Государственное образовательное учреждение
высшего профессионального образования
**«Томский государственный университет
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ТЕМАТИЧЕСКИЙ РЕФЕРАТИВНЫЙ СБОРНИК № 41-2/1

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

Публикации в трудах конференций

Источник: *Digital Library IEEEXplore*
Язык: *английский*
Глубина поиска: *2007 – 2011 гг.*
Дата формирования: *март 2011 г.*
Составитель: *В.И. Карнышев*

Томск – 2011

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"3D Multiple Maneuvering Targets Tracking in Active and Passive Radar Composite Guidance"

Active and passive radar composite guidance has been developed into a promising technology for target tracking in the electronic counter measurements (ECM) environment. Based on the technology, this paper investigates the problem of 3D multiple maneuvering targets tracking in the presence of sea clutter and jamming. We present a set of algorithms and establish a complete tracking system composed of measurement generation, data association, track initiation, track filtering, track management, track correlation and missile guidance. The simulation results indicate that the proposed algorithms can offer significant tracking and anti-jamming performance. The ideas and methods presented will also bear important significance for developing similar tracking systems in practice. [C1]

"A Novel Image Based Multi-Channel SAR-GMTI Algorithm"

A novel three-channel SAR-GMTI algorithm based on the compressed image rather than the azimuth-uncompressed raw data is proposed, which employs the classical DPCA technique and FrFT. The chirp characteristics of DPCA signal of the moving target in the SAR image domain is investigated for the first time in this paper. The scheme introduce FrFT to detect the moving target and estimate the position, velocity and radial acceleration, which lead to a more overall description on motion parameters than that of the majority of estimation algorithms. The excellent anti-noise ability of FrFT and the ideal clutter cancellation of DPCA technique results in great GMTI performance during a clutter-rich and low SNR environment. The simulation results indicate the efficiency and availability of the novel algorithm. [C2]

"A Novel Polarimetric CFAR Target Detection Method"

A new polarimetric synthetic aperture radar (PolSAR) image CFAR target detector is proposed in this paper. By introducing the inverse Gamma distribution which is extensively used in modeling, the distribution of polarimetric matched filter (PMF) metric, denoted as P_G0, is derived on the product model; Furthermore, a fast and exact parameter estimation method of P_G0distribution is presented using the "second kind statistics" based on the Mellin transform; Finally the formula of the CFAR detection threshold is deduced, and the target detection using the proposed constant alarm rate (CFAR) detector is performed on the RADARSAT-2 PolSAR data. Experimental results demonstrate the great efficiency of the P_G distribution and the corresponding parameter estimation method in data fitting of areas with different degree of homogeneity. Moreover, the successive CFAR detector can successfully complete the automatic target detection with low false alarm rate and high detection rate in complex clutter environment where the homogeneity of terrain varies sharply. [C3]

"Ship Detection after Removal of Ambiguities by Using PolSAR Images"

Ambiguities in SAR image are very common phenomena. For maritime applications, as the high intensities of the ambiguities in low radar backscatter background of sea environments, they can be mistaken as targets and cause false alarms in ship detection. Thus, through the analysis of polarimetric characteristics of ships and ambiguities, we propose a ship detection method which applies the eigenvalue to differentiating the ship target and azimuth ambiguities. One set of Cband JPL AIRSAR polarimetric data covered Kojimawan Bay, Japan has been chosen to evaluate the method that can effectively remove false alarms caused by the azimuth ambiguities. [C4]

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

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

more efficient than only utilizing wavelet decomposition in a big clutter background. [C5]

"Considerations in measuring vital signs cross section with Doppler radar"

This paper describes the different considerations and challenges in measuring human cardiopulmonary radar cross section (RCS). The effect of clutter on the received signal is explained as well as the importance of preserving baseband dc content for valid readings. The center estimation algorithm with dc-cancellation is presented as a solution to restore dc content in the baseband signals and to exclude clutter contribution. The far-field conditions for the target range are revisited. By modeling the human torso as a half-cylinder and assuming unity reflectivity, the ratio of the RCS of the back of the torso with respect to the front is a function of wavelength. At 2.4 GHz and for a chest breadth of 30 cm, the back is expected to have an RCS that is 10 times that of the front while the RCS of the side is expected to be 4 times smaller. [C6]

"Implementation of Adaptive FIR Filter for Pulse Doppler Radar"

Digital Signal Processing (DSP) systems involve a wide spectrum of DSP algorithms and their realizations are often accelerated by use of novel VLSI design techniques. Now-a-days various DSP systems are implemented on a variety of programmable signal processors or on application specific VLSI chips. This paper presents the design of Adaptive Finite Impulse Response (FIR) filter for moving target detection in various clutter conditions in Radar Receiver. The design uses pipelined COordinate Rotation DIgital Computer (CORDIC) unit and pipelined multiplier to get high system throughput and reduced latency in each of the pipelined stage. Saving area on silicon substrate is essential to the design of any pipelined CORDIC. The area reduction in proposed design can be achieved through optimization in the number of micro rotations. For better adaptation and performance of Adaptive Filters and to minimize quantization error, the numbers of iterations are also optimized. [C7]

"Moving target estimation using distributed MIMO radar in non-homogeneous clutter"

In this paper, we consider parameter estimation for moving target detection using a distributed MIMO radar, where the multi-static transmit-receive configuration causes non-homogeneous clutter. Specifically, the clutter power for the same resolution cell may vary significantly from one transmit-receive pair to another, due to azimuth-selective backscattering. Moreover, the clutter power may also vary across resolution cells in the neighborhood of the test cell. In this work, the non-homogeneous clutter is modeled using a subspace approach, whereby the subspace is spanned by a few Fourier bases and the non-homogeneity of the clutter is captured by coefficients that vary with different transmit-receive pairs and/or different resolution cells. The choice of the Fourier bases is based the fact that the clutter Doppler spectrum is bandlimited. We develop a maximum likelihood (ML) estimator for the parameters associated with the target and clutter. The Cramer-Rao bound (CRB) for velocity estimation is also derived. Numerical results show that the proposed estimator outperforms an alternative solution that ignores the non-homogeneous nature of the clutter. [C8]

"Performance analysis in heterogenous environment and implementation on DSP processor of a GOWMAX CFAR detector"

In this paper we present the results of performance analysis of a GOWMAX CFAR detector in non homogenous environment. The study is made for radar targets of Swerling I type embedded in white Gaussian noise. The results are presented in terms of probability of detection and false alarm. Also we expose the algorithm considered and the results obtained for its implementation on DSK 6711 card using a DSP TM320C6711 processor. [C9]

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

Performance estimation and comparative study of different kinds of time-frequency distributions (TFDs), especially Wigner-Ville distribution (WVD), as well as bispectrum-based distributions: Wigner-bispecrum (WBD), parametric (PBD) and non-parametric (NPBD) obtained by real non-stationary echosignal measuring in ground surveillance Doppler radar are considered for solving moving object recognition and classification problems. Automatic target recognition (ATR) performance has been examined by using information features contained both in the TFDs and cepstral coefficients. Experimental results performed by ground surveillance radar operating in millimeter wavelength for walking human, group of walking humans, bicyclist, vehicles and vegetation clutter show that bispectrum-based approach seems to be attractive tool for ATR systems comparing to the conventional energy-based approaches. [C10]

"Novel Space-Time Processing Method for Airborne SAR to Detect and Image the Slowly Moving

Targets"

In the paper the problem of the ground clutter rejection for airborne SAR is discussed. The features of space-time clutter filtering and clutter spectrum of airborne SAR imaging are analysed. It is pointed out that there exist some problems such as Doppler ambiguity and blind speed band expansion when STAP filtering is applied to the ground clutter cancellation. Aiming at the solving of difficulties in detecting and imaging the slowly moving target with single-channel airborne SAR, a new method suitable for multi-channel airborne SAR to detect and image the slowly moving target is proposed, which can effectively avoid the blind speed and Doppler ambiguity and keep the processed data rate lower. Computer simulation results show that this method is valid. Compared with other method for detecting and imaging the slowly moving targets, the improvement factor obtained by the proposed method is narrower than that. [C11]

"Ground target position estimation in passive location"

Ground target tracking is difficult and actual problem. Because of the high target density and maneuverability, high clutter, low visibility due to terrain masking, etc., ground target tracking presents unique challenges that does not present in tracking of other targets types. But many tracking approaches have been developed for air targets and they work poorly for ground targets tracking. This article includes research work results in radar position estimation for passive range-difference location. Radio source is stationary and performs circular scan. Transmitted signal is received in three points. But beside true measurements of time difference of arrival (TDOA) there are false measurements originated by clutter. Usually clutter measurements are modeled as independed identically distributed. But real experimental data processing shows that in crosscountry its distribution may be multimodal. Therefore standard tracking algorithms are not efficient in this situation. Multimodal distribution is caused by re-reflected signal from underlying terrain. Some ground objects re-reflect signal and imitate additional (false) targets. We propose special approach to decide position estimation problem in such high clutter environment and verify it on experimental data [C12]

"Diversity employment into target plus clutter SAR imaging using MIMO configuration"

Multiple Input Multiple Output (MIMO) configurations in radar systems provide architectural and performance advantage over conventional monostatic and bistatic systems due to the implicit diversity characteristics of any MIMO system. Various authors are individually addressed either of these diversities. This work aims at parameterizing all the three, spatial, frequency and waveform diversities and hence designing a new MIMO SAR system for high resolution achievement. This system is designed taking into account both target and clutter, as clutter background pollutes the images substantially. The parameterizations and hence the constraints obtained on the system architecture and transmit signal properties ensure high resolution and better performance over conventional SAR imaging systems. [C13]

"Design and implementation of a highly configurable low power robust signal processor for portable ground based "multiple scan rate" surveillance radar"

FPGA based realization of a highly configurable low-power robust signal processor for a portable ground-based multiple scan ratesurveillance radar is presented. Portability feature of the radar demands a compact radar system which should be able to detect low flying aerial targets against clutter/interference background. All requirements could be met in a FPGA-based design of a multi-channel signal processor to cater for low peak power large bandwidth waveforms, separate processing for special targets and an embedded softcore processor. Reliable self-test mechanisms-external as well as internal have been built into the signal processor for functional verification of entire radar system. [C14]

"Textile antenna for the multi-sensor (impulse GPR&EMI) subsurface detection system"

The performance of a planar elliptical dipole textile antenna for the multi-sensor (impulse GPR&EMI) subsurface detection system is investigated. This is a new application of textile antenna. The textile material of antenna does not create an EMI clutter comparing solid Cu material. The antenna characteristics of the proposed antenna in the multi-sensor head are measured and compared with the simulated ones. A buried target into soil, is successfully detected by the multi-sensor system with the usage of the textile antenna in the GPR sensor. [C15]

"A simulation tool for analysis of MTD algorithms employing STAP techniques"

The purpose of this work is development and program realization in MATLAB computational environment of a tool suitable for modeling and evaluating the performance of a pulse doppler MTD (Moving Target Detector) radar with LFM (Linear Frequency Modulated) signals employing STAP (Space Time Adaptive Processing) techniques. It supports numerical design choices with selectable system and signal processing parameters so

that different designs can be traded-off or optimized. This software tool is also able to simulate selectable target, clutter and jamming and thus particular scenarios of interest can be evaluated. The obtained results can be a good base for real time implementation. [C16]

"Wind turbines as distorting scattering objects for radar-clutter aspects and visibility"

Wind turbines WT are planned to be constructed often close to radar systems, e.g. air traffic control, air defense, weather radar. The WT are scatterers and may affect the radar operation in-acceptably. The WT are a clutter problem and are not false targets as sometimes treated if the WT are visible to the radar. Clutter characteristics are presented and discussed. [C17]

"A novel detection warning signal creation method for hand-held GPR applications"

In this paper a novel detection warning signal creation method is proposed for pulse Ground Penetrating Radar (GPR) data, especially for small non-metallic targets, in time domain. Background removal is applied to the data through a sliding window scheme and Target Energy Function (TEF) is obtained as correlation summation of consecutive A-scan signals. Then Auxiliary Detection Function (ADF) is defined and a novel automatic Detection Warning Signal (DWS) creation is applied. The proposed method has been tested specifically for a set of small sized dielectric targets which are not easily detectable. The results are promising as full detection performance and zero false alarm rate in original dataset. Moreover, it is obtained that the immunity of the proposed method against noise is very satisfactory. [C18]

"Background removal from GPR data using Eigenvalues"

A GPR radargram of an underground scan has reflections not only from the target but many unwanted objects known as clutters. Additionally, the signal is corrupted by the direct wave and coupling effect of the antennas and background noise. In order to successfully extract the target signature, these extra noise effects need to be eliminated. Though the clutters cannot be totally removed from the data, background removal techniques suppress their effect to quite an extent. Usually mean subtraction is used as a background removal technique but the results are just satisfactory and further improvements can be made. In this paper an Eigenvalue based background removal technique in collaboration with mean subtraction is presented. This proposed method decreases the effect of clutters and the output is much more refined. Even though this method takes slightly more time than the traditional background removal methods, the output eliminates major portion of the clutter therefore the segmentation and classification stages in an automated GPR data processing system would be much more efficient hence reducing the overall time consumption for near real time GPR data processing. The method has been implemented on a number of different data sets and the results indicate that the proposed method gives significant improvement in background removal over the existing background removal methods. [C19]

"An ultrawideband time reversal-based RADAR for microwave-range imaging in cluttered media"

This work presents a new RADAR prototype built for the purpose of imaging targets located in a cluttered environment. The system is capable of performing Phase Conjugation experiments in the ultrawideband [2-4] GHz. In addition, applying the D.O.R.T. method to the inter-element matrix allows us to selectively focus onto targets, hence reducing the clutter contribution. We aim to experimentally explore the use of this focusing wave into an inversion algorithm, in order to improve its robustness against noise. Before testing this idea, we show here the first results validating the prototype separately in the frame of selective focusing via the DORT method and of multistatic-multifrequency inversion. [C20]

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

In this paper, an ultra-wide band (UWB) through-the-wall radar (TWR) prototype is described, and experiments are performed on detecting human targets behind wall. An adaptive background subtraction method is applied to signal processing to reduce clutter and antenna couplings. Range-time histories of an adult male person behind wall are presented for different locomotion states such as standing, marking time, and walking along cross-range direction. [C21]

"Robust automatic target recognition using extra-trees"

In this paper, we describe a new automatic target recognition algorithm for classifying SAR images based on the PiXiT image classifier. It uses randomized sub-windows extraction and extremely randomized trees (extra-trees). This approach requires very little pre-processing of the images, thereby limiting the computational load. It was successfully tested on an extended version of the public standard MSTAR database, that includes targets of

interest, false targets, and background clutter. A misclassification rate of about three percent has been achieved. In this paper, we describe a new automatic target recognition algorithm for classifying SAR images based on the PiXiT image classifier. It uses randomized sub-windows extraction and extremely randomized trees (extra-trees). This approach requires very little pre-processing of the images, thereby limiting the computational load. It was successfully tested on an extended version of the public standard MSTAR database, that includes targets of interest, false targets, and background clutter. A misclassification rate of about three percent has been achieved. [C22]

"Multipath exploitationwith adaptivewaveform design for tracking in urban terrain"

We integrate multipath exploitation with adaptive waveform design in order to increase the tracking performance of a vehicle moving in urban terrain. Mitigation of both clutter and strong multipath returns can result in increased target detection. However, exploiting multiple bounces from obstacles such as buildings can be shown to increase radar coverage and scene visibility, especially in the absence of direct line-of-sight paths. For this purpose, we formulate the multipath propagation of an arbitrary number of specular bounces in urban terrain for three-dimensional motion. We then further exploit and optimize multipath returns by dynamically selecting the parameters of the transmitted waveform to minimize the predicted mean-squared tracking error. We demonstrate our proposed approach in a realistic urban environment by varying the type of measurement to include regions of obscuration and different number of multipath bounces. [C23]

"Fixed-point based autoregressive parameter estimation for space time adaptive processing"

Space time adaptive processing (STAP) is useful in radar processing to detect a target by filtering the clutter and the additive thermal noise. A derived version based on a multichannel autoregressive (M-AR) model of the clutter has the advantage of reducing the computational cost. Nevertheless, the estimation of the AR matrix parameters is a key issue because the clutter is not Gaussian in real cases. When dealing with an off-line solution, the multichannel least squares method (MLS) can be considered, but the estimation of the disturbance covariance matrix is required. In this paper, we suggest using the so-called fixed point method since it has "matrix- and texture-constant false alarm rate" property (matrix-CFAR and texture-CFAR) and it provides an unbiased and consistent estimate in a non-Gaussian case. A comparative study is then carried out between off-line M-AR based STAP methods and it points out the relevance of the solution we propose. [C24]

"Detection of dismounts using synthetic aperture radar"

This paper presents an approach to detect people, or dismounts, using synthetic aperture radar (SAR). This approach is compared qualitatively with ground moving target indication (GMTI) radar and then quantitative results are presented using a P-band single phase center SAR. It is demonstrated that SAR provides an excellent methodology to detect dismounts. [C25]

"Performance prediction of Firefinder radar using high fidelity simulation"

Thales Raytheon Systems' PC Simulation (PCS) tool allows a rapid simulated evaluation of Firefinder radar performance from a personal desktop computer. Firefinder radars are designed to track hostile rocket, artillery and mortar (RAM) projectiles in order to accurately estimate weapon ground location. The Firefinder tactical code is used within PCS. This design provides a low risk path to rapid prototyping and evaluation of candidate software changes. PCS is used to evaluate candidate software changes to the Firefinder. Candidate design changes which perform well in PCS testing require minimum system level checkout before being checked into the tactical software baseline. The PCS tool contains a simulation engine which reads program control information from input data files. The PCS tool also generates and maintains simulated targets and clutter, simulates the radar signal processing function, performs Monte-Carlo "batch" processing, produces complex target trajectories internally or from an input text file and creates simulation data recording files identical in format to those created by the actual radar. This paper summarizes the capabilities of the lastest PCS. [C26]

"Bat-inspired ultrasound tomography in air"

Classification of targets is of great interest to the radar and sonar community. The development of modern systems has resulted in a drive to improve automatic target recognition in order to be able to identify targets under all weather and clutter conditions. Echolocating mammals, such as bats, have an imperative to identify the targets they depend on for their survival and have evolved an excellent ability to detect, select, and attack prey even in the most challenging environments. They acquire multi perspective information as to construct an image of the target in the way a typical tomographic image is developed. In this paper ultrasound high range resolution profiles of a real scaled target are processed to exploit tomographic images at ultrasound frequencies in air. Results are discussed and related to the radar case. [C27]

"Advanced radar cross section clutter removal algorithms"

Producing good quality radar cross section (RCS) measurement data of a target is proportional to the extent of clutter mitigation. Although RCS measurements usually include clutter reduction methods, typically some level of clutter remains in the target data. In order to achieve maximum RCS data quality several computational clutter removal algorithms have been developed, each having strengths and weaknesses, which is the subject of this paper. There are three fundamental algorithms for computationally excising RCS clutter: 1. Coherent Background Subtraction 2. Image Edit Subtraction 3. Mean Subtraction Each clutter removal method is formulated, described, and demonstrated in the paper on actual target measurement data collected in a difficult field-based clutter environment. The paper furthermore demonstrates a novel composite subtraction approach using a combination of algorithms for improved clutter removal. [C28]

"Robust waveform design for MIMO radars"

The problem of robust waveform design for multiple-input, multiple-output radars equipped with widely-spaced antennas is addressed here. Robust design is needed as a number of parameters are unknown, e.g., the target scattering covariance matrix and, possibly, the clutter covariance matrix. A min-max approach is proposed, so that the code matrix is designed to minimize the worst-case cost (or equivalently maximize the corresponding figure of merit) under all possible target (or target and clutter) covariance matrices. Surprisingly, the same min-max solution applies to many commonly adopted performance measures, such as the average signal-to-clutter-plus-noise ratio, the mutual information between the received signal echoes and the unknown target response, and the approximation of the detection probability in the high- and low-signal regimes. [C29]

"Adaptive Threshold for Fast Signal Detection in Multi-target Tracking"

An adaptive threshold algorithm is used for frequency-shift keying (FSK) demodulation in multi-targets and radar communication system. The special algorithm is needed because of the radar burst signal in this system. The selection of the threshold is generally a tradeoff between the goals of maximizing the probability of detection while minimizing false alarm. It replies radar pulse immediately without carrier synchronization, so the threshold is calculated by the priori knowledge of the signal amplitudes. CIC filter can save resource and is used after first down-conversion, but its performance of detection is not as good as FIR filter. Simulation results show that the adaptive threshold algorithm can reduce the probabilities of miss detection and false alarm. [C30]

"Track-before-detect algorithm based on dynamic programming for multi-target tracking"

A new dynamic programming based track before detect (DP-TBD) algorithm is presented to detect and track multi-target when SNR is low and target number is unknown. The technique combines the possible target state estimation using PDA with standard DP-TBD algorithm. And with the assumption that one measurement can originate from one target or clutter, the track separation phenomenon can be minimized and the target number can be obtained. Since the like-ratio function is not included in the merit function, the new method can be used without the priori information of the noise. Simulation results reveal that the new DP-TBD method has good performance when detecting target number and recovering target trajectories. [C31]

"Through-wall radar imaging system utilizing a light-weight low-profile printed array"

An UWB through-wall imaging system is proposed based on a planar low profile aperture array operating from 0.9 GHz to 2.3 GHz. The goal is to provide a lightweight, fixed array to serve as an alternative to synthetic aperture radars (SAR) that require continuous array movement while collecting data. The proposed system consists of 12 dual-linear printed elements arranged within a triangular lattice, each forming a "flower" shape and backed by a ground plane. The array delivers half-space radiation with wideband performance, necessary for imaging applications. UWB capability is realized by suppressing grating lobes via the introduction of virtual phase centers interwoven within the actual array feeds. Several high resolution 3-D images (of a cluttered room) containing a few sparsely distributed targets are presented. These images are forged in a non-typical fashion, incorporating both coherent and non-coherent processes. Specifically, several coherent images are forged from various fixed aperture locations (referred to as "snapshot" locations) and appropriately combined to create a fused scene image. Future work to optimize image quality is discussed, including algorithms for resolution enhancement, clutter mitigation, and image fusion treatments. [C32]

"The Reverberating Chamber as emulator of radar ground clutter Doppler spectra"

The emulation of real scenarios is a topic of considerable interest in several radar applications especially for determining the performance of target detection against ground clutter. The development of new applications

calls for emulators able to physically reproduce real scenarios. This paper introduces a new employment of the Reverberating Chamber (RC) as emulator of radar ground clutter Doppler spectra. Experiments accomplished at the Universita di Napoli Parthenope (formerly Istituto Universitario Navale, IUN) show how by properly modulating the velocity of stirrers used for measurements, real scenarios, such as windblown vegetation under several wind speed conditions, can be emulated in RC. [C33]

"On the Approximation of the PDF of the Sum of Independent Generalized-K RVs by Another Generalized-K PDF with Applications to Distributed Antenna Systems"

The generalized-K (Gamma-Gamma) composite fading model has been proposed in the past to represent the statistics of the instantaneous power of target and clutter scattering in radar systems. Recently, this model was used in wireless communications as an alternative to the analytically intractable lognormal-based composite fading models. In this paper, a simple approach is proposed to approximate the probability density function of the sum of independent generalized-K random variables by another generalized-K one using the moment matching method. The numerical evaluations show that the proposed approximation of the sum distribution is sufficiently accurate for realistic scenarios in wireless channels. Furthermore, the applications of the obtained closed-form expressions to the performance analysis of distributed antenna systems are presented. [C34]

"An Adaptive Radar Detection for the Target in Clutter with Unknown Covariance Based on the PPPT"

In this paper we consider the problem of radar detect a fluctuating target in Gaussian clutter with unknown covariance. To this end we devise the detector based on the prior posterior ratio test (PPPT) criterion. The likelihood ratio is the prior-posterior PDF ratio of amplitude of the echo from the target. For the estimate of the unknown covariance of the clutter, We resort to the Maximum likelihood ration method, which means to minimize the posterior PDF of the amplitude of the echo. The simulation results show that the devised detector has a much better performance compared to the GLRT detector. [C35]

"Pulse Doppler radar waveforms"

Modern military airborne radars are highly sophisticated, multi-mode systems which are required to detect difficult targets in all aspects and over a large range/velocity detection space. There are particular difficulties associated with the airborne case such as the limited antenna aperture, high platform velocity and severe clutter levels which present difficult waveform design challenges. This tutorial will consider the design parameters of high pulse repetition frequency (PRF) and medium PRF waveforms commonly used in airborne pulse Doppler radar modes. The majority of this tutorial will be devoted to the issues concerning the selection of the number of PRFs and of the PRF values used in the medium PRF mode. PRF optimisation methods using evolutionary algorithms used by the author and his colleagues in a number of recent studies will be described. Examples will be given of airborne fire control radars, airborne early warning systems and active radar seekers used in anti-aircraft missiles. [C36]

"Design of an optimal radar signal waveform for a range-doppler spreading channel"

This paper deals with the optimal radar waveform design problem using the quadratically constraint quadratic programing (QCQP) in the narrowband signal echo to range-doppler extended target regime. The solution is obtained in the sense of signal to interference plus noise ratio(SINR) maximization with resolution and fixed transmit power constraints. The performance is compared with other conventional waveforms such as continuous wave (CW) pulse and linearly frequency modulated (LFM) pulse, in terms of resolution through ambiguity function. [C37]

"A Viterbi data association algorithm based on adaptive clutter density model"

There are many false tracks which are produced by large of non-uniform and non-stationary distributed false clutters in the OTHR target tracking. To solve this problem, an adaptive clutter model is introduced into the Viterbi data association algorithm, and on this basis an adaptive clutter model Viterbi data association (ACM-VDA) algorithm is put forward. Simulation results show that the number of false of ACM-VDA algorithm will be much less than that of VDA algorithm and VDA-AI algorithm. [C38]

"An entropy-based HRR detection strategy in compound Gaussian clutter with partially correlated texture"

This paper addresses the detection strategy of a single pulse for range-distributed targets. The background is assumed to be compound Gaussian-distributed clutter with partially correlated clutter. Firstly, the definition of

information entropy is introduced. Then, a new nonparametric detection strategy based on Renyi's quadratic entropy is proposed. Moreover, we present numerical results for the performance analysis of the newly proposed detector, which suggest that the entropy detector is robust and outperforms the conventional integrated detector. [C39]

"HRR detection theory in coherent Weibull clutter"

In this paper, we first introduce the definition of spherically invariant random vector (SIRV) and then give the representation of Weibull distribution by SIRV and two detection algorithms for Weibull clutter. In particular, the optimum detector is derived for the distributed target by the Neyman-Pearson (NP) criterion. Since the optimum NP detector is impossible to realize at the practical situations, we also introduce the GLRT-based adaptive detector. Finally, the numerical results show that the performance loss due to adaptively estimating the covariance matrix and texture component is negligible. [C40]

"Phase-modulated waveform design for the target detection in the presence of signal-dependent clutter"

The problem to be considered is a phase-modulated waveform design for detection of extended targets contaminated by signal-dependent clutter returns and additive channel noise in practical radar systems. We first introduce an optimal waveform design algorithm for extended target detection in a band-limited radar system by maximizing the signal-to-clutter-and-noise ratio (SCNR) at the output of the receiver, and give the analytical solution of the optimal signal energy spectral density (ESD). In order to make full use of the transmission power, a phase iterative algorithm to design the phase-modulated waveform with constant envelop is proposed, which is proven to be able to achieve a small SCNR loss by minimizing the mean-square spectral distance between the optimal waveform and the designed one. The results of extensive simulations illustrate that our approach provides less than 1 dB SCNR loss when the signal duration is greater than 1 μs. [C41]

"Two-Step Moving Target Detection Algorithm for Automotive 77 GHz FMCW Radar"

Today, 77GHz FMCW (Frequency Modulation Continuous Wave) radar sensors are used for automotive applications. In typical automotive radar, the target of interest is a moving target. Thus, to improve the detection probability and reduce the false alarm rate, an MTD(Moving Target Detection) algorithm should be required. This paper describes the proposed two-step MTD algorithm. The 1st MTD processing consists of a clutter cancellation step and a noise cancellation step. The two steps can cancel almost all clutter including stationary targets. However, clutter still remains among the interest beat frequencies detected during the 1st MTD and CFAR (Constant False Alarm) processing. Thus, in the 2nd MTD step, we remove the rest of the clutter with zero phase variation. [C42]

"Improvement of bearing-only tracking fusion strategy based on bionics with infrared sensor"

This paper* mainly studies some improvements of bearing-only data association with a single passive sensor to overcome the existing problems in the applications of JPDA approaches for bearing-only target locating and tracking. First, some adaptive modified rules are presented by deep analysis of JPDA application. This bearing-only association approach reduces computational complexity clearly under the premise of better tracking precision. Then, an effective track management strategy is designed. This strategy helps to set up a clear tracking level and manage historical the information of the target. The application of the proposed approach in a simulation and engineering system proves its effectiveness and practicability. [C43]

"Diagonal Loading for STAP and Its Performance Analysis"

For the moving target detection with space-time adaptive processing (STAP), the non- homogeneity will cause the covariance matrix estimation error, which substantially results in the STAP performance degradation. Diagonal loading has long been used as a means to improve the robustness of the spatial filter against mismatches in both the desired spatial signature and the spatial correlation matrix. In this paper, we consider the application of diagonal loading to improve the detection performance for STAP, especially for the covariance matrix mismatch (statistical mismatch) in STAP, namely, there is a mismatch between the actual covariance matrix of interest and the presumed one. For the diagonal loading, the key problem is the choice of the loading level, and the method for selecting the loading level is given, and the particular performance analysis indicates that the diagonal loading can improve the detection probability and the output signal-to-noise ratio. Numerical simulations attest the validity of the analysis. [C44]

"The impact of internal clutter motion on a sample matrix inversion space-time adaptive processing

algorithm and the GMTI minimum detectable velocity"

A MATLAB simulation was constructed to better study the effects of internal clutter motion on a notional X band monostatic airborne radar employing a ground moving target indicator (GMTI) algorithm to detect slow velocity targets of low radar cross section. A sample matrix inversion (SMI) fully adapted post-Doppler space-time processor (tapered and untapered) was utilized and the internal clutter motion model of Ward [1] was applied to the overall simulation. As one would expect, the untapered version yielded slightly better results but in all cases final minimum detectable velocities of about 1.0 meter/second were obtained. By judicious choice and implementation of a reduced rank/dimension algorithm, it should be possible to obtain similar MDV results. [C45]

"Target RCS exploitations in compressive sensing for through wall imaging"

In this paper, target radar cross-section (RCS) is utilized to improve the performance of compressive sensing (CS) when applied to sensing through wall based on RF modality. Using step-frequency SAR imaging, it is shown that the selection of frequencies emitted at each antenna position of the SAR system can benefit from a priori knowledge of the target RCS. Frequencies with high target response allow the CS performance to be more robust to noise and are able to reveal target presence in noisy and cluttered environments. [C46]

"ISAR imaging in sea clutter via compressive sensing"

We investigate the application of compressive sensing (CS) to inverse synthetic aperture radar (ISAR) imaging of moving targets. We present our results for a simulated target immersed in different levels of sea clutter. Comparison between traditional and CS approaches to ISAR imaging reveal that our based CS algorithm offers some advantages compared to traditional ISAR imaging under certain limited operating conditions that are nevertheless of practical interest. We conclude by pointing out directions for future work in extending the results of this paper. [C47]

"Assessment of statistical models for clutter and target in SAR images"

Accurate knowledge of statistical properties of SAR data plays an essential role in SAR image processing and understanding. Several studies have been made for discovering the relationship between the physical features and statistical properties of SAR data, and some statistical models for modeling SAR data having been proposed and studied. In this paper, we focused on four often used statistical models: the Weibull, Log-normal, Gamma and K distributions. These models are used to fit target and clutter regions in SAR data provided by MSTAR, and through three different goodness-of-fit tests, we assess the performance of the four statistical models for modeling the clutter and target in the SAR images. The results show that K distribution performs best and Log-normal performs worst for modeling clutter region, on the other hand, Log-normal distribution performs best while K distribution performs worst for modeling target region. [C48]

"A novel single-channel SAR-GMTI method based on defocusing shifted difference"

A novel single channel SAR-GMTI method is proposed in this paper. When the azimuth mismatch filter performs compression, it induces shifted difference between the stationary and moving targets because of having different Doppler center. The proposed method employs this character to separate moving targets from stationary targets. It can produce two images by pulse compression which make use of two symmetrical mismatch filters in azimuth direction, and then cancel stationary and retain moving targets by subtracting one image from another. Compared with traditional methods, it is applicable to both low and high squint case and the detection capability is significantly improved. The simulation results validate the effectiveness of the proposed method. [C49]

"Low speed target detection with short CIT in HF surface wave radar"

High frequency surface wave radar can detect targets beyond the horizon. It needs long coherent integration time (CIT) to detect low speed targets, such as ships, in the environment with sea clutter. In order to improve the efficiency of the radar system, and avoid the Doppler broadening caused by long CIT, it is necessary to shorten coherent integration time. Modern spectrum estimation technique is adopted to extract Doppler information from HF radar echo signals. It can provide high resolution to realize ship detection in short CIT. The real data processing and analysis show that the autoregressive spectrum estimation technology is effective to detect low speed target in short CIT in high frequency surface wave radar. [C50]

"A fuzzy adaptive tracking algorithm based on current statistical probabilistic data association"

In this paper, a new fuzzy adaptive maneuvering target tracking algorithm based on current statistic model is proposed. How to track a maneuvering target is a key problem of target tracking in clutter. Current statistical model needs to pre-define the value of maximum accelerations of maneuvering targets. So it may be difficult to

meet all maneuvering conditions. The Fuzzy inference combined with Current statistical model is proposed to cope with this problem. Given the error and change of error in the last prediction, fuzzy system on-line determines the magnitude of maximum acceleration to adapt to different target maneuvers. Furthermore, the difficulties of the maneuvering target tracking lies in the uncertainty of state model, and the clutter make it more complex. The algorithm combines current statistical algorithm with probabilistic data association algorithm. At last, the results show this algorithm can estimate a maneuvering target in clutter efficiently. [C51]

"Space-time adaptive processing for sea clutter and jamming suppression in radar seekers"

When radar seeker searches and tracks moving target on sea surface, sea clutter spectra severely spread out due to the strong effect of sea conditions. Conventional methods for suppressing sea clutter have achieved poor performance. This paper mainly analyzes the sea clutter characteristics in azimuth-Doppler domain and clutter spectra with different scanning angles. Then space-time adaptive processing (STAP) technique is applied to suppress sea clutter. Research results indicate that sea clutter spectra have some special characteristics in space-time distribution, and the proposed STAP algorithm can detect slow moving targets effectively as it can suppress sea clutter and strong jamming. [C52]

"A segmentation-based CFAR algorithm for subsurface targets detection in FLGPSAR"

Forward-Looking Ground Penetrating Synthetic Aperture Radar (FLGPSAR) has the capability of forming two-dimensional high-resolution images of subsurface objects from a standoff distance. This paper addresses the detection of subsurface targets, i.e. landmines, in FLGPSAR images. The conventional Constant False-Alarm Rate (CFAR) algorithm has been widely used in SAR image target detection, but its performance will degrade in subsurface targets detection because of the presence of interfering targets and clutter power transition. In this paper, a segmentation-based CFAR (S-CFAR) algorithm is proposed. The S-CFAR algorithm can remove the interfering targets or clutter power transition before estimating the parameters of the clutter background to achieve a better performance than the conventional CFAR algorithm. The real data processing results are given to validate the efficiency of the proposed method. [C53]

"Stistical relax method for super resolution ISAR imaging"

An effective statistical method of detecting the scatterers center for super-resolution ISAR imaging is presented. By exploiting the statistics of background noise and clutters, Gaussianity test(GT) is applied to extract the scatterers center in range cells under desired constant false alarm rate(CFAR). Combined with extended Relax algorithm, super resolution ISAR image of target is generated. Theoretical analysis and experimental results of real data show that proposed method exhibit better performance with expected to conventional high resolution method. [C54]

"Low velocity small radar target detection in maritime environment"

Researches on target detection are mainly focus on the amplitude characteristics nowadays. Sometimes the only use of amplitude characteristics is not enough to describe the signal, so that the target detection performance is usually poor. In this essay a method to make use of the information "hidden" in the signal phase is put forward, the theory is based on polynomial fitting of the signal phase train structure. At last, the method is validated using actual data. [C55]

"Enhanced detection of planar retro-reflective arrays using polarization properties"

This paper presents a design concept to aid in the detection and tracking of objects in a cluttered environment at 26 GHz. Target tracking can generally be accomplished with the use of retro-reflectors which are able to return an incident signal back in the same direction with a radar cross section (RCS) that is independent of angle of arrival for a large range of incidence angles. [C56]

"Advanced through-the-wall radar imaging using spectral and wall estimation techniques"

Two techniques are introduced and combined to improve SAR imaging of TWR scenarios, namely wall estimation and spectral estimation imaging using MUSIC. It was shown that homogeneous walls can be eliminated from SAR images although a significant amount of clutter remains if the wall shows inhomogeneities. Furthermore, applying the MUSIC algorithm can significantly clear up the image and make the targets behind the wall more visible. In conclusion, both the described wall estimation technique and MUSIC imaging can enhance TWR images, allowing a clearer interpretation or building a more reliable basis for further processing like target detection. [C57]

"A Parallel Centralized Multi-sensor General Association Algorithm"

This paper has researched on the problem of centralized multi-sensor multi-target tracking against a background, which has a high demand of real-time and a relative demand of tracking precision, and analyzed the advantages and disadvantages of the existent classical algorithms theoretically in this environment. Based on the research and the analysis, general association algorithm has been extended into multi-senor system through the parallel structure and a new algorithm named parallel centralized multi-sensor general association algorithm has been proposed. In this algorithm, a lot of hypotheses are built with the measurements of each sensor and the track of each target, the score of every hypothesis could be obtained with the formula of the score function in multi-sensor general association algorithm, and the state estimation of the fusion center is gained finally. The simulation results show that this algorithm could track the targets effectively with the high density clutter and the general performance of this algorithm is better than that of sequential centralized multi-sensor joint probabilistic data association algorithm and parallel centralized multi-sensor probabilistic nearest neighbor standard function. [C58]

"Distributed GOSCA-CFAR Detection Based on Automatic Censoring Technique"

This paper present a new distributed constant false alarm rate (CFAR) detector based on automatic censoring technique. In the scheme, every local decision of individual detector, resulting from the comparison between its sample level and the estimation of the background based on GOSCA-CFAR (generalized order statistic, cell averaging-CFAR) algorithm, takes the value zero or one. Then, the fusion center makes the final decision utilizing the total local decisions, which are transmitted from each local detector. The overall decision, which is zero or one, is obtained at the data fusion center based on "AND", "OR", and "k/N" fusion rule. The results show that for the nonhomogeneous background caused by multiple interfering targets, particularly in multiple target situation, it exhibits good robustness in distributed sensor network. Under Swerling 2 assumption, the analytic expression of detection probability and false alarm probability are derived. [C59]

"Track initiation in Monostatic-Bistatic Composite High Frequency Surface Wave Radar Network based on NFE model"

Though a Monostatic-Bistatic Composite High Frequency Surface Wave Radar Network (MBC-HFSWR Network) is established to cover the shortage of the monostatic radar, how to judge the real target update from the plausible measurements to initiate tracks quickly and accurately still remains a challenging problem. A novel method utilizing unconventional characteristics for track initiation is proposed in this paper, which uses more accurate information and avoids the problem of low detection precision of high frequency radar. A highly intelligent information fusion model which is a combination of Neural network, Fuzzy reasoning and Expert system (NFE model) is presented to solve the problem above and the validity of the provided method is demonstrated by Monte Carlo simulations. [C60]

"Comparison between genetic programming and Neural Network in classification of buried unexploded ordnance (UXO) targets"

In this paper, we present the results of our next step effort in comparison of classification performances between the NN and the GP techniques based on the simulated scattering patterns of UXO-like object and non-UXO objects. For this comparative study, 2 dimensional scattering images from one UXO target and four non-UXO objects were generated by numerical simulation tool (FEKO). For non-UXO objects, the most challenging targets to discriminate from UXO, since all these objects produce resonance signal as UXO-like targets do [6], were selected. Classification performances of both techniques (NN vs. GP) in different level of noise and in the case of presence of untrained data were examined and the results and observations are discussed. [C61]

"MIMO radar detection and adaptive design in compound-Gaussian clutter"

Multiple-input multiple-output (MIMO) radars with widely separated transmitters and receivers are useful to discriminate a target from clutter using the spatial diversity of the scatterers in the illuminated scene. We consider the detection of targets in compound-Gaussian clutter. Compound-Gaussian clutter describes heavy-tailed distributions fitting high-resolution and/or low-grazing-angle radars in the presence of sea or foliage clutter. First, we introduce a data model using the inverse gamma distribution to represent the clutter texture. Then, we apply the parameter-expanded expectation-maximization (PX-EM) algorithm to estimate the clutter texture and speckle as well as the target parameters. We develop a statistical decision test using these estimates and approximate its statistical characteristics. Based on the approximation of the statistical characteristics of this test, we propose an algorithm to adaptively distribute the total transmitted energy among the transmitters. We demonstrate the advantages of MIMO and adaptive energy allocation using Monte Carlo simulations. [C62]

"A stochastic-gradient method to design optimal space-time codes for MIMO radar detection"

We consider a MIMO radar system with widely-spaced transmit/receive antennas and study the problem of designing the signal waveforms transmitted by each source node so as to maximize the detection probability for a fixed false alarm rate under correlated Gaussian clutter. The proposed design procedure relies on a stochastic-gradient search and is general enough to be applied to any statistical target model. Examples are provided to compare the performance of the proposed codes with other known coding schemes. [C63]

"A Hotelling T-squared GIP test for detection of over resolved targets"

A new technique for detection and discrimination of stationary or slow-moving over-resolved targets on the ground, based upon a Hotelling T-squared test/generalized inner product (GIP) approach to signal analysis is presented. This robust detector separates radar returns from interference via a coherent process. This GIP-based processing can be applied to single-receiver channel systems, multiple spatial channel systems, multiple polarization channel systems or systems with multiple spatial and polarization channels. [C64]

"Probability hypothesis densities for multi-sensor, multi-target tracking with application to acoustic sensors array"

Random sets theory offers a uniform framework for the multi-source data fusion, and all problems of the data fusion could be describe, analyzed and solved in this framework. The multi-sensor multi-target tracking problem could be natural represented in the framework. It is of engineering importance to tracking low altitude moving targets with acoustic methods due to the blindness of the traditional radar detecting. In this paper, an algorithm for tracking the low altitude or ground moving targets is put forward based on the Probability Hypothesis Density (PHD) Filter. The PHD Filter based on Finite Set Statistics doesn't need consider data association for multi-target tracking, which propagates the PHD or first moment instead of the full multi-target posterior, and it could estimating the unknown and time-varying number of targets and their states under clutter environment. In the practical, we use the Sequential Monte Carlo (SMC) method to approximate the PHD. The paper presents a novel and fundamentally well-grounded framework for tracking multiple acoustic targets using PHD Filter and passive acoustic localization technique. Simulations are also presented to demonstrate the performance in tracking a randomly varying number of targets in a clutter environment. [C65]

"Implementation of a radar tester for air traffic control applications"

In this paper we present a method, and a fully implemented and tested hardware, for testing the operation of primary radars, may it be used in air traffic control or in military service. The realization of the radar tester was based on the theory of controlled radar cross section (CRCS), this way creating spurious targets or clutters, with known parameters, on the screen of the radar. According to the difference between the created and the measured parameters (e.g. velocity, fluctuation and distance), any minor or major degradation or failure can be detected. The tester is capable of scanning the radar system from the antenna, via microwave hardware elements, all through to the digital signal processor (DSP) unit, achieving great diagnostic properties. Emphasis was put on the realisation of the hardware. The produced equipment was tested in real life using a primary ATC radar in Hungary, with satisfying results. [C66]

"CFAR detectors for through wall tracking of moving targets by M-sequence UWB radar"

In this paper different CFAR detectors for detection of multiple targets for UWB radar system will be described. In this paper, the cell averaging CFAR (CA-CFAR) cell averaging with greatest of (CAGO-CFAR) and ordered statistics CFAR (OS-CFAR) will be represented. The detectors outputs will be illustrated and compared. The properties of all detectors will be illustrated by real radar signal processing obtained by the measurement with the M-sequence UWB radar. [C67]

"System performance prediction of Firefinder radar"

Thales Raytheon Systems' PC Simulation (PCS) tool allows a rapid simulated evaluation of Firefinder radar performance from a personal desktop computer. Firefinder radars are designed to track hostile rocket, artillery and mortar (RAM) projectiles in order to accurately estimate weapon ground location. The Firefinder tactical code is used within PCS. This design provides a low risk path to rapid prototyping and evaluation of candidate software changes. PCS is used to evaluate candidate software changes to the Firefinder. Candidate design changes which perform well in PCS testing require minimum system level checkout before being checked into the tactical software baseline. The PCS tool contains a simulation engine which reads program control information from input data files. The PCS tool also generates and maintains simulated targets and clutter,

simulates the radar signal processing function, performs Monte-Carlo "batch" processing, produces complex target trajectories internally or from an input text file and creates simulation data recording files identical in format to those created by the actual radar. This paper summarizes the capabilities of the lastest PCS. [C68]

"Modeling and Simulation of Adaptive Thresholding in Marine RADARs"

In order to detect targets upon sea surface or near it, marine radars should be capable of distinguishing target reflections from the sea clutter. Our proposed method in this paper relates to detection of dissimilar marine targets in an inhomogeneous environment with clutter and non-stationary noises, and is based on adaptive thresholding determination methods. Variation and mean vales of the noise have been estimated in this paper, based on non-stationary, statistical methods and thresholding has been carried out using the suggested two-pole recursive filter. Fixating the rate of false alarm, the concerned threshold resolves the assumption problem of existence or absence of the signal. Performance of the mentioned algorithm has been compared with method known as CA-CFAR in terms of decreasing the losses and increasing calculation speed. The algorithm provided for detection of signal has been implemented at the end of signal-processing algorithms of sea marine radars. The results obtained from the algorithm performance in a real environment indicate appropriate workability of this method in heterogeneous environment and non-stationary interference. [C69]

"HF radar performance analysis based on AIS ship information"

High-Frequency (HF) radars are operated in the 3-30 MHz frequency band. For oceanographic applications low transmit power HF radar systems have been developed, which use surface electromagnetic wave propagation along the salty ocean surface. The WERA HF radar system transmits a power of 30 watts but achieves detection ranges up to 200 km, which are far beyond the conventional microwave radar coverage. Hence the radar system can be used for coastal monitoring. Due to external noise, radio frequency interference, and sea clutter the radar detection capability is limited. Real measured radar data from the WERA system were recorded for a 12-hour period. The measured radar data were correlated with simultaneously available Automatic Identification System (AIS) information, which shows current ship position, speed, course and type. This paper presents statistical analysis of maximum detectable range and target reflectivity to estimate the radar performance in case of different cargo ship sizes. Based on the order-statistic constant false alarm rate (OS-CFAR) detection rule the potentially detectable target range and aspect angle of different ship categories were analyzed. [C70]

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

In this paper, theory is developed for the prediction of the false alarm (PFA) and detection (PD) performance of surface targets in K-distributed sea clutter detected by means of Doppler processing techniques. Vital to this analysis is the inclusion of the correlation properties of the sea clutter between all the pulses within a burst of pulses. The resultant technique allows for the prediction of PFAand PDfor each of the bins in the output of the Doppler processing stage of a fixed-threshold detector. The technique provides the ability to specify different thresholds for each of the Doppler bins. The analysis is extended to include Swerling type 1 and 2 targets for the calculation of PD. The performance of a noncoherent detector is provided for comparison. Results that demonstrate the application of the developed theory are also presented. [C71]

"Double-step fast CFAR scheme for multiple target detection in high resolution SAR images"

A new double-step fast CFAR scheme is proposed for multiple target detection in SAR images. The conventional multiple-cell based CFAR (MC-CFAR) detector is performed to find a potential target area. MC-CFAR carries out a quick search by which the CFAR sliding window is shifted by several cells for the reduced computational loads and it can also effectively reduce the small sized false alarm in the vicinity of the test cell. For the final target decision, the single-cell based CFAR detection is only applied to the pre-processed potential target areas. Using real-SAR image, the proposed CFAR scheme is compared with the conventional method in the sense of computational time and false alarm rate, which shows the faster computational speed and the lower false alarm rate. [C72]

"A Bayesian perspective on sparse regularization for STAP post-processing"

Traditional Space Time Adaptive Processing (STAP) formulations cast the problem as a detection task which results in an optimal decision statistic for a single target in colored Gaussian noise. In the present work, inspired by recent theoretical and algorithmic advances in the field known as compressed sensing, we impose a Laplacian prior on the targets themselves which encourages sparsity in the resulting reconstruction of the angle/Doppler plane. By casting the problem in a Bayesian framework, it becomes readily apparent that sparse regularization can be applied as a post-processing step after the use of a traditional STAP algorithm for clutter

estimation. Simulation results demonstrate that this approach allows closely spaced targets to be more easily distinguished. [C73]

"On the design of mismatched filters with an adjustable matched filtering loss"

We present a method for the design of mismatched filters minimizing the interference from unwanted targets (point target or clutter) under the constraint of matched filtering loss. The method method seeks to find the optimum filter minimizing the interference and having a desired cross-correlation with a given transmitter waveform. The method is applied to get the minimum integrated side-lobe level filters and to optimize the receivers of the pulse diversity systems. [C74]

"X-band FMCW radar system with variable chirp duration"

For application in a short range ground based surveillance radar a combination between frequency modulated continuous wave (FMCW) transmit signals and a receive antenna array system is considered in this paper. The target echo signal is directly down converted by the instantaneous transmit frequency. The target range R will be estimated based on the measured frequency shift fBbetween transmit and receive signal. Due to an extremely short chirp duration Tchirp, the target radial velocity vтhas only a very small influence to the measured frequency shift fB. Therefore the radial velocity vтwill not be measured inside a single FMCW chirp but in a sequence of chirp signals and inside each individual range gate. Finally, the target azimuth angle is calculated utilizing the receive antenna array and applying a digital beamforming scheme. Furthermore, in order to unambiguously measure even high radial velocities, a variable chirp duration is proposed on a dwell to dwell basis. [C75]

"Small target detection in SAR image using the Alpha-stable distribution model"

The Constant False Alarm Rate (CFAR) algorithm is most commonly used for small target detection in SAR images. As the goodness-of-fit of distribution model to SAR clutter has great effect on the performance of algorithm, after a comprehensive statistical analysis of background clutters of different SAR data, a modified CFAR algorithm based on the Alpha-stable distribution is proposed for detecting small targets in SAR images, especially under the extremely inhomogeneous background clutter. Considering for the complexity of Alpha-stable distribution model, the parameter estimation and threshold determining steps of the modified algorithm are introduced in detail. Performance of the algorithm is assessed by experiments on ADTS data. Compared with typical two-parameter CFAR (TP-CFAR) algorithm based on Gaussian distribution and K-CFAR algorithm based on K distribution, the proposed method is demonstrated to be most suitable for detecting small target in extremely inhomogeneous regions. [C76]

"Clutter suppression scheme for vehicle radar"

Vehicle radar receives echoes from the natural environment such as road and building. These echoes are called clutter which can be much higher than vehicle echo. It is therefore expect to improve the detection performance by summing all the radar echoes available from the vehicle. However, heavy road clutter should not be suppressed less than the vehicle echo by conventional integration schemes such as pulse integration and CFAR (Constant False Alarm Rate). Also the radar echo should include multiple vehicle targets as well as the clutter. Therefore it is not easy to detect multiple vehicle targets from heavy road clutter. In this paper, multiple targets detection with new clutter suppression scheme is discussed and the usefulness is investigated by conducting the measurement. As a result, the suggested scheme is found to suppress the heavy clutter significantly. [C77]

"Hybrid array for the detection and imaging of termites"

This paper describes a 24 GHz radar receiver array, designed to detect and image termite activity, behind a wall, floor or ceiling. This hybrid array is composed of two sub-arrays. A Direction of Arrival (DOA) sub-array for wide area detection of termites, and a 3D high resolution imaging sub-array for imaging individual termites. Here, we introduce an enhanced DOA algorithm, to resolve arbitrary numbers of targets, and compare simulation results with video of actual termites. [C78]

"New detection manifolds for radar signal processing"

This paper examines direct data domain (DDD) moving target detection for multi-channel space-based radar (SBR). DDD techniques differ from data-adaptive processing methods in that they do not rely on statistically stationary and homogeneous training data in order to estimate and null out clutter or interference and thereby reveal potential targets; instead, they operate on each range-Doppler cell independently, after any necessary preprocessing to compensate for platform motion and/or array calibration. Prior work examined a maximum-likelihood angle-of-arrival (AOA) technique and the associated target power estimator to detect slow moving

targets. In this paper, we extend that methodology and propose novel detection manifolds for optimally partitioning the two-dimensional statistical space. The two dimensions are formed by the passive AOA likelihood function and the estimated target power. A computer simulation of a space radar system and associated geometry is used to assess the characteristics and performance of the new concept. We show that the two-dimensional probability densities corresponding to the target absent and target present hypotheses (H0 and H1, respectively) occupy regions in this space that are not optimally separated by independent thresholds. This immediately leads to the novel detection manifolds (or curved boundaries between detections and non-detections) that improve the detection probability while also reducing the false alarm rate. [C79]

"A New Detection Method for MIMO Radar Using Hidden Markov Model"

MIMO radar is a new radar technique developed recently. It can achieve better detection performance than conventional phased radar. Based on the scattering statistic of clutter and man-made target, we propose that hidden Markov models (HMM) can be used to model the clutter and target signals, and that the HMMs can be used to detect target. Simulation results verify its efficiency. [C80]

"RF Effect Algorithms of Terrain Environment in Signal-Level Radar System Simulation"

In radar system simulation, the reliability of simulation results depends not only on radar and target models, but also on RF (radio frequency) environment models, including clutter, multipath and diffraction. In radar function simulation, all of these factors are treated as a single pattern-propagation factor and can only give limited information for radar models. In signal-level simulation, radar models require that simulated echoes should include information such as delay, phase shift, doppler frequency, polarization, etc. By discussing and analyzing the principles and algorithms of RF environment effects of ground, a ground RF environment model is proposed, which can provide a reliable RF environment for signal-level simulation of radar systems. A simulation example involving clutter model is carried out and analyzed. [C81]

