of the different range intervals. Performance degradation of target detection using the pseudo-random phases is also examined. Target detection with strictly pseudo-random phases is found to degrade in comparison to the conventional constant phase methods. A technique that utilizes both constant phase and pseudo-random phases is proposed that performs both detection and target ranging well [C1451]

"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 [C1452]

"Shadow-feature-enhanced ML-CFAR detection for a Swerling 1 target in Weibull clutter"

This paper describes a shadow-feature-enhanced technique for the maximum-likelihood CFAR (ML-CFAR) detector, which is known to have a low CFAR loss. A general 15 dB signal-to-clutter ratio detection enhancement for a shadow length of 5 bins is obtained for a Swerling 1 target in Weibull clutter across a wide range of detection rates [C1453]

"Target tracking in an environment of nearly stationary and biased clutter"

The probabilistic data association (PDA) filter is considered for the tracking of a single target in an environment of randomly distributed clutters. Significant performance degradation occurs when the measurements originate from biased and nearly stationary clutters rather than a non-stationary nor non-biased one. We propose a modified PDA filter to achieve a successful tracking in such an environment. Simulation results demonstrate the feasibility of the proposed approach [C1454]

"Optimization of waveform and detection threshold for target tracking in clutter"

We formulate an optimization problem to obtain the combined sequence of waveform parameters (pulse amplitudes and lengths, and FM sweep rates) and detection thresholds for optimal target tracking in clutter. The optimal combined sequence minimizes a tracking performance index under a set of parameter constraints. The performance index can include the probability of track loss and the estimation accuracy. The effect of the false alarms and clutter interferences is taken into account in quantifying the performance index. A measurement model is developed based on the resolution cell in the delay-Doppler plane for a Gaussian pulse. Numerical experiments were performed to solve the optimization problem for several example problems [C1455]

"A study of judging target extinction in target tracking"

It is important for target tracking to judge targets' extinction in clutter environment. When a target is in clutter domain, the conventional method of sliding window detection cannot judge target extinction in the clutter domain appropriately, because it considers nothing but target existence probability in gate when a target is in clutter environment. To solve the problem, we propose a new target extinction judgement method which is determined by clutter density, target detection probability and target existence probability in gate. The effectiveness of the

proposed method is confirmed through computer simulation [C1456]

"Autofocus of multi-band, shallow-water synthetic aperture sonar imagery using shear-averaging"

A significant problem with Synthetic Aperture Sonar (SAS) imaging is the compensation of compensating for unknown errors in the sonar path trajectory. Unknown path errors in SAS have the effect of blurring and smearing the sea-floor image. Inertial navigation systems as used in Synthetic Aperture Radar (SAR), are not accurate enough for use in SAS. To deal with this problem, techniques for estimating and compensating the path errors from the gathered data (autofocus algorithms) have been developed. In this paper we present enhancements to an existing sonar autofocus algorithm presented in 1995 by Johnston et al. These enhancements help prevent the autofocus being biased by strong targets. Improvement in autofocus is significant and more apparent whenever an extended prominent target is far stronger than the surrounding seafloor clutter signal. We have tested both algorithms using and simulated data and the results are presented in this paper. In addition, we demonstrate the advantage of using single pass multiband imagery to improve the autofocus result [C1457]

"Statistical properties of L-band sea clutter measured with a polarimetric synthetic aperture radar"

The limiting factor affecting the performance of most airborne radar systems in detecting targets on or near the surface of the sea is return echoes from the sea surface or sea clutter. The objective of this paper is to provide an analysis of the statistics of Australian sea clutter for an L-band VV-polarised airborne radar system from sampled measured values. Polarimetric synthetic aperture radar (POLSAR) image of the North-West region of Australia, acquired in 1996 by the Jet Propulsion Laboratory (JPL) was used to study, the backscattered statistics of the sea surface. Using this POLSAR image, a number of different candidate distribution functions have been investigated, and their goodness-of-fit have been carried out using the Kolmogorov Smirnov goodness-of-fit test. The log-normal, Weibull and K-distributions have been applied to model the statistical properties of multi-look polarimetric SAR sea clutter. The K-distribution has been found to have good agreement with the observed sea clutter intensity distributions [C1458]

"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 [C1459]

"Reduction of cardinal effects in SAR imagery of densely populated urban areas by suppressing strong multiple returns"

In SAR imagery, strong returns from a group of man-made reflectors obscure adjacent target areas leading to a significant loss of information. The wide dynamic range of response levels from urban area is the source to degrade the SAR image characteristic. In this paper, we explore a way to interpret this problem in SAR imaging and propose a waveform design technique to improve target detection performance [C1460]