"A GLRT detector in partially correlated texture based compound-Gaussian clutter"

This paper addresses the problem of target detection in the presence of a non-Gaussian clutter modeled in compound-Gaussian form which realizes the clutter process as a product of two independent random processes `texture' and `speckle'. The likelihood ratio test (LRT) detector applied to this detection problem reduces the detector to a matched filter (MF) when the texture is considered as completely correlated during a coherent processing interval (CPI). However, in practical applications, the textural component exhibits a correlation which is less than unity. The conventional form of MF based detectors existing in the literature yield a significant fall in the detection performance in such clutter scenarios. In this paper, we propose a generalized likelihood ratio test (GLRT) detector which can effectively detect a fluctuating target in the presence of a compound-Gaussian clutter with partially correlated texture. The results are presented to show the performance superiority of the proposed detector over the existing MF detector in such varying texture scenarios. [C82]

"New Technology and Applications on Millimeter-Wave Sensors"

Some new technology and applications on millimeter-wave sensors are reviewed. A novel method of human presence detection using passive millimeter-wave (MMW) sensors is presented. The method focuses on detecting a standing human from a moving platform in a cluttered outdoor environment using MMW radiometry. Millimeter-wave stepped-frequency sensor and millimeter-wave interferometric sensor are completely realized using microwave integrated circuits (MICs) and microwave monolithic integrated circuits (MMICs). The millimeter-wave stepped-frequency sensor operates from 29.72 to 37.7GHz and has demonstrated abilities in surface and near-surface sensing, including profile mapping, liquid-level monitoring, and anti-personnel mine locating. The millimeter-wave interferometric sensor operates at 35.6GHz and has demonstrated its multi-functional capability for measurement of displacement and low velocity. A new radar sensor architecture comprising an array of transceiver modules. Target applications of the sensor are automotive driver assistance systems. Experimental results with an eight channel radar sensor in the 76-77GHz frequency band are presented, which demonstrate the feasibility of the proposed architecture and show the performance of the modulation sequence and signal processing. Finally the technical challenges of millimeter-wave sensor systems are discussed. [C83]

"Performance Analysis of OSAP-CFAR Detector in K Distribution Background"

The OSAP-CFAR employs soft rule based on fuzzy logic to give better detection probability than that of OSGO and OSSO-CFAR detectors for Weibull clutter. However, studies show that the K distribution provides a better fit for many clutter situations. The performance of the OSAP -CFAR is studied and compared with OSGO and OSSO-CFAR for the Swerling II target model in K distributed clutter. The results represent that the detection performance of OSAP-CFAR detector is superior to that of OSGO and OSSO-CFAR detectors both in the

homogenous background and in multiple interfering targets situations. [C84]

"Detecting and tracking of small moving target in avian radar images"

A sequence of plane position indicator (PPI) images containing a small moving target is collected using an experimental avian radar surveillance system, which is constructed by modifying a standard marine radar. Smoothing trajectory of a small moving target is separated from the image sequence after background subtraction, clutter suppression, measurements extraction and tracking. The background image is generated by Fast Independent Component Analysis (FastICA). Low segmentation value is set in clutter suppression to improve detecting rate at the cost of introducing a great deal of clutters. Therefore, false alarm rate need to be reduced by tracking. Meanwhile, a modified Hough transform method is applied for track initiation. Monte Carlo data association is proposed for track maintenance and Kalman filtering is adopted for target state prediction and update. Finally, the trajectory is smoothed and then fused with a satellite map for further observation. [C85]

"Study on adaptive monopulse with reduced dimension STAP technique"

For airborne radar, the estimation performance of moving target parameters is greatly affected by the residuals of ground clutter after space-time adaptive processing (STAP). The non-homogeneity of environment, which results in the lack of available secondary data, will make this problem worse. In this paper, a novel method, which utilizes small amount of secondary data, is proposed for getting more accurate estimation under non-homogenous environment. In this method, the spatial and temporal dimensions are reduced properly for the benefit of low secondary data support and exact clutter covariance matrix estimation; additionally, by combining a STAP processor with monopulse technique, target parameters will be obtained. The simulation results are shown this method is more accurate and adaptable than the previous adaptive monopulse with STAP method under the non-homogeneous environment. [C86]

"PMHT with Application of Road Information Based on GMTI"

Probabilistic Multi-Hypothesis Tracking (PMHT) is an algorithm for multiple target tracking when association of measurement and track is unknown. PMHT is an efficient algorithm for GMTI in cluttered environments of which the computational complexity is linear in the number of targets and measurements. An algorithm is presented in this paper to apply road information to PMHT. Road information is used to adjust estimated target state during the process of Kalman filter. Tracking performance of PMHT is increased apparently with the application of road constraint. [C87]

"Diversity gain for MIMO radar employing nonorthogonal waveforms"

Initially we formulate a very general hypothesis testing problem where we attempt to distinguish between zero-mean Gaussian clutter-plus-noise only and returns which are a linear transformed version of a zero-mean Gaussian random vector plus this clutter-plus-noise. We show that the diversity gain of the optimum processing for this hypothesis testing problem must be less than or equal to the rank of the linear transform. Next we apply this result to study diversity gain for optimum MIMO radar processors for cases with M transmit antennas, N receive antennas, and a target composed of Q scatterers. If the transmitted waveforms span a lower dimension M' than M, then the largest possible diversity gain is no greater than min(NM', Q). We also show a diversity gain of min(NM', Q) can be achieved under certain conditions. For a general correlated Gaussian clutter-plus-noise model and a general correlated Gaussian reflection coefficient vector, the diversity gain for noncoherent and coherent processing is discussed. Extensions of all results to cases with nonGaussian reflections and clutter-plus-noise are discussed. [C88]

"Some Analysis of Fuzzy CAGO/SO CFAR Detector in Non-Gaussian Background"

In order to improve radar's detection performance under non-Gaussian background clutter. We design a new distributed fuzzy CAGO/SO-CFAR detection system including two sensors. Both sensors compute the value of the membership function mapping to the false alarm space according to the samples of the reference cells, in the fusion centre two values are combined according to four kinds of fusion rule to estimate the background clutter power. The simulation results prove the detection improvement of CASO based on algebraic-sum rule under multi-target environment, and present better false-alarm-control capacity of CAGO based on MIN rule under clutter-edge environment. [C89]

"Comparison of PHD based filters for the tracking of 3D aerial and naval scenarios"

The Probability Hypothesis Density (PHD) filter is applied to realistic three-dimensional aerial and naval scenarios to illustrate its performance in detecting, initiating and terminating tracks in presence of clutter. Radar

measurements are available every two seconds. A comparisons between different approximations of the PHD recursion, namely the sequential Monte Carlo and the Gaussian Mixture approximation, is given on different scenarios using the OSPA metric and different levels of clutter. [C90]

"Spatially-varying calibration of along-track monopulse synthetic aperture radar imagery for ground moving target indication and tracking"

In this research, we have developed an algorithm to reduce the residual artifacts of the background clutter (that is, stationary targets) that appear in the MTI imagery that are generated by Global Signal Subspace Difference (GSSD) of the monostatic and bistatic images of an along-track monopulse synthetic aperture radar (SAR) data. We have also established the theoretical foundation for estimating the motion track and parameters of the detected moving targets. We will show the results of these algorithms on measured SAR data. [C91]

"Long-time coherent integration for radar target detection base on Radon-Fourier transform"

Based on the internal coupling relationship among radial velocity, range-walk and Doppler frequency of moving target's echoes, this paper proposes a novel method, i.e., Radon-Fourier transform (RFT), to realize the long-time coherent integration for radar target detection. The RFT realizes the echoes spatial-temporal decoupling via joint searching along range and velocity directions, as well as the successive coherent integration via the Doppler filter bank. Besides, it is shown that RFT is a kind of generalized Doppler filter bank processing for targets with across range unit (ARU) range walk. Finally, numerical experiments are provided to demonstrate the effectiveness of the proposed methods. [C92]

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

The work described in this paper is a continuation of previous analytical work that has progressed to an experimental phase. The paper discusses the development of an ultra-wideband (UWB), forward-scatter radar (FSR) system for the detection and (ultimately) automatic recognition of low reflectivity maritime targets. Here we present the concept, developed hardware and selected initial experimental results. A number of novel ideas have been developed to reduce cost, size, prime power requirement, complexity and utilise the advantages of FSR operation. System benefits include increased target cross section (over conventional bi/monostatic radar), increased target detection capability, robustness to stealth targets, decrease in sea clutter effects from synthesis of extremely narrow beams whilst using omni directional antennas and sub-Hertz Doppler frequency measurement capability. The experimental work investigates the use of an UWB FSR fence for security, UWB propagation measurements, UWB sea clutter measurements at very low grazing angles, UWB spectral coverage and the synthesis of narrow beamwidth antennas using forward scatter pulse transmission. [C93]

"Characterization of Doppler effects in the context of over-the-horizon radar"

This paper addresses the problem of the characterization of Doppler effect of maneuvering targets in the context of over-the-horizon radar. The received signal has a complex Doppler structure which is composed of several arrivals, each corresponding to a particular path. In essence, it consists of several close time-frequency components with non-linear signatures in the time-frequency domain. The nonlinearities are the projections of the target's motion vectors on the propagation paths. Estimating the time-frequency contents of all paths reveals the Doppler effects characterizing the target's trajectory. Analysis of such signals in the presence of strong clutter requires effective non-stationary signal processing techniques. In this paper, we propose a new technique based on local analysis of the phase information using warped high-order ambiguity function. The results depict resolvable multipath estimates which are very close to the ground truth. [C94]

"Analysis of sea clutter distribution variation with Doppler using the compound k-distribution"

Sea clutter is the backscattered returns received by a radar system from the sea surface. Maritime radar signal processing has the ability to partially compensate for clutter to achieve effective detection of targets on or near the sea surface. This paper investigates the fit of the compound k-distribution model to sea clutter amplitude statistics, within individual Doppler bins across the Doppler spectra. The data used was recorded with a monostatic coherent X-band radar on an airborne platform; both horizontally and vertically polarized data has been analysed. The statistics of the sea clutter distributions have been evaluated using the probabilities of false alarm (PFA), which are the calculated from the sea clutter cumulative amplitude distributions. These curves are plotted as a function of detection threshold. K-distributions have been fitted to the PFAof the sea clutter across the Doppler spectrum. The variation of the fitted shape parameter with Doppler bin has been used to identify the relationship between backscattered sea clutter and Doppler. The results show a clear variation with Doppler of the shape parameter obtained from the fitted distribution. The variation is also found to change with polarisation. [C95]

"Detection of runway boundary in ATC ground radar"

The radar environment is usually nonstationary and an efficient adaptation requires real-time exploitation of a priori knowledge concerning the environment surrounding the radar. In an airport contest, the radar scenario is heavily influenced by the inevitable presence of interferences, the background clutter, but other interferences (presence of vehicles and unwanted signs on the runway) contribute to make difficult the target detection. In particular, the paper addresses the detection of the runway boundary in ATC (Air Traffic Control) ground radar signal which can be not well defined due to the grass growth in different period in the islands near the runways. The grass growth can cause critical situation because the signal level of the grass zones is equal to that of the asphalt and it needs a visual analysis by a human operator to determine the presence of objects and targets in this clutter area. An active contour search algorithm (Snake algorithm) is used for detecting the runway boundary in SMR radar images. In our application a standard Snake algorithm is adapted and it is possible to obtain a reasonable approximation of the actual contour, which greatly reduces drawbacks related to the presence of the local minima. The performance of the active contour algorithm is tested on a set of radar images extracted from SMR radar images acquired in Italian airports. [C96]

"Two-step GLRT design of MIMO radar in compound-Gaussian clutter"

This paper mainly deals with the target detecting problem using a MIMO radar against compound-Gaussian clutter with an unknown covariance matrix. The space-time coding MIMO radar model has adopted, and developed to compound-Gaussian case. The detector based on generalized likelihood ratio test (GLRT) criterion is studied, and two-step design procedure is adopted. Specifically, the GLRT is derived by assuming known covariance matrix, and then, a suitable estimate based on secondary data is inserted into the derived detector to make fully adaptive. Some numerical results are given, showing that the derived GLRT can provide a good performance in spikier clutter and the adaptive loss is acceptable. [C97]

"Clutter properties for STAP with smooth and faceted cylindrical conformal antennas"

Conformal antennas, which assume the shape of the platform, have several advantages; like reduced weight and space, aerodynamic design and increased field of view. We are interested in detection of moving ground targets with air-borne radar with faceted or smooth vertical half-cylinder or planar antennas with different subarray sizes. We simulate radar systems and study clutter properties which are important for suppressing the clutter with STAP (Space-Time Adaptive Processing), properties by which we can compare the antennas. We use old analysis tools and propose some new which are easy to interpret and draw conclusions from. We find that the faceted and smooth half-cylinder antennas have no significant differences in clutter suppression performance. The plane antenna has poorer performance. The subarray division is more important than the antenna geometry. The number of antenna channels is related to the clutter rank and the clutter fraction of the signal space. [C98]

"Performance bounds on MIMO radar with optimized coded constant modulus waveforms"

A multiple-input, multiple-output (MIMO) radar system uses multiple, spatially diverse transmitters and receivers with separable, independent waveforms with the goal of enhancing resolution and, thus, improving performance. Key to the achievement of these performance benefits is the degree to which the transmitted waveforms may be separated on receive, e.g. the correlation properties amongst the waveforms. A previously defined correlation metric useful for designing "good" waveforms is simplified and its global minimum prescribed for M coded constant modulus waveforms each consisting of N chips and shown to be equal to M-1 (independent of the number of chips). The theory is validated using random phase waveforms as well as optimized waveforms using a previously defined iterative procedure ("CAN"), which is shown to effectively achieve the derived minimum bound. An important consequence of this large level of correlation residue for an optimal waveform set when used to perform a ground moving target indicator (GMTI) function in an airborne radar observing distributed clutter is that the rank of the resulting MIMO interference covariance is increased beyond that of an idealized orthogonal waveform set leading to significant degradation in the clutter mitigation performance, as shown through simulation. An approach to mitigating this effect through the use of partially optimized waveforms tailored to the scenario of interest is demonstrated to achieve the performance of an idealized orthogonal waveform set. [C99]

"A fast FRFT based detection algorithm of multiple moving targets in sea clutter"

On the basis of the detection and estimation model of multiple moving targets, a new algorithm based on wavelet packet transform (WPT) and fractional Fourier transform (FRFT) is proposed for weak moving targets detection in sea clutter. The multi-resolution property of WPT and the characteristic of good energy concentration on LFM signals in FRFT domain are combined together. At first, optimal wavelet tree is calculated using

"minimum Shannon entropy" and threshold censored method is used to suppress sea clutter of different frequency bands. Then, take the absolute amplitude of signals after FRFT as test statistic and search for peaks in two dimensions with the threshold. Grading iterative method is used for parameter estimation with fast calculation speed and the shading problem between multiple targets is solved through "CLEAN" method. In the end, simulations with IPIX data indicate that the proposed algorithm has good performance of detecting low-observable moving targets in sea clutter. [C100]

"STAP analysis using multi-channel airborne radar data from flight trials"

Flight trials have been performed within the NORA program in order to acquire multi-channel clutter data for different types of terrain, terrain scattered interference, and SAR data. The acquisition of clutter and terrain scattered interference has been made in order to prepare a database for future development of operational space-time adaptive processing (STAP) algorithms applicable to active electrically scanned antenna (AESA) systems employing multiple sub-aperture configurations. In this paper we show some preliminary results that illuminate the benefit of using all four dimensions of multi-channel radar data in a clutter rejection perspective. To illustrate the behavior of multi-channel clutter we employ spatial spectrum estimation methods such as Fourier and MUSIC. We also demonstrate post-Doppler STAP results for the air-to-air case. The results are very promising and indicate that multi-channel processing will indeed enhance the ability to detect targets obscured by clutter. [C101]

"Adaptive polarization processing for improved detection/classification of stationary targets"

A new technique for detection of stationary or slow-moving over-resolved targets on the ground, based upon a Hotelling T-squared test/generalized inner product (GIP) approach to signal analysis is presented. This robust detector separates radar returns from interference via a coherent process. This GIP-based processing can be applied to single-receiver channel systems, multiple spatial channel systems, multiple polarization channel systems or systems with multiple spatial and polarization channels. [C102]

"MIMO radar sparse angle-Doppler imaging for ground moving target indication"

We present in this paper a regularized sparse signal recovery algorithm, referred to as sparse learning via iterative minimization (SLIM), to provide ground moving target indication (GMTI) through multiple-input multiple-output (MIMO) radar angle-Doppler imaging. A slow-time modulation scheme with code division multiplexing is employed to achieve transmit diversity. In this way, we avoid the high correlation properties of orthogonal waveforms and the Doppler ambiguity that is encountered with Doppler division multiplexing schemes. After removing jammer and clutter effects using semi-unitary projections, we show that SLIM, using primary data only, is able to form sparse angle-Doppler images and to provide for accurate target localization. [C103]

"Resolving complex targets in multipath environments using ARI RADAR systems"

In this work, we introduce Frequency Modulated Angle-of-arrival-assisted Relative Interferometry (FM-ARI), which leverages the unique talents of ARI systems to provide robust high-resolution 3D imaging of complex targets given the presence of other reflectors (clutter) in the environment. The proposed approach is described and analyzed. [C104]

"Detection in heterogeneous clutter by filter output prediction"

This paper introduces an innovative method for ground moving target indication with a multichannel air or spaceborne radar. It is based on comparing the power of the filtered receive signal with a predicted power level. This prediction is found using data from the range line under test only. No potentially misleading prior magnitude information is employed. Thus, the false alarm probability is stabilized and the method is especially suited for rapidly varying heterogeneous terrain. [C105]

"Topology of high-contrast patches in SAR images"

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

lack a significant geometric structure. [C106]

"Phase-coded-linear-frequency-modulated waveform for low cost marine radar system"

This paper proposes a continuous waveform to realize low transmitted power in a Radar system. The proposed waveform utilizes a pulsed compression scheme based on phase-coded modulation and linear FM which combines the desirable properties of both types of modulation. This paper also verifies waveform operation under channel effects such as multipath and noise. We determine power optimization due to waveform compression gain for given system specifications and use correlation values to detect both unambiguous range and Doppler shift. With a pre-determined noise and Doppler threshold, we can distinguish targets from sea clutter. Finally, we show the improvement in accuracy of elevation measurements by simulation when auto-correlation instead of signal strength ratios are used to determine target height. [C107]

"Stochastic system identification approach to radar data processing"

Space-time adaptive processing (STAP) algorithms typically consist of a data transformation step to reduce the number of degrees of freedom and a sampling step wherein radar returns from adjacent range bins are used to estimate interference statistics. The reduction in degrees of freedom, inadequate sample support, presence of target in sampled data, and range dependence of interference are some of the main reasons for STAP performance loss. In this paper, we present another approach to target detection and localization that mitigates these performance losses. The approach is based on the well-known stochastic realization algorithm from system identification theory. In this approach, we use the radar return data for a given range bin to identify a minimal stochastic state space model for the return data. The angle and Doppler for all targets in the range bin are computed from the state space matrices. All the computations involved use standard linear algebra. As interference statistics are not directly computed and since there is no sampling from adjacent range bins, the proposed approach is more robust to sample support, target in training and range dependence of clutter. A numerical comparison of the proposed approach with beam-space post-Doppler STAP using simulated data is given. [C108]

"Cramйr-Rao lower bounds for monopulse calibration using clutter returns"

Successful geolocation of ground moving targets utilizing monopulse techniques requires accurate characterization of the array manifold (i.e. monopulse response to off-boresight targets) and antenna pointing information. Utilizing techniques similar, in spirit, to those applied in synthetic aperture radar (SAR) to estimate the Doppler centroid of an image, we develop techniques to accurately estimate azimuth monopulse slope and boresight shift of an airborne ground moving target indicator (GMTI) antenna utilizing clutter returns from normally scheduled CPIs that are also used for target detection and geolocation. A statistical signal model is developed for the clutter returns as observed through the monopulse channels. Cramer-Rao lower bounds (CRLB) are developed for monopulse slope and boresight shift and compared to CRLB developed with SAR centroiding techniques as summarized in the literature. Analytical and numerical CRLB results show potential gains of one to two orders of magnitude at moderate to high clutter to noise ratios for a sum-difference system. [C109]

"A probabilistic model of the radar signal-to-clutter and noise ratio for Weibull-distributed clutter"

We consider four effects relevant to the determination of the ratio of radar signal to clutter and noise. These effects are atmospheric turbulence, target fluctuations based on the Swerling models, zero-mean Gaussian background and receiver noise, and Weibull-distributed clutter. Radar return signal levels are affected by target fluctuations and atmospheric turbulence, characterized by target fluctuations according to the Swerling models and a lognormal distribution, respectively. Since these distributions are not independent and identically distributed (IID), they cannot be simply added, and must be treated by combining them in a manner similar to convolution. Also, clutter and noise are not IID, and must be combined in a similar way. The ratio of these two combinations comprises a probabilistic model of the ratio of radar signal to clutter and noise. This ratio is the probability that a given signal level will be achieved in the presence of atmospheric and target scintillations divided by the probability that a given clutter and noise level will be observed. To determine the ratio of the actual signal to clutter and noise, we must multiply these probabilities by the mean powers resulting from these phenomena, as will be shown later. We treat several cases of interest by varying the average radar cross section, the log intensity standard deviation of turbulence, the radar threshold-to-noise and signal-to-noise ratios, and the distribution of Weibull clutter mentioned above. [C110]

"Canadian HF Over-the-Horizon Radar experiments using MIMO techniques to control auroral clutter"

High frequency Over-the-Horizon Radar (OTHR) provides an economical means to track noncooperative air targets over large expanses of land and ocean. However, early attempts to run OTHR in Canada in the 1970s were confounded by the presence of intense radar clutter originating in the auroral zone. Recent advances in Multiple-Input Multiple-Output (MIMO) OTHR technology, namely orthogonal waveform transmit arrays and fully sampled receive arrays, provide an opportunity to revisit the possibility of OTHR in Canada. An OTHR testbed has been built in Ottawa, Canada to determine the capabilities of the technology. The testbed consists of a MIMO OTHR with 4 transmit channels and 4 receive channels. Some preliminary data show that MIMO processing is effective in suppressing the clutter. It is then proposed to upgrade the testbed to a larger-scale system. [C111]

"The effect of clutter on the automatic target classification accuracy in FSR"

The clutter influence on the automatic target classification (ATC) accuracy in forward scattering radar (FSR) is presented. To study the ATC at various signal-to-clutter ratios (SCR), a simulated vegetation clutter is artificially added to the real clutter-free targets recorded signals. It is shown that using conventional clutter-uncompensated ATC system can achieve high target classification accuracy at high SCR only, but the accuracy drops significantly with SCR decreasing. The employment of clutter-compensated ATC system is shown to improve significantly the classification accuracy at low SCR. [C112]

"Robust short-range clutter suppression algorithm for forward looking airborne radar"

The short-range clutter has serious range dependence for forward looking airborne radar (FLAR). As a result, when a radar detects moving targets on far range gates, the ambiguous short-range clutter degrades the performance of ground moving target indication (GMTI) obtained by space-time adaptive processing (STAP). The elevation three dimensional adaptive processing can well mitigate the problem, but, the computational load of the method is too heavy to be applied in real scenarios. A robust elevation pre-filtering algorithm is proposed. This method does not need adaptive processing on the elevation elements in a planar-array antenna. Therefore, the computational load can be reduced greatly. This method suppresses the ambiguous short-range clutter by multi-elevation angles restriction and the cancellation weight on the clutter has a deep and wide notch. Moreover, the method is robust to the elevation angle errors. Simulation results show the validity of the method. [C113]

"LORAMbis A bistatic VHF/UHF SAR experiment for FOPEN"

LORAMbis is the experimental part of a joint research program between Sweden and France. The objective is to evaluate the performance of low frequency bistatic SAR for clutter suppression in various applications, e.g. under-foliage target detection or mapping of urban scenes. The airborne bistatic SAR data are acquired using the VHF/UHF component of the ONERA SAR system SETHI and the VHF/UHF LORA system operated by FOI. The first data collection campaign was conducted in December 2009. Focused bistatic SAR images have been formed and indicate that the implemented synchronization method is sufficient. It is based on a GPS disciplined 10 MHz reference signal that is generated in both systems. [C114]

"Multipath Doppler signatures from targets moving behind walls"

Detection, localization, and tracking of moving targets are highly desirable in through-the-wall sensing applications. Since the indoor environment is rich in multipath reflective sources, such as walls, floor, and ceiling, the received signal is composed of the direct path and several multipath arrivals. However, on occasions, the direct path to the target may be blocked as the target traverses behind large metallic objects such as file cabinets, etc. In such cases, multipath is the only observable return and can be exploited to detect and maintain tracking of moving targets. In this paper, we provide range-Doppler analysis of multipath arrivals for a diffuse target moving in an enclosed urban structure, which provides insight for the development of through-the-wall detection and tracking techniques based on multipath exploitation. [C115]

"New results on coherent radar target detection in heavy-tailed compound-Gaussian clutter"

In this work we prove that if the texture of compound-Gaussian clutter is modeled by an Inverse-Gamma distribution, the optimum detector is the optimum Gaussian matched filter detector compared to a data-dependent threshold that varies linearly with a quadratic statistic of the data. The compound-Gaussian model presented here varies parametrically from the Gaussian clutter model to a clutter model whose tails are evidently heavier than any K-distribution model. Moreover, we also show that the GLRT, which is a popular suboptimum detector due to its CFAR property, is in fact an optimum detector for our clutter model in the limit as the tails get extremely heavy. [C116]

"Micro-doppler extraction of vibrating target based on dual-channel ATI technique in SAR"

Aiming at extracting the time-varying micro-Doppler feature of the ground vibrating target within ground clutter environment, the method of micro-Doppler extraction based on dual-channel ATI technique is presented. The ATI technique is utilized to suppress the ground clutter, and preserve the interferometric signal of the vibrating target in the raw data domain, which is presented as a straight line along the azimuth direction. According to this feature, we can find out which range cell the signal locates at, and then by taking the time derivative of its phase, the micro-Doppler modulation can be obtained. Compared to the single-channel situation, there is no need to compensate for the Doppler shift caused by the radar's translation in advance, and we can obtain the micro-Doppler feature induced by the vibration in any direction, which will help to reduce the computation burden and improve the target detectability. Simulated results verify the validity of the proposed method. [C117]

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

In Multiple-Input Single-Output (MISO) HF surface wave radar system, the fact that bistatic operation and the movement of the receiver platform causes the nonstationarity and spreading of sea clutter, which will lead to the difficulty in detecting those immerged targets. The space-time distribution of sea clutter in different geometry is firstly investigated; and a knowledge-aided STAP scheme is proposed for mitigating the clutter. The weights of different range bins are acquired from both the clutter priori and the prefiltered training data by direct data domain (DDD) algorithm. Numerical simulation shows the proposed scheme effective. [C118]

"Impacts of Keystone formatting on Space-Time Adpative Processing in airborne radar"

Keystone formatting (KF) has the capability of compensating multiple targets' (including ground clutter) range walk simultaneously without using any specific knowledge of the target motion. However, due to serious Doppler ambiguity of the fast moving targets, KF will affect the distribution of the clutter and degrade the Space-Time Adaptive Processing (STAP) performance. Based on the above reasons, the impacts of KF on the clutter distribution are analyzed firstly, and then the impacts of KF on STAP are analyzed. The conclusions obtained are helpful to figure out better methods for fast dim air moving target detection. [C119]

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

Space-time adaptive processing (STAP) is an effective method for moving target detection in airborne radar. In this paper, a novel STAP method for fast dim air moving target detection is proposed. The new method suppress clutter in the received data firstly, and then apply Keystone formatting (KF) to compensate the target's range walk. Finally, target is accumulated by the conventional space-time beamforming. Effectiveness of the new method is verified via simulation examples. [C120]

"A method for Ground Moving Target Indication and Velocity Estimation based on InSAR system"

For InSAR system, the increasing clutter degree of freedom (DOF) with the terrain is caused by long cross-track baseline. It degrades the performance of Ground Moving Target Indication (GMTI) greatly. In this paper a new method based on InSAR system is proposed for GMTI and Velocity Estimation. In our approach, the joint pixel technique is adopted to improve the coherence of clutter. In this way the clutter can be well cancelled. For the velocity estimation, neighboring pixel pairs is used to compensate the terrain interferometric phase. Therefore, the accuracy of velocity estimation can be improved. Stimulation experiments illustrate the effectiveness of the proposed algorithm. [C121]

"Weber-Haykin based Automatic Censoring and detection in Weibull background"

In this paper, we study the problem of automatic target detection in Weibull clutter and multiple target situations, without any prior knowledge of neither the non-stationary clutter statistics in which the radar operates nor the number of outliers that may be present in the reference window. In doing this, we develop the Forward/Backward Order Statistic Automatic Censoring and Detection Constant False Censoring and Alarm Rates Detectors based upon the Weber-Haykin adaptive threshold (WH-based F/B-OSACD-CFCAR). These detectors select repeatedly a suitable set of ranked cells among reference cells surrounding the cell under test to estimate the unknown background level and set the adaptive threshold, accordingly. The censoring and detection performances are evaluated by means of Monte Carlo simulations. [C122]

"A new approach to distributed passive radar imaging by 2-D NUFFT"

This paper studies distributed passive radar imaging of two-dimensional (2-D) scene. The echoes and the reflectivity of target are confirmed to be a Fourier transform pair. However, due to the space configuration based on the illuminators of opportunity, the echoes are sampled non-uniformly, which lead to the non-equispaced

property of space-spectrum distribution. In this case, direct 2-D FFT reconstruction doesn't apply now. To retain the fast computing of image reconstruction like FFT, non-uniform fast Fourier transform (NUFFT) is introduced to avoid complex interpolation. We generalize NUFFT to 2-D NUFFT to tackle the problem that the space-spectrum is unequally-spaced in both directions of μ and v. This new 2-D NUFFT method is compared with polar-coordinate method in efficiency and accuracy using both the analytical and numerical approaches. Simulations demonstrate that 2-D NUFFT can reduce the computational complexity while ensuring image reconstruction accuracy. So it's a promising strategy for realtime imaging of distributed passive radar. [C123]

"Target detection of high-resolution radar in non-Gaussian clutter"

The high-resolution radar echo is modeled as a range-spread target. Based on the generalized likelihood ratio test design procedure, the range-spread target detection in spherically invariant random vector clutter is addressed. And a binary integrator with constant false alarm rate property is proposed to detect the whole range-spread target, after single target scatterer detection in each range cell. Finally, the performance assessment shows that, the detection performance is improved as the number of sensors used or the clutter spike increases, while it is robust to the clutter correlation. [C124]

"Spinning targets imaging based on OMP algorithm with radial basis function"

A new radar imaging method is proposed for spinning targets in space. The rapid spin motion of the target induces multi-period sinusoidal modulation of the radar echoes in both range and doppler domain, which causes Range-Doppler (R-D) algorithm invalid in conventional radar imaging. The presented method analyzes the echo model of the target spinning around an arbitrary axis. An exponential radial basis function (RBF) is then constructed from the scatters' range profile based on a distance-weighted criterion, and the image is rebuilt by recovering the projection of the target base on orthogonal matching pursuit (OMP) algorithm with the radial basis matrix. The simulation results show that the proposed method can obtain the radar image more effectively for the target with a uniform speed spin motion. [C125]

"Detection of moving target based on fractional Fourier transform in SAR clutter"

Based on the analysis of the characteristics of SAR target echo and the time excursion of fractional Fourier transform (FRFT), the Article has put forward a time-delay balance method based on FRFT to detect the slowly moving target in SAR echo according to the characteristics of SAR ground clutter. Calculation on the FRFT of echo signal and the FRFT of echo signal after short delay time results in two complex signals, in which, the modules of static backgrounds are just totally same, and in the range of moving target, the amplitude of module will cause an offset, therefore, when calculate the difference of the modules of two complex signals, the static background could be balanced and the moving target could be detected effectively. Simulation analysis indicates that the method in the Article shows its advantages in a background with strong clutter. [C126]

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

When the received echo signal energy reflected from a target is quite small, the target cannot be detected reliably with traditional accumulation and detection method. In this paper, based on the stable factor, an improved method is proposed, which utilizes the difference of correlation characteristics between clutter and target to suppress clutter spike. Then the track-before-detect algorithm based on dynamic-programming is applied to dim radar target detection. Compared with the combination method of coherent and non-coherent integration, the predominance of the algorithm is obtained on dim radar target detection. [C127]

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

The present shadow inverse synthetic aperture radar (SISAR) imaging algorithm is derived based on some assumptions for air moving objects such as long baseline, large target size and so on. For the forward scattering radar (FSR) system to detect ground moving targets, the assumption conditions are often unsatisfied because of relatively small objects size, the strong ground clutter and the short baseline length. Furthermore, the assumptions will result in distorted imaging results for the extraction of profile median line and height difference using the present imaging algorithm. To obtain the accurate imaging results of ground moving target, the more accurate signal model for ground moving target is first time presented based on Fresnel-Kirchhoff diffraction formula and high order phase approximation methods, and the modified imaging algorithm is also proposed for the accurate profile reconstruction of ground moving target. Finally, the effectiveness is verified by simulation results. [C128]

"Relationship of target identification performance and waveform parameters"

In this paper, we established rigorous relationship between target recognition performance and the parameters of a fixed waveform via Kullback-Leibler information number of single observation (KLINs). The method we proposed takes advantage of the methodology of sequential hypothesis test. It depicts the target recognition efficiency of certain radar waveform parameter in the metric of average number of necessary signal (ANS) transmission. Compared with the traditional simulation methods in literature, it is a more efficient and valuable one to find the optimum values of a certain waveform parameter. Simulation results about the parameters of LFM signal show the validity of the method. [C129]

"Research on Scan-GMTI technology of airborne MIMO radar based on STAP"

Through successive azimuth scanning with narrow beam steered to different angles, Scan-GMTI technology provides a significant way to implement wide-area surveillance and track a particular target simultaneously. Applying MIMO mode to Scan-GMTI, abundance channel and frequency resources provide significant advantages for STAP algorithm to implement. The space-time-frequency joint processing will provide an effective approach for improvement of detection of slowly moving targets, reduction of Doppler ambiguities and blind velocities. [C130]

"Generalized likelihood ratio test for distributed targets in heterogeneous environments"

Adaptive detection for distributed target or targets in non-homogeneous environments is studied in this paper. It is assumed that the covariance matrix of the secondary data Msis a random matrix following inverse Wishart distribution with its conditional expectation proportional to that of the primary data, i.e. E(Ms| Mp)= γMp. Firstly, the maximum likelihood estimator (MLE) of Mp, γ and target amplitudes are given and the generalized likelihood ratio test (GLRT) are proposed subsequently, which turns out to be in the form of the summed adaptive coherence estimator (ACE). The detector is coincident with the generalized adaptive subspace detector (GASD) based on deterministic unknown covariance matrix and it has CFAR property. When the target exists only in one range bin, the detector is boiled down into the ACE based on the partial homogeneous environments. [C131]

"Performance of cell averaging constant false alarm rate (CA-CFAR) processors for M-correlated sweeps in multiple target environments"

In this paper, the detection performance of CA-CFAR processor is analysed for M-correlated sweeps in Gaussian clutter environment which contains interfering targets. The performance analyses are done for different number of sweeps, M, and sweep-to-sweep correlation coefficient, R, with Swerling-I target model in homogeneous and non-homogeneous environments. [C132]

"CFAR detection based on decision fusion of order statistic CFAR and order statistic clutter map CFAR processors"

In automatic target detection radars, adaptive constant false alarm rate (CFAR) processors, which determine the threshold, are examined. Two techniques are used for achieving the required CFAR. The first technique determines the adaptive threshold using range neighbouring cells which are located in sliding window. The second one is based on clutter map. In this technique, adaptive threshold is determined using the samples of test cell from previous scans which are assumed to contain no target. In this study, new techniques based on combining the two techniques in the data fusion system (DFS), are proposed. Analytical equations for homogeneous and nonhomogeneous environment are derived and performance analysis are carried out. [C133]

"Range-Doppler ambiguity mitigation via closed-loop, adaptive PRF selection"

In this paper, we present a method of calculating and updating target probabilities in ambiguous range-Doppler cells along with an adaptive pulse repetition frequency (PRF) selection technique based on mutual information (MI). We approach the problem of updating the probability in multiple ambiguous cells by using a multiple hypothesis test for the target state. The probability ensemble is then used to determine which PRF will maximize MI on the next update. Since MI is a measure of the reduction in entropy of the ensemble, it indicates the amount of information the radar stands to learn about the channel due to the selected PRF. We compare the results of MI-based PRF selection to two other PRF selection methods and demonstrate how blind zones and clutter aliasing can be seamlessly integrated into our PRF-selection procedure. [C134]

"Time reversal adaptive waveform in MIMO radar"

EM multipath propagation is common in radar and wireless communications. Most radar systems are designed assuming line-of-sight (LOS), not multipath. In this paper, we extend our prior work on Multi-Input Multi-Output (MIMO) radar in the absence of interference [1], to consider MIMO radar detection in high clutter. We develop a

subspace MIMO target model and a statistical model for MIMO radar clutter that accounts for the spatial and spectral properties of radar returns. We show that, using orthogonal waveform signaling, the time reversal MIMO radar yields higher detection performance than conventional statistical MIMO radar in high clutter. [C135]

"Bistatic SAR along track interferometry with multiple fixed receivers"

This paper presents an along-track interferometry (ATI) study for a bistatic or multiestatic SAR configuration with fixed ground receivers. This technique can be useful for sea current estimation or for any problem of Ground Motion Target Indicator (GMTI). The proximity of the ground receivers to the scene allows to be very sensitivite to velocities with small baselines. This paper also proposes a multibaseline approach for ATI able to diferenciate among different velocity contributions in the same resolution cell. At the end of this paper, some results over real acquired bistatic data will be presented and discussed. The data have been acquired using the C-band SAR Bistatic Receiver for INterferometric Applications (SABRINA) and ESA's ENVISAT satellite, as a transmitter of opportunity. [C136]

"Target detection performance analysis for airborne passive bistatic radar"

For a ground-based/airborne passive bistatic radar, its performance is dependent on the geometrical configuration and the passive transmit signal attributes. Theoretical power budget and ambiguity function analysis using a ground-based non-cooperative transmitter of opportunity with a passive bistatic radar being airborne but stationary (airship, etc.) had shown that target detection performance is limited by the strong direct path coupling signal. In comparison, the bistatic ground clutter power is significantly lower and even more so for noise power. For the passive radar to perform satisfactorily, sufficient attenuation must be provided for the direct path and strong ground clutter signals, corresponding to increasing the height of the target peak on the ambiguity function pedestal. In addition, performance could also be improved by increasing the time-bandwidth product (assuming no target migration issues), which lowers the pedestal of the ambiguity function of the strong direct path interfering signal. [C137]

"Multi-baseline along track SAR interferometric systems for ground moving target indication"

In this paper we analyze the performance of ground moving target detection by means of single-baseline and dual-baseline along track interferometric synthetic aperture radar (SAR) systems, obtained using a generalized likelihood ratio test (GRLT). Detection performance are evaluated in terms of probability of detection and probability of false alarm using data simulated with TerraSAR-X parameters. [C138]

"Roll invariant target detection based on PolSAR clutter models"

Based on the Kennaugh-Huynen decomposition, the Target Scattering Vector Model (TSVM) allows to extract four roll-invariant parameters. Those parameters are necessary for an unambiguous description of the target scattering mechanism. The proposed method consists in applying the TSVM prior to the GLRT-LQ detector for the detection of any oriented target. [C139]

"Clutter detection algorithms for airborne pulse-Doppler radar"

Clutter detection is an important stage of target detection. Clutter may not always appear around zero Doppler frequency when realistic terrain models and moving platforms are considered. Two algorithms developed for clutter detection using range-Doppler matrix elements and their performance analysis are presented in this paper. The first algorithm has higher error rates but lower computational complexity whereas the second one has lower error rates but higher computational complexity. The algorithms detect clutter position by filtering range-Doppler matrix elements via non-linear filters. [C140]

"A novel array calibration method based on spatial correlation matrix for HFSWR"

This paper addresses a new method based on spatial correlation matrix to calibrate uniform linear array for HF Surface Wave Radar (HFSWR). Strong point echoes, such as target, clutter, transponder and so on, which are highly spatial correlated, can be used to structure spatial correlation matrix. And the matrix contains angles of echoes and phase errors information. In this paper, we use two-dimension FFT to estimate angle of strong point echo, and then obtain the corrections. Computer simulations and experimental results are conducted to show the validity of the new method. [C141]

"Improved Variable Index constant false alarm rate radar processors"

In the cases when the statistical distribution of range return samples are not known, constant false alarm rate

(CFAR) processors can be used. Cell Averaging (CA) CFAR radar processors which have the best performance in Gaussian homogeneous environments, exhibits performance degradation in the presence of an interfering target or in regions of abrupt change in the backround clutter power. The Greatest of (GO) CFAR radar processors are designed to control the false alarm rate, during the clutter power transition in the reference window (non-homogeneous clutter environment). The Smallest of (SO) CFAR radar processors improve detection performance when interfering targets exist in the environment but are unable to prevent excessive false alarm in non-homogeneous environments. Variable Index (VI) CFAR processors employs a composite approach based on CA-CFAR, SO-CFAR, GO-CFAR. Enhanced VI-CFAR (EVI-CFAR) radar processors proposed in this paper, shows performance improvement in different non-homogeneous environments when compared with VI-CFAR. [C142]

"Composite scattering from electric-large target over randomly rough surface in numerical approaches"

Numerical study of radar echoes from the targets in environmental clutters has been of great interest in many applications. In this paper, the bidirectional analytic ray tracing (BART) method for composite scattering from three-dimensional (3D) electrically large complex target above a randomly rough surface is reported. Analytic tracing of polygon ray tubes in bidirectional tracing is developed to precisely calculate the illumination and shadowing of facets, which exempt large patches of the target from any finer meshing. It significantly reduces the complexity relevant to the target electric-size. Numerical examples of angularly composite scattering from a three-dimensional electrically large, e.g., a ship-like target over a randomly rough surface are presented and discussed. [C143]

"Target detection above rough surfaces in microwave imaging using Compressive Sampling"

A subspace extraction approach for detection of targets embedded in the clutter is presented in this work. Subspace extraction approach that makes use of both Compressive Sampling and Principal Component Analysis (PCA) is presented in this paper. Inverse Synthetic Aperture Radar (ISAR) Imaging measurement data is used to validate the proposed approach. Experimental results of targets above rough surface with intermediate roughness are presented. Results showed the dimensionality of an intermediate scale rough surface is generally larger than the dimensionality of the finite size targets. Results showed that by compressing the dimensionality through compressive sampling and extracting the principal components, significant improvement in target subspace extraction can be achieved. [C144]

"Adaptive clutter map detector in nonhomogeneous environment"

The Ordered Data Variability (ODV) technique is introduced into hybrid clutter map/L-CFAR technique, which is used to process the echoes on the clutter map spatially. The new method is called as Clutter Map/ODV (CM/ODV) technique. An analytic expression of detection probability in homogeneous environment is presented, and detection performance in three different situations in nonhomogeneous environment is analyzed. The CM/ODV can censor interfering targets adaptively and prevent the masking effect, moreover, it doesn't need any priori information, so the new kind of clutter map technique performs robustly. [C145]

"Influence of rain Doppler frequency on MMW Doppler fuze"

Guided weapon systems require a proximity fuze device to trigger the explosive warhead. Various proximity fuze types are currently employed. The millimeter wave (MMW) radio Doppler fuze is a potential advantage system, and it is required for a wide range of military application. In this paper, the MMW fuze Doppler Effect is discussed in the encounter course of fuze and target. The target Doppler frequencies (DF) caused by the target moving relative to fuze are calculated at 35 and 95GHz. The relationship of the target DF with the distance between fuze and target is obtained. The rain Doppler frequencies induced by the volumetric rain medium for the interested rain area around target moving relative to fuze are calculated at 35 and 95GHz. The relation of the rain DF with the distance between fuze and the interested rain area are given. The influences of rain DF on target DF are analyzed. It is shown that when the distance between fuze and target is less than about 30m, the difference between the rain DF and the target DF decrease gradually with the distance decreasing. The influences of rain DF clutter on target DF information become gradually bigger with the distance approach, especially, for heavier rainfall, a smaller target and a wider fuze radar beam. Therefore, when the encounter distance between fuze and target is less than about 30m, the influence of the rain Doppler clutter on the target Doppler signal is severe, and need be considered for the MMW Doppler fuze application. [C146]

"Advances in numerical simulation of composite scattering from target above rough surface"

Study of radar echoes from the targets in environmental clutters has been of great interest in many applications.

In this paper, research works on theoretical modeling and numerical simulations of composite electromagnetic scattering from target and rough surface are briefly reported. It includes GFBM/SAA, Hybrid KA-MoM, FEM with CMPL-DDM-TLQST, FDTD, and BART, developed in this Lab during recent years. GFBM/SAA: generalized forward backward method with spectral accelerate algorithm Hybrid KA-MoM: hybrid analytic Kirchhoff approximation and numerical method of moment FEM with CMPL, DDM and TLQST: finite element method with conformal perfectly matched layer, domain decomposition method, and two level quasistationary algorithm FDTD: finite difference time domain BART: bidirectional analytic ray tracing. [C147]

"Performance analysis of optimal and reduced-dimension STAP for airborne phased array radar"

The performance of the optimal and reduced-dimension Space-Time Adaptive Processing (STAP) algorithms for the airborne phased array radar is investigated in this paper. The clutter suppression in the mainbeam and the sidelobe clutter regions and the computation load are analyzed and compared between the optimal and two kinds of typical reduced-dimension STAP algorithms, i.e. the 2-D temporal-spatial adaptive algorithm (TSA) and the m-bins Doppler transform-space adaptive processing (mDT-SAP) algorithm. Based on the performance analysis of these STAP algorithms, a new clutter suppression strategy is proposed with consideration of actual clutter environment and the spatial channel and temporal pulse restricted system, which can detect the target more effectively and implement more easily for the airborne phased array radar. [C148]

"Study on the Signal Detection Algorithm of Weak Laser Radar Target Based on Wavelet Transform"

According to the different transmission characteristics under the wavelet transform(WT) domain and the different distribution characteristics of frequency domain of the signal and noise, a novel approach for detecting weak signal laser radar target based on wavelet transform has been proposed. In many cases, wavelet decomposition has been used to de-noise a digital signal submerged by mass noise. Differently in our approach, we applied the wavelet decomposition and the modulus maximum to detect the locations of laser radar echo signal. Simulation shows that the proposed algorithm is more efficient than only utilizing wavelet decomposition in a clutter environment. [C149]

"Algorithm for unknown SNR estimation based on sequential Monte Carlo method in cluttered environment"

In target tracking, radar or sonar sensors provide amplitude information as well as kinematic information, e.g., range and bearing. Considering the amplitude information with kinematic information, tracker can more effectively distinguish measurement origin in cluttered environment. The tracker utilizes the amplitude information in the form of signal to noise ratio (SNR). However, a major challenge comes from the fact that the SNR is often fluctuated according to the target's aspect and effective radar cross section. So the certain level of uncertainty of SNR should be reduced. Focused on the point, we propose a novel SNR estimation algorithm based on sequential Monte Carlo method. Finally, estimated SNR is applied to the probability data association filter with amplitude information. Simulation results demonstrate the effectiveness and high accuracy of the idea of exploiting SNR estimation in heavy cluttered environments. [C150]

"Range tracking filter using measurements with uncertain delays"

In modern marine range tracking systems, both Doppler radar and range sensors are often used to enhance the detection and tracking performance against sea clutters. Due to the delays in communication links, however, the measurements of the sensors do not arrive simultaneously to the data processor where the tracking filter operates. Moreover, the magnitudes of the delays vary irregularly. To cope with this problem of uncertain time delays, in this paper, we propose a new range tracking filter algorithm by adding a ZSB (zero-scan-back) MAP (maximum a posteriori) delay estimator to conventional Kalman tracking filter. Computer simulations are carried out to demonstrate the performance of the proposed filter. [C151]

"A new modified Joint Domain Localized STAP algorithm"

The original Joint Domain Localized (JDL) Space-Time Adaptive Processing (STAP) algorithm is a kind of effective beam-Doppler domain method. However, when there are array element errors in the system, the Localized Processing Region (LPR) in the JDL algorithm must be expanded in the spatial domain in order to gain the same robustness so that the system computation load is increased significantly. In this paper, a new modified JDL algorithm is presented to solve this problem. The Moving Target Indicate (MTI) technique is applied to pre-filter the mainlobe clutter before the original JDL processing, which can reduce the clutter Degrees of Freedom (DoFs) effectively and enhance the system robustness to the array element errors. By comparison of

the new modified JDL algorithm with the original JDL STAP algorithm using the numerical simulation, it is found that the proposed method can improve the system performance significantly. [C152]

"Passive multi target tracking with GM-PHD filter"

This paper considers the challenging problem of multitarget tracking with passive data, obtained here by geographically distributed cameras. We use a Gaussian Mixture Probability Hypothesis Density filter approach to solve this difficult problem. As we make no spatial assumptions for the birth process, we use a slightly modified filter to obtain our results. We first describe the modified filter and detail our application before we present some results obtained on a realistic test scenario. Our simulations demonstrate that the proposed Probability Hypothesis Density filter is a promising candidate for three dimensional passive multi target tracking in clutter. [C153]

"Active clutter reduction through fusion with passive data"

Active and passive sonar systems often provide complementary information. Active systems generally provide good localization but are subject to high rates of clutter from bottom and volumetric scatterers. Passive systems generally have good resolution only in bearing and only can detect objects that emit acoustic energy. By fusing measurements from both types of systems, the passive data can be used to reduce the clutter in the active data. The result is improved target tracking, as shown in two examples, including the injection of a single target into a recorded active clutter dataset. [C154]

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

Airborne tracking and identification (ID) of high value ground targets is a difficult task impacted by sensor, target, and environmental conditions. Layered sensing, using a combination of standoff and short-range sensors, maintains target track and identification in cluttered environments such as cities or densely vegetated areas through sensor diversity. Data, feature, decision, or information fusion is necessary for high confidence target classification to be achieved using multiple sensors and sensor modalities. Target identification performance is improved by exploiting the extra information gained from independent sensing modalities through information fusion for automatic target recognition (ATR). Increased target ID has been demonstrated using spatial-temporal multi-look sensor fusion and decision level fusion. To further enhance target ID performance and increase decision confidence, feature level fusion techniques are being investigated. A fusion performance model for feature level fusion was applied to a combination of sensor types and features to provide estimates of a fusion gain. This paper presents a fusion performance gain for Synthetic Aperture Radar (SAR), electro-optical (EO), and infrared (IR) video stationary target identification. [C155]

"Adaptive pulse compression via maximum signal minus interference level in clutter environments"

Standard matched filter for pulse compression causes high range sidelobes, which may mask neighboring small targets. The adaptive pulse compression (APC) based on reiterative minimum mean square error (RMMSE) can mitigate the range sidelobes in white noise. However, its performance degrades in clutter environments. In this paper, an APC algorithm based on maximum signal minus interference level criterion (MaxSMIL) is proposed, in which the result of signal power minus interference power is maximized so that interferences including range sidelobes, clutter and noise are suppressed adaptively. Simulation results show that the proposed algorithm outperforms the APC based on RMMSE in Weibull clutter environment. [C156]

"Application of AIS in Marine Search and Rescue Radar"

Nowadays marine radar detects targets by Constant False Alarm Rate (CFAR). But the search and rescue efficiency is low in poor visibility or serious interference. In this paper, we reference learning mechanism, set up the AIS information for the sample and estimate the threshold t of the search targets with Maximum Likelihood (ML). Then any ship can be distinguished and searched. Experimental results show that using this method can improve the efficiency and accuracy of marine search and rescue radar searching the targets. [C157]

"Search Aid System Based on Machine Vision and Its Visual Attention Model for Rescue Target Detection"

The prompt search and rescue of lifesaving target is very important in the case that a marine casualty occurs. To detect the small target in the wide views over the sea, we have proposed a machine vision system to aid search and rescue on the sea, which combines remote sensing, radar, infrared with visual light technology. One of the detection methods in this system, which is based on visual attention mechanism, is proposed in this paper to find rescue target from visual light image. The color information, image intensity and other image properties

are used to generate the feature maps that form the saliency map subsequently with the weighted integrating strategy. The experimental results show that the proposed method is efficient to detect the small target in cluttered ocean scene. [C158]

"3D simultaneous multi-beams radar processing by using planner array antennas"

In this study a planner array with beam forming and beam shaping techniques are designed in order to develop and simulate 3D simultaneous-multi-beams (3DSMB) radar. Two targets are obtained, firstly developing 3D radar with 4 simultaneous-pencil beams, secondly, developing 3D with 4 simultaneous-different beams, such as Pencil, Fan, Transmit, and Intermediate beams. The new development in this paper provides in conjunction with enhanced processing techniques superior innovative war-fighting solutions to the dramatic change in the nature of threats (i.e. Missile, Anti Radar Missile, Jammers, and heavy clutter). A new software package is developed for the 3DSMB Radar in order to obtain the lobbing pattern coverage for a complex topography, because the previous studies didn't obtain the lobbing pattern for the 3D radar. Also, the cost will be much cheaper for the new mentioned development because instead of using different radars for different tasks and different targets platforms, the new development will be one radar processing different tasks and different targets platform at the same time, in addition to minimizing size and increasing processing speed and saving processing time. [C159]

"An FPGA based semi-parallel architecture for higher order Moving Target Indication (MTI) processing"

The design and implementation of a higher order Moving Target Indication (MTI) engine is presented. This is part of a single chip radar signal processor also incorporating the subsequent algorithms. The bottleneck in use of higher order filters for MTI is not an algorithmic one but one related to implementation. Thus the challenge is to minimize area utilization and achieve the required speed. The proposed architecture employs the use of multiple offchip memory banks for achieving the required memory bandwidth and use of dedicated FPGA resources for area minimization. The requirement of stacking a large number of radar returns in memory and then reading them all for filtering within a single return time demands a parallel memory reading and data processing approach. But this demand has to be balanced with the requirement to consume as little area as possible to leave room for the following algorithms. Considering these constraints, a semi parallel architecture employing multiple filters, each built around a DSP48 slice configured as a Multiply Accumulate (MACC) unit in a time shared manner is used. An analysis of various factors that affect speed and area is also made. The architecture is implemented on a Virtex-4SX35 FPGA using Xilinx XtremeDSP Kit. The design is tested using unprocessed baseband data from a TA-10K air traffic control radar. Results show a marked improvement in the clutter suppression capability of the radar. The design achieves the required speed using only 7% of the available FPGA slices. Thus, not only can the other algorithms be implemented on the same chip but there is room for enhancements as well. [C160]

"Parameter estimation of moving target for stepped-frequency radar under temporal-correlated clutter"

Proposed is a maximum likelihood (ML) estimation method to estimate the parameter of the moving target for high range resolution stepped-frequency radar in strong clutter background. In this study the temporal correlated clutter is used. By transmitting frequency-hopping waveform and using the spectrum density of the clutter, the method may accurately estimate the moving target parameter in strong clutter. Numerical experiments illustrate the effectiveness of the proposed method. [C161]

"A modified anti-RGPO jamming algorithm"

An algorithm which integrated triple threshold test with nearer range selection method is presented to deal with the deficiency of RGPO jamming in this paper. The triple test has minimum probability of error decision. Nearer range selection to data association can eliminate the effect of the RGPO and clutter simultaneously. The experiment results demonstrated that the method proposed in this paper has better performance and obvious improvement on tracking precision when suffering RGPO jamming compared to the present methods. [C162]

"Method to determine CPI for ubiquitous radar"

Ubiquitous radio: is a new radar system that provides continuous and uninterrupted multifunction capability within a coverage volume. Continuous coverage from close-in "pop-up" targets in clutter to long-range targets impacts selection of waveform parameters. The CPI (Coherent Processing Interval) must be long enough to achieve a certain signal-to-noise ratio (SNR) that insures the efficiency of detection. This paper analyzes the condition of detection in the case of low SNR, discusses three different cases that would occur during integration and

presents a method to determine the CPI. The simulation results show that it is available to determine the CPI for targets detection with SNR as low as -26dB in the experimental system. [C163]

"Research on adaptive beamforming for airborne phased array radar"

PD mode is usually adopted in airborne phased array radar. However, there are two problems which severely degrade the performance of adaptive beamforming. One is the ground clutter return in the training data, the other is the target return in the training data. Therefore, in this paper, the two problems above are analyzed in detail, and then the methods suitable for engineering realization are presented. Computer simulation results are presented for illustration. [C164]

"Parameter estimation for stepped-frequency radar under temporal-spatial correlated clutter"

Proposed is a maximum likelihood (ML) estimation and minimum target error function (TEF) method to estimate the parameters of the moving target for high range resolution stepped-frequency radar in temporal-spatial correlated clutter background. The compound-Gaussian model is used for the temporal-spatial correlated clutter. Both of the velocity and range of the moving target can be accurately estimated for stepped-frequency radar. Numerical experiments illustrate the effectiveness of the proposed method. [C165]

"The combination of ACDA and FCM for Data Association in multi-target tracking"

For improving the performance of ACDA (Ant Colony Data Association) for data association in multi-target tracking, we propose the combined method of ACDA and FCM. Since FCM is a determinate algorithm, in nature based on NN (Nearest Neighbor), it could generate reasonable results in any case, which is a backup when ACDA becomes divergent. Experiments have been done in three cases-ACDA as data association method only, FCM only, and the combined method of ACDA and FCM. The results show that the performance of the combined method is superior to the other two methods. [C166]

"Adaptive network fuzzy inference system used in interference cancellation of radar seeker"

The method of adaptive network fuzzy inference system (ANFIS) applied to the interference cancellation system of radar seeker was described in this paper. When the antiaircraft missile, which adopts the pulse Doppler radar seeker, attacks the low altitude target in the down-looking mode, the seeker of missile will receive strong ground clutter. As we all know the ground clutter will seriously affect the seeker's properties of target detecting and real-time tracking. To dealing with the seeker signal, the model of clutter should be constructed firstly. But it is difficult to handle because of the uncertainties and non-completeness characteristic of the clutter model. In order to solve the problem and overcome these, the nonlinear model, which used for clutter signal processing by the ANFIS is accepted in the interference cancellation system. In some researches, it was proved that the artificial network based on ANFIS not only has the ability of nonlinear mapping but also has the function of self-learning. Especially, ANFIS has small calculating costs. In my study, to possess a desired robust model, the adaptive side lobe clutter cancellation system depended on ANFIS was introduced. Through the side lobe clutter cancellation, the signal noise ratio (SNR) of echo signal got obviously improvement. The simulation results of experiments showed that the method of ANFIS can sharply improve the detecting performance of pulse Doppler radar seeker's looking for lower altitude target. [C167]

"Improving target tracking performance by incorporating classification information"

This paper presents approaches for incorporating classification information into target tracking algorithms, specifically in a multistatic active sonar context. In addition, this paper describes the framework designed for simulation and classification of return time series from simulated targets and clutter in a realistic underwater environment. The simulated target and clutter returns are integrated into an existing contact-based tracking dataset (TNO Blind dataset) for which time series are unavailable. Simulations compare the integrating classification of contacts at different stages of tracking algorithms. Results show improvements in some tracking metrics with no degradation of the others. [C168]

"Compact microstrip antenna design for microwave imaging"

An ultra-wideband microstrip antenna design is considered with respect to applications in breast cancer detection. The underlying design concept is based on ground penetrating radar (GPR). Simulated and measured prototype performance show excellent performance in the input impedance and radiation pattern over the target range from 4 GHz to 8 GHz. The 4 GHz to 8GHz frequency band for microwave imaging perform better in comparison with other microwave frequencies. The antenna also shows a reasonable uniform radiation performance in the broadside direction which contributes to the reduction of clutter levels, thus aiding the

reconstruction quality of the final image. [C169]

"Mean shift track initiation algorithm based on Hough transform"

To solve the problem of initiating tracks for multi-target in dense clutters environment, a Mean shift track initiation algorithm based on Hough transform is proposed. In the algorithm, firstly, hough transform is applied to transform observation points from input space, referred to as feature space into curves in a special parameter space; then a Mean shift clustering algorithm is executed to cluster the items gained in the parameter space, and the problem of peak seeking is also solved adaptively. Furthermore, a fuzzy influential factor, which is based on the vote number of accumulation matrix and distance between items in the parameter space and clustering center, is defined to design kernel function of Mean shift; thus clutters are removed more effectively. Experimental results show that proposed algorithm has high detection accuracy and can initiate tracks effectively. [C170]

"A two-stage gating algorithm for joint probability data association filter"

Gating techniques for maneuvering target tracking using a joint probability data association filter (JPDAF) are considered in this paper. A way of estimating the gate size via the performance of the data association filter has been proposed recently, by which the gate size can be estimated by looking for the optimal performance of the data association filter. Combining the elliptic tracking gate with the direction tracking gate, a modified performance estimation function was proposed. As a feasible implementation, a suboptimal two-stage gating algorithm has been proposed also. Simulation results show that the suboptimal algorithm can offer advantages of decreasing the number of the feasible association events and reducing the calculation load of JPDAF, especially in a heavy clutter and/or false alarm environment. [C171]

"Application of particle filter for angle measure"

In anti-ship terminal guidance radar tracking system, the target echo is always corrupted by the sea clutter. When sea clutter is large at high sea state, the signal -to-noise ratio (SNR) of the target echo is usually relatively low as a result of the effect of sea clutter. The precision of angle error extraction in radar tracking servo is low, while the fluctuating error of angle measure is large in low SNR region. The radar antenna has to adjust itself very frequently to keep tracking its target. While it leads that the radar can not always hold on tracking the target steadily. To improve the precision of angle error extraction and steady off-boresight angle measure of the target, a novel angle measure method based on particle filter is proposed, which achieves off-boresight angle estimation by approximating the posterior probability diversity with particle set, and the steps of algorithm are presented. Finally the simulation experiment confirms the valid of the proposed algorithm. [C172]

"Scan-to-scan sea-spikes filtering for radar"

High range resolution radars are often a solution to the problem of small target detection in the presence of sea clutter, however this solution leads to a high density of sea-spikes echoes. The number of false plots can be very high and need to be regulated in order to be able to control the tracking load and limit the number of false tracks. In this paper a solution for the Coast Watcher 10 and Coast Watcher 100 products is derived. The new patented scan-to-scan algorithm used to filter plots before tracking is presented. It uses the position and Doppler information of the plots on several scans to regulate the number of false plots at tracking level. [C173]

"Detection against the background of non-Gaussian clutter from underlying surface"

The method for the operating characteristics of the radio systems estimation based on using of model of non Gaussian clutter from underlying surface (sea, land plots) is proposed. This method was done by nested semi-Markov based processes. The characteristics of parametric (Neumann-Pearson, adaptive control of threshold and filter band of moving-target indication) and non-parametric (sign and linear rank) detectors are analyzed theoretically and are compared to results of the experimental investigations. [C174]

"A model-based track-before-detect strategy"

This paper addresses adaptive detection and tracking of a point-like target in thermal noise plus clutter which is assumed to be heterogeneous from one range cell to another. To this end, a track-before-detect scheme is derived and assessed; its design relies on autoregressive modeling of noise returns. A preliminary performance assessment, based upon Monte Carlo simulation, shows that it can outperform previously proposed TBD strategies. [C175]

"An s-band ultrawideband time reversal-based RADAR for imaging in cluttered media"

This work presents a new RADAR prototype built for the purpose of imaging targets located in a cluttered environment. The system is capable of performing Phase Conjugation experiments in the ultrawideband GHz. In addition, applying the D.O.R.T. method to the inter-element matrix allows us to selectively focus onto targets, hence reducing the clutter contribution. The system has been validated by ph-syically backpropagating the focusing wave into the medium all over the frequency band and observing the expected focusing properties. [C176]

"Parameter estimation of moving target based on linearly constrained space-time adaptive monopulse technique"

Technique of space-time adaptive processing (STAP), which is usually employed by airborne radar to reject the ground clutter and jamming and at the same time, detect the ground moving targets, can not estimate the spatial-temporal parameters of the corresponding targets. Monopulse technique, as a mature method for parameter estimation can be used on airborne radar, however, the estimation performance of this method is dramatically effected by the ground clutter and jamming components present, even when these components falls into the mainbeam interval. By combining the STAP technique with the monopulse technique, a new method for estimating the spatial-temporal parameters of moving targets is proposed and referred as to LC-STAM in this paper. Additionally, the proposed method utilizes the beam null, monopulse slope, and decoupling constraints to remove the worse influence on the beam shape from the mainbeam clutter, maintain the characteristic of the monopulse ratio, and increase the veracity of parameter estimation. Simulation results illustrated that the LC-STAM method possesses the excellent estimation performance of the spatail-temporal parameters by comparing with the other similar methods. [C177]

"Characterisation of dismounted combatants radar signature from airborne platforms"

The radar signature of dismounted combatants as observed from a moving airborne radar platform was examined and quantified. The dismounted target presented a characteristic amplitude and frequency modulated signature which proves useful in distinguishing true targets from those due to uncancelled clutter discretes. [C178]

"Fractal based detection using blind box-counting method in high resolution radars"

Sea clutter refers to the radar returns from the sea surface. Accurate modelling of sea clutter and detection of low observable targets within sea clutter are major problems in remote sensing and radar signal processing applications. Recently fractal geometry is applied to the analysis of high range resolution radar sea clutters. The box-counting method is widely used to estimate fractal dimension but it has some drawbacks rarely considered in literature. We explain the problem of box size range and present a novel method to select an appropriate range. [C179]

"Solid state pulse Doppler radars for maritime traffic surveillance-Review of architecture and trade-off analysis"

Maritime traffic surveillance radars are in use for several decades, they are mostly based upon magnetron pulse emitters and simple non coherent signal processing. While the lack of coherent signal processing capabilities is compensated by strong pulse power, there is still a demand for improving detection and tracking performances especially in front of heavy sea clutter for detecting small and evasive targets. The solutions that address such demands are based upon the use of solid state transceivers which allow to generate and to process specifically designed waveforms incorporating for example frequency or phase codes. [C180]

"Antenna size versus sea clutter rejection: A new analysis of coastal radar performances and optimization"

In the field of coastal surveillance radar, and more generally in maritime environment, the overall radar performance for the detection and tracking of small target is primarily linked to the capability of the radar to reject the sea clutter. Sea clutter is the radar signal return of the sea surface illuminated by RF waves and can often be a strong as the target radar return. A conventional method to counter sea clutter is to use very large antennas providing high angular resolution trying to optimize the signal to clutter ratio in the radar processing by defining the smallest possible illuminated cell of sea surface. This paper provides an in depth analysis of the pro and cons of large slotted waveguides antennas and shows that bigger is not better: Parasitic effects, correlated to antenna dimensions, in the beam forming process of big antennas tends to degrade the antenna performance and leads to the conclusion that the optimal antenna size is often smaller than the one currently used on existing

coastal surveillance radars. [C181]

"Knowledge assistance for ground target tracking and resource management"

Tracking slow moving ground targets from airborne phased array radar is a challenging task. Some of the major issues are heading accuracy of slow moving target and radar resource management in clutter regions. In this paper, we propose a novel tracking framework using digital map and clutter knowledge bases to efficiently track the ground moving target using airborne phased array radar. The proposed technique uses offline processed digital map for fast retrieval of road parameters. Also, the proposed radar data processor provides feedback to populate and update the clutter knowledge-base. A fast yet robust method is employed for ground mapping of targets and to detect map features such as road junctions. Experimental results show (i) the robustness of the map knowledge assisted tracking approach when target moves along different kinds of path (i.e. on/off the road) (ii) better heading accuracies achieved by knowledge assistance and (iii) radar resource management in clutter region with knowledge-base. [C182]

"A Fit-to-Sine based processing chain to handle multiple-target scenarios"

The full coherent processing of non-equidistant sampled data has been the topic of many research activities. In this paper we propose a processing chain based on such an algorithm, the Fit-to-Sine function, which is able to handle multitarget and target/clutter radar signals. Starting from the computation of a least squares cost function in dependency of frequency, followed by a feature extraction method and the suppression of unwanted sidelobes, we conduct a simple noise/target distinction by utilizing basic fuzzy logic characteristics and operations. Finally we exemplify our processing chain and the achievable results on a real radar scenario with a target moving in strong clutter. [C183]

"Medium-PRF detection by non-coherent integration"

The document describes a detection and inherent ambiguity resolution scheme for Medium-PRF waveforms. Medium-PRF waveforms are characterized by ambiguous measurements of both range and doppler. Ambiguities are resolved by changing the pulse repetition frequency (PRF) from burst to burst and by combining the ambiguous results of adjacent bursts. The classical binary integration procedure applies a detection threshold on burst level and combines detections from burst to burst including unfolding of the ambiguities. In this paper the more optimum method of non-coherent integration from burst to burst with inherent ambiguity resolution is discussed. The method provides a significantly improved detection performance. Of particular interest for non-coherent integration is the appearance of ghost targets. The paper proposes a method for deghosting. [C184]

"Microwave-range imagery with an ultrawideband time reversal-based RADAR"

This work presents a new RADAR prototype built for the purpose of imaging targets located in a cluttered environment. The system is capable of performing Phase Conjugation experiments in the ultrawideband [2-4] GHz. In addition, applying the D.O.R.T. method to the inter-element matrix allows us to selectively focus onto targets, hence reducing the clutter contribution. The system has been validated by physically backpropagating the focusing wave into the medium all over the frequency band and observing the expected focusing properties. [C185]

"Improved range resolution for FMCW HF surface wave radar"

A modified signal processing for FMCW waveform has been proposed that yields an improved range resolution without increasing the transmitted signal bandwidth. The chirp duration is reduced by an appropriate factor while the interval of the beat signal sequence considered for the range transform is kept constant. This modification implies a range transform over several chirp sweeps and an interleaving technique for the Doppler transform. Range resolution is improved without affecting the maximum unambiguous Doppler. This is achieved on the expense of a reduction of the maximum unambiguous range. Actually, this is not a restriction for HF SWR systems where the maximum range is limited by surface wave attenuation. However, a minimum practical range bin size is given either by the size of the targets considered or by the acceptable size of range side lobe level coming along with increasing range resolution. With this approach first and second order sea clutter is reduced which is of significant interest for ship detection. [C186]

"Vessel detection and classification: An integrated maritime surveillance system in the Tyrrhenian sea"

In recent years a number of organizations, both national and international, have put significant efforts in developing knowledge-based integrated maritime surveillance (IMS) systems. The final aim is to have a clear

picture of the position, classification, identification and movement of cooperative and non-cooperative targets entering and leaving the 200 nautical miles limit of the Exclusive Economic Zone (EEZ). Each sensor (i.e. satellite-based, ground-based, shipborne or airborne) has its own task and, in such a context, high frequency (HF) surface wave (SW) radars are inexpensive tools for long range early warning applications in open waters. They allow maximizing the effectiveness in dealing with fisheries protection, drug interdiction, illegal immigration, terrorist threats, search and rescue tasks. This paper focuses on the possibility of combining automatic identification system (AIS) data with HFSWR data for vessel detection and classification purposes. Three algorithms for target detection in compound Gaussian HF sea clutter are presented and their performance evaluated. The combined use of AIS plots provided by cooperative targets can allow the operator to discriminate non-cooperative targets and possible threats. The concurrent exploitation of AIS and HFSWR data is presented and discussed by means of real data recorded during the NURC experiment in the northern Tyrrhenian Sea in May 2009. [C187]

"Radar waveform design for detection of weapons"

We present waveform design based on signature exploitation techniques for improved detection of weapons in urban sensing applications. We consider a single-antenna monostatic radar system. Under the assumption of exact knowledge of the target orientation and, hence, known impulse response, matched illumination approach is used for optimal target detection. For the case of unknown target orientation, we propose waveform design based on subspace decomposition of the target impulse response matrix corresponding to the various aspect angles. Numerical electromagnetic modeling is used to provide the impulse responses of an AK-47 assault rifle for various target aspect angles relative to the radar. Simulation results depict an improvement in the signal-to-noise-ratio (SNR) at the output of the matched filter receiver for both matched illumination and subspace waveforms as compared to a chirp waveform of the same duration and energy. [C188]

"Model based adaptive detection algorithm with low secondary data support"

In this paper the problem of adaptive target detection in structured Gaussian clutter is considered. The clutter is modeled as an auto-regressive process with known order but unknown parameters. To solve this problem, we have modified a well known adaptive detector (Kelly's GLRT) in four different forms. In this detector an estimation of covariance matrix is needed. In order to estimate the covariance matrix, we estimate the AR parameters based on secondary data and use the results in covariance matrix estimation. Then, we use the estimated matrix in the detector structure. In order to estimate the AR parameters using more than one set of data, we have extended four classical AR parameter estimation techniques to use more data sets. The performance of the proposed detectors have been evaluated using Monte-Carlo simulations and compared with each other. [C189]

"Simultaneous detection and tracking of multiple objects in noisy and cluttered environment using maximum likelihood estimation framework"

We discuss a versatile framework for multiple target detection and tracking based on maximum likelihood estimation with expectation maximization and a cognitive theory called dynamic logic. In this contribution extend the framework to detection of moving objects in video sequences. The paper presents the theory and an example of detection and tracking using a real world video sequence. [C190]

"Target tracking in state dependent wake clutter"

Tracking methods attempt to follow the movement of a target of interest while suppressing irrelevant clutter. A particularly troublesome source of clutter is wakes that appear behind the target. This problem arises in sonar tracking of human divers, in the tracking of boats using surveillance radars, and also in radar tracking of ballistic missiles. Previous research has integrated a solution to this problem in the popular Probabilistic Data Association filter (PDAF). This paper proposes a new solution to this problem in the same framework. While previous research has used an approach described as probabilistic editing, the new solution solves the wake problem in a Bayesian framework by means of marginalization. Monte-Carlo simulations show that the new solution provides significantly increased robustness as compared to both the standard PDAF and the probabilistic editing approach. As the new solution has improved theoretical underpinnings, we hope that it can be useful for further research on tracking in the presence of wake clutter. [C191]

"Utilizing Q-Learning to allow a radar to choose its transmit frequency, adapting to its environment"

Recent research show that utilization of knowledge of the environment can allow a radar system to adapt its processing to improve its performance. Furthermore, a radar system that utilize both a-priori and measured knowledge in an adaptive close loop manner could seem to be cognitive of its environment, able to adapt to

changes to optimize performance. Reinforced learning could play a vital role as part of such a closed-loop cognitive radar system. The Q-Learning algorithm is hypothesized to be useful for this cognitive radar domain. This paper investigates the problem of adaptively choosing the radar transmit frequency through application of Q-Learning on measured radar data. A comparison is made against other frequency selection algorithms and its shown that Q-Learning manages to learn a good strategy to adaptively select radar transmit frequency, mostly outperforming the other methods tested in the scenario investigated here. [C192]

"A Migrating Target Indicator for wideband radar"

The standard way to suppress clutter in narrowband radar is to use Moving Target Indicator (MTI) cancellation techniques. High Range Resolution (HRR) radars are becoming more and more important because they can detect and track targets more accurately. As for such radars the bandwidth is increased, the resolution is decreased and leads to target range migration over the coherent pulse interval (CPI). Due to this range walk, standard low resolution MTI processing is not adapted anymore to HRR MTI radar data. We propose here to extend the principle of the MTI processing to the wideband case. We refer to this method as the Migrating Target Indicator (MiTI), since it eliminates the non-migrating targets from the received signals. [C193]

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

In this paper, HCAC's research and development efforts on the development of integrated and low cost HF radar for coastal surveillance and other Homeland Security applications are summarized. The proposed design incorporates electrically small antenna for rapid deployment, supports operation on floating platforms by using enhanced DSP algorithms to mitigate clutter, incorporates improved propagation modeling to more accurately select optimum frequency channels based on atmospheric conditions and overcome the errors due to terrain effects, utilizes Genetic Programming for automatic target recognition and classification, and provides for passive radar operation utilizing existing broadcast transmitters to enable covert operation. [C194]

"MIMO radars or is it smart antennas?"

Radars were originally designed as detectors of targets. The goal was to transmit a signal with the maximum available power and then observe whether the received signal contained a portion of the transmitted signal. A matched filter was then designed using the transmitted waveform to detect the received signal and based on some statistical hypothesis testing a decision was made on whether a target is present or absent. However, when multiple targets are to be examined or one wants to search for a low observable near a large target, the conventional detection based radar processing is not adequate. A need for finding small targets in the presence of clutter and jammer evolved into an estimation theory problem rather than detection. It is illustrated that use of a phased array in a SIMO mode can perform quite well as one does not have to worry about the inhomogenity of the clutter associated with multiple transmissions in a MIMO system as the processing becomes quite complicated. Also, the compensation of mutual coupling becomes difficult in a practical deployment on a moving platform. It is important to note that one can still exploit the advantages of super-resolution processing using estimation theory keeping the advantages of a single high power transmitting antenna in a phased array deployment. This paper illustrates such a methodology which has been in the published literature for at least a decade and compares it with the recent MIMO developments. Examples are presented related to a single snapshot based least squares methodology that can cancel interferer in the main beam using a phased array radar but performing a deterministic processing using the same number of degrees of freedom as a multisnapshot case for coherent processing. [C195]

"Adaptive filtering and target detection for ultrasonic backscattered signal"

In radar, sonar, medical ultrasound, and ultrasonic nondestructive evaluation, environmental noise makes target detection challenging. Therefore, clutter rejection and noise cancellation are necessary for the system to correctly identify targets. In this study, an adaptive filtering algorithm is used to reject clutter and detect small targets in noisy ultrasonic backscattered signals. Simulation and experimental results show that adaptive filter can efficiently reduce the clutter and improve the detection capability. [C196]

"MIMO GMTI radar with multipath clutter suppression"

This paper address ground-moving target indicator (GMTI) radar operation in the presence of strong multipath spread-Doppler clutter (SDC). Spacetime adaptive processing (STAP) for single-input-single-output (SIMO) radar is designed to mitigate direct-path SDC which leaks into the sidelobes of a moving radar platform. However, multipath SDC often returns via the receiver mainlobe and cannot be suppressed in a SIMO radar without also canceling the target. In this paper, we study multipath SDC mitigation using multiple-input-multiple-output (MIMO) GMTI radar. Clutter loci and adaptive array patterns for MIMO GMTI are presented in multipath SDC. By

achieving range-dependent nulling on transmit, the effectiveness of MIMO GMTI radar at suppressing multipath SDC is shown. [C197]

"An improved CFAR detector for non-homogeneous clutter environment"

An improved CFAR detector for non-homogeneous clutter environment is proposed. At LFMCW radar receiver, after moving target detection (MTD) and linear-law envelop detector, CFAR detector is usually adopted to detect radar targets, the threshold of CFAR detector should be adaptive to the local background noise/clutter environment. Interfering targets often exist in the leading and lagging windows of the test cell which results in an increased detection threshold and a degraded probability of detection (PD). In the improved CFAR detector, an order statistic VI CFAR detector (OSVI-CFAR) is proposed to adaptively remove the interfering targets from the reference windows and increase the PD. Simulation and experiment results are given to prove the feasibility of the OSVI-CFAR detector. [C198]

"Polarimetric suppression of early-time scattering for late-time target identification"

One can suppress the strong signal amplitude of the early-time scattering, relative to the late-time signal containing the natural resonances (for target identification) using various techniques. This paper discusses the use of polarization for the early-time suppression. [C199]

"A comparison of two CA-CFAR loss calculation methods in spatially correlated K-Distributed sea clutter"

Radar target detection of targets in sea clutter modelled by compound K-distribution is examined from a statistical viewpoint by Monte Carlo simulations. The target detection is processed by Cell Averaging Constant False Alarm Rate (CA-CFAR) processor and the performance evaluations are quantified by CFAR loss. Curves for CFAR loss versus the spatial correlation and spikiness of sea clutter, number of cells of CA-CFAR processor and the number of non-coherently integrated pulses are presented. [C200]

"Fetch limited sea scattering spectral model for HF-OTH skywave radar"

Sea Normalized RCS, and Doppler spectra have been revised for HF-OTH Clutter Modelling. The Hasselmann model is firstly introduced to predict the sea directional spectrum of fetch-limited sea and results have been compared with the Pierson-Moskovitz model used for large scale ocean remote sensing. Results show that the closed fetch-limited sea has lower NRCS compared with ocean for similar wind intensity and direction. For this reasons RCS and Doppler spectra must be predicted taking into account of the fetch dimension. In future work we will generalize this interesting approach to fetch-limited wind, time-limited pulse, in order to show the waveform effect on Doppler spectrum. [C201]

"Advanced classification of UXO using fully polarimetric GPR and frequency-polarization features"

The classification of buried UXO has been a difficult task due to the large amount of false alarms resulted from troublesome clutter objects. This paper closely examined scattering characteristics of such clutter objects by using numerical simulations. From the numerical study, we found that some clutter objects, which mainly causes the false alarms, produce multiple resonances at different frequencies and different polarizations. Based on these observations, we developed new classification algorithms which utilize the frequency-polarization dependent responses of complex targets in order to discriminate UXO-like objects form such trouble some clutters. The developed algorithms were tested by experiments in a test plot. In the test, the new classification algorithms clearly discriminated such clutters from UXO-like targets. In this paper, we present the simulation results for scattering characteristics of complex clutters and the new classification algorithm based on frequency-polarization dependent responses will be discussed. Finally, results from experimental verification will be presented. [C202]

"Multiple Sub-Spaces particle filtering for multi-target tracking"

A new multiple target tracking method based on Bayesian filtering and Sequential Monte Carlo approximating method is proposed in this paper. The key principle of the proposed method is to decompose the multiple target tracking problem into multiple single target tracking problems by allocating Sub-Spaces which are sub-sets of single-target state space to targets. The computational cost of the proposed method is remarkably reduced by avoiding jointly estimating posterior probability distribution used in many conventional multi-target tracking methods. And compared with Finite Set Statistics based methods, the proposed method is more general, moreover, it could supply high level applications with trajectory of moving targets which is not available in Finite Set Statistics based method. The proposed method is tested by tracking pedestrian in video sequence captured

from real-world and the tracking result shows that all targets are well tracked in real-time while the number of targets is unknown and varies with time. [C203]

"A novel multi-channel SAR-GMTI algorithm based on raw data"

This paper presents a novel SAR-GMTI algorithm based on the range-compressed raw data. FrFT is introduced to the classical three-channel DPCA system to realize the moving target detection, parameter estimation and SAR imaging, acquiring an exact GMTI image of accelerative moving targets. As a pretreatment, Keystone transform is firstly applied to process the echoes receiving from each sub-aperture respectively in order to remove the range migration. Our scheme is available even under a clutter-rich and low SNR environment. The simulation results indicate the efficiency of the method. [C204]

"CFAR and KPCA for SAR image target detection"

A SAR target detection model based on CFAR and KPCA is presented in this paper. This Detection is divided into a pre-screening and discrimination process. Within the large-scale and low-resolution SAR imagery, pre-screening adopts classic CFAR techniques, while the discrimination process adopts kernel principal component analysis to separate the target from clutter. Experimental results show that the detection performance of our algorithm appears to be superior to the classic CFAR methodology. The combination of both pre-screening and prior knowledge of targets can effectively enhance detection rate and inhibit false alarm at the same time. [C205]

"Progressive SAR imaging technique"

A progressive SAR imaging technique is proposed as a novel SAR raw data processing scheme in this paper. Different from the classic SAR imaging algorithms which focus the SAR raw data as a whole regardless of the backscattering signal, the novel scheme discriminate the backscattering signal and choose the proper ones to be focused progressively according to some application context while the others will be discarded. The new scheme makes the SAR imaging algorithm not only focus the energy back to the scattering points but also form an image more suitable for some special applications. In this paper, a realization of the scheme present via Atomic Decomposition (AD)[1]-[3]. AD helps estimate the parameters of backscattered signal of a scattering point and detach it from the raw data. With the parameters, the backscattering-signal can be reconstructed and focused. Targets or scatter-points in the scene will be imaged progressively in a sequence of their energy due to the greedy natural of matching pursuit employed during AD. Therefore, the contents in the final SAR image can be controlled by an energy threshold. Besides the interested targets can be extracted easily from the background clutter and this may be helpful for the SAR image understanding. [C206]

"Target detection based on granularity computing of quotient space theory using SAR image"

Target detection is a hot topic and key technique of SAR image interpretation. There are many detection methods, such as CFAR detector and Extended Fractal (EF) feature detector. In order to overcome their shortcomings and combine their merits at the same time, the combination of some different detection methods need be implemented. Granularity computing is just an approach that solves the problem at different granularity space due to different principles. Therefore, SAR image target detection based on granularity synthetic algorithm of quotient space theory is proposed in this paper. Firstly, CFAR detector and EF feature detection method are performed to generate different detection results as coarse granularity spaces. Then combine the different quotient spaces and construct the fine granularity space by using granularity synthesis algorithm. Finally, obtain the final target detection result. The experimental result of RADARSAT-I C band SAR image proves that the proposed algorithm is effective. [C207]

"Sparsity enhanced fast subsurface imaging for stepped frequency GPRs"

A sparsity enhanced and fast data acquisition and imaging method is presented for stepped-frequency continuous-wave ground penetrating radars (SFCW GPRs). In previous work it is shown that if the target space is sparse like the point like targets, an image of the target space can be constructed with making measurements at only a small number of random frequencies by solving an l1minimization problem. This greatly reduces the data acquisition time but the computational complexity for the imaging method is high. In this work, subsurface imaging is done with a suboptimal but fast method, orthogonal matching pursuit. Similar results to l1minimization images are obtained within much shorter times. Also the results are sparse and less cluttered compared to standard backprojection images. [C208]

"Space-time focusing of HF skywave radar signals with application to nonlinear scattering phenomenology"

Increasing the power density incident on a target without raising the radiated power may offer a number of benefits to HF skywave radar systems. Among these is the prospect of detecting nonlinear echoes, which could greatly enhance detection in sea clutter. Other prospects include improved detection of low RCS targets and more effective use of sub-apertures for multiple simultaneous task operations. In this paper we review the physics underlying these missions and assess the potential of various approaches to concentrating energy in localized regions within the illuminated zone. [C209]

"Ship detection with RadarSat-2 Quad-Pol sar data using a notch filter based on perturbation analysis"

Target detection of marine feature is a major topic for the security and monitoring of coastlines. Synthetic Aperture Radar (SAR) has been shown to be particularly useful for this application because of its all-weather and night capability. In this paper a new ship and iceberg detection methodology is described. The algorithm proposed is based on a perturbation analysis in the target space recently developed and published by the authors, which was focused on land based target detection. The algorithm can be considered to be a negative filter focused on sea. Consequently, all the features which have a polarimetric behaviour different from the sea are detected. To demonstrate and validate the technique two RadarSat Fine Quad-Pol mode scenes were acquired off the south coast of the UK at Portsmouth harbour. An extensive ground truth campaign was also conducted that was coincident with these acquisitions. Portsmouth is one of the busiest harbours in the UK and this afforded the opportunity to capture a wide range of vessel sizes and types for analysis. [C210]

"3D velocity model and ray tracing of antenna array GPR"

Migration is an important signal processing method that can improve signal-clutter ratio and reconstruct subsurface image. Diffraction stacking migration and Kirchhoff migration sum amplitudes along the migration trajectory, which generally is hyperbolic. But when the ground surface varies acutely, the migration trajectory is not hyperbolic. To computer the migration trajectory need the technique of ray tracing. We introduce a method of ray tracing based on 3D velocity model. Firstly, we build the 3D velocity model depending on the estimation of both ground surface topography and velocities. Then we compute the travel time between transmitter, receiver and each subsurface scattering point, and search the propagation ray depending on the Fermat's principle. The method is tested by an experiment data acquired by the stepped-frequency (SF) CMP antenna GPR system. The target is a metal ball that is buried under a sand mound. A nice result of ray tracing is shown in the case. [C211]

"Stap based ground moving target detectability in the airborne/spaceborne array radar"

A space-time adaptive processing (STAP) can be effective in detecting the ground moving targets from the airborne/spaceborne moving platform in the severe ground clutter and jammer environments. In this paper, the characteristics of target, ground clutter and jammer signals are analyzed and designed the adaptively weighted clutter notch filter in two dimensional spatial and temporal azimuth angle-Doppler domains. The simulation is performed for ground moving target detection by rejecting both clutter and jammer simultaneously through the STAP processing. The probability of target detection is investigated depending on the SNR and the minimum detectable velocity (MDV) in the given false alarm rate. The simulation results show that the MDV can be ideally achieved up to 2 m/s ~ 3 m/s at the 90 % of detection probability in the given false alarm rate of 10-3and 10-6. This technique may be applied for the surveillance and traffic monitoring of moving vehicle on the road. [C212]

"A random finite set based detection and tracking using 3D LIDAR in dynamic environments"

In this paper we describe a fully integrated system for detecting and tracking pedestrians in a dynamic urban environment. The system can reliably detect and track pedestrians to a range of 100 m in highly cluttered environments. The system uses a highly accurate 3D LIDAR from Velodyne to segment the scene into regions of interest or blobs, from which the pedestrians are determined. The pedestrians are then tracked using probability hypothesis density (PHD) filter which is based on random finite set theoretic framework. In contrast to classical approaches, this random finite set framework does not require any explicit data associations. The PHD filter is implemented using a Gaussian Mixture technique. Experimental results obtained in dynamic urban settings demonstrate the efficacy and tracking performance of the proposed approach. [C213]

"Fast Target Detection for SAR Images Based on Weighted Parzen-Window Clustering Algorithm"

To solve the inefficiencies and high false alarm probability problem of the target detection in synthetic aperture radar (SAR) images and to improve the weakness of the two-parameter CFAR detector, a fast constant false alarm rate(CFAR) algorithm based on Weighted Parzen-window clustering (WPWC) is proposed. The principles and flow of the WPWC algorithm is introduced and a fast two parameter CFAR detector taking WPWC as a

preprocessing, which reduced the effect of clutter and eliminated many false target detections from background. According to the theoretical performance analysis and the experiment results of some typical SAR images, the proposed algorithm is shown to be of good performance and strong practicability. Meanwhile, the corresponding fast algorithm greatly reduces the computational load. [C214]

"Back Scattering from Target above Random Rough Surface"

This paper is concerned with an analysis of the back scattering of an electromagnetic wave by a target moving along just above a random rough surface such as desert, hilly terrain, sea surface and so on. First we introduce the discrete ray tracing method (DRTM) for the field analysis of back scattering. Second we investigate the effect of clutter due to back scattering from the random rough surface on the radar cross section (RCS) of the target. Finally we show some numerical examples for back scattering from a target above a Gaussian type of random rough surface with arbitrary height deviation and correlation length. It is demonstrated that the clutter is predominant in the back scattering and it is mainly caused by the diffraction related to reflection from the random rough surface. [C215]

"A Study of Suppressing Strong Clutter in Radar Signal Based ICA"

It is great difficult to handle the clutter in Radar signal processing. To reduce the influence of clutter, the paper firstly attempts to use FastICA algorithm by separating the target signal and clutter to suppress the strong clutter. The pretreatment of increasing the dimension and dividing the frequency is used before Fast ICA algorithm because of the special radar complex signals. In the same matched filter conditions, Fast ICA algorithm is proved effectively through the increased peak side lobe ratio (PSLR) and signal clutter ratio (SCR). [C216]

"Robust adaptive ground moving target indication technique applied to distributed spaceborne SAR system"

Through formation flying, distributed SAR satellites system can increase the number of spatial degree-of-freedoms (DOFs) and provide flexible multi-baselines for SAR-GMTI(ground moving target indication), while improving the system performance. This letter proposes a robust optimum adaptive clutter suppression technique for SAR-GMTI applied to the distributed spaceborne synthetic aperture radar (SAR) systems. Some realistic problems related to the implementation of the processor are investigated, which include decorrelations from multiplicative speckle noise and moving target steering vector mismatch. Diagonal Loading (DL) techniques is resorted to improve the estimation of clutter statistics in the presence of multiplicative speckle noise. A prior information, like road network information, is integrated into the optimum adaptive processor to reduce moving target steering vector mismatch. Simulation experiments and performance analysis demonstrate the effectiveness and robustness of the proposed processor. [C217]

"A modeling method of radar seeker in the presence of electronic warfare"

Due to the requirements of evaluating the performance of the radar seeker in the combat conditions or in the presence of electronic warfare, this paper gives a design of A Sensitive and Generalization Modeling of The Radar Seeker simulation system, and describes its Modularization, Parameterization, Interface support, Sensitivity Analysis Support design method, a pulse Doppler radar seeker based simulation system which is designed according to the method is given in details, the working flow of the simulation system and conclusions are given at last. [C218]

"Information-theoretic algorithm for waveform optimization within ultra wideband cognitive radar network"

A novel information-theoretic approach for designing the excitation ultra wideband (UWB) waveforms within a cognitive radar network is developed. This method utilizes the mutual information (MI) between subsequent radar returns to extract desired information from the radar scene. With this approach, the radar system constantly learns about its surroundings and adopts its operational mode accordingly based upon the MI minimization criterion. Subsequently, the positioning algorithm makes use of this information about the radar scene to generate more accurate location estimates. Numerical results demonstrate an improvement in the probability of target detection even at low values of receive signal-to-noise ratio (SNR). The proposed algorithm also promises a better delay-Doppler resolution of the target, which can be analyzed through the radar ambiguity function (AF). Simulation data show an improvement in the target discrimination ability in the presence of noise and clutter. [C219]

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

The detection scheme for robust detection and target location in the presence of interference is presented. The problem of detecting the slow-moving target at noisy background is addressed in this paper. A novel kind of Odd-Symmetry Template Correlation (OSTC) process is developed as the first-step of the detector. The OSTC method has a better performance due to interference suppression than traditional ones. The Range-Extended Constraint and Threshold Feedback technique is proposed as the second-step for detecting range-extended target and controlling the false alarm rate. The Multi-Cycle Fusion method completes the third-step detection procedure, and improves the detection reliability by reducing false alarms. Experimental results are given to demonstrate the efficiency of this approach. Moreover, the effectiveness of this method allows for real-time execution. [C220]

"Multitarget tracking in clutter using two-scan data association algorithm and fixed-lag smoothing"

The performance of multitarget tracking in clutter can be improved by using higher accuracy data association algorithm and more efficient state estimation method. This paper presents a novel fixed-lag TSDA-AI smoothing algorithm, which enhances the accuracy of state estimation by using fixed-lag smoothing, and improves the probability of real "measurement-target" combination by using two-scan measurements and the associated amplitude feature in the data association method. Its efficiency has been confirmed by computer simulations. [C221]

"Data association for GM-PHD with track oriented PMHT"

Gaussian Mixture probability hypothesis density (GM-PHD) filter is a closed-form solution to the probability hypothesis density filter, which could estimate states and time-varying number of targets based on theory of random finite set. Probability multiple hypotheses tracking (PMHT) is a multi-target tracking algorithm combining data association and expectation-maximization. However, GM-PHD can not give trajectories of target because of its disability of providing identity of target. Furthermore, PMHT need known number of targets and several frames trajectories of targets at first which are difficult in practical application. Firstly, we propose track oriented PMHT tracker (TO-PMHTT), then an approach of data association combining the advantage of GM-PHD with TO-PMHTT is designed in this paper. GM-PHD acts as the pre-filter of TO-PMHTT when there are no crossing targets in the scenario, while interaction between GM-PHD and TO-PMHTT is performed when targets enter crossing zone. Computer simulation results show that the method can provide association for both separated and crossing targets tracking. [C222]

"Inverse scattering using a Time Reversal RADAR"

This work presents a new RADAR prototype built for the purpose of imaging targets located in a cluttered environment. The system is capable of performing Phase Conjugation experiments in the ultrawideband GHz. In addition, applying the D.O.R.T. method to the inter-element matrix allows us to selectively focus onto targets, hence reducing the clutter contribution. We aim to experimentally explore the use of this focusing wave into an inversion algorithm, in order to improve its robustness against noise. [C223]

"Study on the Time-Frequency Two Dimensional CFAR Algorithm for Moving Targets on Ground in PRC-CW Radar"

PRC-CW radar is mainly used to detect moving targets on ground. Ground clutter heaves fiercely, and its distribution is complex, which makes it difficult to detect targets correctly from time domain. The characteristics of moving targets and ground clutter differ in frequency domain. And the spectrum of targets may change with time, so, this paper designs the time-frequency two dimensional constant false alarm rate(CFAR) algorithm. Based on the analyze of pulse compression and moving targets detection(MTD) of this type radar, the two-dimensional CFAR algorithm is proved to be feasible via simulation. The results of simulation show that, the algorithm can measure the velocity and range of targets correctly. The clutter and noise are also restrained effectively. [C224]

"Identify Islands by Complex SAR Image"

The performance of interferometric synthetic aperture radar (INSAR)-based objects identifying in sea environment with clutter background is researched by many literatures, but most of them are mainly about detecting dynamic objects, such as ship targets. A new method is presented in this paper, which utilizes SAR image and point target analysis method to identify islands on sea surface in near and far range from mainland, especially for islets which can be confused with big ship or other objects such as floating, oil platform and so on. In the sea, either islands or islets is static objects, and other thing is dynamic characteristics, according to this characteristics, islands can be distinguished by spaceborne synthetic aperture radar (SAR) images joint point target analysis (PTA) method. The processing procedure includes three main phases: interferometric phase fringe, coherence evaluation, and sublook analysis. This method is applied with TerraSAR-X SSC image in

HONHKONG area. [C225]

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

Range, intensity and Doppler images can be obtained by using coherent LADAR (laser radar). Range image is closely relative to physical structure property of target surface, and it can reflect essential characteristics of targets. At present the research on automatic target recognition technology for LADAR is attention-getting. The Back-propagation neural network (BPNN) has been used in multi-layered feed-forward adaptive neural networks, deserving special attention. In this paper, BPNN is introduced to recognize Vehicles on the ground with different carrier to noise ratio (CNR) of clutters, different orientations of target, and different distances between the object and sensor. The results of simulation show that the BPNN is feasible and effective for the target recognition. [C226]

"Study on Automotive Anti-collision Radar System and Its Signal Processing Algorithm"

Through analyzing the applied require for millimeter wave automotive anti-collision radar, we design the simple structure of radar system. For satisfying the demands of digital signal processing and dispatching affairs, the signal processor is designed by linking DSP and SCM. Considering the complexity of radar signal received, high efficient digital signal processing algorithms should be applied to radar. Useful targets can be detected in clutter through self-adaptive filtering, and the targets' distance/velocity can be measured through frequency domain pairing. So we introduce a signal processing algorithm through combining self-adaptive filtering with frequency domain pairing in order to get the targets' accurate distance/velocity information in clutter and multi-targets environment, and simulate the algorithm by computer. The simulation results prove that this algorithm is effective. [C227]

"OTHR impulsive interference detection in strong clutter background"

External impulsive interference (IMI) will severely degrade the performance of an Over-the-horizon radar (OTHR), and detection and suppression of IMI in strong clutter environment is the prerequisite for the target detection. This paper proposes a novel method based on the signal subspace properties, aiming at effectively detecting IMI with easy or without clutter suppression. Selective survey on median eigenvalues variation and discarding two largest eigenvalues can suppress clutter and simultaneously show peaks indicating the IMI position, which can be viewed as a joint clutter suppression and interference detection. Its operational performance is evaluated using experimental data from a high frequency surface wave(HFSW) OTHR system. [C228]

"MLE-based order statistic automatic CFCAR detection in Weibull background"

In this paper, we address the problem of automatic target detection in Weibull clutter and multiple target situations, without any prior knowledge of neither the non stationary clutter statistics in which the radar operates nor the number of outliers that may be present in the reference window. In doing this, we develop the forward and backward order statistic automatic constant false censoring and alarm rates detectors based upon the maximum likelihood estimator, MLE-based F/B-OSACDC-FCAR. The censuring and detection algorithms are a two in one built detector. They select repeatedly a suitable set of ranked cells among all reference cells surrounding the cell under test to estimate the unknown background level and set the adaptive threshold accordingly. The performance of these detectors is evaluated by means of Monte Carlo simulations. [C229]

"Multistatic tracking using bistatic range-Range rate measurements"

In this paper, we implement a multidimensional assignment based multistatic tracker and test it on a 3D multitarget tracking scenario that includes crossing targets as well as targets moving in formation. We find that the assignment based multistatic tracker can successfully keep tracking initiated tracks accurately. However, efficient track initiation needs further study. [C230]

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

The linear frequency modulation (LFM) signal is the main signal form of the high resolution radar. By analysis for the principle of the LFM radar signal to realize the high range resolution profile and the impact of clutter and noise over target echo signal, we propose the method of using spectrum estimation based on the characteristic decomposition to estimate the frequency and realize the LFM signal range profile. The simulation results prove that this method to the goal 1D range profile is effective under low signal-to-noise ratio conditions. [C231]

"Breaking wave study from in situ experiments"

This paper describes the setting of the experiment for in situ measurements of breaking waves. The aim is to provide an insight in the wave breaking mechanism and the possible outcome is a statistical description of this mechanism which will be used together with airborne radar (SAR) data acquired on the same spot. It is well known that when the sea-state is high (3 to 4) the radar clutter is displaying many spikes due to the breaking waves. So far this phenomenon is not correctly described and it is impairing the analysis of the sea surface, especially when possible targets are present. [C232]

"Search detection modeling and simulation for missile-borne high resolution radar"

Missile-borne high resolution radar search detection is a very important aspect in its signal processing flow, their modeling and simulation is an extremely necessary and basic work. In this paper, a coherent video signal simulation is applied to establish signal received model (i.e. antenna gain model, clutter receiver model, the target receiver model) and signal processing model based on missile-borne high resolution radar. Simulation is carried out and the results validate the efficiency. [C233]

"Adaptive MIMO radar detection in non-Gaussian and heterogeneous clutter considering fluctuating targets"

Previously, the Generalized Likelihood Ratio Test-Linear Quadratic (GLRT-LQ) has been extended to the Multiple-Input Multiple-Output (MIMO) case where all transmit-receive subarrays are considered jointly as a system such that only one detection threshold is used. The new MIMO detector is Constant False Alarm Rate (CFAR) with respect to the clutter power fluctuations. In this paper, the adaptive version of this detector is considered, as well as a fluctuating target model similar to that of the Swerling Target. The degradation of the detection performance due to the estimation of the covariance matrix and the fluctuation of the target is studied through simulations for both the well-known Optimum Gaussian Detector (OGD) and the new MIMO detector under Gaussian and non-Gaussian clutter. [C234]

"Effect of range ambiguity on space based AMTI clutter suppression and mitigation method"

Air moving target indication (AMTI) using space based radar (SBR) is attractive. In order to detect airborne target in clutter and measure the target's range at the same time, SBR usually use medium PRF waveform. Theoretical analysis and experimental results show that range ambiguity cause target's range ambiguity and clutter's range foldover. Range ambiguity significantly degrades the clutter suppression performance. A method based on orthogonal waveform for mitigating the range ambiguity effects is presented in this paper. The orthogonal waveform is launched in sequence. Then multi-channels matched filter is used to receive the replay pulse. Experimental results illustrate that the method is effective. [C235]

"Long-Term Integration Algorithm and System Design Using the Stepped-Frequency Signal"

A novel algorithm of multi-burst stepped-frequency signal co-processing are proposed, from which the high resolution in both range and velocity profile of moving targets can be achieved. A fast keystone transform is presented to remove the range migration between the bursts causing by the long-term integration, which is of efficiency to implementation. A real-time signal processing system is designed to process multiburst stepped-frequency signal in real-time and employ velocity compensation algorithm based on keystone transform. [C236]

"Likelihood Ratio Detection and Tracking"

Likelihood Ratio Detection and Tracking (LRDT) is an extension of Bayesian tracking that simultaneously estimates whether a target is present and its state if present. It is particularly suited to difficult detection and tracking situations involving low signal-to-noise ratios or high clutter density. LRDT extends the basic Bayes Markov single target recursion by adding a null state to represent the possibility of no target present. By converting to likelihood ratios, one obtains a recursion which is parallel to the Bayes Markov single target recursion and does not explicitly retain the null state as a separate state. This allows LRDT to use un-thresholded or below-threshold sensor responses and to provide a natural and correct method of incorporating information from multiple sensors and disparate sensor types. LRDT performs incoherent integration of sensor responses over time by cumulating measurement likelihood ratios over possible target paths (tracks). When the cumulative likelihood ratio exceeds a specified threshold, a detection is called and a state estimate is extracted. LRDT is a recursive, Bayesian, Track-Before-Detect (TBD) system that does not require explicit association of sensor responses to target tracks. This allows LRDT to consider a vastly larger set of possible target paths than TBD systems based on multiple-hypothesis tracking or other track-based techniques. We give examples of the application of LRDT to (1) the detection of periscopes by surface ship radar, (2) the detection of submarines by

multi-static active sonar, and (3) the automatic detection and tracking of acoustic sources by passive acoustic arrays. The similarity of certain forms of the LRDT recursion to those of the PHD and Multitarget Intensity filters is also discussed. We close by considering some non-traditional extensions of LRDT beyond classical detection and tracking such as monitoring the maritime supply chain to detect suspicious behavior. [C237]

"Suboptimal JPDA for tracking in the presence of clutter and missed detections"

A new heuristic for data association on multi-target tracking systems is presented. The algorithm is based on the existing JPDA (Joint Probabilistic Data Association) algorithm, more specifically, on the Suboptimal JPDA approximation. However, compared to Suboptimal JPDA, the presented method exhibits a significant improvement on tracking performance for scenarios in the presence of clutter and missed detections, at negligible increase of computation cost. In fact, it approaches the performance of the classic JPDA, requiring, however, drastically lower computational resources. It is also be shown that the proposed method is more robust with respect to trajectory crossings than the original Suboptimal JPDA. [C238]

"Maximum likelihood approach to HF radar performance characterization"

As part of NURC maritime surveillance research activities, there is a need to characterize the performance of HF radar vessel-detection processing, in support of subsequent automatic tracking as well as fusion with other available sensor data. In particular, HF radar detection and localization performance for a given contact SNR threshold must be determined. This paper examines two approaches to do so: one based on the maximum-likelihood criterion, the other using a localization threshold on target-originated contacts. The differences in and merits of the two approach are discussed with simulated and real maritime HF radar data. We introduce a multi-stage track-extract-track approach to HF radar tracking that is effective in a heavily-cluttered environment. Finally, we introduce scalar information metric for sensor characterization and discuss its relevance to sensor selection and detection threshold determination. [C239]

"Research of Small Target Detection within Sea Clutter Based on Chaos"

In this paper, based on the prior knowledge of chaotic character of sea clutter, we discuss a method for detection of small target in sea clutter using neural network as a predictor. Neural network can capture the dynamics of strange attractor generating sea clutter. After the reconstruction of real-life radar data, BP and RBF networks are regularized, and then a set of sample data from real-life data is inputted into the networks to train the neural networks respectively. As a sequence, according the nature of neural networks, these trained networks could approximate the model of dynamical system responsible for sea clutter. These networks can be used to detect small target within sea clutter as a predictor. [C240]

"Sidelobe comparison of golay and PRBS codes for subsurface radar applications"

Ultrawideband (UWB) radar is an evolving area of great interest with many potential defense and civilian applications. Broadly, UWB waveforms could be classified into non-random and random waveform categories; both nonlinear and linear frequency modulated (LFM) and typical coded waveforms fall in the former category, while random noise-like and pseudorandom noise-like waveforms are the examples of the latter. Since the waveforms transmitted by the radar systems can affect the target detection, accuracy, resolution, ambiguities, and clutter rejection, etc., there is a great interest to design and implement various transmit waveforms with predetermined criteria. [C241]

"Automated noise measurement system for radar and EW transmitter components"

The development of a 2-18 GHz instrument for radar and EW transmitter test and measurement is reported. The transmitter component analyzer was developed by NSWC crane to measure critical performance parameters of the AN/SPY-1 radar's components. Typical measurements include clutter attenuation, clutter improvement factor, intrapulse noise, moving target indicator residues, random pulse jitter, systematic pulse jitter, phase noise, and amplitude noise. [C242]