"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 [C1461]

"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 [C1462]

"Wideband coherent airborne radar systems: performances for moving target detection"

In this paper, the main advantages and limitations of unambiguous instantaneous wideband (10%) coherent radar systems for air-ground and air-air applications are analysed in detail, and validated through simulations of targets in realistic clutter [C1463]

"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 [C1464]

"Preparing the Joint Multi-sensor Mine-signatures project database for data fusion"

The Joint Multi-sensor Mine-signatures (MsMs) project was started in the year 2000 and has as its main goal to organize and execute an experimental campaign for collecting data of buried land-mines with multiple sensors. These data sets are being made widely available to researchers and developers working amongst else on sensor fusion, and signal processing for improved detection and identification of land-mines. The. outdoor test facility (6Ч80 m) of the Joint Research Centre (JRC) of the European Commission, located at Ispra (Italy), houses the test minefield. Six test strips of 6Ч6 m consisting of different soil types (cluttered grassy terrain, loamy soil, sandy soil, clay soil, soil with high content of organic matter and ferromagnetic soil) are complemented with one reference test strip of 6Ч6 m consisting of pure sand. The list of objects buried in the minefield includes mine simulants of three different dimensions with either a low or a high metal content, reference targets for position referencing and calibration checking, and clutter objects including empty bullet cartridges, metal cans, barbed wire, stones, wood, plastic boxes, etc. This test minefield is going to be left intact for a long period, in order to be able to perform multiple runs on it. For the test campaign of the year 2000, the core sensors were a metal detector a ground penetrating radar, a microwave radiometer and several thermal infrared imagers. The first data sets are in the process of being released right now. This paper aims to prepare the first results to be obtained by fusing the data coming from these different sensors, by presenting the available datasets [C1465]

"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 [C1466]

"Adaptive radar clutter suppression"

The clutter return presents a severe problem in target detection for radar systems. Conventional radar systems assume the clutter is stationary, with energy concentrated in the low frequency domain. To minimize the effect of clutter, radar systems use a fixed high pass filter (HPF) to eliminate the clutter. When the target Doppler frequency is below the cutoff frequency of the high pass filter, or the clutter energy does not concentrate on the low frequency domain, the performance of radar system is severely degraded. This paper proposes an adaptive clutter suppression scheme. This scheme provides more efficient clutter suppression for non-stationary clutter and provides the ability to detect a slow moving target. The computer simulation is presented to compare the performance of this adaptive clutter suppression technique and the fixed clutter suppression filter [C1467]

"Space based GMTI using scanned pattern interferometric radar (SPIR)"

A method of performing space based Ground Moving Target Indication (GMTI) using radar interferometric processing is presented. The algorithm, referred to as Scanned Pattern Interferometric Radar (SPIR), uses the high angular variability of a sparse array Point Spread Function (PSF) to collect sufficient data from the signal return that the clutter and targets can be separated without an a priori assumption of the clutter statistics. It is shown that clutter within the main lobe of the individual aperture pattern can indeed be separated from the

targets, using the deterministic geometric relationship between observation direction and clutter Doppler shift. If the computational domain is extended to the side lobes of the gain pattern, clutter entering through these lobes can also be extracted. Constraints on the cluster geometry are derived from the invertibility of the PSF matrix [C1468]

"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 [C1469]

"Determining the importance of learning the underlying dynamics of sea clutter for radar target detection"

Existing evidence for and against sea clutter being chaotic and nonlinearly predictable is briefly discussed. Despite the uncertainty surrounding the chaotic nature of sea clutter, and its nonlinear predictability, the purpose of this paper is to examine what the best design criterion is for a nonlinear predictor which is to be used to detect targets against clutter which is known to be chaotic: mean square error performance or capturing the chaotic clutter's underlying dynamics. Single pulse detection analysis using a Swerling I target and chaotic "clutter" is carried out using predictor-based detectors in an attempt to determine which criterion is most suitable. The predictor detectors are compared with standard detection strategies [C1470]

"A numerical waveform design approach to decorrelate target and noise"

Traditional radar detection relies on predefined models for assessment of probability of detection and probability of false alarm. These models assume a target uncorrelated with clutter or other sources of interference. This assumption concerning decorrelation between the target and interference is not strictly true. We propose an iterative approach to design “optimal” waveforms that maximally decorrelate target and clutter returns while still keeping target signal-to-interference-plus-noise ratios (SINR) levels maximized [C1471]