"Target Detection Using Radar with Dynamic Programming Approach"

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

previously developed algorithm. [C243]

"Performance of PDAF-based tracking methods in heavy-tailed clutter"

Harbor surveillance above and below the sea surface depends on sensors such as surveillance radar and multibeam sonar. These sensors attempt to detect and track moderately observable targets such as small boats or human divers in environments which often are characterized by heavy-tailed backgrounds. This paper provide simulation results which quantify the inevitable performance loss encountered in heavy-tailed environments. The results show that the performance loss can be reduced by accounting for heavy-tailedness in the detection and tracking processes, and by the utilization of Amplitude Information (AI). Two new amplitude likelihoods developed in a preceding paper come favorably out of this comparison. Furthermore, the evaluation of the Modified Riccati Equation (MRE) is outlined for the combination of AI and heavy-tailed clutter. The MRE can be used to decide the false alarm rate for the detection process preceding target tracking. [C244]

"Performance analysis of the Probabilistic Multi-hypothesis Tracking algorithm on the SEABAR data sets"

The probabilistic multi-hypothesis tracking (PMHT) algorithm is a batch type multi-target tracking algorithm based on the expectation-maximization (EM) method. Unlike other more popular methods (e.g., multi-hypothesis tracking, MHT) the computational burden of PMHT grows linearly in the size of the batch, the number of clutter detections, and the number of targets tracked. The SEABAR sea tiail was conducted by the NATO Undersea Research Center in 2007 to investigate the suitability of some experimental high gain deployed active sonar receivers for tracking underwater contacts of interest. The sea trial yielded several useful multi-static active sonar data sets. The purpose of the effort reported here is to assess the target tracking performance of PMHT using structured multi-static active sonar sea trial data collected during the SEABAR experiment. This study quantifies the effects of batch size on the ability of PMHT to hold track on constant velocity and maneuvering contacts to determine the values that provide acceptable tracking performance. Situations involving contact maneuvers or temporary loss of detection (a.k.a., drop outs) are of particular interest. Specifically, the ability of PMHT to hold track as a function of batch size for two multi-static active sonar sea trial data sets containing contact maneuvers and drop outs will be assessed. [C245]

"Meta level tracking with multimode space-time adaptive processing of GMTI data"

Ground surveillance of the battlefield provides military analysts with information that is critical to the success of a mission; the type of the information includes the enemy force structure, enemy offensive combat formation, and maneuvering events. The conventional approach uses mainly the synthetic aperture radar (SAR) and electro-optical (EO) sensors to perform detection and identification of stationary targets on the battlefield. Ground moving target indicator (GMTI) radar with space-time adaptive processing (STAP), on the other hand, allows a more complete perception of the battlefield by adding the capability to detect moving objects over a large area. In particular, the simultaneous detection and estimation of angular location of a ground moving target via adaptive cancellation of ground clutter is demonstrated, where a single reflector antenna with a multimode feedhorn is used in a GMTI radar. Based on the GMTI radar output, we illustrate the use of stochastic parsing algorithm with stochastic context free grammar (SCFG) as an unifying framework for data association, target tracking, and situation awareness. [C246]

"Target tracking in heavy-tailed clutter using amplitude information"

Harbor surveillance above and below the sea surface depends on sensors such as surveillance radar and multibeam sonar. These sensors attempt to detect and track moderately observable targets such as small boats or human divers in environments which often are characterized by heavy-tailed backgrounds. Target tracking in heavy-tailed environments is challenging even for moderately strong targets due to the more frequent occurrences of target-like outliers. One strategy for increased robustness is to use the backscattered signal strengths together with the kinematic measurements in the tracking method. This paper proposes two new amplitude likelihoods for target tracking in heavy-tailed backgrounds. The first likelihood works by incorporating the uncertainty of the background estimate. The second likelihood explicitly treats the background as heavy-tailed using the K-distribution. [C247]

"Using lateral length measurements in GMTI convoy tracking"

This contribution deals with tracking of convoys moving on ground by airborne GMTI radar. A technique based on generalized power estimators using multiple beams is used to estimate the lateral length component of an unresolved convoy. In combination with the conventional range measurement, the full length information can be obtained in case of a linear convoy. The main focus of this paper is the exploitation of this attribute information

in order to improve the tracking process. The Bayes algorithm based on our earlier work is improved and incorporated into a JPDAF framework to deal with multiple targets. The processing of Doppler measurements is also included. Numerical results are presented based on a simulation scenario. [C248]

"Use of prior information in active sonar tracking"

A Bayesian tracking model is proposed that uses measurement likelihood functions based on predicted signal-to-noise ratios (SNR) in active sonar data. The predicted SNR modeling can incorporate prior information, such as the presence of known discrete and persistent clutter objects. The likelihood model assumes an exponential distribution of returns with a mean based on the predictive model that incorporates assumed SNR of the targets, known clutter, and background clutter, and the beam response and waveform ambiguity functions. Two variations of an example based on simulated frequency modulated (FM) and continuous wave (CW) signals is used to assess target detection and localization performance. Significant enhancements are observed when prior knowledge of clutter is incorporated into the measurement model in these idealized examples. [C249]

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

Airborne radar tracking in moving ground vehicle scenarios is impacted by sensor, target, and environmental dynamics. Moving targets can be assessed with 1-D High Range Resolution (HRR) Radar profiles with sufficient signal-to-noise (SNR) present which contain enough feature information to discern one target from another to help maintain track or to identify the vehicle. Typical radar clutter suppression algorithms developed for processing moving ground target data not only remove the surrounding clutter but also a portion of the target signature. Enhanced clutter suppression can be achieved using a multi-channel signal subspace (MSS) algorithm which preserves target features. In this paper, we (1) exploit extra information from enhanced clutter suppression for automatic target recognition (ATR), (2) present a gain comparison using displaced phase center antenna (DPCA) and MSS clutter suppressed HRR data; and (3) develop a confusion-matrix identity result for simultaneous tracking and identification (STID). The results show that more channels for MSS increase ID over DCPA, result in a slightly noisier clutter suppressed image, and preserve more target features after clutter cancellation. [C250]

"Integrated clutter cancellation and high-resolution imaging of moving targets in Multi-channel SAR"

An integrated clutter cancellation and moving targets focusing scheme is presented for multichannel SAR (M-SAR) systems. The integration between the two processing steps is made feasible by performing the clutter cancellation processing in the Doppler frequency domain, and performing the moving target focusing by means of a bank of chirp scaling algorithms (CSA). The integration results efficient from a computational point of view, since the azimuth FFT is common to both the clutter cancellation and the focusing processing. The clutter cancellation step allows to achieve sub-clutter moving targets visibility. The bank of CSA filters, each one matched to a different along-track target velocity component allows to produce a high-resolution image of the target itself. The effectiveness of the proposed technique is shown with reference to a sample M-SAR dataset obtained from a SAREX-92 image. [C251]

"Passive short range X-band frequency doubling transponder"

Various radar methods exist to identify and distinguish stationary and moving objects. Well known methods include synthetic aperture radar (SAR), millimetre-wave real aperture radar (RAR) and interferometric synthetic aperture radar (IFSAR) systems. In specific cases, one is interested to recognize a unique signal from objects. For example, in search and rescue operation radars, unique signals are identified from the Search and Rescue Transponder (SART) that is attached to the object of interest. However, unwanted clutter echoes can severely limit the detectability of the target. Clutter can be caused by obstacles, rain and surface reflections, is unpredictable and it cannot be easily removed. This paper presents the development of a low-cost, passive X-band transponder using frequency doubling to eliminate the problem of clutter. The passive transponder comprises of two rectangular patch antennas, a bandpass filter and a passive frequency doubler. Theoretical calculations show that such a passive transponder is able to operate at a range of about 1 km away from the radar. [C252]

"Target's range migration compensation in passive radar"

Ideally the processing gain in passive radar is PG=BT. Where B is the bandwidth and T is the integration time. So by increasing T the target detectability will also increase. But practically, when we deal with moving targets, increasing T will result in a problem: target migration from its range cell that in turn results in decreased processing gain. In this paper we have suggested a method, by which we can compensate target's migration, while keeping the computational load low. [C253]

"Adaptive waveform generator for radar systems"

Purpose of this paper is to present basic concepts and an automatic tool for the design of radar waveforms suitable for implementation in modern multifunctional or surveillance systems. [C254]

"Monopulse and coherent integration: perfomance and waveforms"

Purpose of the paper is the description of a technique dedicated to the recovery of monopulse performance loss in phased array radars (PAR) using both Low PRF Waveforms and High PRF Waveforms (here in after LPRF and HPRF respectively). [C255]

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

Fisher information matrix can be seen as the metric of a Riemannian manifold, Fisher-Rao metric. As such it can be evolved through Ricci flow. For the case of the estimation of two parameters, the two dimensional manifold is also conformal. In this case we show that the Cramer-Rao bound is saturated as a scalar function always exists that is a also a solution of Liouville equation. This implies that in order to have an optimal estimation of parameters one have to solve this equation. This result can be extended in higher dimensions when the Fisher information matrix can be cast into a similar form as for the two-dimensional case and the estimator vector admits a potential field. Applications of this result are wide-ranging going from tracking to control theory and clutter analysis. We present an example for the analysis of sea clutter data. [C256]

"Feature-Based Probabilistic Data Association (FBPDA) for visual multi-target detection and tracking under occlusions and split and merge effects"

Uncertainties in the sensor data such as measurement noise, false detections caused by clutter, as well as merged, split, incomplete or missed detections due to a sensor malfunction or occlusions (both due to the limited sensor field of view and objects in the scene) make multi-target tracking a very complicated task. Thus one of the big challenges is track management and correct data association between detections and tracks. In this contribution we present an algorithm for visual detection and tracking of multiple extended targets under occlusions and split and merge effects. Unlike most of the state-of-the-art approaches we utilize low-level information integrating it in a unified approach based on a threshold-free probabilistic conception. The introduced scheme makes it possible to utilize information about composition of the measurements gained through tracking of dedicated feature points in the image and resolves data association ambiguities in a soft decision using a globally optimal probabilistic data association approach. Beside existence evolution consideration we also exploit the spatial and temporal relationship between stably tracked points and tracked objects, which along with observability analysis, allows us for reconstruction of compatible measurements and thus correct track update even in cases of splits, merges and partial occlusions of the tracked targets. [C257]

"Passive multitarget tracking using transmitters of opportunity"

Passive Coherent Location (PCL), which uses commercial signals (e.g., FM broadcast, digital TV) as illuminators of opportunity, is an emerging technology in air defense systems. The advantages of PCL are low cost, low vulnerability to electronic counter measures, early detection of stealthy targets and low-altitude detection. However, limitations of PCL include lack of control over illuminators, limited observability and poor detection due to low Signal-to-Noise Ratio (SNR). This leads to high clutter with low probability of detection of target of interest. In this paper, multiple target tracking algorithms for PCL systems are analyzed to handle low probability of detection and high nonlinearity in the measurement model due to high measurement error. The converted measurement Kalman filter, unscented Kalman filter and particle filter based PHD filter are implemented and compared for PCL radar systems. The feasibility of using transmitters of opportunity for tracking airborne targets is shown on simulated and real data sets. [C258]

"Characterizing Sea Clutter and Detecting Targets via Surrogate Test"

The surrogate test has been extensively employed in testing the nonlinear characteristics of time series. In this paper, surrogate tests are applied to the real-life IPIX radar data to detect targets within sea clutter. Surrogate tests show that sea clutter represents nonlinear tendency while the echoes of small targets show linear tendency. With their different physical properties, the small targets are detected reliably from sea clutter. Comparative experiments show that the proposed method is more accurate and robust than the detrended fluctuation analysis. [C259]

"A Novel Approach for Angle Measuring Improvement in Monopulse Tracking"

This paper presents a novel approach for angle measuring improvement based on Adaptive Moving Target Indicator(AMTI) and Capon algorithm. Rain clutter has a nonzero Doppler shift in spectrum domain. In monopulse radar system, the clutter reduces radar's tracking ability by means of decreasing the measuring accuracy in Doppler spectrum. The classical Moving Target Indicator (MTI) and Fast Fourier Transform (FFT) method doesn't meet the exacting tracking needs. In order to suppress rain clutter, we choose the Adaptive MTI for obtaining the best mean Improvement Factor (IF). Moreover, Capon approach is used to enhance the measuring accuracy in this article. Compared with the classical MTI and FFT, the AMTI and Capon based algorithm shows better resolution quality. Then it improves the angle measuring precision. Numerical simulation experiments prove the validity of the new method. [C260]

"Respiratory monitoring using a doppler radar with passive harmonic tags to reduce interference from environmental clutter"

A harmonic tag was designed and fabricated to show the feasibility of sensing cardiopulmonary related Doppler shift in the received second harmonic signal. A fundamental frequency of 2.45 GHz was transmitted at a target and a quadrature homodyne receiver used to sense the received signal from a tag on the target. The setup was used to successfully isolate periodic motion from a tag on a programmable mechanical target and to sense respiratory motion of a human subject, even when the targets were in close proximity to other moving objects. [C261]

"A Fast Algorithm for Multiple Targets Data Association in HF Bistatic Radar System Based on MNJPDA"

Joint Probabilistic Data Association (JPDA) is one of the most effective algorithms of Multiple Targets Tracking (MTT) in dense clutter. However, with the increase of the targets tracked and the number of validation measurements, the computational cost of association probability is the choke point in engineering application. Based on the idea of Hopfield neural network applied in TSP and the characteristics of bistatic radar system, a fast algorithm for data association is developed. In this new method, the adaptive tracking gate is distributed to each target according to the location accuracy of the bistatic radar. And the posterior probability of the common measurements lying in the intersection area of target association gates, are fading down referring to a Doppler Frequency shift (DF-shift) quality factor. Simulation results demonstrate that the algorithm ensures the accuracy and real-time tracking for the data association of MTT. [C262]

"Statistical MIMO radar under non-Gaussian target scattering"

We consider a multiple-input multiple-output (MIMO) detection problem with M widely-spaced transmit antennas and L widely-spaced receive antennas, and we optimize the signal waveforms transmitted by each source node. Two figures of merit are investigated for space-time code optimization under a semi-definite rank constraint and a received signal-to-clutter ratio constraint: (1) the lower Chernoff bound (LCB) to the detection probability for fixed probability of false alarm, and (2) the mutual information (MI) between the observations and the target scattering matrix. If the scattering distribution possesses some properties of exchangeability and unitary invariance, we show that MI-optimal and LCB-optimal space-time coding admit a simple closed-form solution. As an application, the detection of a compound-Gaussian target is examined. The robustness of code design under Gaussian scattering is also investigated. [C263]

"Iterative adaptive Kronecker receiver for MIMO over-the-horizon radar"

We introduce an iterative adaptive multiple-input-multiple-output (MIMO) radar receiver that is useful when the KL-variate adaptive transmit-receive beamformer is structured as the Kronecker product of a K-variate transmit and an L-variate receive beamformer. We consider the case of two clutter propagation modes with different elevation angles, and where the direction-of-departure (DoD) of one mode and the direction-of-arrival (DoA) of the other mode coincide with that of a target. For an example simulation scenario, we demonstrate that our iterative adaptive ldquoKronecker receiverrdquo achieves high performance. [C264]

"Application of Radar Signal Processing System Based on DSP in the VTS"

Radar signal processing system is an important part of vessel traffic services. In order to overcome the shortcomings of traditional analog video system, this paper proposes a design solution for digital radar signal processing system based on DSP and a new method that is a constant false alarm rate algorithm based on wavelet transform. This method can suppress the interference of sea clutter without impairing the target resolution. Experimental results demonstrate this system can increase the detection accuracy and reduce the

false alarm rate. Furthermore, the tracking performance can be improved. Radar signal processing system based on DSP plays an important role in the vessel traffic services. [C265]

"Improved Background Prediction Algorithm for IR Small Targets Detection"

For detection problem of infrared dim small targets in complex background, an adaptive filtering algorithm based on the improved M-estimation is put forward to suppress background clutter. In the proposed algorithm, target pixels and observed noise form the mixed interference of background estimation. In order to better estimate the background, the proposed algorithm introduces the correction factor to reduce the influence of target pixels and introduces the forget factor to entreat the non-homogeneous backgrounds. The experimental results to real images show that the proposed algorithm can better suppress background and preserve target information than the commonly-used median filtering algorithm and the LMS filtering algorithm. As a result, the proposed algorithm can detect effectively IR small targets in complex background. [C266]

"Subsurface object detection using UWB Ground Penetrating Radar"

Ultra wideband (UWB) ground penetrating radar (GPR) has been widely used in the detection of buried unexploded ordnance (UXO), particularly for small and/or shallow objects. Detecting subsurface objects from a weak reflection signal against strong clutter from GPR data is an important problem. A detection method which employs principal component analysis (PCA) and digital image processing techniques is proposed in this paper for clutter reduction in underground object location. The proposed method can robustly indicate not only the regular hyperbolas but also the perturbed slant lines as a result of buried objects. Experimental data collected using an UWB GPR system is used to demonstrate that the proposed methods are effective in reducing clutter and detecting subsurface targets. [C267]

"Upper bounds on processing loss for wideband, long-CPI space-time adaptive processing"

The combination of synthetic aperture radar (SAR) and space-time adaptive processing (STAP) for moving target indication (MTI) radar applications allows the use of long, potentially sparse arrays, wide bandwidths, and long coherent processing intervals (CPIs), all of which enable detection of a greater variety of targets than is possible with traditional systems. In this paper, upper bounds on the signal-to-interference-plus-noise (SINR) loss are derived for post-SAR processing in the presence of three types of impairments: internal clutter motion, volumetric clutter, and antenna backlobes. These bounds are important for both the design and assessment of this type of MTI system, as impairments such as these can influence the entire system architecture. [C268]

"Microwave imaging using a time-reversal radar system"

In the present work, we study potentialities of imaging targets using a new radar system. This Radar is able to perform phase conjugation experiments in the electromagnetic domain on the ultra-wide band [2-4] GHz. This way, time reversal experiments can be made, which can be useful for characterizing objects buried in cluttered environment. [C269]

"A New Type of Automatic Ship Detection Method"

A new type of automatic ship detection algorithm is proposed in this paper. By determining whether the local area is heterogeneous, simplex two-parameter CFAR algorithm based on Gauss-distribution or both two-parameter CFAR algorithm based on Gauss-distribution and two-parameter CFAR verification algorithm based on K-distribution are used to detect targets. This new type of algorithm keeps both the ability of traditional two-parameter CFAR algorithm' good features, such as small computation quantity, easy to implement and so on, and the detection accuracy in complex sea conditions at the same time. [C270]

"Convergence analysis of the iterative adaptive Kronecker receiver for MIMO radar applications"

We analyse an iterative adaptive multiple-input-multiple-output (MIMO) radar receiver in the situation where a K L-variate adaptive transmit-receive beamformer is structured as the Kronecker product of a K-variate (transmit) and an L-variate (receive) beamformer. We present results for the special case of two clutter propagation modes separated in elevation angle, where the direction-of-departure (DoD) of one mode and the direction-of-arrival (DoA) of the other mode coincide with that of a target. We introduce the analytical condition of convergence and signal-to-interference-plus-noise ratio (SINR) loss factor for a given training sample volume under a number of assumptions for a sample-matrix inversion (SMI)-based iterative algorithm, and demonstrate that the diagonally loaded SMI algorithm can provide significant improvement in the convergence rate of the iterative "Kronecker MIMO receiver". [C271]

"Efficient fourier based algorithm development for airborne Moving Target Indication"

This paper shows how the signal model that is commonly used as a starting point in multi-channel space time adaptive processing (STAP) for airborne moving target indication (MTI) formally corresponds to a model that can be derived from a bi-static synthetic aperture radar (SAR) model extended for multiple channels. With the help of this generalisation one arrives at an operation that can be performed on the conventional airborne MTI STAP model. The result yields an orthogonal domain that allows for a design of one-dimensional clutter-rejecting algorithms. This should drastically decrease the computational demands in comparison with the high-performance two-dimensional algorithms described in the airborne MTI literature so far. [C272]

"Tracking of a move-stop-move target in clutter: A comparison among MM methods"

In this paper we compare three different sequential estimation algorithms for tracking a single move-stop-move target in clutter. Bayesian estimation algorithms are taken into account, with a special focus on particle filters (PF). The target can undergo three different motion modes: a stopped target mode, a constant velocity mode and a manoeuvre mode. We analyze a realistic car traffic scenario by considering not only additive Gaussian noise, but also detection probability less than unity and false measurements originated by clutter disturbance. The aim of this paper is to compare the so called PDA-MM-PF (probabilistic data association, multiple model, particle filter) and PDA-MM-APF (probabilistic data association, multiple model, auxiliary particle filter) to the well-established Kalmanbased PDA-IMM (probabilistic data association, interacting multiple model) tracking algorithm. Tracking filters ignore a priori information about the true clutter spatial density. Advantages and disadvantages of the proposed algorithms are illustrated and discussed through computer simulations. [C273]

"Detection of Weak Signal in Chaotic Clutter Using Advanced LS-SVM Regression"

In this study, detection of small target in chaotic clutter with unknown dynamics is presented. We achieve this in four steps: (i) by using db3 wavelet decomposition of the signals, (ii) using Takens delay embedding theorem and least-squares support vector machine (LS-SVM) prediction, including increase the symmetric constraint and improve the kernel function, (iii) wavelet reconstruction, (iv) separation the weak signals from the prediction error. Efficiency of the new approach is evaluated by computing the root mean square error (RMSE) and signal-noise-radio (SNR) of the estimation. Lorenz attractor and the data from the McMaster IPIX radar sea clutter database will be used in the simulation. It is demonstrated in the simulation that compared with conventional RBF neural network LS-SVM regression prediction method; this approach has stronger generalization ability and better accuracy. [C274]

"Maneuvering Target Tracking in the Case of Wakes"

An interacting multiple model probability data association method for tracking the wake target is presented. When the detections are fed to a tracking system like the probabilistic data association filter, the estimated track can be misled and sometimes lose the real target because of the wake. This problem becomes even more severe when the target performs maneuvering in the presence of wakes. To prevent this, we propose a probabilistic model of the wakes and deduce the new probability association coefficient, for the target's maneuvering, the interacting multiple model is applied. Simulation result shows, compared with the interacting multiple model probabilistic data association method, the new method could reduce the target loss effectively and retain low target loss ratio with augmenting measurement noise. [C275]

"UWB Radar Sensor Networks Detection of Targets in Foliage Using Short-Time Fourier Transform"

First Page of the Article [C276]

"Detection of low-speed ground moving targets using MIMO radar"

Summary form only given. For airborne radar systems, space-time adaptive processing (STAP) is the approach that is normally adopted to detect ground moving targets in ground clutter, but the technique becomes less effective if the speed of ground moving targets is very low because of the proximity of the Doppler frequency of targets to that of ground clutter. Typical low-speed ground target detection scenarios include detecting ground troops and slowly-moving ground vehicles. Multiple-input multiple-output (MIMO) radar possesses multiple transmitting and receiving channels providing additional diversified reflections for fusion processing in target detection and measurements. MIMO radar has been extensively investigated, but the exact structure of MIMO radar is defined widely different. In this work, an innovative multi-level MIMO radar signal processing architecture is proposed for airborne systems to effectively detect low-speed ground moving targets. The new MIMO-based approach is demonstrated to be effective for detecting such low-speed ground targets in this work, and some

simulation results are presented subsequently. [C277]

"Joint MIMO radar waveform and receiving filter optimization"

The concept of MIMO (multiple-input multiple-output) radar allows each transmitting antenna element to transmit an arbitrary waveform. This provides extra degrees of freedom compared to the traditional transmit beamforming approach. It has been shown in the recent literature that MIMO radar systems have many advantages. In this paper, we consider the joint optimization of waveforms and receiving filters in the MIMO radar when the prior information of target and clutter are available. A novel iterative algorithm is proposed to optimize the waveforms and receiving filters such that the detection performance can be maximized. The proposed algorithm guarantees that the SINR performance improves in each iteration step. The numerical results show that the proposed methods have better SINR performances than existing design methods. [C278]

"Optimal and robust waveform design for MIMO radars"

Waveform design for Target identification and classification in MIMO radar systems has been studied in several recent works. While the previous works considered signal independent noise, here we extend the results to the case where signal-dependent noise, clutter, is also present and then we find the optimum waveform for several estimators differing in the assumptions on the given statistics. Computing the optimal waveforms for MMSE estimator leads to the Semi-definite programming (SDP) problem. Finding the optimal transmit signals for CSLS estimator results in a minimax eigenvalue problem. Finally it is shown that equal power waveforms are the best transmit signals for the SLS estimator. [C279]

"Bistatic SAR using illumination from a tethered Ground Moving Target Indication Radar"

In order to limit the ground clutter obscuration of very slow moving targets, ground moving target indication (GMTI) radars can be operated from stationary platforms. These systems generally cannot detect stationary targets for surface target surveillance. However, by using a small unmanned air vehicle (UAV) as a bistatic adjunct to GMTI system, a synthetic aperture radar (SAR) image can be formed. Modeling of bistatic SAR with a stationary transmitter was carried out to determine limitations on waveform and receiver platform operational parameters. [C280]

"Using complex-valued ICA to efficiently combine radar polarimetric data for target detection"

Target detection in sea clutter is a challenging problem in radar detection, specifically, when the Doppler return of the target and clutter are collocated. Polarization diverse radars provide additional information that enhances target detection. In this paper, we use an effective independent component analysis (ICA) approach, adaptive complex maximization of non-Gaussianity (A-CMN), to efficiently combine polarimetric radar data prior to detection. We show that A-CMN estimates the polarimetric scatter coefficients for the single target in clutter case, thereby providing matched-filter performance without the need for clutter or target models. The detection performance using ICA is evaluated with sea clutter collected with the McMaster IPIX radar off the coast of Canada. We also demonstrates the ability of this approach to adapt to the changing sea clutter conditions using simulation results. [C281]

"Space-time-range three dimensional adaptive processing"

Space-time adaptive processing (STAP) is an effective tool for moving target detection. Conventional STAP methodologies process the angular and Doppler two dimensional data vector. In practical applications, adjacent range cells are statistically dependent due to filtering, since the point spreading function of a target is not an ideal delta function. In this paper, a novel approach incorporating range (fast time) information in STAP is presented for clutter rejection, which we term space-time-range adaptive processing (STRAP). This method takes advantage of the correlation information of neighboring range cells. Therefore, the stationary clutter can be suppressed better compared with traditional STAP algorithms ignoring fast time information, resulting in more effective moving target detection. The validity of the STRAP algorithm is verified by the experiments of processing the real measured data of the three-channel X-band radar and MCARM radar systems. [C282]

"Spatio-temporal adaptive detector in non-homogeneous and low-rank clutter"

Reducing the number of secondary data used to estimate the Clutter Covariance Matrix (CCM) for Space Time Adaptive Processing (STAP) techniques is still an active research topic. Low rank CCM estimates have already been proposed but only for homogeneous and Gaussian clutter. We propose in this paper to extend the low-rank CCM methods for heterogeneous and/or non-Gaussian clutter. We derive a new detector based on low-rank techniques and exploiting properties of the Normalized Sample Covariance Matrix (NSCM). This detector is

shown to exhibit a smaller SNR loss than classical STAP detectors. Moreover, the new detector has a texture-CFAR property with respect to non-Gaussian SIRV model and has more robust behavior when some targets are present in the secondary data. We also give experimental comparison results between the classical STAP detectors and the new one for STAP data. [C283]

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

The rapid rollout of wireless local area networks (WLANs) has provided a ubiquitous source of signal transmissions that may be exploited for surveillance applications using passive bistatic radar (PBR) and passive multistatic radar (PMR) systems. In this study, a series of experiments were conducted to examine the feasibility of using IEEE 802.11 wireless fidelity (WiFi) transmissions for detecting uncooperative targets in high clutter indoor environments. The range and Doppler characteristics of the system were also assessed theoretically from an ambiguity function analysis on WiFi signals having similar transmission parameters. Through-wall detections of personnel targets moving at differing velocities within an indoor environment are presented for the first time. The work demonstrates the feasibility for developing a low cost surveillance device that utilises WiFi networks as transmitters of opportunity. [C284]

"SOSTAR-X flight tests: Statistical analysis of avionic GMTI radar data"

This paper presents the results of the long term statistical analysis performed over real multi-channel radar data collected during the flight tests of the SOSTAR-X avionic program. The analyzed datasets include clutter echo samples collected in GMTI operational modes over a number of geographic regions, each containing homogeneous clutter sources. Temporal and spatial correlation properties are investigated for each region as well as their statistical behavior. The clutter amplitude cumulative distributions are analyzed and compared to standard models (Rayleigh, K, Weibull and Lognormal) via Cramer-Von Mises distance. Power spectra are then estimated and compared with widely used models. [C285]

"A coherent Radon transform for small target detection"

The Radon transform can be used to implement grid based ldquotrack-before-detectrdquo processors. The approach can be described as a range alignment step followed by non-coherent integration. In this paper, a modification of the conventional direct Radon transform is proposed to coherently integrate the energy of the target. In this way, the noise and clutter contributions to each projection angle can be minimized and the overall performance of the system will improve. [C286]

"Cancellation of range ambiguities with block coding techniques"

This paper presents radar signaling schemes for cancellation of late time arriving echos. Signal reflections arriving delayed at the radar when the radar has already emitted a next pulse result in range ambiguities and materialize as potential false targets. In this work we propose pulse block coding techniques to distinguish echo reflections originating through the recently emitted pulse and those impending from subsequent pulses. The methods introduced require only simple matched filtering operations at the receiver and permit usage of arbitrary waveforms with potential for waveform diversity gains. [C287]

"MIMO radar angle-range-Doppler imaging"

Through waveform diversity, multiple-input multiple-output (MIMO) radar can achieve higher resolution and better sensitivity to slowly moving targets than phased-array radar systems. Furthermore, with a MIMO antenna array, the linear independence of reflected signals from scattering points allows for the direct application of adaptive array processing techniques. High levels of noise and strong clutter presence, however, significantly worsen detection performance. The iterative adaptive approach (IAA), a non-parametric and user parameter-free weighted least-squares algorithm, was recently shown to offer improved resolution and interference rejection for array processing applications. In this paper, we extend IAA to perform angle-range-Doppler imaging using a MIMO radar system. We furthermore demonstrate the superior performance of a MIMO radar system compared to a single-input multiple-output (SIMO) radar system. [C288]

"Novel architecture for hardware efficient FPGA implementation of real time configurable "variable point FFT" using NIOS II™"

Signal processor forms the heart of the radar subsystems and is responsible for the discernment of targets from interfering clutter and improving the SNR of the received signal for better detection of targets. Doppler filter bank is one of the modules used in signal processor to extract the Doppler information from the target, to improve the SNR and it also provides information regarding target velocity. In this paper we present a novel and simple

architecture to perform hardware efficient real time configurable ldquovariable point FFTrdquo using NIOSIItrade. The architecture can be used in multiple scan rate radars to reduce the resource utilization which can be used for other additional processing features. The architecture is generic in nature and can be extended to other platforms besides FPGA. [C289]

"An adaptive compensation of moving target doppler shift for airborne radar"

Accurate estimation and compensation of the moving target Doppler shift are essential for the moving target detection of the airborne radar system. In this paper, an algorithm for the real-time estimation and compensation of the moving target Doppler shift due to the moving radar platform and target is presented for the airborne stepped frequency radar system. Under the condition of a small number of sample points, this new algorithm employs the twice compensation method in order to estimate and compensate the mean Doppler shift using high speed DSP based on Doppler FFT processing. Using simulated radar data, the moving target Doppler spectrum is measured and analyzed. The results of simulations show that this new algorithm can reduce the number of sample points and enhance the anti-interfering performance yet still obtain good Doppler estimation and compensation. [C290]

"Adaptive Noise Waveform Design for Radar"

This paper introduces an adaptive radar waveform technique where a standard LFM waveform is used as an initial seed. The seed waveform is changed using a phase-only adaptive technique to minimize the resulting waveform's power in specific areas associated with in-band and adjacent-band spectral regions. Adjacent-band power minimization reduces interference to other spectral users, while in-band power minimization improves the waveform performance in matching interference environments. The resulting waveform retains a constant modulus which is valuable for practical transmitters, yet exhibits a variable degree of phase noise. Results are shown for three levels of computational convergence in the power minimization process. Ambiguity functions are plotted for each waveform to illustrate waveform performance characteristics such as radar resolution, target ambiguities, sidelobe response, and Doppler tolerance. [C291]

"Classification of flowers by bats: comparison with the radar case"

In recent years, with the development of high range resolution radars, the desire to be able to identify targets under all weather and clutter conditions has become of great importance. This is an activity carried out with great success by echolocating mammals such as nectar feeding bats that are able to detect and select flowers of bat-pollinated plants even in a dense clutter environment. In this paper data consisting of acoustically generated high range resolution profiles of four bat pollinated flower heads are analysed. Multi perspective classification performance is assessed and compared with the radar case. There are close parallels that suggest lessons can be learnt from nature. [C292]

"Improved waveform design for target recognition with multiple transmissions"

This paper presents a matched waveform technique for target class identification, i.e., a multiple hypotheses testing (MHT) framework. This technique is shown to improve classification performance of SNR-based matched waveforms derived from a probability-weighted spectral variance (PWSV) approach. The technique, which allows for real-time adaptive waveform transmission, is also shown to be computationally efficient. [C293]

"Multi-target Tracking in Wireless Sensor Networks Using Distributed Joint Probabilistic Data Association and Average Consensus Filter"

The aim of this paper is to develop a distributed multi-target tracking (MTT) algorithm over wireless sensor networks which has the ability of online implementation in low-cost sensor nodes due to its lower computational complexity and execution time compared to the other MTT systems. The Monte Carlo (MC) implementation of JPDAF (MC-JPDAF) is applied to the classical problem of TT in a cluttered area. Also, to make the tracking algorithm scalable and usable for large networks, the distributed Expectation Maximization (EM) algorithm is used via the average consensus filter in order to diffuse the nodespsila information over the whole network. Furthermore, some simplifications and modifications are made to MC-JPDAF algorithm in order to reduce the computation complexity of the tracking system and make it suitable for low-energy sensor networks. Finally, the simulations of tracking tasks for the proposed system are given. [C294]

"Sea Clutter Modeling Improvement and Target Detection by Tsallis Distribution"

Sea clutter is the backscattered returns from a patch of sea surface illuminated by a radar pulse and it's one of difficult domains in radar clutter modeling. A lot of efforts have 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 good, 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 is highly non-stationary. Tsallis distribution is one of distributions that recommend in recent year for sea clutter modeling. This distribution is obtained by maximizing the Tsallis entropy. The Tsallis entropy is a generalization of the Shanon entropy. In this paper was found two weak points, by accomplished simulation analyses: a) By reason of using small step in parameters estimation, the time of modeling is long. b) By reason of using short segment of clutter data, decrease the target detection accuracy. By using the bigger step in this paper, increase the parameter estimation quickness and by using all sea clutter data and decrease performance, was improving the target detection accuracy. [C295]

"Monte-Carlo Based Estimation Methods for Rapidly-Varying Sea Clutter"

We consider two Monte-Carlo based methods for characterizing the scattering function of rapidly-varying sea clutter. The first method uses multiple particle filtering to estimate the clutter space-time covariance matrix by exploiting the structure of the matrix. This method is then compared to a baseline approach that estimates the clutter covariance matrix based on the Weibull distribution approximation. Both methods are evaluated by formulating a detection problem that simulates a small moving target in heavy sea clutter. [C296]

"MIMO Radar with Frequency Diversity"

We propose a new multiple-input, multiple-output (MIMO) radar system with colocated antennas that can greatly reduce target fluctuations. This is achieved by employing frequency diversity. The proposed MIMO radar system results in a radar array with frequency-division multiplexing that can also incorporate beamforming to design the transmission beam pattern. After presenting an overview of existing MIMO radar systems and their related signal models, we provide a detailed description of the proposed frequency diversity technique and the corresponding transmitter and receiver structures. Furthermore, we present a maximum likelihood estimation algorithm that incorporates frequency diversity with MIMO radar, derive the corresponding Cramer-Rao lower bound, and demonstrate its improved performance using numerical results. [C297]

"Adaptive waveform design in rapidly-varying radar scenes"

We consider a waveform-agile sensing algorithm for designing transmitted waveforms in rapidly-varying radar scenes to improve target detection performance. Specifically, we first track the scattering function of rapidly-varying sea clutter in low signal-to-clutter ratios (SCRs) at each burst by estimating the clutter's space-time covariance matrix. Simultaneously, we schedule the waveform to be transmitted in the next burst by minimizing the sea clutter influence based on the estimated clutter statistics. The effectiveness of our waveform-agile sensing approach is demonstrated by detecting a moving target in heavy sea clutter using configured waveforms, and then comparing the resulting performance to that of detecting the target using fixed-parameter linear frequency-modulated w.aveforms. [C298]

"Extensible simulator for waveform diversity testing"

Exotic waveforms can be formulated, and assessed, using purpose-written waveform generators and matched receivers. However, more comprehensive testing in an environment similar to operational conditions requires a large investment in coding. Furthermore, even bespoke simulators are usually written for the monostatic case, and have limited facilities to handle multiple transceivers distributed in space and time. These considerations led to the development of FERS, the flexible extensible radar simulator, which has been launched as an Open Source initiative. The simulator can handle an arbitrary number of transmit / receive nodes, targets, all distributed in time and space. Waveforms and signal processing can be added in a simple way through a well defined interface. This paper discusses the needs for such a simulator, its design, the high performance computing aspects and concludes with some examples. [C299]

"GMTI MIMO radar"

Multiple-input multiple-output (MIMO) extensions to radar systems enable a number of advantages compared to traditional approaches. These advantages include improved angle estimation and target detection. In this paper, MIMO ground moving target indication (GMTI) radar is addressed. The concept of coherent MIMO radar is introduced. Comparisons are presented comparing MIMO GMTI and traditional radar performance. Simulations and theoretical bounds for MIMO GMTI angle estimation and minimum detectable velocity are presented. The simulations are evaluated in the time domain, enabling waveform design studies. For some applications, these results indicate significant potential improvements in clutter-mitigation SINR loss and reduction in angle-estimation error for slow-moving targets. [C300]

"MIMO phased-array for SMTI radar"

Summary form only given. Waveform diversity techniques for radar have gained considerable interest over the past several years. Novel radar waveforms have been proposed to improve detection performance and metric accuracy (i.e., angle estimation performance). This paper explores the potential for using a waveform diversity technique known as Multiple Input, Multiple Output (MIMO) radar to improve the detection performance of slow moving surface targets from a moving radar platform. The MIMO radar system achieves superior performance by transmitting unique uncorrelated waveforms from each antenna subaperture as opposed to the traditional approach of transmitting a single coherent waveform across the entire aperture. The results show that the radar system minimum detectable velocity (MDV) can be reduced by exploiting the ability of a MIMO system to effectively increase the radar antenna aperture. [C301]

"MIMO radar angle-doppler imaging via iterative space-time adaptive processing"

We consider using multi-input multi-output (MIMO) radar to improve the ground moving target indication (GMTI) performance, especially for slowly moving targets, for airborne surveillance systems. The increased virtual aperture afforded by MIMO radar systems enables many advantages, including enhanced spatial resolution, improved parameter identifiability and better performance for GMTI. To obviate the need of secondary data for space-time adaptive processing (STAP), we apply herein a user parameter-free and secondary data-free fully automatic weighted least squares based iterative adaptive approach (IAA) to angle-Doppler imaging via a standard MIMO scheme, two simplified MIMO schemes (which employ switching strategies for transmission), and also a conventional single-input multi-output (SIMO) scheme. The high-resolution angle-Doppler images formed by IAA, using the primary data only, are provided to compare the performance of the three MIMO schemes as well as the SIMO scheme. [C302]

"CA-CFAR detection in spatially correlated K-distributed sea clutter"

Radar detection of targets in sea clutter modelled by compound K-distribution is examined from a statistical detection viewpoint by Monte Carlo simulations. The detection performance of Cell Averaging Constant False Alarm Rate (CA-CFAR) is compared with the performance of fixed threshold detection. The performance evaluations are quantified by CFAR loss. Curves for CFAR loss to the spatial correlation and spikiness of sea clutter, number of cells of CA-CFAR processor and the number of non-coherently integrated pulses are presented. [C303]

"An improvement of an RFID indoor positioning system using one base station"

The proliferation of mobile computing devices and wireless positioning networks has fostered a growing interest in location-aware systems and devices. Most technologies such as radio frequency identification (RFID), RADAR, etc, use at least three base station (BS) for calculating position of target objects. This paper describes an improvement of the previous OneBS algorithm. The proposed system uses only one BS based on the RFID infrastructure for positioning target tags amid the clutter of indoor interference environments. We proposed to fuse the round-trip time of flight (RTOF) and the received signal strength (RSS) in the positioning algorithm. Both information are kept in an intersection box (iBox). The RTOF information is used to focus a target tag's position among groups of four-nearest-neighbor reference tags kept within iBox. Then, the RSS information is weighted using the weighted center of gravity technique to estimate a location of the target tags. Our experiments are based on three dimension (3D) materials within interference environments. The interference environments are simulated based on uniform geometrical theory of diffraction (UTD), for measuring signals in each specific area. Our proposed algorithm gains 50 percents better average distance error compared to the OneBS algorithm. [C304]

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

As a complementary mode to synthetic aperture radar (SAR), high range resolution (HRR) is mainly developed to identify moving ground targets automatically. Previous studies have demonstrated many promising solutions in HRR Automatic Target Recognition (ATR). Most of them popularly build on template-based approach and employ mean square error (MSE) metric in matching algorithm to measure the likelihood between test profiles and template profiles. However, discussion about whether MSE works as it is expected is inadequate. This paper represents a preliminary investigation into MSE metric used in matching algorithm. We firstly illustrate MSE metric theoretically, and then indicate its shortcomings such as random coefficients distorting the difference between profiles in mathematical calculation, excessive emphasis on large difference, and lack of reasonable interpretation in physical distance space. An alternative metric named average absolute error (AAE) is utilized to replace MSE. It is directly based on the distance between profiles and is able to provide a clear physical

interpretation. The experiment results show that no matter estimated aspect angles are given or not during classification, AAE-based HRR ATR significantly outperforms the baseline MSE-based HRR ATR. [C305]

"Rolled-dipole array for GPR with multiple footprints"

Antenna footprint indicates the shape and size of the area illuminated by the antenna on the ground surface or subsurface. For GPR it is important as it determines the cross-range resolution of the radar. In this paper we demonstrate that an array antenna comprising a number of rolled-dipole elements can produce a variable footprint by activating certain elements and deactivating the others. In this way the size of the array's footprint can be adjusted to remain comparable with the cross section of various targets which in turn minimizes clutter and improving the GPR performance. This paper presents FDTD simulation results and preliminary experimental result of the proposed antenna. [C306]

"Exploiting multipath from airborne platforms for direction of arrival estimation"

In the direction-of-arrival estimation, the scattering of the incident signal from airborne platforms is often neglected or considered as a source of clutter. However, these additional signal paths, mostly due to the diffraction from the platform wedges, contain useful information about the incoming waves. Recent research showed that the waves reflected from the known objects surrounding the target improve the accuracy of the target estimation or image. We show that similar improvement is obtained if the array interaction with the hosting platform is taken into the account. We incorporate the multipath into the signal processing algorithms, and study the improvement by computing the Cramer-Rao bound. We show that the exploitation of the multipath from the sensor platforms improves the estimation accuracy significantly. Moreover, the capacity to resolve multiple incident signals is enhanced. [C307]

"An optimal radar detector threshold adaptation for maneuvering targets in clutter"

In this paper, we consider the problem of radar detector threshold optimization for maneuvering targets in clutter. In the earlier works, the problem was studied in the context of the probabilistic data association filter (PDAF) for non-maneuvering targets. In this study, we have extended the ideas, which were applied to the PDAF, to the interacting multiple model PDAF (IMM-PDAF) for maneuvering targets. The proposed optimization problem and its solution show better results over the traditional approaches in terms of track loss percentage and RMS position error criteria. [C308]

"Sea clutter power reduction in radar measurement systems by feedforward multilayer perceptrons with medium input data integration rate"

In radio measurement systems, the backscatter from what is not a target, i.e. the clutter, is usually not desired. So, these systems try to incorporate clutter reduction techniques as efficient as possible. In this way, different signal processing techniques can be used. The case of study presented in this paper shows how to reduce the level of sea clutter measurements in a marine radar. Due to linear linear signal processing is not suitable in these cases, nonlinear signal processing is used, which is achieved by neural networks. In this way, 7 cells to evaluate the output of each cell under test of a radar image (medium input integration rate) are selected. The processed radar images show very promising results from a subjective point of view. On the other hand, objective measurements are used to analyzed the system performance. Those measurements are based on the mean square error and the clutter and target powers at the input and output of the proposed clutter reduction system. Minimum and mean clutter reduction power rates of 7 dB and 10 dB are achieved, respectively. [C309]

"Tracking of metallic targets using a retro-reflective array at 26 GHz"

This paper presents a design concept to aid in the detection and tracking of objects in a cluttered environment. The goal is to uniquely identify large, relatively cylindrical metallic objects in a warehouse setting. In addition to the challenge of determining the object's precise location, it is also desirable to uniquely identify each cylinder. The application is similar to RFID but differs in that much longer range of operation is needed and operation on metallic objects is required. A planar Van Atta retro-reflector is used as the baseline for the RF tag with large angle-independent radar cross-section. [C310]

"Detection of moving intruders from a moving platform using a Ka -band continuous-wave doppler radar"

A scanning-beam Doppler radar has been presented which can detect moving intruders from a moving platform. The limitations of the scanning-beam sensor in terms of platform velocity and rotation rate were discussed for a fixed antenna beamwidth. Targets moving at any velocity relative to the platform can be detected, even when the

person is moving along with the platform, producing no Doppler return. Estimation and removal of the clutter return was demonstrated in order to detect slow-moving targets whose response is within the clutter bandwidth. The optimal threshold value was determined using performance metrics for classifiers under imbalanced data sets. [C311]

"Air traffic control radar tester"

Our aim had been to develop a radar tester equipment for commercial and military services. The task is to create one (or more) target or clutter on the radar screen with given distance, velocity and fluctuation. This equipment is placed within few hundred meters from the radar, so it is able to analyze the whole radar system from the antenna, via microwave hardware elements, to the DSP unit. [C312]

"Analysis of some CFAR detectors in nonhomogenous environments based on switching algorithm"

In radar signal processing distinction of false targets from real targets and fixing their rate in different radar environments is desirable. In this paper, at first, switching constant false alarm rate (S-CFAR) processor has been improved to achieve Improved SCFAR in order to fix the false alarm rate not only in homogenous environment only with thermal noise but also in non-homogenous environment, consisting clutter edge and multiple targets in the background Gaussian noise. Then in continue, a new CFAR detector which is composed of an excisior and a switching CFAR detector, in an environment with K distribution, has been introduced. The new detector is named an excision switching CFAR (EXS-CFAR). The equations have been achieved by assuming the targets in Swerling I and closed form. The simulation results confirm that the introduced processors can fix the false alarm rate in both homogenous and non-homogenous environment with less detection loss. In addition, this method is simpler in implementation comparing with other samples ordering processors. [C313]

"Medium-high correlated Weibull-distributed clutter reduction by neural networks in coherent radar systems"

This paper presents a clutter reduction system when medium-high correlated Weibull-distributed clutter governs the environment of a coherent radar system. This proposal is based on the capabilities of learning of some artificial intelligence techniques, such as the neural networks. This capability of learning of the neural networks is used to learn some statistical characteristics of the radar environment. The results obtained with this proposal show how the desired signals (targets) are emphasized with respect to the environmental interference (clutter), which is reduced. Moreover, several advantages are found if it is compared with other classical approaches to reduce the clutter level, such as Target Sequence Known A Priori techniques. [C314]

"Enhanced multistatic radar resolution via STC"

MIMO radar can improve on conventional target detection, parameter identification, and target classification performance via diversity of, among other things, its simultaneously-transmitted waveforms. However, the mutual interference among the waveforms may lead to considerable performance degradation suppressing clutter near targets. In this paper, we consider the use of space time coding (STC) to mitigate waveform cross-correlation effects in MIMO radar. First, it turns out that a joint waveform optimization problem can be decoupled into a set of individual waveform design problems. Second, a number of monostatic waveforms can be directly used in a MIMO radar system, which offers flexibility in waveform selection. Numerical results demonstrate the effectiveness of STC in MIMO radar for waveform decorrelation. [C315]

"GMTI tracking improved by 18 dB using cognitive algorithm"

Existing tracking algorithms face combinatorial complexity in heavy clutter. Their performance is limited by the number of computer operations, they do not extract all the information available in radar signals, and do not reach Cramer-Rao performance bounds. A cognitively inspired algorithm was developed and applied for improved tracking. Models for GMTI tracks have been developed as well as cognitive architecture incorporating these models. The cognitive tracker overcomes combinatorial complexity of tracking in highly-cluttered scenarios; its performance achieves Cramer-Rao Bounds and results in about 20 dB (two orders of magnitude) improvement in signal-to-clutter ratio. [C316]

"Performance deterioration of the matched filter detector in partially correlated texture based compound-Gaussian clutter environment"

This paper addresses the problem of radar target detection in the presence of non-Gaussian clutter modeled in compound-Gaussian form which realizes the clutter process as a product of two independent random processes can be called as ldquotexturerdquo and ldquospecklerdquo. The existing matched filter (MF) detectors suit and

are applicable to radar target detection in the presence of compound-Gaussian clutter. However, in view of scanning while detecting in a radar the textural component of the compound-Gaussian clutter exhibits a correlation which is less than unity. Therefore, it was needed to model the clutter in compound-Gaussian form considering partial correlation of texture and clutter modulation which arises as a result of antenna scanning. MF based detectors existing in the literature is expected to yield a fall in the detection performance in such clutter environment. Here in this paper, the performance of the existing MF detector is studied in detail for partially correlated texture scenario. Furthermore performance of the detector is mathematically analyzed to show its relationship with the texture correlation value. Analytical and simulation results show that for partially correlated texture the existing MF detector performance degrades significantly as compared to the completely correlated texture case. [C317]

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

This paper is concerned with imaging and moving target detection using a synthetic aperture radar (SAR) platform that is known as Gotcha. The SAR platform can interrogate a scene using an imperfect circular trajectory; we refer to this as nonlinear SAR data collection. This collection can make monostatic and quasi-monostatic measurements in the along-track domain. We present subaperture-based wavefront reconstruction algorithms for motion compensation and imaging from this nonlinear SAR database. We also discuss adaptive filtering algorithms to construct MTI imagery from the two receiver channels of the system. Results will be provided. [C318]

"Improving the radar detection ange of low flying aircraft in clutter with ultra-widband short pulses and active side lobe reduction"

This paper proposes a method for airborne fire control radars in their air-to-air modes to improve the radar detection range of targets intentionally flying to present Doppler returns that fall either into main lobe clutter or altitude return. The use of UWB short pulses improves the target to clutter ratio and hence the radar detection range. [C319]

"An approach to ground moving target indication (GMTI) using multiple resolutions of the clutter covariance matrix"

This paper presents an approach to simultaneous ground moving target indication (GMTI) and synthetic aperture radar (SAR) imaging that promises to outperform current space-time adaptive processing (STAP) GMTI techniques when jamming is not present. An inherent weakness in STAP is its inability to directly estimate the scattering statistics from nonmoving objects in the region under test. A SAR image is a measure of the scattering intensity from an illuminated area on Earth assuming everything in the scene is stationary; therefore, it provides the estimate of scattering from nonmoving targets required for GMTI. Since the homogeneity of the scattering statistics over the scene are unknown, using multiple spatial resolutions of the SAR image to estimate the scattering statistics results in more confidence in the final detection decision. [C320]

"Clutter modeling for bistatic SAR with phased array antenna and arbitrary geometry configuration"

For bistatic synthetic aperture radar (Bi-SAR) with phased array antenna and arbitrary bi-static geometry configuration, this paper proposes a clutter modeling method for clutter suppressing and ground moving target detection. Furthermore, based on the simulated space-time clutter spectrum of four typical specific geometry configurations, the detailed analysis is also given for the clutter suppressing performance with space-time adaptive processing (STAP), Finally, some important conclusions are given for Bi-SAR with different geometry configuration. [C321]

"A multifrequency interferometric CW radar for vital signs detection"

The use of radar techniques to detect minute body movements which are associated with respiration and cardiac activity (vital signs) is known at least since 1975 when J.C. Linn and J. Salinger proposed a non-contact microwave respiration monitor. This paper sets up to discuss further development of CW radar based vital signs detection systems. The purpose here is to enhance target detection probability in a highly cluttered environment and to add range and angle-of-arrival estimation without dramatically enhancing RF spectrum requirements by transition to a multicarrier interrogating signal. [C322]

"Parameter estimation based coherent multistatic processing"

This paper develops the coherent generalized likelihood ratio test (GLRT) and the MVDR statistic for multistatic

radar systems, conditioned on estimation of certain parameters that render the system coherent. Analytical and computer simulation results are presented to show substantially enhanced detection and geolocation of moving targets in clutter. [C323]

"MIMO enabled multipath clutter rank estimation"

Multiple-input multiple-output (MIMO) radar is an emerging technology that has the capability of providing range dependent transmit-domain degrees of freedom via receiver processing. When providing these additional degrees of freedom for target tracking, MIMO radar exhibits a lower signal-to-noise ratio (SNR) when compared to that of traditional single-input multiple-output (SIMO) phased array radar. Previous work has indicated the efficacy of combining MIMO operation with space-time adaptive processing (STAP) techniques in the presence of multipath clutter to improve the signal-to-clutter-plus-noise ratio (SCNR). The tradeoff between target SNR and SCNR in multipath propagation environments is a crucial consideration in MIMO radar. In this paper, a transmit-receive directionality spectrum (TRDS) is used to examine the clutter characteristics at a range-Doppler bin of interest, most notably in multipath situations where MIMO operation is advantageous. In situations where ground clutter is spread in Doppler frequency and azimuth by motion in the propagation environment, the clutter rank can be significantly higher than a Brennan's rule estimate. However, the transmit observability within the MIMO data vector allows for a low rank representation of the clutter when compared to the total available degrees of freedom. A TRDS-based method based on the resolution limits of uniformly spaced linear transmit and receive arrays is presented which furnishes an estimate of the transmit-receive clutter rank in scenarios where Brennans rule provides a significantly underestimated measure. The proposed TRDS-based clutter rank estimation method is applied to both numerical simulations and experimental data. [C324]