"MFR-IRST integration in the naval environment"

A low elevation threat can potentially exploit degradations in radar performance on naval platforms caused by multipath effects and sea clutter. Particularly in littoral environments and when electronic countermeasures are deployed, the use of radar with dissimilar (passive) sensors promises significant improvements in target detection and tracking capability. This paper provides an insight into a research project that has investigated the interactive integration of the Multifunction Electronically Scanned Adaptive Radar (MESAR2) and infrared search-and-track (IRST) sensor, based on the Air Defence Alerting Device, in a technology demonstrator trials programme. The sensor integration was achieved using the sensor fusion and tracking system known as TOTS (Target Oriented Tracking System) [C1472]

"Modeling and simulation for Sensor Craft multi-mission radar"

The objective of this paper is to review the tools available for modeling and simulating the Sensor Craft radar system concept and assess the challenging role and potential for STAP processing to support its intended missions in severe clutter. Airborne surveillance radar systems such as those proposed for Sensor Craft, will operate in a severe and dynamic interference environment. This interference is a sum of clutter, electronic counter measures (ECM), electromagnetic interference (EMI), and noise. The ability to detect weak airborne and ground targets requires the suppression of interference in real time. STAP techniques offer the promise of superior interference suppression capability. Extensive research into STAP for the AMTI mission, i.e. high radial velocity targets competing with clutter from the antenna sidelobes, has proven its superiority over non-adaptive techniques. Looking to the future, the advantages of STAP for the AMTI mission needs to be extended to GMTI, i.e., slow targets competing with clutter from the antenna main beam [C1473]

"Intelligent compression of SAR imagery using multiresolution Markov models"

We present a 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 utilized to discriminate between target regions and natural clutter. Based upon the detected target regions, we apply less compression to targets, and more compression to background data. This methodology preserves relevant features of targets for further analysis, and preserves the background only to the extent of providing contextual information. The resulting system dramatically reduces the bandwidth/storage requirements of the digital SAR imagery, while preserving the target-specific utility of the imagery [C1474]

"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 [C1475]

"A wavelet packet basis optimization approach to radar waveform design"

We describe the process of convolving a transmitted wide bandwidth chirp signal with a simulated target and then show how the result of this convolution can be decomposed using a basis optimization approach algorithm. We then show how the wavelet packet basis set can prioritize the bandwidth in the chirp signal to those frequencies that represent the target while removing other frequencies that might contain clutter and noise. Finally we compare the resulting radar signal to the signal not prioritized by the basis optimization and show improvements in the detection performance of the target at the reduced bandwidth [C1476]

"An overview of advanced processing techniques for RCS measurements"

For the last ten years, VSD (formerly ERIM International) has had the opportunity to work with several government and industry RCS ranges to develop an intimate understanding of the errors that can occur in making RCS measurements of today's sophisticated targets. This has led to the successful development and demonstration of a variety of advanced processing techniques (APTs) to improve the quality and utility of both indoor and outdoor RCS/ISAR data. These include algorithms for removal of clutter, RFI, and target-support contamination (including interactions), prediction of far field RCS from near field measurements, suppression of multipath contamination, and extraction of scattering features. Several of these are summarized in a table. A discussion and examples of each are also provided [C1477]

"An advanced STAP implementation for surveillance radar systems"

Space-time adaptive processing (STAP) has emerged as a key technology for improving the performance of radar systems required to operate in the presence of severe and dynamic interference which generally includes clutter as well as jamming. While the theory of optimum STAP is well known, practical issues, such as interference heterogeneity, finite sample support, mismatched signal models and computational load, need to be overcome when it comes to implementing STAP in operational radar systems. This paper proposes an advanced STAP formulation which addresses important issues facing practical implementation and then tailors this general formulation for the case of interference rejection in over-the-horizon (OTH) radar to evaluate experimentally its target detection and localisation performance [C1478]

"Signal processing techniques for clutter parameters estimation and clutter removal in GPR data for landmine detection"