"Time-frequency entropy of Hilbert-Huang transformation for detecting weak target in sea clutter"

In this paper, Hilbert-Huang transformation is adopted for analyzing the sea clutter with the fixed weak target. It's found that the fixed target only affects the low frequency component of the sea clutter. So the time-frequency entropy of the low frequency component is applied for the weak target detection. Compared with another weak target detection method directly using the box dimension, the method proposed in this paper improves the effect of the fixed target on the sea clutter. And the detection performance of the fixed weak target is improved distinctly. [C325]

"Fractal-based variable step-size least mean square algorithm for radar target detection in sea clutter"

This paper introduces fractal-based variable step-size least mean square(FB-VSLMS) algorithm and proposes a model for radar target detection in sea clutter. FB-VSLMS algorithm deals with a specific class of fractal signals and except one of the step-size parameters requiring time-varying constraints, the constraints on the remaining parameters are time-invariant. And the step-size matrix is determined completely with the knowledge of the deterministic Hurst exponent. The model based on this algorithm is suited for tracking signals from the family of fractal signals that are inherently nonstationary. In the end, the performance of the novel model is analyzed. By the verification of X-band real sea clutter, the model is shown to be effective for point target detection in sea clutter. [C326]

"Ground moving target displacement compensation in the DPCA based SAR-GMTI system"

The velocity and acceleration of the ground moving target can cause the target position to be displaced and defocused in the SAR image. In this paper, the displacement compensation scheme is presented to correct the displaced position and defocused moving target image in the DPCA based SAR-GMTI system. The influence of the ground moving target due to the velocity and acceleration is analyzed in range and azimuth directions, and its compensation method is presented with the simulation results. The performance of the proposed method is compared with respect to the estimated velocity and defocused quantity in both range and azimuth directions. [C327]

"A tri-look detector for single channel SAR-GMTI"

This article studies clutter suppression and detection of moving targets in single channel SAR images. By analysing the most commonly used 3-channel SAR-GMTI principle, a new detector based on tri-look image Cancellation-After-Interferometry (CAI) is proposed where tri-aperture images are constructed by overlapped frequency even-partition of clutter bandwidth. Compared with the single channel SAR detector such as traditional tri-aperture cancellation, simulation results show the proposed algorithm having better robustness against clutter uncertainty especially in strong clutter environments and having capability of detection those with azimuth

velocity vector. The simulation and performance comparison with 3-channel detection method also show that the proposed algorithm has no direct capability of parameter estimation resulted from phase randomness in single channel deployment. [C328]

"Ship detection from polarimetric sar images"

SAR image from sea can constantly contain ships and their ambiguities in azimuth and range directions. For maritime applications, the ambiguities are visible due to their strong intensities in a low backscattering background of sea environment. Thus, the ambiguities can be often mistaken as ships and cause false alarms. Many approaches have been proposed for reducing the azimuth ambiguities in single channel SAR image. This paper analyzed scattering mechanisms of the azimuth ambiguities for PolSAR images and proposed a method for detecting ships from PolSAR images. By using eigenvector-eigenvalue decomposition, three eigenvalues can be used to differentiate ship targets, azimuth ambiguities and sea clutter. One C-band JPL AIRSAR polarimetric data have been chosen to evaluate the method. The experimental results show that the proposed method can effectively reduce false alarms caused by the azimuth ambiguities. [C329]

"GRLT detection of moving target by along track SAR interferometric systems"

In this paper we consider the problem of the detection of a ground moving target using Synthetic Aperture Radar Along Track Interferometric (AT- InSAR) systems. We propose a method exploiting a Generalized Likelihood Ratio Test (GRLT) and based on a Gaussian model for the target response. We also derive the log-likelihood ratio probability density function in closed form, both in the hypothesis of presence of target and absence of target. Numerical results based on simulated data are presented. [C330]

"Velocity estimation of moving targets on the sea surface by azimuth differentials of simulated-SAR image"

Since the change in Doppler centroid according to moving targets brings alteration to the phase in azimuth differential signals, one can measure the velocity of the moving targets using this. In this study, we will investigate theoretically measuring velocity of an object from azimuth differential signals by using range compressed data which is the interim outcome of treatment from the simulated Synthetic Aperture Radar (SAR) Raw data of moving targets considering sea clutter. Also, it will provide evaluation for the elements that affect the estimation error of velocity from a single SAR sensor. In the concrete, by making RADARSAT-1 simulated image, the research includes comparisons for the means of velocity measurement classified by directions of movement as in the four following cases. 1. A case in which the object that becomes the target exists independently, 2. When there is a tidal current of 1 m/s, 3. When there exists moving targets of different velocity on the azimuth, 4. When the target is contiguous to the land where it has high back scatter factor. As a result, when the object, which becomes the target, independently exists on SAR image in the range of 128 pixels, the velocity of object could be measured with high accuracy. However, when there existed other moving targets in the range of 128 pixels or when the target was contiguous to the land of high back scatter factor, the velocity was in error by 10% at the maximum. This is because in the process of assuming the target's location, an error occurred due to the disturbed signals affected by the scatterers. [C331]

"Simulation of dual-channel SAR-GMTI for velocity estimation and compensation"

The velocity and acceleration of the ground moving target can cause the target position to be displaced and defocused in the SAR image. In this paper, the displacement compensation scheme is presented to correct the displaced position and defocused moving target image in the DPCA based SAR-GMTI system. The influence of the ground moving target due to the velocity and acceleration is analyzed in range and azimuth directions, and its compensation method is presented with the simulation results. The performance of the proposed method is compared with respect to the estimated velocity and defocused quantity in both range and azimuth directions. [C332]

"Kernel regression-based background predicting method for target detection in SAR image"

Target detection with SAR image is one of important research topics in remote sensing. In this paper, a kernel regression-based predicting method is proposed for target detection in SAR image. Badly speckle noise and background clutter are two main factors which make the target detection with SAR image difficult. In the proposed method, the kernel regression on local image is used to exactly predict the background interferences and make Gaussian assumption in conventional detector better followed after kernel regression-based prediction and suppression of background clutter. Thus, final CFAR detection is performed on the background clutter-removed SAR image. Experiments conducted on real SAR image show that the proposed algorithm can effectively predict and suppress background clutters, and greatly improve the performance of the conventional

CFAR detector. [C333]

"Sea-clutter analysis at multiple wavelengths (L, C, X) for target-clutter contrast assessment in littoral waters"

This study is aimed at quantifying the statistics and nature of sea-clutter as seen from spaceborne platforms and assessing the target-clutter contrast in the Adelaide harbor area of South Australia. To this end a series of images in mixture of polarizations were collected over this area in typical wide area surveillance mode-ScanSAR single polarization images from TerraSAR-X, Dual-Polarization Wide Beam images from RadarSAT-2 and Full and Dual Polarization images from ALOS-PALSAR. Synchronized with the acquisitions (dawn/dusk orbit of SAR satellites) video over flights with a low light camera were performed to record the sea-state. AIS data was collected for the information on the larges vessels and meteorological buoy readings for surface wind, wave height and swell were noted. [C334]

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

Airborne radar tracking in moving ground vehicle scenarios is impacted by sensor, target, and environmental dynamics. Moving targets can be assessed with 1-D High Range Resolution (HRR) Radar profiles with sufficient signal-to-noise (SNR) present which contain enough feature information to discern one target from another to help maintain track or to identify the vehicle. Typical radar clutter suppression algorithms developed for processing moving ground target data not only remove the surrounding clutter but also a portion of the target signature. Enhanced clutter suppression can be achieved using a multi-channel signal subspace (MSS) algorithm which preserves target features. In this paper, we exploit extra information from enhanced clutter suppression for automatic target recognition (ATR), present a gain comparison using displaced phase center antenna (DPCA) and MSS clutter suppressed HRR data, and generate confusion-matrix identification results. The results show that more channels for MSS increase ID over DCPA, result in a slightly noisier clutter suppressed image, and preserve more target features after clutter cancellation. [C335]

"The effects of reduced bandwidth on HF surface wave radar performance in ship detection"

Bandwidth reduction not only degrades the range resolution of a radar, but may also reduce the maximum detection range. In the clutter-dominated region, the target signal-to-clutter-plus-interference-and-noise power ratio (SCINR) is reduced by the same factor as the bandwidth, but in the external-interference-and-noise-dominated region, the SCINR is unchanged. A dataset from a monostatic pulse HF surface wave radar (HFSWR) operating between 3 and 5 MHz is used to illustrate the effects of a 3-dB bandwidth reduction on the radar performance. The results show that in the detection of large ships, the maximum detection range is essentially unchanged, but in the detection of small ships, the maximum detection range is reduced. [C336]

"Airborne Radar and shipborne sonar: Recent advances and compared solutions"

The detection of slowly moving target in a strong backscattering background (clutter for radar, reverberation for sonar) is a challenge to both Airborne Radars and Surface Ship or Submarine Sonars communities. In this paper, after outlining the similarities and differences between the above and under-water domains, recent advances in the areas of waveforms design and beam-forming will be described. In a first part, more efficient wide-band Doppler waveforms for sonar will be introduced together with their advantages in terms of detection, and wideband coherent waveforms for radar moving targets detection will be presented. The second part will focus on the implementation of adaptive beam-forming for sonar and coloured transmission space time beam-forming for radar. Results on reverberation reduction obtained on a towed array sonar in CW mode will be discussed, and perspectives for coloured transmission radar systems will be outlined. [C337]

"Hierarchical segmentation of Polarimetric SAR images using heterogeneous clutter models"

In this paper, heterogeneous clutter models are introduced to describe Polarimetric Synthetic Aperture Radar (PolSAR) data. Based on the Spherically Invariant Random Vectors (SIRV) estimation scheme, the scalar texture parameter and the normalized covariance matrix are extracted. If the texture parameter is modeled by a Fisher PDF, the observed target scattering vector follows a KummerU PDF. Then, this PDF is implemented in a hierarchical segmentation algorithm. Segmentation results are shown on high resolution PolSAR data at L and X band. [C338]

"Bi-static and multi-frequency experiments of HFSWR"

High Frequency Surface Wave Radar is currently a well-known surveillance system for the Exclusive Economic Zone. We are still trying to improve their performances and reliability. In this new research step, we are trying to

assess the benefits of multi-static as well as multi-frequency configuration. The global ambition is obviously to overcome clutter issue and to increase the coverage for small target. Results presented here highlight the significant contribution of the proposed configuration. [C339]

"Target coherence analysis using canonical correlation decomposition for SAS data"

This paper analyzes the connection between the canonical correlations of sonar signals captured using two linear hydrophone arrays and the spatial coherence of the sources that are observed. Analysis of this connection allows for the use of a canonical correlation decomposition (CCD) framework for performing synthetic aperture sonar (SAS)-like processing. In particular, it can be used to extract correlation features of the targets in the frequency domain, which can then be used as a measure for target detection and classification. Results on real and simulated data indicate that coherence patterns are different in the presence of a target when compared to background clutter, and this pattern also changes as a function of the number of sensors on the array. [C340]

"FDBAQ a novel encoding scheme for Sentinel-1"

Modern operational and/or high resolution SAR satellite missions impose stringent requirements on on-board data compression such as a higher data reduction ratio, more flexibility, and faster data throughput. A novel approach is flexible dynamic block adaptive quantization (FDBAQ). This method outperforms currently used block adaptive quantization with respect to Signal-to-Noise-Ratio related to the compression ratio. The FDBAQ method allows bit rate programmability with non-integer rates. This allows the SAR information throughput to be optimized for different types of targets and down-link scenarios using a tradeoff between thermal and quantization noise. [C341]

"Power Delay Profile Matching for Vehicle Target Recognition"

Radar echo contains unwanted echoes called as clutter, which make it difficult to detect vehicle or obstacle. Especially short-range/wide-angle vehicle radar at 24 GHz suffers from heavy clutter unlike long-range radar at 77 GHz. It is therefore expect to improve the detection performance by suppressing the clutter using a pulse integration and CFAR (Constant False Alarm Rate). However the radar echo should include multiple vehicle targets as well as the clutter, thereby it is not easy to improve the performance. In this paper the target discrimination technique, let say, power delay profile matching scheme is proposed and the usefulness is investigated by conducting the measurement at 24 GHz where the clutter suppression scheme is also considered. As a result, a vehicle target is found to be recognized from multiple vehicles. We have also investigated the effect of bandwidth on the target discrimination capability. [C342]

"Performance analysis of OSGO and OSSO CFAR detectors under pearson distributed clutter"

In this paper, the detection performance of OSGO and OSSO CFAR detectors embedded in heavy-tailed Pearson distributed clutter is analyzed. We derive the closed mathematic form expressions of probability of false alarm rate and detection probability of the two CFAR schemes. While the processing speed of OSGO and OSSO CFAR is two times of that of OS CFAR, simulation results indicate that OSGO CFAR detector's performance is very close to OS, and OSSO CFAR offers better and robust detection performance than OS CFAR in multiple-target situation. [C343]

"Detection scene analysis for high frequency radar"

Suffering from multiform time-variant and fluctuant clutter in High Frequency Radar (HFR), uniform target detection, tracking and clutter mitigation methods will result in false alarm or missing alarm. To select optimized detection and clutter mitigation method in the region of interesting, a method maximizing the separability of the resultant classes in amplitude of range-Doppler map is used for segmentation in multi-level detection background. Statistical and qualitative analysis is operated on the result of clutter extraction. Real data indicated that the proposed method can extract clutter region and adapt for various echo spectral maps for HFR as well, which can offer more accurate prior knowledge for target detection and clutter mitigation. [C344]

"Airship radar imaging for stationary and moving targets based on thinned array and code division signal"

In order to reduce the complexity of airship real aperture radar, the stationary scene and moving targets imaging method is proposed based on thinned array and code division signal. It can obtain the phase center that equivalent to the full array, thus avoiding the thinned array high sidelobe and high integrated sidelobe ratio. For the stationary targets, it images directly. For the moving targets, it first adopts traditional MTI to achieve clutter suppression, performs pulse compression and pulse accumulation, and achieves moving targets detection and

velocity estimation based on the noncoherent integration of all phase centers data. Then choose the Doppler channel data that the moving target exists in to accomplish moving target imaging. The simulation results indicate the validity of the method proposed in the paper. [C345]

"A flexible baseband SAR ground moving targets simulator design and experimental results"

A digital Synthetic Aperture Radar (SAR) simulator of ground moving targets is presented. Real scene data is used as the clutter background for fidelity and moving targets are real-time computed and embedded into scene data in time domain according to pulse repetition frequency (PRF). The experimental results prove the effectiveness of the system. [C346]

"Analysis of bistatic ground clutter characteristics and effects on space-time adaptive processing"

In-depth study of ground clutter characteristics of airborne bistatic radar is significant to clutter suppression and moving target detection (MTD) through space-time adaptive processing (STAP). Based on the geometry configuration that transmitter and receiver align at the same velocity, the paper presents the equation of ellipse on ground and analytic resolution of clutter scatterer location when the two-way distance between receiver and transmitter is constant, derives the clutter ridge expression and gives theoretic explanations to the nonlinear and nonstationary properties of bistatic clutter. Changes of clutter ridge are given under mathematical analysis; meanwhile, STAP performance is briefly analyzed with parameters of platforms at different bounds. Simulations verify the correctness of conclusions given in the paper. [C347]

"Generation of Pulse Compression Codes Using NSGA-II"

Pulse compression technique avoids the transmission of a signal having small pulse width and high peak power for better range resolution by transmitting phase or frequency modulated large pulse width signal having comparatively low peak power signal. This paper demonstrates an application of non dominated sorting genetic algorithm-II (NSGA-II), a multiobjective algorithm, to generate biphase pulse compression codes from length 49 to 59. But the aperiodic autocorrelation function(ACF) of the phase coded signals contains range sidelobes which act as self clutter in radar target detection. The efficiency of these codes depends upon the energy content in the range sidelobes of their autocorrelation functions. Peak sidelobe level (PSL) and integrated side lobe level (ISL) are the two performance measures for pulse compression codes. A code is chosen for an application if the ISL and PSL value is within tolerable limits. In this work PSL and ISL are chosen as the objective functions for generating biphase code. [C348]

"A Method for Recovering Maneuver Targets Spectra Based on the Algorithm of Decontaminating Ionospheric Slow Phase-Path Disturbance"

Both ionospheric slow phase-path disturbance and targets' maneuver will make the targets' echoes broaden in HF radar. Although their mechanism to spread the spectra is different, they are consistent on the view of the phase of targets' echoes. Using the algorithm of ionospheric disturbance decontamination which has been successfully applied in practice, a method for recovering maneuver targets spectra has been presented in this paper. Results of experimental data of HF radar and meter-wave radar verify the correctness of such process. And they also show that the algorithm can effectively improve the quality of the targets spectra to improve the radar target detection and tracking performance. [C349]

"Co-located MIMO radar with orthogonal waveform coding: Cramйr-Rao Lower Bound"

In this paper, we derive and analyze closed form (nonmatrix) expression of the Cramer-Rao lower bound (CRB) for the location and the velocity of moving targets contaminated by a structured noise (clutter echoes) and a background noise. The context of our analysis is the co-located MIMO (multiple-input multiple-output) radar system, ie., we dispose of multiple antennas in transmission and reception which are close in space. In addition as it is standard in modern MIMO radar, several noncoherent orthogonal waveforms are transmitted. The analysis of the proposed expressions of the CRB allows to better understand the characterisation of the target. In particular, we prove (1) the estimation of the direction parameter and the velocity of the target are cross-linked ; (2) it is more difficult to estimate the target velocity if the radar station is moving ; (3) if the radar station is not moving, the estimation of the target velocity is isotropic ; (4) it is more difficult to accurately localize fixed or slow moving targets and finally, the CRB for a MIMO radar is a lower bound of the one for the SIMO (single-input multiple-output) radar. [C350]

"Characteristic study of ionospheric clutter in high-frequency over the horizon surface wave radar"

The presence of ionospheric clutter in high-frequency over the horizon surface wave radar may extremely affect

the performance of radar system and degrade the capability of detecting target. The characteristic analysis of ionospheric clutter is the foundation of studying method to suppress ionospheric clutter. By using the MUSIC algorithm to analyze plentiful radar echoes data, directivity characteristic of several major kinds of ionospheric clutter has been summarized and the superposition situation that two kinds of ionospheric clutter exist at the same altitude has been discussed, moreover, the pertinence between directivity characteristic of ionospheric clutter and the working frequency has been studied. All these works provide convenience for advancing and realizing ionospheric clutter suppression methods based on directivity characteristic of ionospheric clutter. [C351]

"A probabilistic model of the radar signal-to-clutter and noise ratio"

We consider four effects relevant to the determination of the ratio of radar signal to clutter and noise. These effects are atmospheric turbulence, target fluctuations based on the Swerling models, zero-mean Gaussian background and receiver noise, and lognormal-distributed clutter. Radar return signal levels are affected by target fluctuations and atmospheric turbulence, characterized by a variant of the Rayleigh distribution and a lognormal distribution, respectively. Since these distributions are not independent and identically distributed (IID), they cannot be simply added, and must be treated by combining them in a manner similar to convolution. Also, clutter and noise are not IID, and must be combined in a similar way. The ratio of these two combinations comprises a probabilistic model of the ratio of radar signal to clutter and noise. This ratio is the probability that a given signal level will be achieved in the presence of atmospheric and target scintillations divided by the probability that a given clutter and noise level will be observed. To determine the ratio of the actual signal to clutter and noise, we must multiply these probabilities by the mean powers in these phenomena, as will be shown later. We treat several cases of interest by varying the average radar cross section, the log intensity standard deviation of turbulence, the radar threshold-to-noise and signal-to-noise ratios, and the distributions of lognormal clutter. [C352]

"FPGA-based implementation of a CFAR processor using Batcher's sort and LUT arithmetic"

This paper presents the realization of the forward automatic censored cell averaging detector (F-ACCAD), a novel CFAR algorithm for detecting targets in log-normal distribution clutter recently published . The algorithm is realized through an FPGA-based parallel architecture. The timing constraints of high resolution radar applications are considered and satisfied in the system. The sequential nature of the algorithm has been parallelized to achieve the desired processing delay. The intensive statistical calculations and the complexity of the algorithm have been significantly reduced by using lookup tables (LUTs). Batcher's sort, a parallel sorting algorithm, is adopted in this work. The hardware synthesis results and timing analysis are reported at the end. [C353]

"Study of effect of room window on through wall imaging in UWB range"

In through wall imaging (TWI), detection is possible due to dielectric contrasts between target and room environment. Complexity increases if room consists of furniture's and other objects beside desired target. Further detection of desired target becomes complex with the presence of window in back wall of room. Thus in this paper, effect of presence of window in back wall of room is investigated on detection and imaging. A detection technique is proposed in which signal processing technique is applied to extract the target information from clutter signal. A back projection imaging technique is applied to image the target. For this purpose, indigenously a TWI system based on step frequency continuous wave (SFCW) principle is developed in ultra wide band (UWB) range of frequency (i.e., 3.95 GHz to 5.85 GHz), plywood considered as wall and metallic plate is considered as target behind the plywood wall. The results are quite encouraging. [C354]

"Design and Implementation of Radar Video Compression and Network Transmission"

Aiming at the characters of pulse compression radar video echo signal, propose a new radar video compression coding algorithm. Based on the new algorithm, design the network transmission system and validated it. The result shows the new algorithm has better performance, the network transmission system based on it can realize a long time record for radar video, keep the precise structure of target echo, and realize the information sharing. [C355]

"Anderson-Darling Test based CFAR Detection"

An Anderson-Darling(A-D) test based CFAR detector feasible for multiple interfering targets and clutter edge scenarios is proposed and referred as AD-CFAR, which exploits K-sample A-D hypothesis test technique to censor clutter blocks needed for power estimation. Thereafter, AD test is employed for distribution test of the resultant homogenous blocks to select the proper detection algorithm from strategy library composed by the ready-made cell-average (CA), great-of (GO), Log-t detectors. Theoretical analyses indicate that the proposed AD-CFAR outperforms conventional CFAR detectors in non-homogenous clutter while maintains similar

performance in noise-only scenario as CA-CFAR. [C356]

"Combining modern spectral estimation with Time-Frequency representation"

With Joint Time-Frequency Analysis (JTFA), one can estimate the speed of moving targets from Synthetic Aperture Radar (SAR) images. These targets are usually compact. JTFA estimation of water surface speeds is more difficult since the radar returns are weak and generated by Bragg scattering patches, randomly distributed within the radar's footprint, both in time and space. To increase the signal strength, JTFA is applied to multiple range lines, which requires a generalization of the Time-Frequency representation (TFR). To do this, modern spectral estimation (MSE) techniques, which depend on estimating the data covariance matrix, are weaved into the framework of a TFR. The resulting TFR formed along azimuth-lines naturally integrates the data across multiple range-lines. We discuss and illustrate this technique on simulated data and then apply it to estimate the speed of moving water in a single-phase center SAR image. This method also enhances the signal-to-clutter ratio (SCR). [C357]

"Low-observable target detection in sea clutter based on fractal-based variable step-size least mean square algorithm"

This paper introduces fractal-based variable step-size least mean square(FB-VSLMS) algorithm and proposes a model for radar target detection in sea clutter. FB-VSLMS algorithm deals with a specific class of fractal signals and except one parameter requiring time-varying constraints, the constraints on the remaining parameters are time-invariant. And the step-size matrix is determined completely with the knowledge of the deterministic Hurst exponent. The model based on this algorithm is suited for tracking signals from the family of fractal signals that are inherently nonstationary. In the end, the performance of the novel model is analyzed. By the verification of X-band real sea clutter, the model is shown to be effective for low-observable point target detection in sea clutter. [C358]

"Multiple target Doppler estimation under possibly moving radar clutter"

Multi-target detection for pulsed Doppler radars under land/moving clutter characterized by antenna scanning modulation is analyzed using linear prediction based Tufts-Kumaresan's method. Comparison between this method and other line spectra estimation algorithms such as MUSIC and ESPRIT is performed. A technique to determine the model order required by the frequency estimation algorithms, which does not distinguish between targets and clutter, is presented. The clutter region concept is then introduced to identify targets from the clutter. [C359]

"On MIMO radar transmission schemes for ground moving target indication"

We compare several multiple-input multiple-output (MIMO) radar transmission schemes, including code division, time division and Doppler frequency division multiplexing approaches, for ground moving target indication (GMTI). To utilize probing waveforms with low sidelobe levels for range compression, we transmit sequences specifically designed to have low correlation levels. At the receiver side, we apply the iterative adaptive approach (IAA), which uses only the primary data, to form high resolution angle-Doppler images. To mimic real world scenarios, we apply our algorithms to a simulated dataset which contains high-fidelity, site-specific, simulated ground clutter returns. By combining the usage of intelligent transmission schemes, probing waveforms with good correlation properties, and the adaptive angle-Doppler imaging approach, we show that slow moving targets can be more clearly separated from the clutter ridge in the angle-Doppler images and potentially more easily detected by MIMO radar than by its conventional single-input multiple-output (SIMO) counterpart. [C360]

"OFDM MIMO radar for low-grazing angle tracking"

We develop a low-grazing angle (LGA) tracking method considering realistic physical and statistical effects, such as earth's curvature, vertical refractivity gradient of standard lower atmosphere, and non-Gaussian characteristics of sea-clutter. We employ a co-located multiple-input-multiple-output (MIMO) radar configuration using wideband orthogonal frequency division multiplexing (OFDM) signalling scheme. Apart from the frequency diversity provided by OFDM, we also exploit polarization to resolve the multipath signals by using polarization-sensitive transceivers. Thus, we can track the scattering coefficients of the target at different frequencies along with its position and velocity. We apply a sequential Monte Carlo method (particle filter) to track the target. Our numerical examples demonstrate the achieved performance improvements due to realistic physical modeling and OFDM MIMO configuration. [C361]

"Optimum beamforming for clutter-cancellation in radar systems"

In this paper we present improved signal processing techniques which can be used to reduce the discrete as well as spatially spread clutter in radar systems through space-time processing. Several techniques are proposed for clutter reduction, 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 against the known strong clutter background. [C362]

"Spectral estimation for clutter processing in digital radars by Dimension-Adaptive Particle Swarm Optimization (DA-PSO)"

Power spectrum estimation from radar data is essential for target detection. For instance, microburst causes detrimental effects on airplane performance, and hence its detection is critical. We compare auto-regression (AR), Periodogram, Kaiser windowed Periodogram, and multiple-signal-classification (MUSIC) methods for microburst clutter spectrum estimation. Given a long train of returned signal, we are able to segment the signal to obtain multiple estimations of the parameters, which leads to a more accurate estimation after coefficient averaging. The estimated power spectrum is then integrated for clutter magnitude calculation to determine whether a target is present at certain cell. The magnitude of clutters in an ensemble from a wide region spatially or through time temporally is used to estimate the clutter map. We choose a K-distribution mixture model over the traditional Rayleigh distribution to better approximate the tail structure of the distribution to minimize the false alarm rate. We show that Dimension-Adaptive Particle Swarm Optimization (DA-PSO) is robust to sample size in estimating the K-distribution mixture model, which is desirable for real-time implementations. [C363]

"Target tracking via a sampling stack-based approach"

We propose a novel approach to tracking a target in clutter based on the stack algorithm for tree search. The proposed tracking approach reduces the size of the search tree by employing a coarse discretization of the target state space. To reduce the quantization error that results from coarse discretization, the representative value of each quantized region is sampled from an estimated importance sampling function. A forgetting factor is included in the likelihood metric to control the effect of previous decisions and to reduce algorithm complexity. Simulations reveal that the proposed algorithm provides significantly reduced complexity while suffering no performance degradation relative to stack-based tracking with finer quantization. [C364]

"Performance and complexity issues in noncoherent and coherent MIMO radar"

Joint target position and velocity estimation is considered when a MIMO radar system employs either coherent or noncoherent processing and a suitable antenna placement for the processing employed. A theorem is presented for the case of orthogonal signals in temporally and spatially white noise-plus-clutter which shows that the MSE for the estimate of the noncoherent system approaches that of the coherent system as the product of the number of transmit and receive antennas is made sufficiently large. Numerical examples are also provided. Initially, we study systems without constraining the complexity and energy, where each added transmit antenna employs a fixed energy so that the total transmitted energy is allowed to increase as we increase the number of transmit antennas. Later we also look at constrained systems, where adding a transmit antenna splits the total system energy and the total number of antennas employed is restricted. [C365]

"On MIMO waveform design for non-Gaussian target detection"

We consider a multiple-input multiple-output (MIMO) detection problem with M widely-spaced transmit antennas and L widely-spaced receive antennas (not necessarily co-located), and we study the problem of designing the signal waveforms transmitted by each source node under non-Gaussian target scattering and temporally-correlated Gaussian clutter. Two figures of merit are investigated for space-time code optimization under a semi-definite rank constraint and a received signal-to-clutter ratio constraint: 1) the lower Chernoff bound (LCB) to the detection probability for fixed probability of false alarm, and 2) the mutual information (MI) between the observations available at the receive nodes and the MГґB—L Г‚Вїchannel matrixГ‚Вї generated by a target, assumed present tout court. If the scattering distribution possesses some suitably defined properties of exchangeability and unitary invariance, we show that MI-optimal and LCB-optimal space-time coding admit a simple closed-form solution. Finally, a case study of relevant practical interest is examined in depth so as to compare the proposed design criteria and to assess the impact of signal non-Gaussianity on the detection performances. [C366]

"Space-time adaptive processing with a half-cylinder faceted conformal antenna"

Conformal antennas, which assumes the shape of the platform, have several advantages, like reduced weight and space; aerodynamic design and increased field of view.We are interested in detection of moving ground

targets with air-borne radar with three antenna geometries: faceted or smooth vertical half-cylinder and plane forward-looking. We study important clutter properties for suppressing the clutter with STAP (Space-Time Adaptive Processing) and find that the subarray division is more important than the antenna element positions, that the faceted and smooth antennas give similar clutter properties and that all three geometries have better clutter properties the smaller the subarrays are. The largest tested subarrays are probably useless for clutter suppression. [C367]

"Adaptive distributed radar"

In this paper, we develop and evaluate an adaptive distributed radar architecture. We consider the case where the sensor separation leads to uncorrelated target and clutter voltages among the various receivers. The resulting processing architecture is an extension of the single sensor adaptive matched filter applied in a fixed-Earth coordinate system. Using simulated, single transmitter, multiple receiver configurations, we demonstrate the efficacy of the proposed processing approach. [C368]

"The use of SAR-ATI for maritime surveillance and difficult target detection"

This paper discusses the detection of low scatter cross-section maritime targets in a high clutter background using SAR multi-channel along track interferometry. Statistical arguments are presented based on the covariance matrix which enable the determination of the channel weights required to achieve maximum attenuation of false alarms produced by breaking waves. An example is shown of a target (a buoy) with scatter cross-section comparable with the false alarms. A false alarm attenuation of up to 16.1 dB relative to the target is demonstrated for a three-beam interferometer with no a priori knowledge of the target or false alarms. Applications include detection of small stealthy boats and other difficult maritime targets. [C369]

"Modelling X-band sea clutter with the K-distribution: Shape parameter variation"

Performance modelling techniques for maritime radar target detection problems typically make use of a parametric probability distribution for the background ocean backscatter. In this paper, measured X-band sea clutter is analysed by fitting a K-distribution and the variation of its parameters with radar resolution, polarisation, viewing grazing and azimuth angles and ocean wind and wave conditions is examined. Grazing angles lie in the range 10Г‚В° to 45Г‚В°. Earlier work has already characterised the variation in the mean of the distribution. Here, the shape parameter Г‚Вї is studied. Surprisingly, it is found that Г‚Вї exhibits a sinusoidal like variation with azimuth angle which is aligned with the direction of the wind waves rather than the swell. [C370]

"Analysis of the KK-distribution with X-band medium grazing angle sea-clutter"

Robust maritime surveillance with radar requires an accurate description of the backscatter from the sea. An estimated probability distribution of the backscatter is commonly used to determine the threshold for separating targets from clutter at a given false alarm rate. Data collected at medium to high grazing angles by the Defence Science Technology Organisation (DSTO) Ingara fully polarimetric X-band radar demonstrates that the commonly used K-distribution is not always adequate for modelling the probability distribution. This is especially the case for the horizontal polarisation and in regions of high backscatter where target detection can be a problem. An alternative proposed as a more accurate model in this region is known as the KK-distribution. The analysis presented in this paper describes this model with the addition of multiple looks and a thermal noise component to produce greater accuracy in the mean and underlying shape. The threshold required to achieve a constant false alarm rate is then studied and compared with that derived from the K-distribution model. [C371]

"Fast-time STAP for clutter suppression between transmitter and receiver in bistatic radar"

Detection and localization of ground targets in the region between the transmitter and the receiver in bistatic radar is difficult due to strong interference from surface clutter and the direct transmitter signal. We have simulated fast-time (using channels of an array antenna and range bins) and slow-time (antenna channels and radar pulses) STAP (Space Time Adaptive Processing) and find that fast-time gives better interference suppression in this region. We also see that fast-time STAP is useful for all four cases of stationary/moving radar and stationary/moving target and that slow-time STAP with moving radar is useful for both stationary and moving target. [C372]

"Space-time adaptive algorithms for track-before-detect in clutter environments"

In this paper we propose and assess TBD strategies for radar systems adopting STAP. At the design stage we consider a radar system equipped with a linear array of Nasensors that illuminates the surveillance area by transmitting M coherent pulse trains, each consisting of Nppulses, before deciding whether or not a target is

present over L adjacent range cells. As a preliminary step we introduce the target and noise models. Then, resorting to GLRT and ad hoc procedures, we derive adaptive CFAR detectors for both stationary and scan-to-scan varying clutter scenarios (a point better clarified in the body of the paper). The proposed detectors guarantee the CFAR property with respect to the unknown spectral properties of the clutter. The preliminary performance assessment, conducted resorting to Monte Carlo simulation, shows that proposed procedures might be a viable means to implement early detection and track initiation of weak moving targets. [C373]

"Sea Spikes Suppression for high range and high Doppler resolution radars"

High resolution in range and Doppler are recommended to border surveillance X-band radars for the detection of small RCS ground targets in a severe clutter environment. This kind of radars can also be employed for sea border control. However, in this case the radar processor should suppress the sea spike echoes that can be otherwise mistaken with small boats. In this paper a solution for mitigating the problem connected with sea spikes is proposed. A 2D CFAR that uses the information from both the range and Doppler characteristics of the echoes is presented. The performance of this algorithm is compared with the one of a classical CFAR which can instead be efficiently employed in a ground environment. [C374]

"New results on convoy tracking by airborne radar"

In this contribution the authors continue their work on convoy tracking supported by estimating the lateral width of the convoy. New results on the impact of the array size and the data sample size are presented. It is shown that the ML estimator is the most suitable tool for estimating the apparent target length. In a companion paper the tracking performance is analysed. [C375]

"ISAR imaging of ground moving vehicles using PAMIR data"

The airborne system PAMIR is able to acquire inverse synthetic aperture radar (ISAR) data for imaging of ground moving vehicles with very high resolution. The processing sequence contains both steps specifically developed for PAMIR and universal steps. The paper presents the image generation process based on PAMIR data of moving vehicles, which were recorded in spotlight mode. Target motion information is gained in different stages by range-Doppler tracking and a Kalman filter based approach incorporating a road map. [C376]

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

In this paper, the detection of close targets in heterogeneous clutter in high-resolution SAR images is investigated. We adopt a probability distribution mixture model where each pixel intensity image is characterised by two probability density functions: one related to the targets and one related to the background clutter. A specific detection threshold, based on the estimates of the mixture parameters, is used. The statistical characterisation of SAR images modeling is a key issue for detection. The clutter is modelled using the K distribution that is a flexible tool over non-homogenous areas. We show that our method is able to detect close targets at constant false alarm ratio without making any assumptions about their size and their spatial configuration. [C377]

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

In recent years, with the development of high range resolution radars, the desire to be able to identify targets under all weather and clutter conditions has become of great importance. Bat-pollinated plants have evolved flowers to ease classification by nectar feeding bats even in a dense clutter environment. In this paper we analyze three real images of a Cobaea scandens corolla. These were collected by means of an acoustic radar capable of very high range resolution. The features of these flowers that allow high classification performance by bats are exploited. Results are discussed and related to the task of classification in radar systems. [C378]

"Algorithm based on data adaptive processing to compensate clutter range dependence for bistatic radar"

A method based on adaptive data processing to compensate clutter spectrum range dependence is proposed in this paper. The method takes of data interpolation theory to interpolate the range heterogeneous short distance data to the range homogeneous far distance data, in order to provide enough number of samples to carry Space Time Adaptive Processing (STAP) on the far distance data. Through computer simulation of two geometry of bistatic radar shows the data adaptive method can decrease the range dependence and the number of the large eigenvalues of the clutter covariance, and improve performance of (GMTI) ground moving target indication for bistatic radar. [C379]

"Chaos-based target detection from sea clutter"

The feasibility of applying chaotic features to the maritime target detection is studied in this paper. Experimental results on measured IPIX data shows that embedding dimension, box dimension and correlation dimension, which are not sensitive to the sea state, can reflect the difference between targets and clutter effectively. Such characteristics provide a new idea for further research in obtaining robust maritime target detector. [C380]

"Target detection based on wideband PD radar with linear frequency modulation"

The target detection issue of the PD guidance radar is firstly analyzed in clutter regions under the trail-attack and low-altitude condition, and then a novel method is proposed, which utilizes new wideband linear frequency modulation system to enhance the target detection performance in clutter region. The signal processing and detection performance are discussed theoretically and calculated for this wideband linear frequency modulation PD seeker radar. The result indicates that the technology of wideband linear frequency modulation can be applied in the PD radar for its improving detection performance in the clutter regions significantly. [C381]

"Detection of ground slow-moving targets in airborne fire-control radar using adaptive processing"

In the ground slow-moving target detection of airborne fire-control radar, the clutter spectrum varies with range due to the variation of elevation angle and shows high nonhomogeneity. In this case, good detective performance can not be obtained by using conventional method. In this paper, a new method based on "filter-then-adapt" is proposed for single channel airborne radar. The new method can weaken the nonhomogeneity and suppress the clutter returns adaptively. Experimental results with real data illustrate the good detection performance of the proposed algorithm for ground slow-moving target. [C382]

"A novel detector of range-spread targets"

The detection of the high-resolution radar (HRR) range-spread targets is studied in this paper and a novel method based on strong scattering centers for detecting range-spread targets in Gaussian clutter is proposed. The proposed detector has a two-threshold scheme. First of all, strong scattering centers of target are obtained by setting a first threshold with certain false alarm probability. And then, the detection statistic is formed based on generalized likelihood ratio test (GLRT), which is compared with the second threshold. The experimental results show that the proposed detector is better than the one out of N (1/N) detector, the spatial scattering density-GLRT (SDD-GLRT) detector and the integrator, and also show its robustness. [C383]

"Fuzzy fractal algorithm for low-observable target detection within sea clutter"

In this paper fuzzy fractal algorithm for discrete signal processing is introduced. The two major concepts of the algorithm are fuzzy fractal dimension and grade of fractality, which merge fuzzy theory and fractal theory. The fuzzy concept of fractality in discrete time series can be reconstructed as a kind of fuzzy set and the objective short time series can be used by a new membership function. In order to process long time series, sliding measurement is adopted. In the end, the local grade of fractality is applied to X-band real sea clutter and the performance of the detection algorithm is analyzed. [C384]

"An approach to compensate clutter range dependence for bistatic airborne radar"

In a bistatic airborne geometry, snapshot statistics are range dependent. Straight averaging degrades the accuracy of clutter plus noise covariance matrix estimation. To mitigate the range dependence, a new method is presented in this paper. The method interpolates short range space-time steering vectors to the referenced range by using subspace fitting technique. And moving target steering vector restrictions are added to avoid ground moving target elimination. Compared to conventional sample matrix inverse (SMI) method, this approach can significantly improve the performance of ground moving target indication (GMTI). At last, simulated results are presented to verify the effectiveness of the proposed approach. [C385]

"Characteristic research of ionospheric clutter in over the horizon HFSWR"

The presence of ionospheric clutter in high-frequency over the horizon surface wave radar may extremely affect the performance of radar system and degrade the capability of detecting target, so it should be suppressed. The characteristic analysis of ionospheric clutter is the foundation of studying method to suppress ionospheric clutter, so it is necessary to research characteristic of ionospheric clutter. Aim at ionospheric clutter which specifically appears at some altitude range, the conception of spread Es-layer clutter is advanced to classify this kind of ionospheric clutter, which is helpful to expound directivity characteristic of ionospheric clutter. By using the MUSIC algorithm to analyze plentiful radar echoes data, directivity characteristic of several major kinds of

ionospheric clutter has been summarized and the superposition situation that two kinds of ionospheric clutter exist at the same altitude has been discussed, thereby it is more convenient to advance and realize ionospheric clutter suppression methods based on directivity characteristic of ionospheric clutter. [C386]

"Study on Polarimetric measurement and radar target identification in instantaneous polarization radar system"

Instantaneous polarization radar can obtain radar target polarization scattering matrix (PSM) by taking advantage of single pulse echo signal. The Polarimetric measurement properties and weak target detection of this system is verified by external field experiment. The actual measured data is used to target classification by applying polarization statistical properties and transformation of target polarization scattering matrix or decomposition. Two different radar target identification subject to its polarization properties has been demonstrates the effectiveness of using Polarimetric data and motivates the use of polarimetry for target detection in clutter and interference environment. The back-scattering power and optimized transmission polarization of the system is also involved. [C387]

"Passive location and precision analysis based on multiple CDMA base stations"

The use of multiple non-co-operative CDMA base stations as external illuminators for passive radar target detection and location is investigated. A signal-processing scheme is developed to locate moving targets. Clutters resulted from direct-path and multi-path signals are filtered adaptively using a well-designed cost function. The target's range and speed information are acquired via pulse compression. Finally by fusing couples of location parameters, the target could be located and the multiple base stations could bring about an improvement in location precision. The real data and simulation results verify the feasibility of this passive location system. [C388]

"A novel method for ship detection in polarimetric SAR images using gopce"

In this paper, a novel method for ship detection in fully polarimetric SAR images is developed. This method employs the Generalized Optimization of Polarimetric Contrast Enhancement (GOPCE) to maximize the target-to-clutter ratio in an image. For comparison, the traditional OPCE, Polarimetric Matched Filter (PMF) and Polarimetric Whitening Filter (PWF) are also used. Experiments results of the NASA/JPL AIRSAR C-Band image over Sydney Coast show that the proposed method has a considerably improvement as to enlarge the separation of ships and sea clutter, demonstrating a robust detection performance. [C389]

"Doppler processing for PRC-CW radar in strong-clutter background using Duffing oscillator"

Based on the theory of Duffing oscillator, a new method of Doppler processing for pseudo random-code continuous wave (PRC-CW) radar signal in strong-clutter background is presented in this paper. By identifying the state of the chaotic oscillator system, Doppler frequency-shift is detected in order to calculate the speed of the target and solve the problem of Doppler sensitivity of pulse compression. At the same time, a fast method is introduced to accelerate identifying the states of the chaotic system. In order to estimate the phase of the Doppler component and prove the validity under stochastic phase, the influence of phase separation is also discussed. Simulation results demonstrate the effectiveness of this new method. [C390]

"Space-time resampling method for the range-dependence of clutter spectrum in non-sidelooking STAP radars"

The clutter Doppler frequency depends on range in non-sidelooking arrays for Ground Moving Target Indication, which would lead to an inaccurate estimate of the covariance matrix of the clutter at the range bin of interest in space-time adaptive processing(STAP). According to clutter model, we propose a space-time resampling method which can mitigate the range dependence of clutter spectrums by adjusting the space-time sampling rate. Different from other compensation methods, the method uses an interpolation filter to obtain identical clutter spectrum in both the mainlobe and the sidelobes. STAP is then applied to the output of the filter. The method has low computational complexity. Simulation results show the validity of the proposed method. [C391]

"Marker-controlled SAR image segmentation algorithm"

This paper presents an algorithm for automatic segmentation of SAR imagery into target, shadow, and background clutter regions, which is a key pre-processing step for SAR image based automatic target recognition. Power transformation is employed in this algorithm to transform SAR image data to nearly Gaussian distributed data, followed by which is a de-nosing processing by using partial differentiation equation. A marker-controlled based SAR image segmentation algorithm is used to segment the de-noised images. We introduce a

new sliding window method to find extreme value in SAR image, which is used as marker for controlling segmentation region. Experiment results show that this algorithm can overcome the influence of impulse noise and the correlation and dependency of adjacent pixel in SAR imagery,and get trim borderline and good segmentation performance. [C392]

"Ground moving targets detection and unambiguous motion parameter estimation based on multi-channel SAR system"

This paper introduces an approach for ground moving targets detection and motion parameter estimation based on multi-channel SAR system which requires three consecutive operations as follows: array calibration, clutter rejection and motion parameter estimation. The analytical expressions of cross-track velocity, along-track velocity, cross-track acceleration and along-track acceleration are derived for multi-channel synthetic aperture radar (SAR) system. On this basis, these motion parameters can be well estimated. Before clutter rejection, array calibration is performed to provide precise parameter estimation latter. Radon transform is used to detect the range walk and correct it. Doppler ambiguity is mitigated by compensating the cross-track velocity estimation. Simulated and real measured data verify the effectiveness of proposed approach. [C393]

"A new CFAR method based on test cell statistics"

In this paper, a new Constant False Alarm Rate (CFAR) algorithm, which is called a Modification of the Switching CFAR (SOSGO-CFAR) that takes into account the statistics of samples, is proposed. It employs a composite approach based on the Switching CFAR (S-CFAR) and Ordered statistics with Greatest Option (OSGO-CFAR). Results show that the detection performance of SOSGO-CFAR is similar to that of CA-CFAR in homogeneous background. The ability to control false alarm of the SOSGO-CFAR is close to that of OSGO-CFAR in clutter edges. The detection performance of SOSGO-CFAR is far better than that of S-CFAR in multiple target situations. [C394]

"Clutter-knowledge-based target tracking method in complex conditions"

High Frequency Ground Wave Radar (HFGWR) target tracking is a challenging task because of dense false alarms and missed/disturbed measurements caused by strong sea clutter. A clutter-knowledge-based tracking method is presented to cope with multi-target tracking in this kind of complex envionment. Modified initiation methods based on characterestic anslysis of multiscan asssociation results are proposed to suppress false tracks. Then, the available sea clutter knowledge is exploited to filter tracks and special treatments with algorithm adjustments are executed to preserve tracks may be affected by the first order sea clutter. Simulated and real data are both processed to demonstrate that the presented method can greatly improve the formation and maintenance performance with a little increase of false tracks. [C395]

"Analysis and simulation on earth clutter of space-based radar"

The performance of Space-Based Radar (SBR) to detect air or ground moving targets is influenced by earth clutter, so an effective algorithm to suppressing clutter can be designed if knowing the power and distribution of earth clutter. In this paper, based on the model of airborne pulse-doppler radar, the model of SBR on power density spectrum of earth clutter in range-doppler space is deduced, and simulated with a phased array antenna. Simulation results show the effectiveness of the proposed model. [C396]

"Signal fusion network for spatial diversity MIMO radar"

This paper concerns target detection algorithms of spatial diversity MIMO radar. The GLRT algorithm is developed, under the assumption that clutters in different spatial diversity channels follow independent Gaussian distributions with different covariance matrix. The global test statistics turns out to be a production of the local test statistics. Three signal fusion networks are introduced, in which each local site can detect targets with the CFAR property. The CFAR thresholds for the fusion centre and the local sensors can be estimated by offline numerical experiments. It is shown that the signal fusion network yields a better detection performance than that of the decision fusion network. [C397]

"Target detection based on correlation and power features in sea clutter"

In this paper, an adaptive filter is presented for sea clutter suppression that is based upon the real-time median estimation of the power spectrum of sea clutter from the echoes of the detected cells and adjacent secondary resolution cells. The ACSF can suppress most sea clutter in a received time series while retaining possible echoes from a target with small distortion. Two features relevant to the correlation and average power of the filtered time series are proposed for target detection. With the real sea clutter data and simulated target echoes,

the experiment results show that the proposed ACSF is effective, and the detector provides better detection performance than some existing methods do. [C398]

"A M out of n detector based on scattering density"

To improve the detection performance of the binary integrator detector (M out of N detector or M/N detector for short) when the spatial scattering density is sparse, the M out of N detector based on scattering density (BSD-M/N) is proposed. First of all, the average false alarm probability and the average detection probability are obtained. And then, the relationship between the detection performance of the proposed detector and the second threshold M is analyzed for different spatial scattering density and different clutter power levels. Moreover the expression of calculating the optimum M is given. Finally, the experimental results show that the proposed detector outperforms the M/N detector when the spatial scattering density is sparse. [C399]

"Feature aided tracking algorithm based on Generalized Probability Data Association"

In traditional multi-target tracking algorithm, only target kinematic information has been used for data association. A new association algorithm is presented in this paper-Feature Aided Tracking (FAT) algorithm, which is based on the Generalized Probability Data Association (GPDA) algorithm. FAT algorithm combines target feature information with traditional kinematic information in a probabilistic way, which preferably resolves closely spaced targets in dense clutter environment. This idea is demonstrated via an example where the target 1D range profile measurement is incorporated into data association. Simulation results verified that the FAT algorithm outperforms the conventional probability data association algorithm. [C400]

"New detection algorithm for range spread target via statistical property diversity"

Based on the statistical property diversity of target and disturbance, a new detection algorithm for range spread target is proposed in this paper. To this end, we first resort to secondary data set to obtain the statistic property of clutter of the cells under test. Then two detectors which focus on calculating the statistical difference of clutter and target plus clutter are designed. Their performance assessment and the comparison with a previously proposed detector show that the proposed detectors can be a viable means to cope with uncertain detection environments. [C401]

"Two dimensional optimal linear detector for slowly fluctuating target"

In this paper, we propose a two dimensional optimal linear detector (2-D OLD) for slowly fluctuating target in Gaussian interference. We assume that the samples of received signal in the range and in the successive pulsation times are collected in a two dimensional array. In conventional detectors, each column of this matrix (the Samples of the same pulsation time) is detected separately and the binary results may be integrated for successive pulsation times in order to improve the detection performance. In fact, by applying binary integration, we ignore the considerable correlation among 2-D data in the azimuth direction. In the proposed 2-D OLD detector, this correlation is considered, aiming to improve the detection performance. Our simulations show that, this detector outperforms conventional one dimensional OLD, as well as the AND and the OR binary integrators. This improvement is more considerable, whenever the clutter samples are more correlated in azimuth direction. [C402]

"A novel velocity compensation algorithm by geometrical inference matching method"

The velocity of moving target is an important factor affecting the performance of stepped frequency radar. In order to solve the problem, a novel velocity compensation algorithm is proposed. By extracting all potential scatters of two range profiles as two point patterns, the algorithm matches the point patterns by means of geometrical inference matching method. The velocity is estimated by the distance of correspondent points. The simulation experiments on range profiles with varying SNR, false scatters, and clutter aiguilles show the robustness of the new algorithm. [C403]

"Structure of robust signal detector for multiple sensors with unkonwn signal-to- clutter ratio"

In practical mutisensor system, the signal-to-clutter ratio of the returns of the same target at different sensors may be unknown and variant, which leads to the nonexistence of the uniformly most powerful test. By investigating the demonstration of the nonexistence, it was found that the canonical detector based on the likelihood ratio test can not possess robust performance of detection. Therefore, a structure of robust detector was proposed that synthesize the results of several canonical detectors to form a robust one. Finally, an example was given to illustrate the effectiveness of the structure. [C404]

"Analysis of sea clutter in distributed shipborne OTH radar"

In distributed shipborne high frequency (HF) surface wave over-the-horizon radar (DS-OTHR) system, the movement of radar can make the system more complex. In this paper, we analyze the geometrical change of the distributed shipborne system with the T-Rnmechanism and its effect to the echoes of target and sea. Then we discuss the method to get the range and velocity of target in this dynamic system, make a detailed analysis on the broadening spectrum of first-order sea clutter. Moreover, we study the space-time distribution characteristics of first-order sea clutter and research the azimuth difference of the target and sea clutter with the same Doppler frequency. Finally, simulation proves the correctness of the analysis of the first-order sea clutter in this system. [C405]

"Integrating a prior information to spaceborne dual-channel SAR-GMTI"

Many present spaceborne SAR systems are constrained to two channels to detect and measure moving targets on the ground. SAR-DPCA (Displaced phase centre antenna) is a suboptimal linear clutter filter and cancels the clutter perfectly regardless of the moving target signal. In this letter, the optimum linear clutter filter integrated with a prior information is proposed, which maximizes the output signal-to-clutter plus noise ratio (SCNR). The constant false alarm rate (CFAR) detectors, which include the generalized likelihood ratio test (GLRT), the adaptive matched filter (AMF) and the adaptive coherence estimator (ACE) technique, are exploited in a uniform analytical expression with performance comparisons. Simulation experiments demonstrate the effectiveness of the proposed method. [C406]

"Distributed space-based GMTI with synthetic aperture radar"

In this paper, a new target detection and location approach which is performed in three stages is proposed, i.e. array manifold calibration, clutter rejection and target radial velocity estimation. Once the array manifold has been calibrated based on clutter echoes in range-Doppler domain, the objective of clutter cancellation can be achieved by the linear combination of the joint pixels data with the corresponding adaptive weighting vector. This step does not require target steering vector searching. The last stage is carried out at determinate cell under test (CUT) to locate moving target by velocity searching for that one fitting best to the moving target signal, thus the location performance would not be sacrificed in order to suppress clutter and/or interference and the high resolution radial velocity estimation can be achieved. Simulation results demonstrate the effectiveness and robustness of the proposed method. [C407]

"A non-homogeneous STAP approach combined with RD-ATI technique"

In this paper, a non-homogeneous Space-Time Adaptive Processing (STAP) approach is proposed. In the approach, Range-Doppler domain ATI (RD-ATI) technique is used as a Non-Homogeneous Detector (NHD) which provides prior knowledge of moving targets, then Power Select Training (PST) method is employed to restrain clutter power non-homogeneous, and Frequency Domain Substitution (FDS) method used to eliminate the discrete interference. The approach improves conventional STAP performance significantly and greatly reduces computational burden, which has a great practical value. The result of real data from a three-channel SAR/GMTI system shows efficiency of the approach. [C408]

"A signal processing method for airborne three-channel SAR-GMTI"

Aiming at airborne three-channel SAR-GMTI system, a signal processing method based on Clutter Suppression Interferometry(CSI) is presented including the processing diagram and the principle of clutter suppression. Channel calibration is proposed to correct the magnitude and phase imbalance between inner channels utilizing the test signal, SAR imaging and clutter cancellation are done successively, finally the accurate target parameters (location and velocity) are obtained. The signal processing approach which has been applied in real data proved its good performance and turned out to be efficient. [C409]

"An improved ATI method on airborne SAR ground slow moving target detection"

Based on airborne dual channel SAR, this paper improved AT I technique, put forward a weighting factor from DPCA to AT I to improve ground slow velocity moving target detect capability, the method integrated the advantage of DPCA and ATI technique, using the weight value received from DPCA to weighting process the result of interferential ATI, further more, bringing forward a new moving target detect method. The outcome of computer emulation indicates that compared with ATI method, this paper's method can effectively decrease false target number and detect feebleness target efficiency. Compared with DPCA method, it can detect slower moving targets which DPCA cannot detect because of excessive counteraction. [C410]

"A novel double-pulse detection method for aircraft target in ISAR"

Double-pulse or multi-pulse detectors have better performance than single pulse detectors in inverse synthetic aperture radar (ISAR) system. The more echoes we use, the better performance we have if the optimum detectors are utilized. The conventional inter-period correlation processing (IPCP) utilizes the received echoes directly. In this paper, a novel triple stage double-pulse detector is derived. We propose the first stage (nonlinear shrinkage map) to realized noise removal, and the second stage to estimate range migration number. Finally, we utilize the modified IPCP receiver to improve accuracy without the increase of the compute load compared with the conventional IPCP system. The proposed receiver is compared with other conventional detectors based on measured aircraft radar data and achieves satisfied performance. [C411]

"A new approach to range spread target detection based on information entropy"

Based on the diversity between the information entropy of target echo and disturbance introduced by high resolution radar, a new detection algorithm for range spread target via Renyi's entropy is proposed for the first time in this paper. The proposed entropy detector's performance assessment and its comparison with two previously traditional detectors show that the entropy detector can achieve satisfactory performance for the range spread target detection. Remarkably, the proposed entropy detector is not needed to estimate the parameters of clutter environment and is robust to the cells number of range spread target. [C412]

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

This paper investigates the restrictions of Synthetic Aperture Radar (SAR) ground fast moving target indication based on the conventional clutter suppression method in image domain which ignores the problems of range cell migration (RCM) and azimuth defocus. A technique for fast moving target indication and motion parameter estimation is proposed based on Doppler ambiguity resolving. In range frequency and compressed azimuth time domain of tri-channel SAR/GMTI data, the clutter is suppressed with DPCA technique, and the Doppler ambiguity number can be estimated from the residual signal using Radon transform. This approach exploits the relation between the line slope and the Doppler ambiguity number of fast moving target. Azimuth focusing is carried out with the criterion of entropy-minimization after azimuth cell migration correction (ACMC), and at last the fast moving target is imaged after range compression. The feasibility of the approach is validated by the real airborne data. [C413]

"A robust approach to ground moving target detection and localization for multi-channel SAR system"

The strong target contamination has a great influence on the performance of the conventional clutter suppression method. In this paper, a robust approach to clutter suppression and ground moving target detection has been proposed for multi-channel SAR system. Firstly, the modulus normalized vector corresponding to the pixel data vector is constructed and its covariance matrix has been formed. Secondly, the ground clutter is suppressed using the new adaptive clutter suppression weight. Lastly, target detection and localization are carried out. The effectiveness and robustness of the proposed approach are confirmed by performance analysis and real measured data processing. [C414]

"Ground moving target displacement compensation for DPCA based SAR-GMTI system"

The velocity and acceleration of the ground moving target can cause the target position to be displaced and defocused in the SAR image. In this paper, the displacement compensation scheme is presented to correct the displaced position and defocused moving target image in the DPCA based SAR-GMTI system. The influence of the ground moving target due to the velocity and acceleration is analyzed in range and azimuth directions, and its compensation method is presented with the simulation results. The performance of the proposed method is compared with respect to the estimated velocity and defocused quantity in both range and azimuth directions. [C415]

"Array configurations and space-time adaptive processing for spaceborne distributed GMTI radar"

Ground moving target indication (GMTI) is an important, challenging application of space-based distributed aperture radars. Due to the large baseline of the sparse array, the main beam clutter Doppler spread can be reduced and minimum detectable velocity (MDV) can be improved. The cost is the blind zone problem introduced by spatial ambiguities and the grating lobes due to undersampling in spatial frequency domain. This paper investigates some solutions to the blind zone problem of space time adaptive processing (STAP) technique due to grating lobes and spatial ambiguities. In particular, the concepts of Minimum Redundancy Arrays (MARs) and Optimally Irreducible Arrays (OIAs) are introduced to STAP technique for space-based distributed aperture radars

in order to solve the blind zone problem. We propose a method by using Optimally Irreducible Arrays combined with waveform diversity to improve the detection performance and present simulation results to show the effectiveness of the method. [C416]

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

A local cell-averaging fast CFAR scheme is proposed for multi-target ship detection. The proposed algorithm is based on global censoring scheme to avoid multitarget situation in reference cell. Fast CFAR scheme is employed to reduce computational load. Local average in the vicinity of test cell can remove small sized false alarms so that additional binary clustering is not required for final decision. The test results using real SAR images show good performance in multitarget situation and heterogeneous environment. [C417]

"A novel method of SAR multiple moving targets detection and parameter estimation"

This study proposes a moving targets detection and parameter estimation technique based on short-time fractional Fourier transform (STFRFT) for airborne synthetic aperture radar (SAR). It is able to increase the signal-to-clutter ratio (SCR) and get the Doppler center frequency and Doppler frequency rate for moving targets even they are lying in the same line in the time-frequency plane. At the end, a comparison between the new method and fractional Fourier transform method is provided to illustrate the advantages. [C418]

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

Because of the characteristics of its imaging principle, strong speckle and impacted by background clutter, SAR image is very difficult to be interpreted, especially for the complex military targets. An interactive recognition system framework is proposed in this article which using contextual information, geospatial information and multi-temporal images, etc, as assistant knowledge in the recognition workflow. It can help detecting and recognizing some target which is difficult to be detected and recognized through human vision or automatic target recognition technology alone. [C419]

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

In this paper, the applicability of texture feature coding method (TFCM) to synthetic aperture radar (SAR) automatic target recognition (ATR) is studied. The TFCM cooccurrence matrix (CM) is used as an additional image feature for adaptive boosting (AdaBoost) algorithm which uses originally 2D-DFT coefficients as an image feature. The TFCM CM extracts the connected texture information from the image while 2D-DFT gives the value of the spatial frequency components. The TFCM CM is invariant under the rotation of images. With these characteristics, the TFCM CM can discriminate a confused target which is not classified properly using 2D-DFT. The TFCM CM is combined with 2D-DFT in fusion process of the AdaBoost algorithm. In experimental results, it is shown that the correct-classification probability of the proposed scheme is larger than that of the conventional scheme which uses only 2D-DFT and raw image as image features. [C420]

"Range-Doppler measurements based target locating for active radar seekers"

This paper focuses on the estimation of the missile-target relative position using range-Doppler measurements. Firstly, we analyze the observability of the relative position for different trajectories in depth, and arrive at a very interesting conclusion: the missile must have the acceleration component `not aiming at target' to obtain the 3-D relative position of the target. Secondly, the relative position estimation methods, using measurement series, is presented. Through the computation of Cramer-Rao Lower Bound, we can see the effects on the location errors of the observation series length, the initial missile-target range, the cross-range and radial velocity of the missile, and the cross-range acceleration of the missile, respectively. [C421]

"A fast order method on OS-CFAR detector in SAR images"

Radar fast threshold constant false alarm rate (CFAR) detector, which keeps CFAR by estimating background and adjusting adaptive threshold, is widely used for detecting targets in synthetic aperture radar images. Two typical CFAR detectors based on sliding windows, the cell-averaged CFAR (CA-CFAR) detector and the order-statistics CFAR (OS-CFAR) detector are compared in this paper firstly. The results show the OS-CFAR detector has a better performance at high resolution, but it suffers from the computation burden. This paper proposes a fast algorithm to reduce the computational intensiveness of the OS-CFAR detector and the corresponding analysis of computational savings are given. According to the experimental results of real SAR data, the experiment result is in good agreement with the theory. [C422]

"The new criterion to evaluate SAR jamming effect based on the statistical distinction"

In this paper, a new criterion which is based on the statistical distinction to evaluate SAR jamming effect is proposed. The radar signal and jamming signal come from different signal source, and the statistical characteristics are not same, thereby the two signals are considered as independent. Here, the SAR images jammed can be look as the signal source mixed target signal with jamming signal, the jamming removal problem can also be described as blind signal separation problem. Using Independent Component Analysis (ICA) method, which is regarded as the statistical distinction tool of the mixture signal source (SAR images), estimates the orthogonal basis from the images. Moreover, we introduce the kurtosis as the criterion to classify the basis images and select threshold to decide which basis images span into target signal subspace and which basis images span jamming signal subspace. The SAR images jammed by Gaussian noise jamming and similar clutter jamming(SCJ) method are used as the input to the ICA algorithm respectively, the results provide that the effect on the jamming removing is degraded contrasted to the Gaussian noise jamming, because of the clutter jamming signal is similar to the target returned signal on the statistical characteristic. [C423]

"A signal separation method for phased array radars"

Interferences, clutter and thermal noises greatly influence the target detection by using phased array radars at low signal-to-noise ratio. A blind signal separation based brief and effective signal detection model for phased array radars is brought forward in order to extract the target information Based on the advanced mixing signal model, a method combining the wavelet transform (WT) and independent component analysis (ICA) is proposed. The signal separability of the phased array radars' signals in the clutter and jamming environment is discussed. Simulation results demonstrate that the proposed method is quite effective to extract the target signals and the jamming signals, which is quite practical in the modern war. [C424]

"Detection of ships for OTHR based on AR-MUSIC algorithm"

In order to ensure the data rate, ship detection within short coherent integration time (CIT) is an operational requirement for over-the-horizon radar (OTHR). However, the resulting low Doppler resolution of short CIT brings difficulties in discrimination of the ship target peak and the powerful ocean clutter. To solve this problem, high resolution spectrum estimation techniques have been used to replace the conventional Fast Fourier Transform (FFT) for Doppler spectrum analysis. In this paper, a new spectrum estimation algorithm is proposed for ship detection by OTHR, which has higher Doppler resolution compared with the conventional method. In addition, in case that the signal-to-noise ratio (SNR) is low or the Doppler frequency of the target is close to that of the first-order ocean clutter Bragg peak, the presented algorithm can still effectively be used for ship detection for OTHR. The superiority of the proposed algorithm is illustrated by simulated OTHR data. [C425]

"Clutter processing for digital radars based on FPGA and DSP"

Clutter processing is a key link for vessel traffic services. According to the shortcomings of traditional analog video system, this paper proposes a design solution for digital radar signal processing system based on FPGA and DSP and studies both related preprocessing method and constant false alarm rate algorithm based on wavelet transform. This method can suppress the interference of sea clutter without impairing the target resolution. Experimental results demonstrate this design can decrease the false alarm rate, increase the detection accuracy and improve the tracking performance. Thus, signal processing system based on FPGA and DSP plays an important role in the vessel traffic services. [C426]

"A fast algorithm based on two-stage CFAR for detecting ships in SAR images"

Ship detection is an important application of SAR imagery in ocean surveillance. After analyzing the statistical characters of sea clutter, a fast algorithm of ship detection in SAR image is proposed in this paper. The method consists of two CFAR detection stages. The first step utilizes a lognormal based CFAR to sort out the potential target pixels at a high false alarm rate; in the second step, these potential targets are refined under a local process of K distribution based adaptive CFAR detection. Space-born SAR images are used to validate this fast detection algorithm, and results show great improvement on efficiency of the proposed method without decreasing detection performance. The fast algorithm satisfies application demands of ship detection in SAR images. [C427]

"Forward scattering micro radars for situation awareness"

In the paper a progress in the netted forward scattering radar research is presented. A special attention is paid to the optimal and sub-optimal signal processing algorithms. These algorithms are assumed to be efficient when the signal is received at a background of Doppler clutters and AWGN. [C428]

"Detection of ships using sub-aperture airborne PolSAR data"

The objective of this paper is to assess the sub-aperture analysis for ship detection using airborne polarimetric SAR data. Three optimal non-normalized coherences can be obtained by tuning the polarization status using the full polarimetric SAR data. These parameters are used to greatly improve the contrast between ships and ocean clutter, since it preserves the intensity and phase information of the coherent target. The airborne polarimetric SAR data is applied to evaluate the results of polarimetric sub-aperture detection for the ships over the ocean. In this way, the improvement in ship detection performance that is realized by using polarimetric information and coherence product is demonstrated in this paper. [C429]

"Denial jamming technique development against pulse-doppler radars using genetic algorithms"

Modern radar jammers offer great flexibility in programming jamming techniques. While this results in opportunities for producing more efficient jamming techniques, it also poses a challenge in terms of technique optimization. The increased flexibility results in a vast solution space of potential techniques. In this paper we demonstrate the applicability of using genetic algorithms for developing jamming techniques for advanced digital RF memory jammers against pulse-Doppler radars employing constant false alarm rate detection algorithms. Results against different types of radar processing and target dynamics are obtained through simulations and tested empirically in a lab-based radar-jammer experiment. [C430]

"Use of adaptive non-causal transmit beamforming in OTHR: Experimental results"

We report results from an experiment that applied multiple-input multiple-output (MIMO) waveform techniques to over-the-horizon radar (OTHR). The experiment objective was to demonstrate that adaptive transmitter beamforming could be used to reject spatially discrete radar clutter. In MIMO radar architectures, conventional or adaptive transmitter beamforming occurs following waveform transmission, propagation, scatter from targets and clutter sources, return propagation and finally signal reception. We have successfully rejected spatially discrete clutter to the noise floor of the radar return with rejection in excess of 35 dB achieved using common adaptive algorithms and straightforward training data selection. As part of this we estimated the transmitted waveform direction-of-departure from the transmitter array to the target and used the estimate as the preserved steer direction in the adaptive beamformer. The direction-of-departure estimates agreed well with the true values. [C431]

"Robust detectors for targets of unknown correlation in clutter"

A multilayer perceptron (MLP) based detector is proposed for approximating the average likelihood ratio (ALR) detector in composite hypothesis-testing problems. The case of detecting colored gaussian targets with Gaussian autocorrelation function (ACF) and unknown one-lag correlation coefficient (rhos), in colored Gaussian interference with Gaussian ACF is considered. The robustness of the likelihood ratio (LR) detector for known rhosis studied, and and the ALR detector for rhosvarying uniformly in [0, 1] is formulated. Due to the complexity of the involved integral, neural network (NN) based solutions are proposed. NNs not only are capable of approximating the ALR detector, but the implemented approximation is expected to have lower computational cost that other numerical approximations, a very important characteristic in real-time applications. MLPs of different sizes have been trained using a quasi-Newton algorithm to minimize the cross-entropy error. Results prove that MLPs with one hidden layer with 17 neurons can implement very robust detectors. [C432]

"Full digital High Frequency Surface Wave Radar: French trials in the biscay bay"

Assessment of actual detection capabilities obtained with high frequency surface wave radar (HFSWR) is a key issue for the global surveillance of the exclusive economic zone (EEZ). ONERA (The French Aerospace Lab) has just finished a ten month trial cycle of its new full digital HFSWR system. This system uses digital signal generation, digital receivers, high computational power workstations and low power transmitters. All results extracted from the trial database are compliant with the theory in particular concerning sea clutter and ionospheric clutter. Moreover, the detection of vessels up to 170 km and aircrafts up to 75 km (results obtained with cooperative targets and ground truth data) shows the over the horizon capabilities of the system. Finally, clutter reduction prospects are also presented. [C433]

"adaptive mitigation of spread clutter in high frequency surface-wave Radar"

High frequency surface-wave (HFSW) radars are cost-effective systems for maritime surveillance and sea-state mapping of ocean areas in the Exclusive Economic Zone (EEZ). The effective mitigation of disturbances, either from interference sources or unwanted radar echoes scattered from the ionosphere, is fundamental to ensure the successful operation of such systems. This paper addresses the mitigation of ldquoionospheric clutterrdquo

spread in delay (i.e. range) and Doppler frequency by adaptive spatial filtering for the problem of target detection in surveillance applications. An alternative adaptive processing method that jointly exploits the spatial and temporal information of range-gated signals, over receivers and pulses, is proposed and applied to experimental data from an Australian HFSW radar. Target detection performance is compared against conventional and standard adaptive beamforming techniques. The author thanks the High Frequency Radar Branch of the Defence Science and Technology Organization (DSTO), Australia, for supporting this work and making the experimental data available. [C434]

"A new deceptive jamming method for SAR based on false moving targets"

In SAR/GMTI, static jamming such as noise and deceptive scene will be eliminated as clutter, and will make no sense. In this paper, a deceptive jamming method for SAR is lucubrated to protect military moving targets. For false moving targets (FMT) consisting of many scattering centers, we propose an improved way to generate false signals. Through separating the response function of false signals into range-related and azimuth-related parts, the new method can reduce the algorithm complexity effectively. Moreover, the factors which will affect the jamming efficiency are analyzed. Simulation results show that the new method is effective to SAR/GMTI and the conclusions are valid. [C435]

"Comparison of MHT and PDA track initiation performance"

The relative performance of multiple hypothesis tracking (MHT) and probabilistic data association (PDA) track initiation is investigated using simulated wide-area-surveillance radar data. The scenarios involve single targets that are low-observable (i.e. a low probability of target detection and a high probability of clutter detection) and non-manoeuvring. Divergent track counts and the receiver operating characteristics (ROCs) are determined and compared. The PDA implementation is extended to incorporate automatic track initiation using the concept of target visibility (PDAv). The MHT implementation uses a log likelihood track score to rank and prune hypotheses. A normalised overlap integral is used to eliminate duplicate hypotheses. The correlation between performance and the number of maximum number of retained MHT hypotheses was examined. A favourable linear performance/complexity relationship was observed. It was found that PDAv is more likely to suppress false tracks and to quickly confirm true tracks than MHT; however, the confirmed true PDAv tracks are more likely to be divergent. [C436]

"Ground Moving Target Tracking with context information and a refined sensor model"

For the detection of targets moving on ground, airborne ground moving target indicator (GMTI) radar is well-suited. In the tracking process, complex target dynamics, particularly stop and go maneuvers, and target masking due to Doppler blindness, often lead to track losses. By means of a refined sensor model it is possible to detect and handle such diverse target states. In addition, the generation of precise and continuous tracks from GMTI radar plots often is a demanding task due to terrain and technical obscuration and clutter. The exploitation of topographic background information such as road maps and terrain data is therefore highly desirable for the enhancement of track quality and track continuity. In the present paper these two aspects have been merged. The significant gain in track quality and track continuity is demonstrated in a number of simulation scenarios involving Doppler blindness and terrain obscuration. [C437]

"Inverse methods for Refractivity From Clutter"

Predicting the radar coverage in low troposphere is a critical problem for detection of the low above sea flying or floating targets. To predict the radar coverage, the electromagnetic wave propagation can be modeled using parabolic wave equation resolution methods, but a description of the refractive index of the medium is required. Refractivity from clutter is a method to obtain this refractive index from the backscattered power received by the shipborne radar. An advantage of the method is that it does not require additional equipment. This paper presents a comparison of four inversion methods, whose two recent, in the refractivity from clutter purpose on ideal simulated data and shows the feasibility of a system using inversion methods based on pre-generated databases. [C438]

"Controlling track coalescence with scaled Joint Probabilistic Data Association"

Track coalescence is undesirable when estimating the states of multiple manoeuvring targets, with a less-than-unity probability of detection, in clutter. Simple and compound forms of coalescence are defined and discussed. Simple coalescence is when two or more identical tracks follow a single target; compound coalescence is when two or more identical tracks follow the midpoint (or centroid) of two or more targets. It is shown that the incidence of compound track coalescence in joint probabilistic data association (JPDA) may be reduced using a scaling factor to favour the most likely association hypothesis. This prevents multiple hypothesis equivalence

when tracking closely-spaced or crossing targets. The performance of the scaled JPDA (SJPDA) algorithm is compared with probabilistic data association (PDA) and JPDA using real and simulated data. Larger scaling factors decrease the likelihood and duration of compound track coalescence; however, they also increase the likelihood of track divergence on clutter or other targets. A value of unity corresponds to JPDA. The optimal value may be chosen to suit the application. A factor of two was found to give good results in the test data. [C439]

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

This paper simply introduces the structure and working principles of one space surveillance radar simulation system, and analyzes the signal processing (SP) simulation system. In order to improve the radarpsilas ability to detect multiple targets and keep the false alarm probabilities constant, 2D-OS-CFAR and Clutter-Map CFAR are adopted as the algorithms of CFAR, and the detection threshold coefficient of OS-CFAR is studied and modified. Finally it gives the simulation results. The results show that the signal processing sub-system can detect the targets and their position, velocity exactly. And it can also satisfy the need of detecting far target, high measuring precision, the ability of detecting multi-targets and the false alarm probabilities in heavy clutter background. [C440]

"Effect of integration time on detection performance of MTI and STAP algorithms in HF radar"

Surface wave over the horizon radar systems have a potential to detect targets falling far beyond optical horizon. Unfortunately, first and second order clutter scattered from the ocean surface, in combination with interferences, can prevent successful deployment of such systems. In this paper we compare different adaptive MTI and space-time adaptive processing algorithms applied to the surface wave high frequency radar system data. The aim of the experiments was to detect small targets (20-30 m long) at distances about 50 km. Radar system used in the experiments is an oceanographic, surface-wave, high-frequency system WERA, designed to perform continuous monitoring of sea currents and waves. System used in this research is located at the east coast of France, in Brittany. Main task of the system is to provide continuous, real-time information about currents and waves in the English (La Manche) Channel entry area, where heavy ship traffic is present. [C441]

"State dependent detection and object tracking"

Target tracking algorithms usually treat the probability of detection as a constant, independent of the target state. In most cases this is not true, one obvious example being the Doppler frequency based clutter rejection, the other is obfuscation (shadowing) of ground based targets. This dependency modulates the measurement likelihood, which in turn introduces measurement non-linearity. In this paper we first present a general algorithm for target tracking in clutter when the probability of detection is target state dependent, and then proceed to an algorithm where both target state estimate and the probability of detection are modeled as Gaussian Mixtures. Probability of target existence is recursively updated as the track quality measure used for false track discrimination. A two sensor based ground target tracking in clutter simulation validates this approach. [C442]

"GLR approach for MIMO radar signal sampling in unknown clutter parameter"

Multiple-input multiple-output (MIMO) radar has been shown to provide enhanced performance in theory and practice. The MIMO radar is a type of multi-static radar, that uses multiple antennas at both the transmitter and receiver to improve the detection performance. In this paper, we propose a generalized likelihood ratio test (GLRT) for target detection by MIMO radar in unknown Gaussian clutter. We focus on MIMO radar with widely separated antennas. Mathematical results indicate that the number of receiver antennas should be more than the number of received signal samples in a pulse repetition interval (PRI); i.e, in each processing round, the number of secondary data set (from different antennas), should not be less than the number of the received signal samples in each antenna receiver. [C443]

"Characterisation of low-PRF X-band sea-clutter doppler spectra"

Understanding the characteristics of the sea is critical in forming a picture of the sea-clutter as seen by a radar. Current research at the DSTO is interested in the properties of sea-clutter at medium grazing angles, over all azimuth directions, with full polarisation and differing weather conditions. This paper builds on previous work which studied the Doppler spectrum over all azimuth directions using the three component Walker scattering model. An improved model is presented here which includes the aliasing present in low pulse repetition frequency (PRF) data collected using Ingara-the DSTOpsilas X-band synthetic aperture radar (SAR). This enables a large number of data sets to be analysed with differing grazing angles and weather conditions. The goal of this work is to characterise the sea-clutter and improve the fidelity of future analysis into the performance of medium grazing angle target detection algorithms in the maritime environment. [C444]

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

Radar-based microwave imaging has been proposed as a complementary modality for early stage breast cancer screening. A considerable challenge for the successful implementation of this technique is the reduction of clutter, or components of the signal originating from objects other than the tumor. To remedy problems that arise due to the breast shape, size and tissue variations, a novel technique is presented that identifies and localizes the source of a target response. The ability of the algorithm to predict the time-of-arrival of a tumor response in a signal corrupted by clutter is demonstrated. [C445]

"Insideness and collision detection algorithms"

Motivated by the need of ATC systems for insideness, intrusion and collision detection, a number of efficient algorithms were designed and implemented. For the determination of the insideness of points in polygons, a simple generalization of the commonly used zero winding and even-odd rules is presented, and, building thereupon, a point-in-polygon algorithm based on the binary addressing of quad-tree nodes and prefix hashing. Subsequently, an octree-based high-performance algorithm for the intersection of rays with polygonal meshes is presented. For all of the presented methods, tests and performance analyses were conducted that confirm the low theoretical runtime complexity. The methods are in practical use in the PHOENIX radar data processing system. [C446]

"Evaluation of some features for extended target extraction in polarimetric radar"

Detection in most surveillance radars is based on the condition of point targets against a more or less homogeneous background. Currently, the resolution of many new types of radar is increasing, at least in the range dimension. Therefore many objects no longer can be considered as points. Also as a consequence, the background is getting more diverse, in statistical terms. The scene addressed in this paper concerns a ground clutter environment, and extended objects observed with a polarimetric radar with modestly high resolution (i.e. 6m resolving power in range). A staged approach is proposed to detection and parameter assessment of extended objects and adding classification based on polarimetric features. The evaluation of this approach is based on recordings of real natural scenes and artificially inserted extended objects. It has been observed that in the multi-stage detection the object classification benefits from several features, amongst which polarimetric ones. It is proposed that the quality of the contour circumscribing the object is the prime factor for quality of the features next to the polarimetric features. Clutter is affecting the edges of the contours, and therefore may have a major impact on features that are dependent on these contours. [C447]

"Feature aided probabilistic data association for multi-target tracking"

Feature aided tracking can often yield improved tracking performance over the standard radar tracking with positional measurements alone. However, the complexity of the tracker may dramatically increase due to the inclusion of the target feature state. In this paper, we study the situation where the target feature is a constant or slowly varying parameter with respect to the target state and can be observed together with the target position. We consider using such target feature data for data association which is a significant problem and dominates the outcomes of multi-target tracking in clutter. Extra target discrimination is obtained by computing a joint measurement likelihood which is typically used in a PDA framework. This idea is demonstrated via an example where the target down-range extent measurement is incorporated into a standard IPDA tracker to resolve closely spaced targets in clutter. A simple target extent model is therefore proposed. Our results indicate that when using the proposed feature aided data association process the complexity of data-to-track association can be greatly reduced. Moreover, the tracking performance of the IPDA tracker is greatly improved. [C448]

"Naпve Bayesian radar micro-doppler recognition"

A comprehensive evaluation of a naive Bayesian classifier used for micro-Doppler signature (mu-DS) radar automatic target recognition has been performed. An initial estimate of performance is made using the Bhattacharyya bound on the error probability that gives results of approximately 60% of the measured value. The classifier input data is pre-processed using the CLEAN algorithm, the Fourier transform and principal component analysis to provide feature vectors exhibiting only mu-DS information. The classifier includes ldquounknownrdquo input rejection that falsely declares known targets with a probability of just 0.07. The probability of correct classification is 0.94. [C449]

"Ground moving target detection using bistatic image feature-based space-time processing (BIFSTP) for airborne bistatic radars"

Bistatic image feature-based space-time processing (BIFSTP) is proposed for effective ground moving target detection for airborne bistatic radars. Moving target detection from ground clutter using BIFSTP is performed based on the separation of target and clutter and their different features in the Doppler-angle domain without the need for clutter estimation. The proposed algorithm is simulated for typical airborne bistatic radar operation geometries. [C450]

"Estimation of the parameters of complex exponentials under radar land clutter and single snapshot observation using Modified Forward Backward Linear Prediction"

Estimation of the frequencies, amplitudes and phases of complex exponentials that model the targets present in radar data under additive white Gaussian noise and land clutter, is investigated stating Maximum Likelihood (ML) and employing spectrum estimation techniques. Use of Tufts & Kumaresanpsilas Modified Forward Backward Linear Prediction (M-FBLP) [D.W. Tufts and R. Kumaresan, 1982] in the defined problem, to the best of our knowledge, seems unpublished. The essential part of the work is that line spectra estimation techniques model the clutter process also as a complex exponential. To estimate the amplitudes and phases given the frequency estimates, two methods are employed and compared. Cramer-Rao bounds are also provided. It has been concluded that for the selected SNR range, M-FBLP shows better performance compared to others. In addition, it is stated that the optimum linear time invariant filter that can be placed before the M-FBLP deteriorates the operation. [C451]

"Multistatic target tracking using specular cue initiation and directed data retrieval"

The effective fusion and tracking of multistatic active sonar contacts is challenging, due to high levels of false alarm clutter present on all sonar nodes. Exploiting the occurrence of high strength detections generated by the specular geometric condition, a cueing approach can be used to selectively extract further data stored locally on the individual sonar nodes for ingestion into the multi-sensor, multitarget tracker. This approach can significantly reduce the data rate at the input to the fusion/tracking algorithm, and reduce node-to-fusion-center communication link throughput requirements. This paper describes this concept, its associated multistatic tracking algorithm, and provides results obtained using simulated multistatic data from the Multistatic Tracking Working Group (MSTWG). The results show effective tracking performance using this approach, yielding a single high quality target track with zero false tracks. The method is shown to have excellent potential in reducing the overloading of the communication links, the automated tracking algorithm, and the operator. [C452]

"Multi scan target tracking with finite resolution sensors"

Target tracking algorithms operate in an environment of uncertain measurement origin. Targets are randomly detected, and clutter measurements from unwanted random scatterers are present. A vast majority of target tracking algorithms have been developed with the assumption of infinite sensor resolution, where a measurement can have only one source. This assumption is not valid for real sensors, such as radars, where measurements from multiple sources may merge. This paper presents a multi-scan target tracking algorithm which removes this restriction. For each measurement the probability that this is a measurement formed by merging a clutter measurement with the target detection is calculated. The merging event creates new data association possibilities, and alters the track quality measure. Both a single target and a suboptimal multi target tracking algorithms are presented. A simulation study shows the benefits of this approach. [C453]

"A modified direct data domain method in spacetime adaptive processing"

Traditionally space-time adaptive processing(STAP) approaches have been implemented to detect target in airborne radar systems. These approaches typically assume a wide sense stationary environment and utilize data in neighbor range cells to estimate the statistics of cell under test. Unfortunately the airborne radar environment can be highly non-stationary, which could drastically impact statistical STAP performance. Various approaches have been investigated to address this problem. One approach is direct data domain (D3LS) method. This paper does research an modified method based on D3LS approach in spacetime adaptive processing. On a snapshot-by-snapshot basis, this algorithm can restrain jamming and clutter effectively while keep the signal of interest. Real weights connected with the space-time data reduce the computational complexity. By implementing multiple space-time constraints, system gain is maintained on the signal of interest when the signal arrivals slightly offset in angle, Doppler, or both. Simulation results show the effectiveness of this method. [C454]

"Research for scattering properties of spatial and frequency diversity MIMO radar targets"

In this paper, for the problem of spatial correlation and frequency correlation of targets echoes in receiving channels of diversity MIMO radar, based on two-dimensional scatter model in polar coordination system,

correlation coefficient and independent condition of radar target echoes in spatial and frequency diversity receiving channels are developed, indicating that for round shaped scatter model targets with scatters intensity isotropic and i.i.d zero-mean distributed, its spatial correlation and frequency correlation are unified. Therefore in view point of target detection, spatial diversity technique and frequency technique in MIMO radar are equivalent. The correlation coefficient is rectified by numerical experiment. [C455]

"Hardware realization of a novel Automatic Censored Cell Averaging CFAR detection algorithm using FPGA"

In this paper we present hardware realization of a novel Automatic Censored Cell Averaging (ACCA) Constant False Alarm Rate (CFAR) detection algorithm based on Ordered Data Variability (ODV) using Field Programmable Gate Array (FPGA). This algorithm has been recently proposed in the literature for radar target detection in non-homogeneous environments. The unknown background level can be estimated by dynamically selecting a suitable set of ranked reference window cells and by doing successive hypothesis tests. The ACCA-ODV based CFAR detector does not require any prior information about the background environment and uses the variability index statistic as a shape parameter to reject or accept the ordered cells under investigation. Recent advancements in modern FPGAs and availability of sophisticated electronic design tools have made it possible to realize the ACCA-ODV CFAR detector in a cost-effective way. The designed hardware is modular and has been physically realized in Altera Stratix II FPGA device. [C456]

"Target Detecting Based on Improved WVD-HT for Radio Frequency Interference to UWB-SAR"

Ultra-wideband synthetic aperture radar is interfered by ground clutter and artificial jamming. In many cases the targetpsilas scatter signal can be approximated as linear frequency modulated signals. Time-frequency Distribution, such as Winger-Ville distribution, provides a direct and effective analysis method of the time-frequency structures of linear frequency modulated signals. Meanwhile, the cross terms of the Winger-Ville distribution can be smoothed through the smoothed pseudo Winger-Ville distribution. Combine Hough transform the time-frequency concentration is improved and better precision of parameter estimation will be obtained. Target detecting and parameter estimation by the smoothed pseudo Winger-Ville distribution and Hough transform for frequency-modulated jamming are simulated in this paper. The method proved to be efficient for target detecting and parameter estimation of ultra-wideband synthetic aperture radar. [C457]

"Space-time ODN suppressing reverberation method"

Reverberation of active sonar that resemble clutter of airborne radar has space-time coupling characteristic. Based on which, a method of space-time ODN reverberation is presented in this paper. Project matrix method is utilized to design time and space ODN filters. The time ODN filter is used to suppress the mainlobe reverberation with the same direction as the target. The space ODN filter is used to the sidelobe reverberation with the same Doppler frequency as the target. Compared with other space-time adaptive processing approaches, this method involves smaller computation and makes real-time processing possible, while the system performance is close to optimal. [C458]

"Method of stepped frequency signal processing based on fractional Fourier transform"

This paper proposes a method of the stepped frequency signal processing based on fractional Fourier transform. Conventional IDFT processing of stepped frequency signal without velocity compensation will cause high resolution range profile aberration, thus reduce the detection performance. As the echo wave of the moving target in Doppler dimension can be considered as chirp form, so high resolution range can be obtained by detecting and estimating the parameters of the chirp signal through fractional Fourier transform (FRFT). As a linear transform, the FRFT avoids the cross term interference while dealing with multi-component signals. The method based on FRFT does not need velocity compensation, furthermore it realize the combinational estimation of the high resolution range and velocity of the target. Fast algorithm of the FRFT is adopted in this paper, which makes the computations of the FRFT be comparable to that of FFT. Simulation results and experiments on real data show the efficiency and validity of the proposed method. [C459]

"Performance characterization of two adaptive range-spread target detectors for unwanted signal"

The adaptive detection of range-spread targets in non-Gaussian clutter is addressed. The clutter is modeled as spherically invariant random vector. After the sample covariance matrix based on secondary data, is inserted, in place of the true normalized covariance matrix, into the test, two adaptive detectors are derived, which are called as ANSDD-GLRT and ASDD-GLRT. The constant false alarm rate property for both detectors is proved. The experimental results show that the ANSDD-GLRT converges faster than the ASDD-GLRT, while the latter can

reject the unwanted signal more effectively. [C460]

"A novel approach for clutter cancellation in HPRF stepped-frequency radar"

In this paper, a novel approach is proposed to canceling clutter in high pulse repetition frequency (HPRF) stepped-frequency radar by utilizing the Doppler spectrum diversity between target and clutter, via the DFT of the data within different bursts at a same carrier frequency. Both the signal processing steps and particular parameters design rules are brought forward in detail. The simulation results show, it is not subject to the product of pulse width and frequency step size. Even if the target is masked by the clutter in range profile, it also can obtain both high detection performance and fine high resolution range profile (HRRP) with lower SCR or SNR. [C461]

"Radar sea clutter suppression and target detection with α-β-γ filter"

Sea clutter refers to the radar returns from a patch of ocean surface. When a radar detects targets on or above the sea surface, it has to overcome the interference from sea echo itself. Sea clutter presents obviously non-Gaussian, non-stationary for many diverse factors, such as radar polarization mode, working frequency, antenna visual angle, sea state and wind direction, which limit the detection capability of radar. In this paper, we elaborate the production mechanism of sea clutter in detail and propose a new alpha-beta-gamma filter to suppress sea clutter and detect targets. In addition, the performance analysis and parameter choosing standard are given and the algorithm is proved to be effective with real data. [C462]

"A detector based on fractal for range extended targets"

This paper analyzes the statistical characteristic of clutter and that of signal plus clutter, and then a new detector of range extended target is proposed, which is based on box dimension of high resolution radar range profile. The box dimension is calculated as the detection statistic, and then is compared with the threshold. Finally, the detection performance of the proposed detector with different azimuths and in different clutter is analyzed. Experiment results show that the proposed method outperforms integrator in a certain azimuth, and its detection performance in non-Gaussian clutter is better than that in Gaussian clutter. In comparison with the energy accumulation method, the proposed method does not need to estimate the power level of the clutter and has strong applicability. It is also a CFAR detector. [C463]

"Discrimination method to track before detect based on Dynamic Programming"

The TBD algorithm based on dynamic programming is an effective method for detecting dim target. But the DP process during the multi-frame integration causes the expansion of targets and strong noise which may produce a large amount of false targets. To reduce them, a new discrimination method which takes advantage of the feature of trajectory is proposed in this paper. The false alarm caused by noise reveals strong randomicity on its trajectory which is different from that caused by true target, and the new method based on the statistics of different level direction histogram can be used to reduce false targets caused by noise. Moreover a new concatenated discrimination scheme of SDH+LEV is proposed. The simulation indicates that the discrimination method of SDH is good for reducing false alarms caused by noise and preserving real targets at the same time. The concatenated discrimination scheme can delete false alarms caused by noise effectively. [C464]

"An effective BSE-ST method for radar target detection in inhomogeneous clutter/interference environments"

This paper proposed a novel BSE-ST processing framework for improving the detection performance of radar array in inhomogeneous clutter/interference environments. We suggested BSE algorithm based linear prediction and the localized GLR algorithm for this framework. The results showed that the detection probability is close to 1 when the normalized Doppler frequency is more than plusmn0.1 Hz under SINR ges -10 dB. The detection performance of the proposed method is close to that of the joint-domain optimal processing in homogeneous clutter/interference environments at this SINR. The feasibility and the effectiveness of the proposed method are verified. [C465]

"Target Detection Based on Sea Clutter Model Using Neural Network"

A novel method to detect small target embedded in sea clutter is presented for high frequency (HF) radar. The method is rooted in different characters between instantaneous radial velocity of sea current and moving target, and relies on the neural network for its implementation. By estimating the instantaneous velocity of sea current and target, we find that a spatial nonlinear model rather than deterministic chaos model is more appropriate to describe the relationship among radial velocities of neighbor sea areas. Then we built a neural network model to

approach to a predictor for sea clutter. So an incoming target will be detected for its more predicted error than a certain threshold. The method performs well on ocean echo data acquired by the HF radar system OSMAR2003. [C466]

"Low power High Frequency Surface Wave Radar application for ship detection and tracking"

High-frequency (HF) radars are operated in the 3-30 MHz frequency band and are known to cover ranges up to some thousand kilometers. Sky wave over-the-horizon radars (OTHR) utilize reflection by the ionosphere, but they require a transmit power up to 100 kilowatts. Especially for oceanographic applications, low power high frequency surface wave radar (HFSWR) systems have been developed, which use ground wave propagation along the salty ocean surface. The WERA HF radar system transmits a power as low as 30 watts, but achieves detection ranges up to 200 kilometers, which are far beyond the conventional microwave radar coverage. Due to external noise, radio frequency interference, and different kinds of clutter, special techniques for target detection have to be applied. This paper describes a new signal processing approach based on a curvilinear regression analysis for thresholding combined with a constant false-alarm-rate (CFAR) algorithm for detection. The target locations detected by the HF radar are passed to a tracking filter utilizing range, azimuth, as well as radial and azimuthal velocities to track the ship locations. For a 12-hour period real HF radar data from the WERA system were processed and secondary ship locations were recorded from the automatic identification system (AIS). This data set is used to assess the performance of the HF radar detections. Comparisons have been made for a maximum distance of 5 km between AIS and radar detected locations. The deviation between AIS and radar detected locations was below 1 kilometer in 77% of these comparisons. A number of ships was detected and tracked by the radar, but could not be used for comparisons due to the lack of AIS information. [C467]

"Maritime UWB forward scattering radar network: Initial study"

A scenario for an ultra-wideband (UWB) forward scattering radar (FSR) network for detection of low radar cross section (RCS) maritime surface targets is suggested. A chain of buoys equipped with transceivers which forms a FSR for target detection is considered. In this paper, the first stage of the study is described and major aspects of future work are discussed. It was shown that the high level of surface clutters related to FSR might be reduced by utilisation of UWB technology. As a preliminary further investigation, a numerical simulation of the 3-D RCS for comprehensive models of small maritime targets is obtained and comparisons with simplified target models are made. [C468]

"Sea target detection using passive DVB-T based radar"

This paper presents a new approach to passively detect targets using noise-like emitters of opportunity. This method combines Wiener filtering to improve clutter rejection and an adapted direct data domain (D3) method. This theoretical approach is confirmed by the detection of a boat by a bistatic radar using a digital video broadcasting terrestrial (DVB-T) transmitter. [C469]

"Adaptive waveforms selection for IMM-UKF tracking architecture: application to multifunctional radar systems in heavy cluttered scenario"

Modern phased array radars are able to adaptively manage the way in which they explore the surroundings, both in the space domain (thanks to their beam steering capability) and in the time domain (via a smart selection of convenient waveforms), in order to suit a variety of environments. Multifunction radars, more than tracking radars, are in big need of an efficient way to allocate their limited resources (namely, the radar time) to a number of tasks, so that being adaptive is not only a boost for the tracking performances, but also a way to spare resources during undemanding tasks (i.e. big targets in clear areas) and reroute them towards more difficult ones. [C470]

"Statistical measures of S-band sea clutter and targets"

We conducted a low grazing angle S-band sea clutter trial in November 2006 on the Kangaroo Island of South Australia using a quad-polarised S-band radar developed by DSTO. This paper reports some statistical measures of S-band sea clutter, including range profiles, sea clutter coefficients, temporal and spatial correlation and distribution properties, and as well as Doppler spectra for both the HH and VV sea clutter. Strong and weak target signals are also analysed and classified into Swerling models accordingly. Differences between the HH and VV sea clutter as well as target signals are shown. [C471]

"Small-target detection in sea clutter based on the Radon Transform"

Small target detection in sea clutter is a challenging problem. This paper presents a novel and heuristic

approach based on the application of the Radon Transform to a set of consecutive range profiles. The performance of the detection technique has been tested with real sea clutter data, acquired with a high resolution CWLFM (continuous wave linear frequency modulated) millimetre-wave radar demonstrator. Results show that performing the detection on the Radon domain makes the detection of very small targets possible while keeping the false alarm rate controlled. [C472]

"Coherent scattering from distributed targets"

Based on the formulation for coherent backscattering from distributed targets previously published by the first author, this paper presents a unified formalism for incorporating the small amplitude, the small slope, the physical optics as well as a ldquotwo-scale modelrdquo approximation into analyses of backscattering by irregular air-dielectric interfaces. The distinguishing feature of this approach is that it takes explicit account of the antenna radiation properties and provides a direct means of numerically assessing the effects of spatial coherence of the surface irregularities on the receiver response. In particular, this leads to a generalization of the normalized backscattering cross-section which becomes dependent on both the antenna radiation properties and surface scattering characteristics. Numerical results obtained under the small amplitude approximation show that spatial coherence of the surface irregularities can lead to significant deviations from the classical Bragg scattering formula. [C473]

"PaRaDe-PAssive RAdar DEmonstrator family development at Warsaw University of Technology"

The paper presents a family of passive coherent location (PCL) radar demonstrators, called PaRaDe (passive radar demonstrator), which were developed at Warsaw University of Technology. The systems exploit commercial FM radio transmitters as illuminators of opportunity in order to detect and track airborne targets. In the paper, the details of demonstrator systems are described and the results obtained in tests are presented. [C474]

"Time Frequency Representations for Classification of Landmine Using UWB Impulse GPR"

In this paper, Time Frequency Representations (TFRs) for classification of landmine using Ultra Wideband (UWB) impulse Ground Penetrating Radar (GPR) is presented. GPR signal is composed of three parts: ground bounce, clutter and target echo signal, the target signal is seriously deteriorated by ground bounce and clutter. To extract intricate structures of target signal, wavelet packet transforms (WPT)-based algorithm is used to ground bounce removal and clutter reduction. Then the Fisher Dsicriminant Ratio (FDR) for feature subset selection method is used to select the suboptimal feature subset of target signal, thereby a Learning Vector Quantization (LVQ) classifier is designed. Experimental results based on GPR measured data are presented, showing that the feasibility and advantage of the presented algorithm. [C475]

"Tracking algorithm using N-back scan MHT under dense environments"

MHT(multiple hypothesis tracking) is well-known tracking algorithm for its association performance in dense environments. In the MHT, hypotheses are reduced by calculating probability and upper hypotheses are selected in a usual way to reduce computational burden. In the field of visual tracking, the N-back is applied as hypothesis reduction method and its efficiency is verified. The method maintains all hypotheses in recent N scans and selects the best hypothesis in past over N-scan, for hypotheses reduction. We apply the method to radar tracking and evaluate its performance, through Monte Carlo simulation of track maintenance for a low observable target. From the result of simulation, we have confirmed that N-back scan MHT shows better performance than conventional MHT. For example, the former has shown 30 point improvement with respect to tracking success rate for tracking a maneuvering target than latter. [C476]

"Empirical Study on Ultra-Wideband Vehicle Radar"

High range-resolution radar using ultra wideband radio attracts considerable attention as a short range automotive radar. Radar echo from a target often contains unwanted echoes called as clutter, which make it difficult to detect the target. In order to suppress the clutter, therefore, it is important to investigate the clutter distribution and to develop the clutter model. In this paper, traffic road clutter is measured and characterized for various bandwidths from 10 MHz to 5 GHz. It is also quantitatively compared with the model of log-normal, Weibull and log-Weibull. [C477]

"Symmetry in target recognition"

Symmetry has important consequences for target recognition. Rotation and reflection symmetry for targets near a ground or water surface not only help to identify the targets, but also aid in data processing to increase

accuracy. While clutter (other scatterers) interfere with the target signatures, symmetry in the clutter can be used to suppress this interference. [C478]

"Clutter reduction and detection of landmine objects in ground penetrating radar data using likelihood method"

In this paper, an algorithm is proposed to reduce clutter signal due to the reflection from the ground surface in ground penetrating radar (GPR) measurements. The proposed technique has been applied to a GPR, which has been used to detect subsurface anti-personnel (AP) landmines. A very simple model is used to model the GPR clutter and the target signal. This model has been used to derive a detector based on a likelihood ratio test using some estimated parameters. A new threshold formula has been derived and has been applied to the data. The data sources include 1 GHz pulse GPR data and 1 GHz to 4 GHz stepped- frequency GPR data, from laboratory measurements. In all measurements, the reflections from the surface have been removed or at least reduced in great quantities. [C479]

"Effects of transmitter phase noise on millimeter wave LFMCW radar performance"

The transmitter phase noise has important effects on the performance of millimeter wave LFMCW radar. A beat signal spectrum is analyzed with consideration of transmitter phase noise after in the paper. Returns of a large RCS target will leak into the adjacent range bins and can even swamp smaller targets around the large RCS target. It is shown that a millimeter wave LMCW radar has a stronger ability to detect moving-target signals superimposed on clutter signals if its transmitter phase noise level is lower. [C480]

"Multi-component target detecting of SAR based on improved WVD-HT for frequency-modulation jamming"

Multi-component target detecting and parameter estimation of SAR are of most significance for military applications. In practice SAR is interfered by ground clutter and artificial jamming. The jamming can be restrained by multi-component target detecting that adopts the smoothed pseudo Winger-Ville distribution. Meanwhile, the cross terms of the Winger-Ville distribution can be smoothed. Combine Hough transform the time-frequency concentration is improved and better precision of parameter estimation will be obtained. Multi-component target detecting and parameter estimation by the smoothed pseudo Winger-Ville distribution and Hough transform for frequency-modulated jamming are simulated in this paper. The method proved to be efficient for target detecting and parameter estimation of SAR. [C481]

"Study on STAP in Non-homogeneous Clutter Environment"

The performance of space time adaptive processing (STAP) is greatly affected in nonhomogeneous clutter environments. In this paper, the effect of nonhomogeneous clutter on STAP is analysed, then a nonhomogeneous clutter suppression scheme is proposed. In this scheme, First, the power nonhomogeneous phenomenon is restrained by means of secondary sample weighting method. Second, the effects of interference target and discrete interference on STAP are eliminated by interference point substitution method. Finally, the conventional STAP algorithms are used to detect target. The computation simulation results prove the effectiveness of the proposed scheme. [C482]

"Using Measured RCS in a Serial, Decentralized Fusion Approach to Radar-Target Classification"

A decentralized fusion problem is a hypothesis-testing problem where the decision algorithm is not provided with raw measurements but rather is provided only with results from so-called local decision functions. In a serial decentralized fusion problem, these local decisions are fused into a global decision one-by-one until all local decisions have been included or until a stopping criterion is achieved. In this paper, we consider serial decision fusion with a single radar sensor using a local decision function based on the radar cross section (RCS) characteristics measured across multiple dwells. In a single-sensor situation, the serial topology is convenient because local decisions are naturally sequential in time. A serial topology also supports the calculation of system performance measures and adapts easily to a distributed or multi-sensor situation. From dwell to dwell, measured RCS fluctuates due to noise, errors, and target scintillation. By examining the results from multiple dwells, the measured RCS can be separated into fixed-amplitude and Rayleigh components. The relative magnitudes of these components vary depending on both target type and sensor-to-target geometry. Spreading measurements and local decisions in time allows the sensor to observe a moving target from different aspect angles and thus introduces changing geometry into the decision data. In this way local decisions at different times are based on observations of different fixed to Rayleigh-amplitude ratios. Results based on a high-fidelity radar simulation along with different fixed- versus-Rayleigh RCS profiles are used to investigate issues related to

serial multi-hypothesis decentralized fusion. Simulation results and performance measures demonstrating the efficacy of the proposed method are presented and sensitivities with respect to RCS profiles and to local-decision rates are investigated. [C483]

"Optimized Bernoulli Trial Technique for M Out of N Binary Integration of Radar Signals"

Binary integration is used in radar systems where M successful events out of N trials represent the detection of a target where multiple pulse-repetition frequencies (PRFs) are used. If the probabilities of the single events are equal, the probability of M events occurring out of N can be represented by a binomial distribution. If, however, switching the PRF at each event causes differing clutter to interfere with the signal, the event probabilities are not binomially distributed but are represented by a more complicated polynomial. An optimization procedure is presented that minimizes the radar resources needed for the M out of N binary integration of detector outputs with unequal signal-to-interference noise ratios (SINRs). The amount of coherent integration for each PRF output is optimally adjusted to yield a minimum total integration time over the batch of PRFs. The optimized integration time is computed for a number of different sequences of detector output SINRs and compared to the results from a binomial distribution. [C484]

"Experimental Verification of a Two-State Model for the Cumulative Distribution Function of GSM Passive Radar Clutter"

Modeling clutter signal is a major task in characterizing radar performances. Clutter distributions pertaining classical radar systems have been widely investigated, but in the past few years passive radars have raised interest among researchers for some specific features that make them very appealing in modern applications, thus bringing about the need for researching appropriate models for the noise signal received under no-target conditions. The paper proposes a new two- state model for the statistical distribution of clutter signal in a passive radar based on the GSM cellular system. A dedicated measurement station has been set up to carry out experiments in a real environment. Results give evidence of the suitability of the proposed model. [C485]

"Phased array-Technology and trends"

This paper introduces the requirements of naval radar systems from past to present. It describes phased array technologies (digital and analog) that are presently available in the market. Power sources architectures, A/D evolutions, transceiver architecture and system on chip configurations are described as the main technologies at phased array system. The correlation between the various technologies and phased array architectures trends is also discussed. [C486]

"A Novel Technique for Preventing Signal Cancellation in Space-Time Adaptive Processing"

This paper addresses the issue of space-time adaptive processing (STAP) when the target signal is present in the training data. Target cancellation will occur in the STAP processing when the target signal leaks into the neighbouring range-gates for estimating clutter covariance matrix. In this paper, some linear constraints are added both on target signal and clutter to prevent target signal from being cancelled when the target signal is in the estimated covariance matrix. Computer simulation results verified the efficiency of the proposed algorithm. [C487]

"Impact of signal bandwidth on airborne wideband radar echoes"

Model the output echo power from the matched filter of airborne radar receiver. Based on the same pulse time width, the same transmitted power and the same radar operation scene, signal-clutter-noise power ratio of the matched filter output is presented, and some new results different from the intuitionistic viewpoints is put forward. The impact of signal bandwidth on airborne radar echoes and target detector is discussed in detail. At last, computer simulations about typical airborne radar operation scene provide the verification and analysis. [C488]

"Methods of eliminating Doppler dispersion in synthetic wideband signal"

As the technological advances, it is possible to perform wide bandwidth signal processing for high range resolution and target identification in the modern radar systems. In order to prevent the deleterious effects of dispersion for wideband signals, a wideband signal can be synthesized by coherently combining the individual narrow band components, meanwhile, clutter mitigation, estimation and discrimination of target's velocity is enabled by performing coherent pulse train in each subband. However, the separate and independent processing using conventional Doppler filter bank in a subband can also introduce deleterious effects of target Doppler dispersion among subbands and cause the distortion on synthesized one-dimensional range profile. In this paper, we first analyze the target Doppler dispersion among subbands and deleterious effects of following

recombination, and then propose an effective method to eliminate the deleterious effects of target Doppler dispersion in subbands. The method is easy to be realized and tractable and do not require an increment of computation. Its good performance is verified by simulation results. [C489]