Ground penetrating radar (GPR) has become widely accepted as a major technique for subsurface investigations, mainly in civil engineering. Considerable efforts are put in the development of GPR systems for the detection of shallow buried landmines. However, the GPR performs inadequately due to clutter, which dominates the data and obscures the mine information. The clutter varies with surface roughness and soil conditions and lead to uncertainty in the measurements. It is therefore necessary to overcome these surrounding effects when processing GPR data for detecting small, shallow buried objects. We present improved signal processing techniques which can be used to reduce the clutter through data preprocessing. Several approaches are proposed for the GPR clutter reduction techniques, most of them model the clutter statistically. The proposed clutter reduction technique models the clutter using parametric modeling. The clutter contained in the measurements is treated as an ARMA model. The advantage of such approach lies therein that once the clutter is satisfactorily known, any target will show up as a small anomaly in against the known clutter background. This method suggests that the clutter shows a certain amount of correlation. Experimentally it is shown that the

dominant interference in GPR data is correlated clutter, i.e., interference, which has a large correlation coefficient for tags greater than zero. However, the clutter environment cannot be considered completely stationary. An ideal filter would then be an adaptive filter, which estimates the slowly varying local clutter parameters, all the time ignoring the small parameter jumps caused by the buried targets to be detected. Kalman filtering is used for the estimation of the clutter parameters in the presence of random noise, detects jumps that occur at unknown points in time, and provides estimates of the new parameter values, without altering the target return [C1479]

"Fully-polarimetric ground penetrating radar application"

The ground penetrating radar (GPR) has broad applications in the fields of geology, civil engineering, archeology and military . It is usually used as a non-destructive inspection sensor for monitoring, inspecting and characterizing obscured objects by means of electromagnetic radiation, propagation and scattering. Unlike radars operated in the open air, the medium between the GPR and the target usually determines the performance instead of the target and the radar. The sensitivity of GPR applications is limited by clutter instead of noise or radar system. The increasing needs for better detection and discrimination capability have driven GPR users and researches to investigate the pattern and polarization characteristics of the GPR antenna designs. New GPR antenna designs were developed to provide improved sensitivity and stability. An example of fully-polarimetric GPR application that has not been seen previously is presented. Some important issues such as clutter sources, radiation patterns and propagation efficiency faced by the most GPR applications are also discussed [C1480]

"Bayesian optimum radar detector in non-Gaussian noise"

A theoretical expression of the optimum nonGaussian radar detector is derived from the non-Gaussian SIRP model (spherically invariant random process) clutter and a Bayesian estimator of the characteristic function of the SIRP. The SIRP model is used to perform coherent detection and to model the clutter as a complex Gaussian process whose variance is itself a positive random variable (r.v.). The PDF of the variance characterizes the statistics of the SIRP and after performing a Bayesian estimation of this PDF from reference clutter cells we derive the Bayesian optimum radar detector (BORD) and its statistical asymptotic form without any knowledge about the statistics of the clutter. We evaluate BORD performance for an unknown target signal embedded in K-distributed clutter and compare with optimum detectors performance (such as optimum K detector-OKD-in K-distributed clutter). [C1481]

"Target-aided compression of SAR imagery for transmission over noisy wireless channels"

We present a target-aided, error-resilient 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 utilized to discriminate between target regions and natural clutter. Based upon the detected target regions, we apply less compression to targets, and more compression to background data. This methodology preserves relevant features of targets for further analysis, and preserves the background only to the extent of providing contextual information. The resilience to channel errors is obtained without the use of channel coding or error concealment techniques. The robust nature of the coder eliminates the appearance of impulsive channel-error-induced artifacts in the decoded imagery, 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 the digital SAR imagery, and is shown to provide outstanding performance in adverse channel conditions. [C1482]

"Suppression of the sea clutter in marine radar system"

The purpose of this paper is to analyze the radar echo signal data in a marine radar system, and we tackle the problem of the suppression of sea clutter on a marine radar display by using the wavelet transform, which gives optimum cut-off frequency with time (distance). Also, we propose a signal to clutter ratio (SCR) to evaluate our method and optimum cut-off wavelet coefficients. The experiment was carried out by using the X band radar (3 cm wave length) of the marine practice center of our school in Awaji Island. In short, the collection of the radar echo signal data reflected from floats, a test buoy and a ship was carried out in smooth and moderate sea conditions, and target distances 0.13, 0.24 and 1.17 nautical miles. The received signals are processed by an 8 bit, 120 MHz A/D converter and stored in the 8 Mbytes memory of our system. [C1483]

"Clutter adaptive tracking of multiaspect targets in IRAR imagery"

We present in this paper a clutter adaptive, multiframe Bayesian algorithm for joint detection and tracking of a multiaspect target in cluttered image sequences. The target template is randomly translated, rotated, scaled and sheared from frame to frame. Tracking performance studies with a sequence generated from real data infrared

airborne radar (IRAR) imagery show a reduction in the steady-state position estimation error and in the target acquisition time when the Bayes detector/tracker is compared to the association of a bank of matched filter detectors and a linearized Kalman-Bucy tracker. [C1484]

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