"Air traffic control radar tester"

Our aim is to develop a radar tester equipment for commercial and military services. The task is to create one (or more) target or clutter on the radar screen with given distance, velocity and fluctuation. This equipment is placed within few hundred meters from the radar, so it is able to analyze the whole radar system from the antenna, via microwave hardware elements, to the DSP unit. We have some experience in this field, included in the references but also briefly introduced in this paper. [C490]

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

In this paper we propose an automatic target recognitionalgorithm to recognize and distinguish of three classes oftargets: personnel, wheeled vehicles and animals, based on thedoppler signatures they produce when moving, using a low-resolutionground surveillance pulse doppler RADAR. Using signal processingtechniques such as the short-time Fourier transform (STFT)and the chirplet transform, various parameters of the targets canbe extracted from the signal. This paper proposed classification ofmoving targets with use of the chirplet transform. The algorithmwas trained and tested on real radar signatures of multiple examplesof moving targets from each class and the performance wasshown to be invariant to target speed and orientation. [C491]

"Polarization optimization for scattering estimation in heavy clutter"

Controlling the polarization information in transmitted waveforms enables improving the performance of radar systems. We consider the design of optimal polarization for the estimation of target scattering embedded in heavy clutter. The goal is to minimize the mean squared error of the scattering estimation subject to an average radar pulse power constraint. We show that such a problem is equivalent to the optimal design of a radar sensing matrix that contains the polarization information. We formulate the optimal design as a nonlinear optimization problem which can be recast it in a convex form and is thus efficiently solvable by semi-definite programming (SDP). We compare the sensing performance of the optimally selected polarization over the conventional approaches. Our numerical results indicate that a significant amount of power gain is achieved in the target scattering estimation through such an optimal design. [C492]

"Application of Doppler resilient complementary waveforms to target tracking"

The use of complementary codes as a means of reducing radar range sidelobes is well-known, but lack of resilience to Doppler is often cited as a reason not to deploy them. This work describes techniques for providing Doppler resilience with an emphasis on tailoring Doppler performance to the specific aim of target tracking. The Doppler performance can be varied by suitably changing the order of transmission of multiple sets of complementary waveforms. We have developed a method that improves Doppler performance significantly by arranging the transmission of multiple copies of complementary waveforms according to the first order Reed-Muller codes. Here we demonstrate significant tracking gains in the context of accelerating targets by the use of adaptively chosen waveform sequences of this kind, compared to both a fixed sequence of similar waveforms, and an LFM waveform. [C493]

"Modelling of the Impact of Antenna Rotation on Clutter Improvement Factor in Naval Radars Operating in Littoral Environments"

Naval operations are increasingly conducted in the littoral environment, requiring extremely high clutter improvement factors (CIF) to be achieved to enable small target detection. This paper describes a littoral clutter model to support synthetic baseband radar data generation and examines the impact of antenna rotation on the clutter filtering required to achieve these high clutter improvement factors. The impact of this analysis on waveform and signal processing design for future naval radars is discussed. [C494]

"Clutter Mapping for Airborne Pulse Doppler Radar"

This paper presents a quick and simple method to model the surface clutter map of an airborne radar operating in a medium pulse repetition frequency (PRF) mode and in a look-down scenario. The basic model derives a clutter map in the range/velocity detection space of the radar specific to each PRF used within the radar schedule. Additional functionality may be introduced which permits regions of differing clutter statistics to be defined and which computes target detectability over the range/velocity detection space of the radar. The models

described here have been used successfully in a variety of research tasks to optimise PRF selection and weighting functions of a phased array antenna. [C495]

"Clutter Modelling for Space-Time Adaptive Processing"

The presence of clutter can be highly detrimental to detection of targets. STAP attempts to alleviate the problem by exploiting angle-Doppler inter-relationships to suppress clutter. The simulation of clutter data that is suitable for the application of STAP is considered in this paper. Examples of clutter generated using the ELMBAARC program in bistatic applications and forward facing and sideways facing monostatic applications are provided. Modelling of internal clutter motion is considered, together with its effect on the clutter domain in angle-Doppler space. [C496]

"Performance Metric Issues for Space Time Adaptive Processing Methods"

Space time adaptive processing was introduced to the radar community in the 1970's as a multi-dimensional filtering method to discriminate moving targets from clutter when observed from an air-borne/space-borne multi-channel phased array radar. Numerous variants of this filtering technique have been developed and are often compared to some baseline performance with respect to output signal to interference plus noise ratio or minimum mean square error. Under clairvoyant conditions these metrics have a direct relation to probability of detection. However under non-clairvoyant conditions, such as with recorded data, probability of detection is not measured directly and secondary metrics, such as signal to interference plus noise ratio and minimum mean square error, are used to measure performance. This paper attempts to show a case where using a metric such as minimum mean square error can indicate erroneous favorable performance. [C497]

"MIMO Phased-Array for SMTI Radar"

Waveform diversity techniques for radar have gained considerable interest over the past several years. Novel radar waveforms have been proposed to improve detection performance and metric accuracy (i.e., angle estimation performance). This paper explores the potential for using a waveform diversity technique known as multiple input, multiple output (MIMO) radar to improve the detection performance of slow moving surface targets from a moving radar platform. The MIMO radar system achieves superior performance by transmitting unique uncorrelated waveforms from each antenna subaperture as opposed to the traditional approach of transmitting a single coherent waveform across the entire aperture. The results show that the radar system minimum detectable velocity (MDV) can be reduced by exploiting the ability of a MIMO system to effectively increase the radar antenna aperture. [C498]

"Adaptive Threshold Mapping Technique for Moving Target Detector in Modern Radar"

In this paper we propose a new adaptive threshold mapping (ATM) technique for moving target detector (MTD) in modern radar. This technique is proposed to reduce the false alarms resulting from weather clutter and interference with relatively high Doppler frequency shift and MTD is not able to suppress it. The technique is based on controlling the receiver sensitivity according to the status of the output signal at the post detection. Also the technique is to control the signal processing path with relatively high probability of detection. The Simulation results show that this technique is a powerful solution to keep the post detection output with high probability of detection and minimum probability of false alarm rate compared with traditional MTD without ATM technique. [C499]

"Radar clutter mitigation via space-time wavefront adaptive sensing"

Space-time adaptive processing (STAP) in complex radar propagation and inhomogeneous clutter environments is often precluded because neither the target wavefront is sufficiently known nor is signal-free training data available. In recent work, wavefront adaptive sensing (WAS) was proposed to overcome these challenges by combining minimum variance (MV) adaptive processing and blind source separation (BSS) for distributed sources. In this paper, WAS is compared with conventional BSS and MV processing both analytically and via simulation. In an over- the-horizon radar (OTHR) spread-Doppler clutter environment, WAS is shown to avoid MV signal cancellation at high SNR and poor BSS threshold performance at low SNR. [C500]

"Multi-location wideband through-the-wall beamforming"

Significant multipath propagation and heavy clutter in indoor environments renders through-the-wall radar imaging a difficult and complex proposition. It is highly desirable to properly interpret the radar images and determine the contents of the indoor scene with a high level of confidence. Data collected from multiple positions around a structure can be used to improve imaging visibility into the indoor scene, thereby enhancing indoor

target detection and localization. In this paper, we consider multi-location radar imaging. Image fusion techniques for combining radar images acquired from multiple locations along two sides of an enclosed structure are presented. Supporting results, based on real-data, are also provided. [C501]

"Multi-scale Modeling Approach for Detecting Low Observable Targets within Sea Clutter"

Sea clutter refers to the radar backscatter from the ocean surface. Accurate modeling of sea clutter and rough sea surface is an important problem in radar signal processing and applications, as it facilitates robust detection of low observable targets within sea clutter, which has significant importance to coastal security, navigation safety and environmental monitoring. Great efforts have been made to model sea clutter. However, the nature of sea clutter is poorly understood and the important problem of target detection within sea clutter remains a tremendous challenge. We propose a systematic, multi-scale approach to model sea clutter. By extensively utilizing available real data, we (1) develop methods to better fit non-stationary and non-Gaussian sea clutter, (2) characterize correlation structure of sea clutter on multiple time scales, and (3) develop accurate and readily implementable methods to detect low observable targets within sea clutter. [C502]

"Doppler Keystone Transform for SAR Imaging of Moving Targets"

A synthetic aperture radar (SAR) data reformatting approach named Doppler Keystone transform (DKT) is proposed to correct the range migration of the moving target. By combining the DKT and the Doppler phase compensation methods, the moving target can be well imaged in high signal-clutter-ratio (SCR) case. Moreover, the DKT-based algorithm is suitable for parallel implementation. [C503]

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

In multiple-input multiple-output (MIMO) radar, the efficiency of target detection in clutter that is distributed over a certain range bin-Doppler frequency region depends on the sidelobe level of the waveformspsila auto- and cross-ambiguity functions within this region. We introduce the MIMO ambiguity function as the sum of all auto- and cross-ambiguity functions of the K MIMO radar waveforms, with the integral of this function over some range-Doppler region serving as a measure of the orthogonality (separability) of the waveforms within this region of interest. We derive an upper bound on the attainable ldquoclear areardquo for the MIMO ambiguity function, and show that, with respect to the conventional single-waveform ambiguity function, the maximum clear area is K times smaller for the MIMO system. [C504]

"Chirplet-based target recognition using RADAR technology"

In this paper, q-chirplet based signal processing is applied to data from a low-resolution ground surveillance pulse Doppler RADAR, to classify three classes of targets: personnel, wheeled vehicles and animals. We utilize Zernike moments (ZM) over the chirplet parameters to determine the pertinent features. Our work provides a new approach for multiresolution analysis and classification of non-stationary signals with the objective of revealing important features in an unknown noise and clutter environment. The algorithm is trained and tested on real RADAR signatures of multiple examples of moving targets from each class. The results show the proposed algorithm invariancy against speed and orientation of the targets. [C505]

"Polarization filtering enhancement of buried landmine"

Here the optimum polarization of antenna for buried landmines detection in soil surface clutter is investigated theoretically to enhance radar target back scattered power. An expression of the Mueller matrix from this fractal surface is obtained. The optimum polarization to reduce clutter is given. Then, the variations are found of power density of buried landmines with polarization state, and the optimum polarization is given to increase power density. In the end, the paper researches the polarization filtering enhancement of buried landmines in soil surface clutter. [C506]

"Design and real time implementation of a radar data extractor"

In this paper, we propose a parallel processing architecture, based on two TMS320C44 VME-bus DSP boards, for real time implementation of Cell Averaging and Clutter Map Constant False Alarm Rate (CFAR) detectors, and a data extractor based on a centroidal interpolation of the position of the detected target. The optimal processing speed has been achieved by fully exploiting the capacities of the dasiaC44 processor. The implemented system is well adapted for two dimension radars. The overall processing scheme interconnections and the real time implementation results are presented and discussed. [C507]

"Study and analysis of a new detector of radar targets using CFAR with Gabor transform"

In this paper, we consider the problem of radar detection using the Gabor transform in presence of unknownpsilas noise and clutter. We proposed a new constant false alarm rate (CFAR) detector in time frequency domain to locate the positions of the targets exactly. This method is efficient in measurement as the case of no homogeneity is dealt with thus the detection of the targets to weak radar cross section, as well as the detection of the targets flying tangentially to the circle of radius target-radar. To show the performance of this detector in presence of noise and clutter, we analyses the behavior of the clutter before and after Gabor transformer. [C508]

"Using a clustering technique for detection of moving targets in clutter-cancelled QuickSAR images"

The ability to detect and track moving targets in synthetic aperture radar (SAR) images has become a topic of much current research. The authors have been reporting on a multi-channel phase interferometry technique for detecting moving targets in SAR images for some time. They have also shown that the phase interferometry between two channels can be utilized to cancel ground clutter from one channel by subtracting a phase-weighted version of the image from the other channel. This is analogous to, but not the same as, the well known DPCA (displaced phase center antenna) technique for clutter cancellation. This paper reports on a clustering technique we have successfully used to detect moving targets, which in almost all cases occupy many more than one or a few pixels in the clutter-cancelled SAR image. This technique greatly reduces false alarms. [C509]

"Constructive neural network for landmine classification using ultra wideband GPR"

In this paper, constructive neural network for landmine classification using ultra wideband (UWB) ground penetrating radar (GPR) is presented. GPR echo signal is composed of three parts: ground bounce, clutter and target echo signal, the target echo signal is deteriorated by the clutter. Firstly WP-based preprocessing algorithm is used to ground bounce removal and clutter reduction and feature extraction of GPR echo signal. Then wrapper based approach is adopted to feature subset selection of GPR echo signal using genetic algorithm(GA) in conjunction with constructive neural network learning algorithm, and at the meanwhile, the result of classification of landmine is obtained. Experiment result based on GPR measured data shows that the feasibility and advantage of the presented algorithm. [C510]

"Detection and tracking of a moving point target in infrared image sequence using auxiliary particle filter"

An appropriate measurement likelihood function is proposed from the measurement image model employed by most of the track-before-detect (TBD) approaches. Based on the likelihood function and a target motion model, we design an auxiliary particle filter-based Bayes multiframe method for detection and tracking a moving point target in infrared (IR) image sequences. Experimental results show its effectiveness for the detection and tracking of a low signal-to-noise ratio (SNR) point target. [C511]

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

The challenge of modern sensor systems is besides the tracking of targets more and more their classification. The knowledge of the target class has significant influence on the identification, threat evaluation and weapon assignment process of large systems. Especially, considering new types of threats in anti asymmetric warfare the knowledge of a target class has an important drawback. Also the target class is used to optimize track and resource management of todaypsilas agile sensor systems. A technology is presented that fuses different classifiers to decide between persons, tracked vehicles, wheeled vehicles, helicopters, propeller aircrafts and clutter for a 2 dimensional, electronically scanned radar system. A first classifier analyses the Doppler sound of the target to decide its target class. Therefore, a cepstrum based feature extractor and a hidden Markov model (HMM) is applied. Similar to techniques that have been well proven in speech and image recognition, the time-varying nature of radar Doppler data is exploited. A second type of classifier extracts dynamic features of the target found by the underlying target tracking methodology. Through a fusion of these classifiers a highly reliable classification result is established. [C512]

"Time reversal SAR technique for imaging extended target shielded from line-of-sight"

In this paper, we present a novel time reversal SAR technique for imaging extended targets completely shielded from line of sight. The secondary scattering between the cluttered environment and the shielded targets results in ghost images in the difference SAR imaging (with and without targets) and can be significantly enhanced by a

developed time reversal technique. By matching the obtained ghost image with forward FDTD simulations using the scatters obtained from SAR imaging, a complete image of the extended target can be reconstructed with relatively high confidence. With a highly cluttered environment that generates sufficient secondary scattering, the ghost images are distinctively different for distinctively different extended targets, yielding a high distinction correlation in the forward matching process. [C513]

"Experimental through-the-wall detection in cluttered environment using time reversal processing"

The detection and localization of persons through obstacles is becoming a great stake in both civil and military fields. One of the most important applications is certainly sensing through walls which can be very useful in safety, peace-keeping and law enforcement operations. Radar systems are likely to provide an adequate answer to this kind of problem and various processing methods are nowadays studied and considered to reach the final solution. In this paper, we focus on ultra-wideband radar techniques applied to human sensing. In particular, we assume that we have an antenna array on reception. Many signal processing methods can be considered for target localization. We choose to focus on an emerging method in electromagnetic detection field, especially in a cluttered environment: time-reversal [1] adapted here to through-the-wall localization. In this work time reversal processing is applied to experimental data to demonstrate the localization of dielectric objects behind a 10 cm thick brick wall. [C514]

"Image feature-based space-time processing (IFSTP) for bistatic ground moving target detection and clutter rejection"

IFSTP has been proposed as an alternative approach to traditional STAP for bistatic radars to detect ground moving targets from clutter and jammers. The new approach can be implemented without resorting to the clutter estimation, which may be difficult to implement in inhomogeneous clutter environment. Target detection is carried out based on different features of target and interference signals in the Doppler-angle domain. The image features and a region-growing algorithm are specifically defined and developed for target feature extraction and detection. Simulation results validate that the developed IFSTP algorithm can effectively detect ground moving targets for airborne bistatic radar. [C515]

"A new track initiation method for multi-target tracking"

This paper introduces a novel track initiation technique for the bearings-only two-sensor-multi-target tracking system. Observing that each target is of the characteristic of uniform rectilinear motion, a new objective functional derived from the thought of Hough transform is investigated. On the basis of it, the ant colony optimization (ACO) algorithm, a kind of heuristic optimization method, is utilized to initiate tracks of interest. Numerical simulation results are presented and show that the proposed ACO-based track initiation method performs well compared with other traditional ones such as rule-based, logic-based, and Hough-transform-based track initiation approaches. [C516]

"Practical problems with covariance matrix estimation for adaptive MTI and space-time adaptive processing for target detection in HF surface wave radars"

Surface wave over the horizon radar systems have a potential to detect targets, that are hidden under optical horizon. This possibility is, however, difficult to implement as a result of first and second order clutter scattered from the ocean surface in combination with interferences. In this paper we compare adaptive MTI and space-time adaptive processing algorithms applied to the surface wave high frequency radar system data. The aim of the experiments was to evaluate different techniques and their usefulness to detect targets at distances 50-200 km off shore. In the experiments authors used the data from an oceanographic, surface-wave, high frequency system WERA, designed to perform continuous monitoring of sea currents and waves. Data were collected at the west coast of France, in Brittany. [C517]

"Model based adaptive detector with low secondary data support"

In this paper the problem of adaptive target detection in structured Gaussian clutter is considered. The clutter is modeled as an auto-regressive process with known order but unknown parameters. Here a detection algorithm which can manage the cases with few secondary data is proposed. We have modified a well known adaptive detector in four different forms. First of all, we estimate the AR parameters based on secondary data and use the results in covariance matrix estimation. The performance of the proposed detectors have been evaluated using Monte-Carlo simulations and compared with each other. [C518]

"Segmentation of Spectrum Map for HFSWR Based on Feature Extraction"

When targets fall in different types of clutter and noise background in High Frequency Surface Wave Radar (HFSWR), uniform detection algorithms always result in poor detection and tracking performances. To solve the problem, two methods are proposed in this paper by extracting the background features according to the probability distribution and the image characteristic of the spectrum map. The first method uses Parzen window for estimating probability density function and Kullback-Leibler convergence for evaluating the difference between the Azimuth-Range-Doppler cells in spectrum map which can be used to distinguish the homogenous detection background from the non-homogenous. The second method is proposed based on the image edge feature in multi-scale space. The real data results about HFSWR show that the proposed methods can not only identify noise/clutter but also help choose appropriate detection/tracking algorithms to improve performances in such complex environments. [C519]

"Range-Dependence Compensation Method for Bistatic STAP Radar"

In this paper, we study 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. This paper proposes a new method of obtaining an estimate of the covariance matrix using power spectrum registration based on nonuniform frequency sampling technique. Simulation results show a significant improvement in processor performance as compared to conventional STAP methods. [C520]

"CFAR robust detection of moving target in presence of fluctuating background"

The paper describes the techniques for the autonomous detection of moving targets by processing a sequence of sensor imageries in remote sensing applications. Two detection algorithms, which do not need a matrix inversion, are developed by extension of Hotellingpsilas principal-component method showing excellent performance and robustness. The detection of small, barely discernible, moving objects in presence of correlated fluctuating background and unknown background intensity are presented and tested experimentally. [C521]

"Classification of ground moving targets in the exoclutter region of airborne radar signals"

An airborne radar sensor operating in ground moving target indicator (GMTI) mode is able to distinguish between airborne targets and ground moving targets. Further it is possible to separate stationary from moving ground targets. For military radar applications, it is desirable that the GMTI mode be extended to allow classification of detected ground targets. In addition, such an extension should permit classification of Helicopters. A model-based classification algorithm suitable for GMTI processing as well as for Doppler signal evaluation is presented, using only signals in the exoclutter region (clutter-free region of the range-Doppler domain) and not requiring STAP processing. [C522]

"Performance analysis of a weighted max CFAR processor"

In this paper, we study the performances of a novel CFAR in homogeneous environment. This processor consists to take maximum power of cells in the reference windows and multiply it by a coefficient alpha (alpha < 1) to obtain the background level estimate. We assume that the target is embedded in a white Gaussian noise and fluctuate according to a Swirling I model. Closed form expressions of the probabilities of detection and false alarm are determined and the performance of the proposed detector is investigated. [C523]

"Detecting targets of variable acceleration with High Frequency Surface Wave Radar"

According to the conventional hypothesis, the velocity of target in the coherent integration time (CIT) is invariable in the application of utilizing high frequency surface wave radar to detect target. First, this paper proposes a more proper hypothesis in which the velocity and acceleration of target are treated as time-varying. However the acceleration of target can be regarded as invariable within the small fraction of coherent integration time. Then the model of echo signal in the hypothesis is analyzed. Considering the disadvangtages of some conventional methods of time-frequency analysis such as short-time Fourier transform (STFT) and Wigner-Ville distribution (WVD), the paper proposes the method of time-frequency analysis based on chirplets signal decomposition which can improve the time and frequency resolution simultaneously and solve the cross-term problem in WVD method. Firstly, we process the small fraction of coherent integration time with the chirplets signal decomposition. Then according to the differences between target signal and ocean clutter echo, the BP neural network classifier can be exploited to suppress ocean clutter. The different fractions of coherent integration time are composed together with the method of the nearest correlation. Lastly, the feasibility of the method for detecting targets of variable acceleration is proved by its processing the actual data. [C524]

"Lower bounds of moving target estimation in low frequency UWB SAR"

Lower bound of moving target estimation, in a multi-antenna channel ultra wide band (UWB) synthetic aperture radar (SAR) system is studied in this work. The main focus is to derive lower bound for systems having a very long integration time associated with position and velocity estimation, which is often connected to low frequency systems. Assuming a flat Earth model we consider the lower bound of the speed components in range and in the cross range direction. The estimation in cross range direction is associated with a considerable integration angle, and therefore the lower bound is determined in connection to a SAR process. It is found that the relative speed influences the covariance matrix of the clutter and therefore also the speed estimate. The influence increases the estimation performance of the relative speed and therefore also the performance of the cross range speed estimation. [C525]

"The effect of target presence in reference channel of bistatic noise radar"

The paper presents the effect caused by the presence of target echoes in the reference channel of bi- or multistatic noise or pseudo-noise radar. Most of the paper on multistatic radars assume that the reference signal is ideal one. In the case, when reference signal is received by directional reference antenna, it can be contaminated by echo signals originated from stationary target like ground clutter and also from moving targets in the vicinity of transmitter or receiver. The presence of the echo signals in the reference paths leads to the generation of false targets. [C526]

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

A classification technology is presented that uses a Wavelet based feature extractor and a Hidden Markov Model (HMM) to classify simulated and real radar signals from six classes of targets: person, tracked vehicles, wheeled vehicles, helicopters, propeller aircrafts and clutter (no match). Similar to techniques that have been well proven in speech and image recognition, the time-varying nature of radar Doppler data is exploited. The method classifies the targets by their different Doppler characteristics. The Wavelet technique has been tested on radar data where the classical signal processing methods failed. The purpose of this paper is to demonstrate the ability of Wavelet methods combined with a Discrete Hidden Markov Model (DHMM) in radar target recognition tasks. [C527]

"Moving target detection and velocity estimation using multiple subband DPCA and ATI method for triple-channel UWB SAR"

With long coherent processing time, the ATI method is suitable to detect moving targets with multi-channel UWB SAR system. However, the traditional ATI method will induce the blind velocity and the velocity ambiguity. Moreover, its detection performance will drop rapidly when the moving target signal is contaminated by the foliaged clutter. To overcome these shortcomings of traditional ATI method, this paper proposes a new multiple subband DPCA and ATI method for triple-channel UWB SAR. By applying a DPCA step before ATI, the introduced method can ldquosift outrdquo the interfering clutter from moving targetpsilas signal and alleviate the influence of clutter on the interfering phase. Moreover, the introduced method can detect moving targets without blind velocity and estimate their range velocities without ambiguity by combining the interferograms at different subband central frequencies. The validity of the proposed method is proved based on the experiments on UWB SAR real data. [C528]

"Strong complex echo removal in noise radar"

A continuous wave noise radar receives all the echoes simultaneously. Thus, strong echoes of nearby targets mask the weak echoes of far targets. Even if the echoes are separated in Doppler and in range, the strong echo produces relatively high sidelobes at the output of the correlation receiver. The sidelobes may prevent the detection of a weaker echo. Classical methods of strong echo removal, based on point scatterer model and successive subtraction of modelled strong echoes, may fail if the strong echo is not a single reflecting point. In the paper, a new method of handling a complex strong echo is introduced, along with computer simulation results. The proposed method is based on a joint modelling of a multipoint target echo. [C529]

"Fusion of FMCW secondary radar signal beat frequency and phase estimations for high precision distance measurement"

The accuracy of a radar operating in a multipath environment or in presence of strong clutter noise is mainly limited by the radar signal bandwidth. In the actual paper a phase evaluation concept is introduced that allows

for the estimation of the distance of a moving target with mm accuracy even under the above mentioned conditions. The concept is based on an algorithm that combines beat frequency and phase acceleration estimations. The paper will discuss the theoretical background of the approach and the performance of the concept will be illustrated by measurement results of a 5.8 GHz secondary radar system. [C530]

"Robustness of polarimetric detection algorithms against steering mismatches"

We analyze robustness of several multichannel radar detection algorithms to mismatches in the steering vector. In particular, we address the scenario of a staged detection, where a history of measurements provides the region of interest and a-priori polarimetric target signatures for a target. The four second stage detection approaches-optimally weighed span, Kellypsilas and Robeypsilas detectors, and Gerlachpsilas secondary data free detector-are considered using these polarimetric features. The evaluation based on recordings of real natural scenes and both real and artificially inserted extended objects concerns robustness of these algorithms to mismatches in the steering vector. It has been observed-for different ground clutter environments into which extended target is placed-that Kellypsilas detector provides the best detection but may suffer severely from the mismatch, Gerlachpsilas detector while allowing higher probability of false alarms, produces the most stable performance and Robeypsilas matched filter gives a suitable trade-off. [C531]

"Analysis of improved switching CFAR in the presence of clutter and multiple targets"

In radar signal processing distinction of false targets from real targets and fixing their rate in different radar environments is desirable. In this paper, the Switching Constant False Alarm Rate (SCFAR) processor has been improved in order to fix the false alarm rate not only in a homogenous environment only with thermal noise but also in a non-homogenous environment, consisting clutter edge and multiple targets. The equations have been achieved by assuming the targets in Swerling I and closed form. The simulation results confirm that the introduced processor can fix the false alarm rate in both homogenous and non-homogenous environment with less detection loss. In addition, this method is simpler in implementation compared with other samples ordering processors. [C532]

"Automatic target classification in a low frequency FSR network"

This paper presents the evaluation of a low-frequency forward scattering radar (FSR) network for the classification of ground targets. The experimental results of automatic targets classification for different operational frequencies are presented and discussed. The possibility of target recognition is shown for system operating frequencies in the VHF band. [C533]

"Matched NLFM pulse compression method with ultra-low sidelobes"

Pulse compression is a promising technique with advantages of high resolution and low peak power. Sidelobe levels are expected to be as low as possible to suppress strong clutters around the target. In this paper, a matched NLFM pulse compression method is put forward that uses Gaussian and sinc functions as the spectral density of the NLFM waveforms. Ultralow sidelobes below -60 dB are obtained with no loss in SNR. Simulation analysis of sidelobe suppression and the Doppler tolerance is presented. Simulation results and hardware implementation show the feasibility and applicability of the generated waveforms. [C534]

"Optimum detection of multiple targets by improved switching CFAR processor"

In radar signal processing, distinction of false targets from real targets and fixing their rate in different radar environments is desirable. In this paper, performance of improved switching constant false alarm rate (ISCFAR) in homogenous and non-homogenous environments consisting clutter and multiple targets in comparison of conventional CFAR processors is derived. The results of detection and false alarm relations of ISCFAR in all radar environments, homogenous and non-homogenous, shows the higher probability of detection with less detection loss in comparison with conventional CFAR processors. Also, simulation results confirm the achievement to an optimum detection threshold in homogenous and non-homogenous radar environment by the mentioned processor. The equations have been achieved by assuming the targets in the Swerling I and closed form. [C535]

"Performance of excision switching-CFAR in K distributed sea clutter"

In this paper a new CFAR detector which is composed of an excision processor and a switching-CFAR detector, in an environment with K distribution, has been introduced. The new detector is named an excision switching CFAR Performance of EXS-CFAR is derived and compared with the some other detectors like CA-CFAR, GO-CFAR and SO-CFAR for Swerling I target model in homogeneous and non-homogenous noise environments

such as those with multiple interferes and clutter edges. The results show that EXS-CFAR detectors considerably reduce the problem of excessive false alarm probability near clutter edges while maintaining good performance in other environments. [C536]

"An Improved Method for Tracking a Single Target in Variable Cluttered Environments"

Tracking moving objects in variable cluttered environments is an active area of research. It is common to use some simplifying assumption in such environments to facilitate the design. In this paper a new method for simulating the completely non-Gaussian cluttered environments is presented. The method is based on using the variable variance of process noise as a description of variability in such environments. The key objective is to find an effective algorithm for tracking a single moving object in variable cluttered environments, with utilization of the presented method. The new methodology is presented in two steps. In the first step we compare the accuracy of estimators in tracking a moving object, and in the second step, the goal is to find the best algorithm for tracking a single moving target in variable cluttered environments. [C537]

"Simulation of GPR returns from finite-length dielectric cylinders"

An approximate analytical solution for time-domain impulse response of low-contrast dielectric targets is derived. The Born approximation is used to calculate the scattered field. The detailed analysis is performed for a finite-length circular cylinder. The way of application of the obtained results to buried dielectric targets is proposed. [C538]

"Maritime target cross section estimation for an ultra-wideband forward scatter radar network"

Preliminary investigation has shown that a chain of buoy based ultra-wideband (UWB) forward scattering radar (FSR) transceivers could potentially be used to overcome clutter problems for the detection of small marine targets on the sea surface. As one stage of a more in depth system investigation, it was deemed that a thorough analysis of the forward scatter radar cross section (RCS) of typical small maritime targets is required for full understanding of the radar system performance. This paper describes the preliminary results of this study, through use of numerically simulated 3-D FS RCSpsilas of complex target models and comparisons with a proposed simplified analytical FS RCS description. [C539]

"Wind turbine clutter mitigation using fully adaptive arrays"

Doppler weather radar are susceptible to clutter contamination from both ground and airborne hard targets. Ground clutter can normally be mitigated through conventional filtering methods based on the assumption that the target is stationary. Wind turbines, which are becoming commonplace across the United States, are fixed in place but the blades rotate causing a significant Doppler shift in their signals. In fact, the blades rotate at such a rate to produce Doppler velocities on the order of 80 m s-1. The wind turbines vane into the wind and therefore the radial component of their motion is not known a priori. This so-called wind turbine clutter (WTC) is problematic because of its non-zero Doppler velocity and is known to cause significant artifacts in weather radar data. Here, the spectral signature of actual WTC from an S-band NEXRAD radar in the United States will be studied. Several examples will be provided proving the challenge in dealing with this interference. As a possible solution, adaptive phased array radars will be proposed as a concept for interference rejection. Sophisticated numerical simulations will be provided, which show the limitations and benefits of adaptive arrays for mitigating WTC. [C540]

"STAP I-Architectures and algorithms"

Space-Time-Adaptive Processing (STAP) is becoming an integral part of modern airborne and space-based radars for performing Airborne Moving Target Indicator (AMTI) and Ground Moving Target Indicator (GMTI) functions. STAP is an application of optimum and adaptive array processing algorithms to the radar problem of target detection in ground clutter and interference with pulse-Doppler waveforms and multi-channel antennas and receivers. Coupled space-time processing is required to optimally mitigate the Doppler spreading of ground clutter induced by radar platform motion. This tutorial will begin with the fundamentals of adaptive beamforming and radar pulse-Doppler processing, move through principles and application of STAP, and conclude with a brief overview of some advanced current research topics. Optimum STAP and a taxonomy of practical STAP architectures and algorithms will be described in depth. Key aspects of a practical STAP algorithm include the methods for estimating the background interference, proper subspace selection, and the technique for computing STAP filter weights. Algorithms for providing rapid convergence, robustness to clutter inhomogeneities, robustness to steering vector calibration errors, and reduced computational complexity will be described. The effect of STAP on subsequent detection and target parameter estimation algorithms will be discussed, with some emphasis placed on adaptive monopulse approaches for STAP radars. Simulation and experimental data will be

used to illustrate STAP concepts and algorithmic issues. [C541]

"STAP II-Advanced concepts"

Space-time adaptive processing (STAP) is an advanced signal processing methodology for the Ground Moving Target Indication (GMTI) mode of airborne and space borne surveillance radar systems. It is used to mitigate motion-induced spread-Doppler clutter that interferes with the echo from ground targets. The course will develop and clearly illustrate the GMTI problem from first principles, showing the need for STAP processing. Traditional STAP processing solutions will be derived from a detection probabilistic perspective-the most pertinent metric for radar. Additionally, the course covers state-of-the-art STAP techniques that address many of the limitations of traditional (ideal) STAP solutions, offering insight into future research trends. [C542]

"Tracking systems"

The tutorial is an overview of tracking and data fusion for surveillance systems with applications both to defense and civilian systems. It is divided into four parts: Part 1-Filtering: Covers the topics related to state estimation for stochastic dynamic systems: optimal Bayesian estimator, Kalman filter, nonlinear filters (extended and unscented Kalman filter, Gaussian sum filter, particle filter); filters for maneuvering motion (Interactive multiple-model filter); Crame-Rao lower bounds for filtering. Part 2-Data association: Due to the imperfections of a detector, the input to a tracking system may lack the target originated detections and often contains false detections (due to clutter). The data association component of a tracking system determines the origin of each input detection. The tutorial will cover techniques such as: gating, (global) nearest neighbor algorithm, (joint) probabilistic data association, multiple hypotheses tracking. In addition, the idea of using random sets for multi-target tracking will be introduced with a review of the PHD filter. Part 3-Distributed multi-sensor tracking: Modern surveillance systems typically consist of multiple sensors connected by a communication network for a data exchange. While the network surveillance offers potentially more accurate and reliable performance, there are many practical issues that need to be resolved beforehand. The tutorial will provide answers to problems: how to choose the multi-sensor architecture, how to avoid a repeated use of the same information, how to perform distributed track association and track fusion, how to ensure proper multi-sensor alignment in time and space. Part 4-Selected applications: The last part of the tutorial will cover several practical applications: ballistic missile tracking, GMTI radar tracking, tracking with hard constraints, angle-only tracking, tracking using TDoA measurements, track-before-detect, video tracking, tracking using an acoustic sensor networ- k, etc. [C543]

"Effect of wind on space-based radar performance"

This paper addresses the effect of wind on target detection performance using a space based radar platform. Forests and lakes are constantly being modulated by wind, which then affects the radar pulse returns by suitably amplitude modulating the temporal returns, thus affecting the Doppler. Billingsley has modeled the windblown autocorrelations using a real symmetric function that is the sum of a constant term and a ldquoCauchy density function typerdquo term. Using a rational system approximation on the Billingsley spectrum, it is shown that a sixth order rational model containing two damped sinusoidal terms and two exponentially decaying terms can duplicate the wind spectrum up to about -80 dB in the case of low wind speed. Each sinusoidal component in the wind spectrum generates an additional clutter Doppler component and the effect of damping is shown to generate a bundle of uncorrelated returns for each such frequency, with each uncorrelated return containing a coherent sum of signals. As a result, the degradation in performance when wind is present can be attributed to the coherent returns that can not be nulled out using standard adaptive processing techniques. [C544]

"Target and change detection in synthetic aperture radar sensing of urban structures"

Cross-correlation based image subtraction for detection of targets within an urban structure from synthetic aperture radar images is presented. In surveillance operations requiring re-imaging of the same scene, small displacements in array element locations may cause large phase and amplitude offsets. Subsequently, clutter will not cancel out, but will rather persist when subtracting two images, one without the target and the other with the target present. We propose a correlation-based robust technique that mitigates image offsets and rotations and is applicable to synthetic aperture radar urban sensing where the statistics are highly non-Gaussian. Simulation results demonstrating the effectiveness of the proposed technique are also presented. [C545]

"Theory and application of optimum and adaptive MIMO radar"

This paper develops the theory of both optimum and adaptive MIMO radar. It is shown that the optimum MIMO transmit-receiver pair consists of a coupled multidimensional eigensystem and whitening matched filter. Also introduced, is an design procedure for the clutter dominant case. After illustrating theoretical performance gains relative to conventional radar, we address the practical problem of adapting the transmit-receiver pair on-the-fly

when the optimization must address multiple possible targets and/or signal (input) dependent noise (e.g., clutter). The resulting architecture combines the orthogonal transmit waveform MIMO radar with the aforementioned coupled transmit-receiver design pair with adaptive estimates for the radar channel. [C546]

"Convex optimization and MIMO RADAR waveform design in the presence of clutter"

Waveform design for target identification and classification in MIMO radar systems has been studied in several recent works. While the previous works considered signal independent noise and found optimal signals for an estimation algorithm, here we extend the results to the case where clutter is also present and then we will find the optimum waveform for several estimators differing in the assumptions on the given statistics. Several different approaches to the optimal waveform design are proposed, including minimizing the error of MMSE estimator, minimizing the maximum error of the covariance shaping least square (CSLS) estimator and minimizing the MSE error of scaled least square (SLS) estimator. Choosing optimal waveform for MMSE estimator leads to the semi-definite programming (SDP) problem. Finding the optimal transmit signals for CSLS estimator results in a minimax eigenvalue problem. Finally it is shown that equal power waveforms are the best transmit signals for the SLS estimator. [C547]

"Optimal signals for MIMO RADAR in the presence of clutter"

Waveform design for target identification and classification in MIMO radar systems has been studied in several recent works. While the previous works considered signal independent noise and found optimal signals, here we extend the results to the case where clutter is also present and then we will find the optimum waveform for MMSE estimator. Choosing optimal waveform for MMSE estimator leads to the Semi-definite programming (SDP)problem, a convex optimization problem which can be efficiently solved through numerical methods. Explicit solution is developed for this SDP problem in two cases. In the first case, target and clutter covariance matrices are jointly diagonalizable and in the second one, signal to noise ratio (SNR)is sufficiently high. [C548]

"Radar signal detection using fractal analysis in K-distributed clutter"

Fractal theory has already been used in radar detection (Le et al., 1993). In this paper, a novel effective approach to detect target from K square clutter has been developed. The approach is based on the use of the fractal dimension estimated by box counting method. Based on this approach, the performance of fractal detector is compared with CA-CFAR detector. It is shown that it is possible to detect the presence of target by observing the fractal dimension of the radar returns especially when the signal-to-noise ration SNR is small. [C549]

"Target recognition and polarimetric SAR"

This tutorial presents a state-of-the-art survey of advanced applications of Synthetic Aperture Radar (SAR). Applications include: the detection and recognition of targets in SAR imagery, and the detection of targets under trees (and in the open) using change detection (coherent change detection, full-polarization change detection, etc). A fully polarimetric SAR sensor is described. Models of clutter and targets are developed from analysis of full-polarization SAR imagery. Algorithms for optimum (GLRT) processing of full-polarization data are derived, including the polarimetric whitening filter (PWF) and the polarimetric matched filter (PMF). Polarization-based discrimination features (polarization entropy, anisotropy, etc.) are developed and applied to SAR image terrain classification. Model-based and template-based target recognition systems are described and classifier performance results versus resolution and polarization are summarized for 10-and 20-target classifiers. Super-resolution algorithms are applied to SAR imagery and target recognition performance improvements demonstrated. Multi-polarization and multi-pass change detection algorithms are developed and demonstrated using UHF SAR imagery of targets under trees; fusion of multi-polarization coherent and non-coherent change detection algorithms is demonstrated. The effect of SAR image compression on change detection performance is quantified. Change detection performance using multi-pass VHF SAR imagery of targets under trees is demonstrated using data gathered by the Swedish CARABAS SAR system. [C550]

"Cognitive detector: A new architecture for target detection and tracking in complex environment"

A new target detection architecture, designated as cognitive detector, is proposed. This method aims at solving the problems arising from simultaneous detecting and tracking targets in various non-stationary and time-variant clutter environment. Image character of detection background and the scene analysis result, which is the information that hasnГ‚Вїt been exploited in any existing integrated detection and tracking system, can help adjust the detection algorithm adapting for the various background and add more information about the target/clutter for data association or tracking to enhance the systemГ‚Вїs performance. Cognitive detector partitions the radar detection scene using the statistical and image character of the detection background. Then, multipolicy detection algorithm and detection oriented data association method operate based on the former

output. At last, feedback structure between detection and tracking algorithm is used to optimize the detection policy. As describing the definition of cognitive detection and its operation processes, the paper focuses on the specific application of high frequency surface wave radar, for which the cognitive detector is rather well suitable. [C551]

"Analysis of EM scattering from electrically large target over 2-D sea surface"

The mechanism of composite scattering from complex electrically large target over the two-dimensional (2-D) randomly rough sea surface is researched based on the modified ldquofour-path modelrdquo. Kirchhoff approximation and the method of equivalent edge currents are applied to analyze the backscattering of the sea model generated with the Monte Carlo method and the electrically large target respectively. The issue of the coupling field between the target and the sea surface is solved with the principle of image. A model of the composite scattering from the complex target over the sea surface is proposed to analyze the affects of sea background to the scattering characteristics of the target. The EM scattering characteristics of the electrically large target in the sea clutter background is discussed with the numerical results. [C552]

"Moving Target Relative Speed Estimation in the Presence of Strong Stationary Surrounding Using a Single Antenna UWB SAR System"

This paper investigates how relative speed estimation of moving targets in synthetic aperture radar (SAR) images is affected by strong stationary surrounding clutter. The result extends previous work by estimating moving target relative speed under the influence of clutter and Gaussian noise. The results obtained show that good estimates can be obtained even in situations with relatively high clutter and noise, i.e. SNR and SCR lower than 10 dB. [C553]

"Difference-time processing characteristics in systems with pulsed noise censoring"

Systems of LFM radar signals coherent packet processing with pulsed noise (PN) censoring at the input of matched filter (MF) and frequency threshold (FT), provided low level of false alarm probability from signals, reflected from point moving clutter (PMC), are considered. Characteristics of moving target signals detection are obtained and values of false alarm rate from PMC in conditions of simultaneously influencing PN are determined. [C554]

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"An improved STAP algorithm by applying APES"

Over the past few decades, GMTI techniques have played an important role in the war. Recently, space-time adaptive processing, as one of GMTI techniques has shown the potential to adaptively cancel the clutter and has been widely used for GMTI radar. For advanced airborne radar system, it must be able to suppress undesired clutter, jamming, and thermal noise so as to detect targets. The problem is complicated due to the motion of the platform, as the ground clutter received by the radar is spread out in range, spatial angle, and also over Doppler. Traditional one-dimensional (1-D) processing strategy is insufficient for separating the moving target from ground clutter. In 1973, Brennan and Reed proposed space-time adaptive processing (STAP) method, which adaptively processes returns from multiple pulses and multiple channels (2-D) to attenuate interference power while preserving target power. Although STAP has good performance in clutter suppression, however usually large number of pulses and channels are required, it means that high computational load is unavoidable. This paper proposed a method by using Amplitude and Phase Estimation (APES) approach to improve the STAP performance without increasing the number of pulses and the number of channels, and in hence, without introducing high computational complexity. Simulations are presented to show the effectiveness of the method. [C556]

"MMSE based waveform design for MIMO radars"

Waveform design problem for MIcircldquoMO radars has been studied in several recent works. Although signal dependent noise (clutter) is considered in some works aiming to design waveform to improve target detection in MIMO radars, there are less works on waveform design problem for target classification and estimation in the

presence of clutter. Thus, here, we investigate this problem In contrast with previous works, our design leads to the convex optimization problem which can be efficiently solved through numerical methods and it can be guaranteed to converge to optimal solution. Optimal waveforms are found for two scenarios. In the first scenario it is assumed that different transmission antennas see uncorrelated aspects of the target and we consider the correlated target aspects (owing to the closed space anttenas) in the second scenario. Due to the interdependence of signal and clutter, target estimation error of the first scenario will not zero even if the transmit power tends to infinity, i.e., clutter power also increases by increasing the transmission power. This is the major problem in target detection and estimation in the presence of clutter in radars. We show that in the second scenario the MIcircldquoMO radar receiver can nullify the clutter subspace. Thus by increasing the transmission power, estimation error becomes zero in the second scenario. Waveform design for MMSE estimator under both scenarios, leads to the Semi-definite programming (SDP) problems. [C557]

"A Novel Adaptive Ground Clutter Removal Algorithm for High Range Resolution MMW Radar"

In this paper we present a novel adaptive ground clutter removal algorithm for high range resolution MMW-radar application where the dielectric contrast between the air and the ground material is close to or even higher than that between the target and the surrounding medium. Most of the ground clutter removal algorithms used nowadays, show weak performances in the case of a rough ground surface or suffer from high computation complexity. The algorithm presented in this contribution is capable to remove the ground clutter resulting from undulated surfaces by estimating not only the position but also the varying signal shape and enables a near optimal ground clutter reduction with a moderate computation complexity. [C558]

"Ranging error of ultra-wideband vehicle radar"

High range-resolution radar using ultra wideband radio attracts considerable attention as short range vehicle radar. Since it provides high range-resolution to the multiple scatters that constitute a vehicle target, range glint is improved and the ranging accuracy will be improved as compared with that of a low-resolution radar system. However there is no paper regarding the ranging error. In this paper we conducted the measurements and discussed the ranging errors for various bandwidths. [C559]

"Theoretical assessment of MIMO radar performance in the presence of discrete and distributed clutter"

We consider mitigation of clutter that is distributed in range and Doppler frequency for scenarios that have a difference in the direction-of-departure (DoD) between a target and a clutter patch at the same radar range. We demonstrate that efficient clutter mitigation can be achieved by a MIMO radar with a specific waveform set by (adaptive) non-causal beamforming of the transmit antenna under certain limitations on the total area in range and Doppler frequency occupied by all possible targets and clutter. [C560]

"Morphological operator and Empirical Mode Decomposition for clutter mitigation"

Maritime surveillance of the Exclusive Economic Zone (EEZ) is a present military and civilian challenge. The High Frequency Surface Wave Radar, as its coverage range is not limited by the radio horizon, is well-suited to fulfil this task. Effect of ionospheric clutter can, however, strongly limits target detection. Ionospheric clutter results from disturbance in ionization. In previous works we proposed using wavelets to remove the clutter. We are now considering another multi-scale analysis. Indeed, we wondered if an evolving basis could overcome the issue. Empirical Mode Decomposition (EMD) might offer such a possibility. The initial idea is still using multi-scale analysis to turn to good account the differences in variation scales of targets and ionospheric clutter. Apart from the fact that basis functions is self-determined by the EMD. We have also tried to associate morphological operators and EMD. We are presenting here the first results of our investigations. [C561]

"Removing ping timing ambiguity via data association"

This paper considers the use of a multiple ping active sonar approach in order to track multiple targets. In most underwater target tracking applications that rely on active sonar observations, the sonar sends out a single ping at each scan interval and receives returns that might either be from target(s) or due to clutter. We propose to use a multi-ping paradigm, with the idea that the better detectability of more pings can, assuming a high clutter density, lead to better localization of targets. However, this introduces a timing ambiguity in the ping returns adding a new level of complexity in the data association. In this paper we propose a multi-ping data association (MPDA) algorithm as a solution. MPDA formulates the assignment problem as a linear program, which could then be solved using a primal-dual interior point approach. A comparison is made between three different scenarios: (a) the sonar sends out a single ping in each scan interval; there is no timing ambiguity (which return is due to which ping), (b) the sonar sends out multiple pings within a scan interval and the timing ambiguity is

avoided by using orthogonal waveforms for each ping, (c) when the sonar sends out multiple pings, each ping being an identical waveform, within each scan, leading to a timing ambiguity. A well known multiple target tracking technique such as the JPDA is used in cases (a) and (b), while the MPDA algorithm is used to solve the assignment problem in case (c), and is shown to perform better than case (a) in high clutter densities. Case (b), the unrealizable bogey, performs best. [C562]

"Small targets detection in low resolution sea clutter"

A kind of EWNI method is proposed in this paper. It can decrease the detectable SCR of small targets contrasted with normal noncoherent integration. To suppress false alarms, MHT method is adopted to reach the le-6 Pfa. The scheme proposed in this paper is suitable for S band marine surveillance radar to detect small targets in sea clutter. [C563]

"Performance Analysis and Improved Method for Airborne Three-Channel SAR/GMTI System"

A new antenna arrange scheme and moving target detection method is presented after analyzing the shortcoming of conventional three-channel synthetic aperture radar (SAR) ground moving target indication (GMTI) methods. The shortcoming of conventional three-channel SAR/GMTI methods is that you cannot improve the performance of minimum detectable velocity, ambiguous speed and blind-velocities simultaneously to meet the requirements of the system. The improved method proposed in this paper solves the problem by rearranging the transmitting and receiving antennae without increasing the number of receiving channels. Theoretical analysis and simulation results show the validity of this scheme. [C564]

"MIMO radar detection of targets in compound-Gaussian clutter"

Multiple-input multiple-output (MIMO) radars with widely-separated transmitters and receivers are useful to discriminate a target from clutter using the spatial diversity of the scatterers in the illuminated scene. We consider the detection of targets in compound-Gaussian clutter fitting for example scatterers with heavy-tailed distributions for high-resolution and/or low-grazing-angle radars in the presence of sea or foliage clutter. First, we introduce a data model using the inverse gamma distribution to represent the clutter texture. Then, we apply the parameter-expanded expectation-maximization (PX-EM) algorithm to estimate the clutter texture and speckle, as well as the target parameters.We develop a generalized likelihood ratio (GLR) test target detector using the estimates and show the advantages of MIMO using Monte Carlo simulations. [C565]

"Subsurface Sensing of Near Surface Object Using Cavity Backed Slot (CBS) Antenna"

This paper presents a novel cavity backed slot (CBS) antenna for subsurface sensing applications. The CBS antenna is designed to be "matched" in the two-half-space configuration (one half space air; and the other ground) over a relatively wide frequency band. As a result, when attached onto ground surface, it is able to efficiently couple microwave power into and out of the ground. In this study, CBS antennas with operating frequency range [8.5 GHz, 13.6 GHz] are designed to detect objects buried in sand. Data acquisition is carried out using a sandpit with size (125 cm times 100 cm times 80 cm) as the test bed. One transmitting CBS antenna is fixed at the center of the sandpit and one receiving antenna is physically moved along a rectangular grid (i.e., multi-static measurement). An inverse synthetic aperture radar (ISAR) algorithm is adopted for inverse processing. A 4-inch-diameter metallic sphere is used as calibration target; and three targets are tested, including a 3-inch-diameter metallic sphere, a T-shaped copper target, and a landmine simulant. Imaging results are presented and compared with those obtained using horn antennas (which are not "matched" to the air-ground interface). Better signal-to-clutter ratios are demonstrated by the proposed CBS antennas. [C566]

"Enhancement of Along-Track Interferometry for Ground Moving Target Indication"

Along-Track Interferometry (ATI) for the indication of moving targets with two channel Synthetic Aperture Radar (SAR) shows a low detection probability for a small number of looks. This paper proposes an enhancement called Better ATI (BATI). It is characterized by a constant parameter added to the interferometric SAR image before determining its phase. Statistical analysis shows that the new technique significantly outperforms ATI, is comparable to Displaced Phase Center Antenna (DPCA) for homogeneous terrain and may outperform DPCA in heterogeneous terrain. The theoretical results are confirmed successfully with experimental data. [C567]

"Extraction of Forest Biophysical Parameters Using Polarimetric SAR"

There is a continual pressing need for the ability to produce accurate, quick and cost-effective forest inventories to assist with forest management and the development of ecological models. Canada Space Agency's recently launched Radarsat-2 offers the ability to significantly advance this field with its multi-temporal and fully

polarimetric C-band SAR capabilities. To explore the usefulness of C-band fully polarimetric data for modeling forest biophysical parameters, Convair-580 polarimetric C-band SAR data have been acquired over the Petawawa Research Forest in Ontario, Canada. An inventory of more than 1600 forest stands with information on species, age, canopy closure, height, stocking, basal area and volume have been obtained in order to determine which SAR parameters are most related to each of these biophysical parameters. The VV polarization, target anisotropy, ratios of the radar cross-section measurements and the order parameter of the K-distributed SAR clutter were found to consistently produce the strongest relationships. [C568]

"Moving Target Detection by Forcusing for Frequency Domain Algorithms in UWB Low Frequency SAR"

Moving target detection at low radar frequencies is associated with long integration time and has to handle azimuth focusing for reliable detection. The detection by focusing in which time-domain is the basis for the focusing approach has been proposed and successfully experimented in reality. The main objective of this paper is to apply and evaluate the detection method for frequency-domain algorithms. Range Migration Algorithm (RM) is chosen as a candidate for this study due to the accuracy of the algorithm with very wide integration angles. The simulated SAR data, which is used in this study, is based on the parameters of a airborne UWB low frequency system such as CARABASII. [C569]

"Target Detection in Multiple-Viewing Through-the-Wall Radar Imaging"

We present a constant-false alarm rate detection scheme for use in Through-the-Wall Radar Imaging. We consider multiple-viewing scenarios with an arbitrary number of vantage points. Classical detection theory is used to fuse the obtained radar images to one reference image. By doing so, clutter and noise artifacts which are strongly represented in the individual images are reduced and targets of interest are more clearly visible. [C570]

"Localization of Inanimate Moving Targets Using Dual-Frequency Synthetic Aperture Radar and Time-Frequency Analysis"

An important task in urban sensing applications is to accurately localize moving and vibrating targets in the presence of significant background clutter. A dual-frequency CW radar, which estimates the range of a target based on the phase difference between two closely spaced frequencies, has been shown to be a cost-effective approach for range estimation of a moving target. Previous work has shown that the use of Fourier transform and time-frequency analysis techniques provides an estimate of Doppler signature and enhanced signal-to-noise ratio (SNR), thereby enabling the range estimation of moving targets and significantly improving the estimation accuracy. In this paper, we consider the combined use of these technologies with a synthetic aperture array for the localization of inanimate moving targets. The synthetic array aperture provides the capability of high-resolution spatial localization of inanimate moving targets, as well as determining the orientation of the rotation or vibration. [C571]

"Computation of Optimum Azimuth Sampling Time for Dual-Channel DPCA System based on Signal-to-Noise Ratio"

This paper starts on the flow of moving target detection in dual channel DPCA system. Firstly the output power density spectrum of moving target and noise in DPCA system is analyzed, and the output SNR is obtained. Then the effect of synthetic aperture time of moving target's echo and azimuth antenna pattern on output SNR in DPCA is discussed in detail. Based on this effect, the paper deduces the expression which describes the variation of output SNR against synthetic aperture time in Dual-Channel DPCA system, where azimuth pattern is Sinc function, and the synthetic aperture time for optimizing the ability of detecting the moving target is obtained. Further more, this method of acquiring the aperture time can be applied for other antenna patterns. It is testified by processed result of simulated data that the relationship between output SNR and synthetic aperture time fits the above conclusion in Dual-Channel DPCA system. [C572]

"A Markov Chain CFAR Detector for Polarimetric Data using Adaptive Linear Discriminant Analysis"

The paper proposes a new Markov chain based CFAR detector for polarimetric data using adaptive linear discriminant analysis. The Markov Chain based CFAR detector extends traditional PDF based CFAR detection to first-order Markov chain model by considering both correlation between neighboring pixels and PDF information in CFAR detection. With the additional correlation information, the proposed approach results in advancing the performance of conventional CFAR detectors. Moreover, to take advantage of full polarizations of polarimetric data, the new polarimetric detector utilizes complementary features from full polarizations for target detection

using adaptive Fisher linear discriminant analysis. Our experimental results both show the superiority of the new Markov chain polarimetric CFAR detector over conventional CFAR detectors. [C573]

"On the benefits of space-time adaptive processing in FM ranging airborne radar"

Frequency modulated interrupted continuous wave (FMICW) waveforms can be used to resolve range ambiguities in pulse-Doppler airborne radar operation. The approach is usually associated with high pulse repetition frequency (PRF) modes where ambiguity resolution by means of PRF scheduling can be difficult. However, FMICW modes can broaden the Doppler bandwidth of clutter and therefore lead to reduced target detectability in clutter limited applications. This paper considers the implications of employing space-time adaptive processing (STAP) for clutter suppression in FMICW modes. It is shown that STAP can potentially provide benefits, but a planar array antenna, offering adaptive degrees of freedom in elevation and azimuth, is ideally required. [C574]

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

The noise existed in Synthetic Aperture Radar (SAR) image weakens the detailed features of region of interest (ROI) such as target and shadow. It also leads to the serious performance reduction of subsequent target detection, classification and recognition. The conventional regularization method could enhance target features in SAR image; however, the high computation complexity limits the real-time application of it. An improved regularization method is introduced in this paper, which increases processing speed of region feature extraction for SAR image significantly. It is theoretically proved that, by optimizing SAR projection operator, computation complexity could be reduced from O(M3N3) to O(MN) without ability losing of the region-based feature enhancement. MSTAR SAR image data is employed for algorithm experiment. The result shows that our method can increase target-to-clutter ratio significantly while restraining the noise in ROI, and then extract target and shadow from background clutters in SAR image more accurately. [C575]

"Moving Target Detection in along Track SAR Interferometry from In-Phase and Quadrature Components Data"

We show that using the in-phase and quadrature components of the two acquired images in AT-InSAR systems produces an increasing of the detection probability of ground moving targets for constant false alarm rates respect to the detection performance obtained with AT-InSAR conventional systems using only phase information. In this paper, we consider a Gaussian model for the moving target response. The improved performances of the proposed method respect to the interferometric phase approach are showed with numerical experiments on simulated data, and varying the signal to clutter ratio (SCR) and the target radial velocity. [C576]

"Doppler Parameter Estimation for Single-Channel SAR Moving Target based on a Novel Model in Complex Image Domain"

In order to characterize the signal of moving target in complex image domain (CID) of synthetic aperture radar (SAR), this paper deduces the model of moving target based on Range-Doppler imaging algorithm and stationary phase principle (SPP). In CID, the target approximately modeled as a linear frequency modulated signal (LFM), which has a great improvement in signal-clutter ratio (SCR), and distributes as mis-located segment in the 2D image. The center and slope of the segment is determined by the Doppler center and Doppler ambiguity integer. Meanwhile, the spreading length is jointly determined by the azimuth velocity and Doppler ambiguity integer. Furthermore, this paper derives the Cramer-Rao Bound (CRB) of parameter estimation in CID. At last, numeric experiments is made to approve the conclusion. [C577]

"Radar tracking of a move-stop-move maneuvering target in clutter"

In this paper we compare three different sequential estimation algorithms for tracking a single move-stop-move radar target in clutter. We consider optimal and suboptimal Bayesian estimation algorithms, with a special focus on particle filters (PF). The target is modeled using Markov Chains switching theory. Target maneuvers are defined by four different motion models: a stopped target model, a constant velocity model, an acceleration and a deceleration model. We analyze a realistic car traffic scenario by splitting the problem into two study cases. In the first case measurements are expressed in Cartesian coordinates, while in the second we address the problem of nonlinearity in the measurement model. Both cases are characterized by the presence of additive Gaussian noise and by a detection probability less than unity. In addition we are also interested in false measurements originated by high level clutter. The aim of this paper is to compare the so called IMM-PDA-ABF (interacting multiple model, probabilistic data association, auxiliary bootstrap filter) to the well-established Kalman-based PDAF (probabilistic data association filter) and IMM-PDAF (interacting multiple model,

probabilistic data association filter) tracking algorithms. Parametric and non-parametric sequential estimation procedures are also taken into account. Advantages and disadvantages of the proposed algorithms are illustrated and discussed through computer simulations. [C578]

"Tracking of ground targets with bistatic airborne radar"

Detection of moving targets in stationary clutter can be accomplished by STAP radar. In contrast to monostatic radar the performance of bistatic STAP depends strongly on the actual radar-target geometry. Even for sidelooking radar the clutter Doppler is generally range dependent which causes special problems in estimating the space-time clutter covariance matrix. For certain bistatic constellations clutter notches as appearing during track (i.e. areas of low probability of detection) may be considerably wider than in monostatic radar. The bistatic transmitter-receiver constellation has strong implications on ground moving target tracking, which is basic for producing a recognized ground picture as well as for analyzing traffic flows, identifying sources and sinks of traffic, or detecting lines of communication. Aspects of a bistatic GMTI tracking algorithm are described and some typical tracking results are given. Special emphasis is placed on a suitable modeling of the bistatic radar characteristics within the tracker. [C579]

"Multipath spread-Doppler clutter mitigation for over-the-horizon radar"

This paper discusses two adaptive spatial processing approaches that have been recently proposed for mitigating spread-Doppler clutter in skywave over-the-horizon (OTH) radar. The first is slow-time MIMO (SLO-MO) STAP which uses conventional waveforms that are phase-coded so as to be orthogonal after Doppler processing at the receiver, i.e. in ldquoslow-time.rdquo SLO-MO STAP is proposed as a means of mitigating transmit array sidelobes without costly redesign of legacy transmit or receive OTH radar hardware. The second approach is wavefront adaptive sensing (WAS) which uses a horizontally stratified ionospheric model to motivate a new application of blind source separation (BSS) methods for discriminating targets of interest from spatially distributed Doppler spread clutter. Comparison of these two approaches suggests they each may offer significant performance gains under different ionospheric propagation conditions. [C580]

"A MAP estimator for target position estimation in high resolution radars"

In this paper a MAP estimator is derived for target position estimation in high resolution radars where the events of backscatters, i.e., reflections, from extended targets and clutter are modeled as non-homogenous Poisson process. Performance of the proposed MAP estimator has been compared to that of the maximum likelihood estimator for the same model and also to that of the most commonly used peak picking estimators, namely, the maximum point and interpolation. Through simulations, it has been demonstrated that, in the case of having prior distribution information about real target range, MAP estimator significantly reduces target position estimation errors. [C581]

"Along track interferometry for foliage penetration Moving Target Indication"

Moving target indication radars for detection and tracking ground vehicles has received significant interest in the radar literature. However, when the vehicles are moving slowly and in foliage, microwave frequency radars such as X-band are not effective. Foliage penetration (FOPEN) radars using ultra high frequency (UHF) synthetic aperture waveforms have demonstrated consistent detection of stationary ground vehicles. In most applications, the vehicles are stationary to support wide angle, high resolution SAR processing. Along track interferometry (ATI) has been proposed for space based radars to detect moving targets due to the high velocity of the radar. This study will examine the target and processing requirements to detect slowly moving ground vehicles using ATI approaches. A detailed simulation of the target and clutter phenomenology is carried out to illustrate the effects of internal clutter motion and signal decorrelation effects on minimum discernable velocity. [C582]

"Moving target localization with multistatic radar systems"

In this paper we describe a method of processing data from a chosen area as surveyed by a multistatic system for the localization of a target. For this purpose data were acquired using the UCL netted radar and processed with two different incoherent approaches for localizing the target on a grid. The first is a centralized scheme and the second decentralized. Results are compared with two coherent approaches that for detection and coverage have been shown to provide the limits on the achievable performance. Numerical minimization of specific functions has to be applied when the estimated target location is used in a tracking algorithm, so we also report an easy and immediate method to localize one (or more) target which expands the domain of application. [C583]

"Heterogeneity detection for hybrid STAP algorithm"

Traditional STAP detectors require a secondary training data set that is target free and homogeneous with the cell under test (CUT). Hybrid detectors have been proposed for heterogeneous environments where the secondary data suffers from a statistical mismatch with respect to the interference in the CUT. These algorithms employ the generalised inner product (GIP) as a heterogeneity measure and eliminate the training data snapshots that are deemed heterogeneous. The GIP, however, does not take the presence of discretes or targets in the secondary data into account. If a target, or discrete, is present but sufficiently displaced from the signal of interest in the angle-Doppler plane, then it will not lead to any significant losses in the detection. Its presence, however, biases the GIP and leads to an undesirable rejection of the training data snapshot. This problem is examined in this paper where we propose the use of a projection-based statistic for heterogeneity detection. We show that this addresses the high target density problem. [C584]

"Performance of low-rank STAP detectors"

In this paper the STAP detector based on the low-rank approximation of the normalized adaptive matched filter (LRNAMF) is investigated for its false alarm probability (FAP) performance. An exact formula for the FAP of the LRNAMF detector is derived using the g-method estimator [4]. The non-CFAR behavior of this detector is shown via simulations using different models for the clutter-plus-noise covariance matrix. The detection probability is also evaluated, and the LRNAMF detector exhibits robustness in the presence of inhomogeneities consisting of interferers in the training data, for both non-fluctuating as well as fluctuating target models. [C585]

"Limits on the detection of low-Doppler targets by a High Frequency hybrid sky-surface wave radar system"

A high frequency (HF) radar system comprising a skywave transmit channel and surface wave receive channel is studied. Simple analytic expressions for the resolution of this radar system are determined by considering the spreading of radar signals in Doppler and angle during the ionospheric propagation. The detection of ocean surface targets within the patch of ocean surface illuminated by the radar beam is then determined by comparing the radar cross section of the ocean patch with typical vessel radar cross sections. It is shown that a hybrid sky-surface wave radar can detect low-Doppler ships down to 30 dBm2cross section during the day and down to 40 dBm2at night, during calm ionospheric conditions. During periods of spread F ionospheric turbulence, where the temporal correlation time decreases by an order of magnitude, the corresponding vessel detection capability decreases by two orders of magnitude. [C586]

"Direct, channel-to-channel clutter cancellation (DC4) with phase-interferometry in multi-channel SAR for detecting surface moving targets"

In a synthetic aperture radar (SAR) image of the ground, moving targets appear at locations different from their true instantaneous locations on the ground. In a corresponding interferometric phase image, all points on the ground nominally appear as a continuum of phase differences while the moving targets appear as discontinuities. By threshold comparisons within the intensity and the phase images, we (and others) have shown that it is possible to detect moving targets in the SAR. In this paper we show that the detectability of moving targets in multi-channel SAR is further enhanced by a direct, channel-to-channel cancellation of the fixed ground image, which acts as the clutter. [C587]

"Amplitude/phase approach for target velocity estimation in AT-InSAR systems"

Along track SAR interferometry (AT-InSAR) systems use more than one SAR antennas (typically two), mounted on the same platform and displaced along the platform moving direction. They are used to detect ground moving target. The information about the radial velocity of the moving target is estimated from the interferometric phase of the images. In this paper we show that exploiting not only the interferometric phase but both amplitude and phase of the two SAR images acquired with the AT-InSAR system the estimation accuracy can be sensitively improved. Moreover a closed form for the target radial velocity estimator and for the Cramer Rao lower bound has been derived. [C588]

"Real-time STAP hardware demonstrator for airborne radar applications"

This paper describes work carried out at QinetiQ to demonstrate real-time operation of space-time adaptive processing (RTSTAP) for airborne phased array radar, in a laboratory environment. RTSTAP processing is performed using field programmable gate array (FPGA) hardware and controlled via a MATLABcopy graphical user interface. The FPGA hardware is connected to the PACER (phased array concepts evaluation rig) antenna. The current realisation of the RTSTAP system employs 16 subarrays and 2 taps, i.e. 32 adaptive channels. It is tested against a number of frequency controlled sources placed in the field of view of the antenna to emulate an

airborne environment containing clutter and a target. [C589]

"Radar detection and angle estimation of over-resolved ground vehicles"

Traditionally, moving target indication (MTI) modes tailored to wide-area surveillance (WAS) have employed waveforms with bandwidths matched to the range extent of targets of interest. Matching range resolution to expected vehicle lengths serves to minimize interfering clutter returns while preserving available target power, thereby maximizing target probability-of-detection. Recent advances in waveform generator technology and high-speed digital signal processors for matched filtering have encouraged radar designers to consider wideband waveforms for WAS MTI needs. While providing information for identification and imaging, wideband waveforms complicate the detection process, as an extended target will be over-resolved; that is, returns from a vehicle will be distributed over multiple, fine-resolution range bins. Algorithms for combining these signal contributions are required for detection and angle estimation. Given such algorithms, one wonders whether over-resolving targets leads to detection and angle estimation performance losses as compared to narrowband operation. In this paper we evaluate methods for collecting energy from an over-resolved target for detection and angle estimation processing. We bound the performance of these techniques on typical ground targets and show that the probability-of-detection and angle accuracy is improved through the use of wideband waveforms at high signal-to-noise levels. [C590]

"Information-theoretic matched waveform in signal dependent interference"

The design of transmit waveforms is critical to the performance of a radar system. Traditionally, pulsed and wideband chirp transmit waveforms are used. Our focus here is on the design of waveforms matched to extended targets. In the literature, optimum transmit waveform design in additive receiver noise has been investigated both from SNR maximization and information-theoretic approaches. In this paper, we extend the information-based approach to the signal-dependent interference problem. In particular, we investigate the use of information theory to generate the optimum waveform matched to a Gaussian distributed target ensemble with known spectral variance in the presence of signal-dependent clutter. Several waveform design examples are shown. We also apply this waveform technique to a cognitive radar application. [C591]

"Detection and localization of high speed moving targets using a short-range UWB impulse radar"

This paper describes a detection and localization method for high speed moving targets using a short-range ultra-wideband (UWB) impulse radar. Equivalent time sampling impulse radar with an antenna array is used to transmit ultra short-pulse and receive the signal reflected from moving targets. A time domain multi-threshold detection method is proposed to detect the useful weak signal buried in noise while eliminating clutter resulting from stationary objects. Then a time difference of arrival (TDOA) based algorithm can be used to localize high speed moving targets. Simulation results show that a reliable detection using such UWB impulse radar can be achieved. [C592]

"Realtime Visual Tracking of Aircrafts"

Aircraft tracking has applications in guided landing, automatic scoring in aerobatics and target tracking for military. Radar based tracking is expensive, gives away the position of the radar and is prone to jamming. However, vision sensors are low cost, passive and robust to jamming hence motivating their use for aircraft tracking. This paper proposes a modified KLT tracking algorithm and tests its performance by tracking aircrafts. Vision based aircraft tracking is challenging because of the higher speed, agility and distance of the aircraft from the camera. The proposed tracker uses a feature clustering criterion to track an object based on its multiple local features. The local features are continuously updated to make the tracker robust to changing appearance of the object. The proposed tracker is generic and can be used to track multiple objects of any kind by defining multiple feature clusters. Experiments were performed on real data collected during the Air Race 2006 which will be made publicly available. The algorithm achieved accurate tracking in the presence of clouds and background clutter as long as the object size was comparable to the feature window. However, tracking failed at very small scales of the aircraft and in the presence of background clutter while the aircraft was flying low, a scenario where radars also fail. [C593]

"Performance analysis of a minimum selected cell-averaging CFAR detection"

In this paper, a new cell-averaging constant false alarm rate (CA-CFAR) detector based on minimum selected cell in sub-reference windows (SRW) is proposed. It takes the minimum cells in sub-reference sliding windows for rejecting some strong interferences or alleviating the clutter-edge effect surrounding the test cell, and then it uses the general cell-averaging technique to detect the target. Under Swerling II target fluctuating model, the analytic expressions of PFA, PD and the average detection threshold (ADT) of the proposed CFAR detector are

derived. By the performance comparison with other schemes through the simulation, it is found that the detection performance of minimum selected cell averaging (MSCA)-CFAR has a similar performance to that of OS-CFAR in nonhomogeneous background with strong interfering target. [C594]

"Dismount modeling and detection from small aperture moving radar platforms"

Future advanced radar systems must detect targets of diminishing radar cross section (RCS) at low radial velocity, in demanding clutter and interference environments. Presently, a deficiency in radar detection performance exists between the capabilities of synthetic aperture radar (SAR) for fixed target indication and space-time adaptive processing (STAP) for ground moving target indication (GMTI) of targets with low ground track velocity. Dismounts, individuals or groups running, walking, or crawling, constitute a class of targets that falls into this netherworld between SAR and STAP. While possessing low RCS levels and radial velocities, dismount detection is rendered even more challenging due to their complicated non-linear phase histories that give rise to significant micro-Doppler energies. In this paper we develop a physiological human-gait model for multi-channel moving radar platforms. We characterize the dismount detection performance of a notational UAV system using linear phase, quadratic phase and sinusoidal phase filters. Finally, we summarize our results and present areas of future work. [C595]

"STAP for airborne HPRF pulse Doppler radar: developing and testing of algorithm on both simulated and real data"

This paper present a STAP algorithm for an airborne high PRF pulse Doppler sensor based on clutter segmentation process that allows the inversion of a LN x LN matrix instead of MN x MN estimated on a single CPI (coherent processing interval). Since the radar works with the spectra of the received signals itpsilas possible to obtain the estimation of the covariance matrix simply eliminating from the CPI space-time data frame the Doppler bins containing the target. The computational reduction makes the algorithm possible to be implemented in a real time system. Results coming from both experimental data (air carry trials, test laboratory) and simulated one show good results in terms of clutter rejection and target enhancement. [C596]

"Precision GMTI tracking using road constraints with visibility information and a refined sensor model"

For detecting targets moving on ground, airborne ground moving target indicator (GMTI) radar is well-suited due to its wide-area, all-weather, day/night, and real time capabilities. The generation of GMTI tracks from these data is the backbone for target identification, ground surveillance as well as traffic flow analysis. The generation of precise and continuous tracks from GMTI radar plots often is a demanding task due to terrain and technical obscuration and clutter. The exploitation of non-standard background information such as road maps and terrain information is therefore highly desirable for the enhancement of track quality and track continuity. The present paper presents a Bayesian tracking scheme that incorporates digital road-map information and a model for the clutter notch of the GMTI sensor. The significant gain in track quality and track continuity is demonstrated in a number of simulation scenarios involving Doppler blindness and terrain obscuration. [C597]

"Impact of measurement model mismatch on nonlinear Track-Before-Detect performance"

The sensitivity of track before detect processing to the choice of clutter model in the measurement correction stage was examined through processing of real and simulated data containing radar echo returns of a small maritime target in sea clutter. The potential for achieving significant detection performance improvements by utilizing K and KA distributed clutter models in place of the simpler Rayleigh distribution was demonstrated through analysis of simulated data representing spiky sea clutter. In contrast, additional analysis using real data revealed that a more accurate clutter model does not imply better performance. Specifically, significantly degraded performance is observed when K and KA based processing is used in place of a Rayleigh based processor utilizing a simple likelihood limiting step to compensate for model mismatches due to sea clutter spikes. [C598]

"A new wall compensation algorithm for through-the-wall radar imaging"

The effects of velocity change, refraction and absorption all must be considered for through-the-wall radar, which can displace the target and defocus in imaging. Based on signal propagation model in presence of the wall and the system concept, the relationship is obtained among the transmit signal, target position and the wall transfer function. In this paper, we will present a method to estimate the wall transfer function using the real data and a new wall compensation algorithm based on the inverse system. The new wall compensation algorithm can eliminate the effects of unknown wall parameters very well, which is proved by processing real data

collected in a laboratory environment. [C599]

"SAR imaging using a modern 2D spectral estimation method"

Modern 2D spectral estimation techniques can be used for SAR imaging. The aim of those techniques is to improve the SAR image quality at the expense of an additional processing load. This paper focuses on applying the 2D minimum variance power spectrum estimation method (MVM) to SAR raw data. MVM process improves the image ISLR and reduces speckle noise. MVM was found to be particularly useful in SAR imaging geometries involving steep depression angles. Such geometries are characterized by high clutter interference, leading to poor contrasts between targets and the surrounding clutter. MVM process enhances the target to background contrast in such images. Parallel MVM process was demonstrated at Elta on a processing array. MVM images of 8000 by 8000 pixels are produced there in few minutes. Examples of MVM images are given and compared to conventional FFT based SAR images. Quantitative measures for ISLR improvement and speckle smoothening are given. [C600]

"PodSAR: A versatile real-time SAR GMTI surveillance and targeting system"

Synthetic aperture radar (SAR) and ground moving target indication (GMTI) systems from an airborne platform are in principle based on very simple concepts. The latter combines radar pulses over a short interval to extract Doppler information in order to detect ground moving targets against a clutter background. The former combines pulses over much longer intervals in a coherent manner to achieve very fine azimuth resolution. However, the many demands that are placed on such systems in terms of resolution, geolocation accuracy and coverage have led to the development of highly sophisticated algorithms. The ability to perform such complex processing in real-time on board the airborne radar platform presents significant computational challenges. This paper describes how a successful implementation of a real-time SAR GMTI system has been achieved with the QinetiQ PodSAR system. It describes the radar system that is mounted on a wide-bodied Andover aircraft. It discusses the design challenges that had to be overcome in order to achieve real-time processing for SAR and GMTI along with showing a number of examples of image exploitation techniques being developed using data from the PodSAR system. [C601]

"Recent results in MIMO over-the-horizon radar"

A demonstration of multiple-input multiple-output over-the-horizon radar is presented. Transmitter signal beam-forming on a multi-element array has been created, not conventionally before transmission at the transmitter facility, but, after radar signal transmission, skywave propagation, target scattering, return signal propagation, and reception using an over-the-horizon radar receiver. Transmitter beam-patterns have been created simultaneously from the signal received at two widely separated locations. The first is within line-of-sight propagation of the end-point of the one-hop ionospheric transmitter to target path, and the second from the signal received at the end-point of the two-hop ionospheric transmitter to target to receiver propagation path. These beampatterns are shown to be practically identical. They reveal the target radar return signal direction-of-departure at the transmitter. This example of a-posteriori transmitter beamforming suggests that it will be possible to create multiple simultaneous adaptive range dependent transmitter beams with an appropriately designed over-the-horizon radar. This has several applications including for the mitigation of Doppler-spread clutter. [C602]

"Estimation of the lateral target length by generalised power estimation: Clutter-free case"

Knowledge about the lateral target length may be useful in several applications such as convoy tracking and alerting a high resolution imaging mode for classification. We focus on the estimation of the apparent length of an extended target with particular emphasis on convoys of ground vehicles. The estimation is done by applying generalised power estimators to the output signals of an array antenna. These estimators take into account that the signal vector is random and characterised by a covariance matrix. A clutter-free environment is assumed. [C603]

"Image-while-scan results from the X-band Wideband Experimental Airborne Radar"

Defence Research and Development Canada-Ottawa has developed an experimental airborne radar referred to as the X-band Wideband Experimental Airborne Radar (XWEAR). The radar was designed to support research into SAR imaging of fixed and moving targets (ocean and land), time-frequency analysis of moving targets, clutter suppression for GMTI radar, and ocean surveillance for small and large target detection. Hence, the system is capable of collecting data in synthetic aperture radar, inverse synthetic aperture radar, ground moving target indication and maritime surveillance modes. In the following, a description of the experimental radar is given. Results from operation in an image-while-scan mode, whereby the system was operating in a maritime surveillance mode and Inverse Synthetic Aperture Radar imagery was produced from the data collected while

the antenna scanned maritime targets, are then presented. Finally, the paper summarizes with a discussion on the utility of performing ISAR while in a scanning surveillance mode. [C604]

"A robust CFAR detector in non-homogenous environment"

In this paper, a robust CFAR detector, composed of an automatic dual censoring algorithm and the cell averaging CFAR detector, is proposed for non-homogenous environment. The new detector is named an automatic dual censoring cell averaging (ADCCA). The proposed detector does not require any prior knowledge about the background environment and uses two threshold values to reject the unwanted samples in the reference window. The performance of the proposed detector is evaluated and compared with those of the CA, OS and ACCA-OVD CFAR detectors. The simulation results show that the ADCCA-CFAR detector not only provides low loss CFAR performance in homogenous background but also performs robustly in presence of interfering targets and clutter edge situations. [C605]

"A new approach to moving terrestrial targets recognition using ground surveillance pulse doppler RADARs"

In this paper we propose a new automatic target recognition algorithm to recognize and distinguish of three classes of targets: personnel, wheeled vehicles and animals, using a low-resolution ground surveillance pulse Doppler radar. Using the chirplet transformation, a time-frequency signal processing technique, the parameterized radar signal is then used by the Zernike moments (ZM) for the pertinent features of the targets. The current work provides a new approach for multiresolution analysis and classification of non stationary signals with the objective of revealing important features in noisy and cluttered environment. The algorithm is trained and tested on real radar signatures of multiple examples of moving targets from each class. The results shows the proposed algorithm invariancy against speed and orientation of the targets. [C606]

"Detection of snow clutter in ATC ground radar signal"

The use of adaptive techniques may prove useful in the processing of radar signals. The proposed radar clutter classificator is aimed to improve the detection of snow clutter presence in data acquired by a ground radar system in an air traffic control environment. The classifier receives as input a set of features which describe the appearance of the same plot in two consecutive scans of the ground radar. The feature set includes two group of parameters, which respectively represent the shape of the plot in each scan, and the displacement of the center of mass of the plot between the two scans. The data set used in simulations has been extracted from a measurement campaign carried out in presence of snow in Italian airports, with the help on an expert operator who manually classified a set of plots as target, or clutter. The performance of the classifier, a multilayer perceptron trained with the backpropagation rule, indicates a correct classification rate of about 98%. [C607]

"Classification of landmines using GPR"

This paper describes a study carried out into the discrimination and classification of anti-personnel landmines using the MINEHOUND GPR. Other techniques, well reported in the literature, are not considered in this study. The techniques investigated enabled the classification of landmines to be achieved on a restricted set of targets. The approach proposes a method whereby a library of radar signatures of landmines is acquired under controlled conditions and then used to classify unknown signatures. Initial results show that this method enables clutter targets to be well separated from landmine targets, with the exception of air voids, such as pipes. The technique offers the potential of a reduction in false alarm rate to 10% of the current performance. [C608]

"detection of multiple targets in non-Gaussian clutter"

Presence of interfering targets causes a significant loss in detection performance. In this study, detectors of multiple targets, which are located at the same range cell but have different Doppler frequencies, are developed. The clutter is modeled to have compound-Gaussian distribution. The detectors that are designed here can alleviate the masking problem by means of considering the existence probability of an interfering target and performing the estimation of the target returns, clutter texture parameter and Doppler frequencies accordingly. The performance analysis was done through simulations and it was shown that the methods enable the detection with high probability, even in the presence of a strong interfering target. Besides, it was shown that the performance loss of the multiple-target detectors in single-target case is insignificant unless the signal to clutter ratio is too low. [C609]

"Analysis of medium grazing angle X-band sea-clutter Doppler spectra"

Doppler analysis of radar sea-clutter is typically performed from a static cliff top location looking out to sea. This

constrains the grazing angle to low values and the radar look direction with respect to the wind. Current research at the DSTO is interested in the properties of sea-clutter at medium to high grazing angles, over all azimuth directions, full polarisation and different spatial resolutions. The sea clutter Doppler spectrum investigated in this paper was collected by an airborne platform and analysed using the three component Walker scattering model modified to include Doppler shifts from the moving platform. The modelling results enable the underlying Doppler spectrum and autocorrelation of the sea clutter to be estimated. This will enable future analysis into the performance of medium to high grazing angle target detection algorithms in the maritime environment. [C610]

"Waveform design optimization using bandwidth and energy considerations"

The problem of joint transmitter and receiver design for optimum output performance in the context of detection in the presence of clutter and noise is addressed here by maximizing the receiver output signal power to average interference plus noise ratio (SINR) at the specific decision instant. The receiver optimization leads to output SINRin terms of the transmit waveform, and transmitter optimization is further carried out subject to energy and bandwidth constraints. The new design proposed here leads to threshold constraints on transmit energy and the overall performance as a function of bandwidth is illustrated here for various target, clutter and noise scenes. [C611]

"Detection of known targets in Weibull clutter based on Neural Networks. Robustness study against target parameters changes"

The coherent detection of targets in presence of clutter and noise is considered in this study. Several clutter models are proposed in the literature, although the commonly used for sea and land clutter returns is the Weibull one. Our case of study involves that the target is known a priori, the clutter is Weibull-distributed and a white Gaussian noise is present. In this case, obtaining analytical expressions for the optimum detector is very difficult, so suboptimum solutions are taken as reference. One of this solutions is the target sequence known a priori (TSKAP) detector. This detector has several problems because it is designed for specific target and clutter parameters. So, in order to reduce these problems, a new solution is proposed, which is based in neural networks (NNs). The NNs selected are the MultiLayer Perceptrons (MLPs), which are able to learn from different environments. But, what does it happen if the radar (target or clutter) testing conditions are different of the design ones? In this case, a robustness study with respect to the target Doppler frequency is done for different radar conditions, which shows that the behavior of the proposed solution against this changes is better than the detector taken as reference, the TSKAP detector. [C612]

"Performance analysis of TM-CFAR detection in time diversity systems for pulse-to-pulse correlated targets in presence of clutter edges and outlying targets: A comparison through extensive simulations"

In automatic radar detection, performance of time diversity systems is proved to be sensitive to how the multiple-pulse sample echoes, from commonly encountered nohomogeneities, are accumulated within the same receiver. Based upon the ldquonon conventional time diversity systemrdquo(NCTDS), we derive exact expressions for the probabilities of false alarm and detection of a pulse-to pulse partially correlated chi-square target with 2K degrees of freedom for the trimmed mean constant false alarm rate (TM-CFAR) detector. Because of the complex mathematics induced by the ldquoconventional time diversity systemrdquo (CTDS), detection performance of this system is carried out using Monte Carlo simulations. The extensive simulation results show that, while the NCTDS achieves a better nonuniform clutter resilience than the CTDS, the latter outperforms the former in multiple target situations. Hence, when both nonhomogeneities are concomitantly present, the two systems performances become nearly similar. [C613]

"MLP solutions for approximating the Average Likekihood Ratio detector in radar applications"

Multilayer perceptron (MLP) based detectors are proposed for detecting Gaussian signals with unknown correlation coefficient (rhos) in additive white Gaussian noise. After proving the low robustness of the likelihood ratio (LR) based detector with respect to rhos, the average likelihood ratio(ALR) based detector assuming a uniform distribution of rhosin [0,1] is formulated. Due to the complexity of the involved integral, two NN based solutions are proposed. MLPs trained with target one-lag correlation coefficient (rhos) varying uniformly in [0,1] outperform the LR-based detector for a fixed rhos, when targets with rhosvarying uniformly in [0, 1] are considered for simulation. Two MLPs with 17 hidden neurons each are trained with rhosvarying uniformly in [0,b] and [b,1], respectively. Different values of b are studied: 0.25, 0.5 and 0.75. These three detectors outperform the single MLP, and the best results are obtained with b = 0.5 and 0.75. Finally, results show that the number of hidden units of the MLP trained with high values of rhoscan be reduced to 8, without reducing the detection capabilities. [C614]

"Multiple moving targets real-time detection in single-channel SAR using median filter"

With the development of hardware, the detection of ground moving targets with single-channel synthetic aperture radar (SAR) can be achieved by a relatively higher pulse repetition frequency (PRF). This high PRF can bring adequate amount of information, but it also expands the non-clutter spectrum which affects the precision of the real-time detection by the Doppler spectrum shifting methods. In order to make sure that the single-channel SAR can achieve real-time imaging and detection of moving targets, a new method based on former Doppler shifting methods is presented in this paper. First, we calculate the azimuth spectrum by Fourier transform in segments. Then, the median filter is introduced to eliminate the high-energy, narrow-spread spikes in the real data, which makes the whole procedure to be realistic and improves the location precision of moving targets significantly. In the end, we confirm the estimated Doppler centroids for the latter imaging and detection of moving targets. The corresponding flow of the whole system is also given in this paper. The effectiveness of this method is illustrated with the simulation results based on the real data. [C615]

"Stepped-frequency range profiling of multiple overlapped targets"

It is a challenging task all along for modern radar systems to detect and recognize multiple targets in heavy clutter. Stepped-frequency radar (SFR) can acquire high range resolution profiles (HRRP) to improve the performance of target recognition greatly. Moreover, SFR can suppress clutter by increasing the pulse repetition frequency (PRF) as well as decreasing the product of the pulse width and the frequency step. However, as PRF increases, range measurement becomes ambiguous, so multiple targets in the same formation will probably overlap each other along the range axis. Accordingly, this paper puts emphasis on solving this overlap problem, namely, estimating HRRP of each overlapped target. It firstly analyzes the special characteristics of the SFR echoes received under the condition of range ambiguity. Then, considering envelop-weighting modification and non-modification to each HRR cell, it proposes two estimation methods, the first of which is based on maximum likelihood estimation (MLE) and reaches the Cramer-Rao low bound (CRLB). Monte Carlo simulation results have verified the validity of the theoretical analysis. [C616]

"Switched order statistics CFAR test for target detection"

In this paper we introduce a new switched order statistics CFAR test (SW-OS) for detecting a radar target in the presence of nonhomogeneous clutter and/or multiple interfering targets situation. Whereas a switching CFAR test (S-CFAR) was recently proposed in the literature for addressing a similar background scenario, unlike the S-CFAR test, the test proposed here does not utilize the test cell statistic in classifying the cells surrounding the test cell as homogeneous or not. The SW-OS test has some similarity to the selection and estimation (SE) test, which was co-authored by the second author of this paper, but is simpler to design. Probability of detection performance results obtained for Rayleigh clutter and Rayleigh target indicate that the SW-OS performs nearly as good as an order statistic test (OS) in the homogeneous background condition and performs much better than OS under the presence of many interfering targets. When compared to S-CFAR, SW-OS performs slightly worse in the homogeneous background, but performs better under the condition of many interfering targets. [C617]

"Adaptive subspace detection of range distributed targets in compound-Gaussian clutter"

This paper addresses adaptive high resolution radar detection of range-distributed target embedded in compound-Gaussian clutter modeled as a spherically invariant random process (SIRP). Echoes backscattered from range-distributed target are modeled as a subspace random signal by using multiple dominant scattering models. At the design stage we resort to the so-called two-step GLRT-based design procedure and assume that a set of secondary data is available. A sub-optimal adaptive detector for range-distributed target is devised. Moreover, the analytical closed-form expression for the probability of false alarm of the proposed detector is derived. The proposed adaptive detector ensures fully constant false alarm rate (CFAR) property in SIRP clutter. Performance of the proposed CFAR adaptive detector is assessed through Monte Carlo simulations and is shown to have better detection performance compared with existing similar detector. [C618]

"A robust CFAR detection with ML estimation"

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

appropriate clutter statistics. It is shown that the new processor improves the radar detection intensively in nonhomogeneous environment. [C619]

"A false discovery rate based detector for detection of targets in clutter and noise"

This paper presents a new framework for detection of targets in clutter and noise. Conventional radar detection techniques involve testing each range cell separately at a predefined probability of false alarm. In this paper, we propose a novel surveillance paradigm that controls the false discovery rate (FDR) for a specified surveillance area (SA), which consists of a number of range cells. This approach is adaptive to the number of targets in the surveillance area, and improved detection performance may be achieved at the cost of slightly higher false alarms over the surveillance area. [C620]

"Efficient wideband processing without subbanding"

A new method for wideband spatio-temporal processing in the context of clutter mitigation and target detection is addressed in this paper. The frequency dependent, spatio-temporal steering vectors, are separated using a series expansion that depends on a sequence of Bessel function terms, and this is used to focus data vectors corresponding to various frequency components to a single frequency component. As a result, narrowband space-time adaptive processing (STAP) can be carried out on the focused data vector for clutter mitigation and target detection. [C621]

"High Range Resolution (HRR) profiling within low elevation search mode"

In this paper, we describe the high range resolution (HRR) profiling technique for generating the target range profile while the radar is in the low elevation search mode. The major advantage of this concept is reuse of the moving target detection (MTD) radar data for formulating the target range profile to provide the early target classification, discrimination, and identification (CDI) decision for all targets. This technique is developed for air missile defense pulse Doppler radar in which transmitting frequency is changing within the transmit pulse width. Here, we also discuss the effects of phase variation introduced by radial target motion and address how to compensate those effects. [C622]

"Estimation of the parameters of the K-distribution using Fuzzy Neural Networks"

This paper addresses a novel approach based on neuro-fuzzy inference system to solve the estimation problem of the K-distributed parameters. The method is based on a network implementation with real weights and the real genetic algorithm (GA) tool is applied for an off-line training of the fuzzy-neural network (FNN) shape parameter estimator. The proposed FNN estimator is based on the arithmetic and geometric means computed from the data in a manner which significantly reduces the computational requirements when compared to Raghavanpsilas and the maximum likelihood methods. The simulation results are presented to demonstrate the validity of the approach as well as the successfulness of the FNN estimator for low variances of parameter estimates when compared with existing MOFM (method of fractional moments) and ML/MOM (maximum-likelihood and method of moments) approaches. In addition, the method yields parameter estimates with lower computational complexity compared with standard techniques. [C623]

"Nonadaptive MIMO radar techniques for reducing clutter"

Multiple-Input, Multiple-Output (MIMO) radars enhance performance by transmitting and receiving coded waveforms from multiple locations. This paper describes how MIMO techniques can be used to improve radar performance, especially in airborne GMTI applications. A previous analysis of the clutter-to-noise-ratio (CNR) for stationary, surface-based MIMO radar is extended to the airborne radar scenario. Our analysis shows that MIMO airborne radars will have lower CNRs, resulting in smaller losses when observing stationary and low-velocity targets. We also address the implementation of MIMO radar modes using Electronically Scanned Arrays (ESAs). Herein, we show that implementing MIMO techniques within a subarrayed antenna can result in high sidelobes and/or reduced search rates. To address this problem, we describe how space-time waveform coding can be used to improve performance. Two space-time waveform encoding approaches are proposed: (1) an overlapped virtual transmit subarray approach, and (2) a beamspace MIMO processing approach. A third approach, involving conventional MIMO waveforms and irregular subarrays, is also briefly considered. [C624]

"Space-Time Adaptive Processing for noise-radar"

This paper presents a comparative study of space-time adaptive processing (STAP) methods, adapted to noise-like signals in general and digital video broadcasting-terrestrial (DVB-T) in particular. The advantages and disadvantages of each method are highlighted through the possibility of a multi-target detection among the

various kinds of interferences, either homogeneous or not. This study emphasizes the efficiency of the hybridization of both the joint domain localized (JDL) and the direct data domain (D3) STAP methods in the conception of a passive DVB-T-based multi-target bistatic radar. [C625]

"Innovative tools for radar signal processing Based on Cartan's geometry of SPD matrices & Information Geometry"

New operational requirements for stealth targets detection in dense & inhomogeneous clutter are emerging (littoral warfare, low altitude asymmetric threats, battlefield in urban area...). Classical radar approaches for Doppler & array signal processing have reached their limits. We propose new improvements based on advanced mathematical studies on geometry of SPD matrix (symmetric positive definite matrix) and information geometry, using that radar data covariance matrices include all information of the sensor signal. First, information geometry allows to take into account statistics of radar covariance matrix (by mean of Fisher information matrix used in Cramer-Rao bound) to built a robust distance, called Jensen, Siegel or Bruhat-Tits metric. Geometry on ldquosymmetric conesrdquo, developed in frameworks of Lie group and Jordan algebra, provides new algorithms to compute matrix geometric means that could be used for ldquomatrix CFARrdquo. This innovative approach avoids classical drawbacks of Doppler processing by filter banks or FFT in case of bursts with very few pulses. [C626]

"Ionospheric clutter mitigation with knowledge aided pre-whiten in High Frequency Surface Wave Radar"

Ionospheric clutter has proven to be the greatest impediment in high frequency surface wave radar (HFSWR). It influences most range bins, all Doppler bins and beams. Knowledge-aided ionospheric clutter mitigation using multiple coherent processing interval (CPI) data was described. The approach is based on estimation of the near vertical incidence clutter by past CPI data to provide improved knowledge of clutter statistics. Knowledge aided pre-whitening filter was used to cancel both near vertical incidence clutter and the range wrap clutter. Experimental results demonstrate that the algorithm is able to suppress the ionospheric clutter whilst preserving the desired characteristics of the target echoes. [C627]

"Enhancing GMTI Performance in Non-Stationary Clutter Using 3D STAP"

In side-looking ground moving target indication (GMTI) radar, the 2-dimensional (2D) space time (azimuth-Doppler) domain can adequately define a clutter spectrum which is accurate for all range gates. However, in applications where the array boresight is not perpendicular to the velocity vector (e.g. forward-looking radar), the azimuth-Doppler clutter spectrum exhibits a dependence on elevation angle-of-arrival, creating range-varying (but elevation-dependent) clutter statistics, or non-stationary clutter. Classical space time adaptive processing (STAP) algorithms suffer substantial performance losses in non-stationary clutter since classical STAP assumes clutter stationary along the range (training) dimension. Planar arrays are inherently able to observe the azimuth-Doppler clutter spectrum as a function of the elevation angle, a capability which linear arrays lack. The incorporation of the planar array's vertical dimension into the joint azimuth-Doppler (2D) STAP domain has previously resulted in 3D STAP. This paper demonstrates the ability of 3D STAP to solve the non-stationary clutter problem by accounting for the elevation-dependent clutter statistics in a 3D covariance matrix. A forward-looking array is used to provide non-stationary clutter, and the performance of 2D and 3D versions of the adaptive matched filter (AMF) and joint domain localized (JDL) are used in a close-in sensing paradigm. The results show a >55 dB improvement in output SINR near the clutter null using 3D STAP algorithms in lieu of 2D STAP algorithms applied to the same (subarrayed) data. [C628]

"Hitchhiking bistatic radar: principles, processing and experimental findings"

An experimental low cost bistatic hitchhiking radar has been developed at FFI utilizing the transmission of a civilian ATC radar. It uses off-the-shelf components in the receiver to produce close to real time traces of targets of opportunity. The processing enables positioning in 2D with good suppression of nearby clutter by continuously monitoring the clutter variation. [C629]

"Soft Decision M-Pulse CFAR Detection in Weibull Clutter"

CFAR detector is an essential component in any radar system. This component ensures that the system may not be overloaded by false targets. In the past it was common to model the interfering signal (clutter) in a radar system with a Rayleigh distribution. But as a progress in the radar systems, nowadays the Rayleigh model is insufficient, therefore some other models such as Weibull and lognormal are proposed and CFAR detectors for these models are developed through the papers. But majority of these proposed CFAR detectors are derived for

single pulse operation. When more than one pulse exists, it is proposed to use binary integrator to improve the performance. It is mentioned through literatures that binary integration leads to some losses. But alternative solutions are not discussed widely so much. In this paper we will introduce some soft rule for combining the statistic of different pulses in a single decision structure and will show out performance of this method in comparison with binary integration. [C630]

"Wavelets: a Versatile Tool for the High Frequency Surface Wave Radar"

Widely used in image processing, wavelets seem to be a promising versatile tool for the high frequency surface wave radar (HFSWR). HFSWR is based on the ability of HF waves (3 MHz to 30 MHz) to propagate along the earth curvature. HFSWR can detect targets up to few hundred kilometers beyond the horizon. The two main applications of the HFSWR are the maritime surveillance of the exclusive economic zone (EEZ) and the remote sensing of the sea. Beside the classical noise which affects all radar signals, the detection capabilities of HFSWR suffer from two limitations: the sea clutter and the ionospheric clutter which are target masks. However sea clutter can be used to perform remote sensing of the sea. In this paper we are studying how wavelets may contribute to the improvement of radar signal processing. We consider general de-noising feature for radar signals, we carry out a wavelet-based improvement of remote sensing of oceanographic parameters and we show the first results of a wavelet-based processing for ionospheric clutter mitigation. [C631]

"Maximum-likelihood based range-dependence compensation for coherent multistatic STAP radar"

We study the performance of space-time adaptive processing (STAP) applied to coherent multistatic radar. The radars we consider are passive (receive only) but are synchronized in order to allow coherent processing of the data among the different radars. One of the major benefit of multistatism is that the full velocity vectors of the targets can be measured. Furthermore, we study the feasibility of estimating the clutter covariance matrix, required to compute the STAP filter. We show that range-dependence effects cause the usual sample matrix inversion (SMI) scheme to fail and we propose a method able to cope with arbitrary multistatic geometries. [C632]

"Radar Scattering from Partially-Submerged Objects in Ducting Environments"

This paper describes the ducted ocean surface scattering integral equation routine (DOSSIER). DOSSIER is a numerically-efficient high-fidelity numerical model for calculating scattering from partially-submerged targets in ducting environments. The model is based on a hybrid 2D-3D integral equation formulation where the 2D formulation is used to propagate the radar energy to the target location, while the 3D model is used to calculate the backscattered field from the target and its proximity. The combined model effectively accounts for shadowing, multipath, and ducting effects on the effective target reflectivity in such a complex environment. [C633]

"Parameter Optimization for Load-Optimal Agile Beam Radar Tracking"

Parameter optimization for agile beam radar tracking is considered to minimize radar resources that are required to maintain a target under track. The parameters to be optimized include the track-revisit interval as well as the sequence of pairs of target signal strengths and detection thresholds associated with successive illumination attempts in each track-revisit. The cost to be minimized is the radar energy resources required per unit time over a given number of track-revisits. This formulation is compared to the optimization problem where the cost is the total radar resources required over a specified tracking period. [C634]

"Dynamic Logic Applied to SAR Data for Parameter Estimation Behind Walls"

Identifying and localizing targets within buildings using exterior sensors will offer superior advantages to the military and law enforcement communities. Research on wall-penetrating radar has produced significant advances in recent years regarding this topic. However, wall parameter ambiguities, multiple reflections, clutter, and measurement noise pose significant challenges to developing robust detection and estimation methods. In the present work we demonstrate can be mitigated using dynamic logic (DL), an adaptive method for iterative maximum likelihood. [C635]

"Adaptive detection of moving target based on velocity synthetic aperture radar"

By dividing a vector sampling at a specified pixel into three components, namely target, clutter, and noise, a novel parametric statistical model is proposed in the multi-channel and multi-look image domain of velocity synthetic aperture radar (VSAR). With the proposed parametric model, an adaptive moving target detection method is also obtained for VSAR, based on which the optimum improvement factors may be achieved. Furthermore, discussions are given for some VSAR systemic parameters. Some detailed numerical experiments

are provided to demonstrate the effectiveness of the proposed model and the parametric methods of target detection. [C636]

"Characterization of Zero-Doppler Clutter Removal Techniques for ISAR Applications"

Inverse Synthetic Aperture Radar (ISAR) processing is used to generate high-resolution images. This work considers an outdoor test range whereby the ISAR processing induces zero-Hz Doppler clutter (ZDC) effects which adversely impact image quality by either (1) masking actual target responses, or (2) inducing responses not directly attributable to target features. Techniques for removing adverse ZDC effects have been developed and are generally user dependant and/or target specific. This work aims to identify key ZDC reduction mechanisms and characterization metrics to be exploited for more generic applications. Two characterization techniques are considered: pixel-average percentage difference and image cross-correlation of pre-ZDC and post-ZDC processed data. The impact of data windowing is also investigated using various window widths and types. [C637]

"Track-Before-Detect of Multiple Slowly Moving Targets"

We describe a new approach for combining range and Doppler data from multiple radar platforms to perform multi-target detection and tracking. Increasing the number of sensors can cause data association by conventional means to become impractical due combinatorial complexity, i.e., an exponential increase in the number of target to signature mappings. If the azimuthal resolution is coarse, this problem will be exacerbated by the resulting overlap between signatures from multiple targets and clutter. Our approach avoids combinatorial complexity during data association by performing an efficient optimization in the space of all target tracks and mappings between tracks and data. The reduced computational complexity of our approach scales only linearly with increasing numbers of targets and sensors. As a proof-of-concept, a simplified (single-sensor, range-only) version of the algorithm is tested on experimental radar data acquired with a stretch receiver. These results are promising, and demonstrate a surprising degree of robustness in the presence of nonhomogeneous clutter. Also the full, multi-sensor, version of the algorithm is tested on synthetic data. These results demonstrate that very accurate tracks can be estimated by exploiting spatial diversity in the sensor locations. The algorithm appears to be robust in the presence of clutter and uncertain knowledge regarding the number of targets present. [C638]

"A Co-Channel Signal Detector Based on Phase Tracking for Pulse Doppler Radar"

Doppler processing is routinely applied to isolate targets from noise, clutter and interference in conventional pulse-Doppler radar. If a target is co-located in range and azimuth and has a similar radial velocity (co-channel) as another target (or interference), that target may not be detected. This is because only amplitude or power information is used in the detection stage, which does not provide sufficient information to discriminate co-channel signals from each other. In this paper we propose a detector which can resolve co-located targets (or target with interference) with similar Doppler frequencies. Instead of only using phase information for the coherent integration, our proposed detector tracks the phase modulation differences of the co-located, co-channel, targets. The amplitude information of the targets can also be estimated and forwarded to the tracker. One application of this method is HF radar where a target may have a Doppler frequency similar to a Bragg line-first order sea clutter. The Bragg lines are generally dominant at all ranges and exist in all directions. Conventional processing fails to discriminate when targets radar features are similar to the Bragg lines. Simulations of the proposed method show promising results that targets with Doppler frequencies near Bragg lines can be detected. [C639]

"MonoPulse Angle Measurement For An Airborne Side-Looking Phased Array PD Radar"

For airborne phased-array radar, target angle measurement generally utilizes monopulse method in sum (Sigma) and difference (Delta) beams. This paper discusses a monopulse angle measurement method in Doppler-domain, which compares the Doppler filter output amplitude of Sigma channel with that of Delta channel, and gets the angle bias by finding the angle bias-table of Sigma channel and Delta channel. And then get the positive or negative of the bias by comparing the phase between Sigma channel and Delta channel. Practical results show the effectiveness of this method. [C640]

"Nanosecond Gigawatt Radar: Indication of Small Targets Moving Among Heavy Clutters"

For indication of low-RCS targets moving among natural clutters, radars with short high-power transmitted RF pulses are known (Skolnik, 2001) to be advantageous over radars with relatively long broadband-coded pulses of the same energy. In accordance with the theory(Skolnik, 2001), an experimental X-band nanosecond-gigawatt-pulse radar proved to be efficient for detection, recognition and tracking of ~1 m2RCS planes, helicopters and motor boats moving within forest and sea clutters. Further upgrades of the radar are possible. [C641]

"Statistics of Clutter Residue in MTI Radars with IF Limiting"

In an MTI (moving target indicator) radar, when the received signal from clutter exceeds the IF (intermediate frequency) dynamic range, i.e., limits in the IF bandpass limiter, the radar literature states that good MTI performance cannot be achieved. Close examination of clutter sequences shows that when the dynamic range of the radar is exceeded, occasional large spikes of clutter residue do occur but good clutter rejection is obtained in most of the clutter cells. This paper provides insight into the cause of the spikes of clutter residue and presents the statistics of the residue for two-pulse, three-pulse, and four-pulse MTI filters. The percentage of clutter-limited cells with good MTI performance supports the conclusion that most of the clutter-limited cells do exhibit good MTI performance. The infrequent residue spikes have a distinct pattern at the output of the clutter filter that is markedly different from targets. With the insight of the time domain view, this paper suggests that false alarms can be avoided with the use of a binary detection scheme and that by using an m-out-of-n detection criteria, clutter rejection performance can be as good as that for linearly processed signals. [C642]

"Estimating instantaneous false alarm rate in a CFAR system by Bayesian and empirical Bayesian methods"

In this paper it is shown that the instantaneous false alarm rate in a constant false alarm Rate (CFAR) system fluctuates from scan to scan and that Bayesian and Empirical Bayesian estimators can be applied to decrease the error between the actual and the assumed false alarm rate. The instantaneous false alarm rate is a random variable and its probability density function is derived for different system configurations. Bayesian estimators are applied in cases where analytical expressions of the mean and variance of the instantaneous false alarm rate can be derived. The mean square error in the estimated false alarm rate is shown to be less than the mean square variations of the instantaneous false alarm rate. Empirical Bayesian estimators are introduced and applied to cases where statistical properties of the false alarm rate are unknown. Empirical Bayesian estimators rely on past data to estimate the current false alarm rate and it is shown that they will converge asymptotically to the equivalent Bayesian estimators as the amount of past data gets large. [C643]

"Affordable Naval Surveillance Radar Concept"

Current planned large surveillance radars for shipboard applications employing active aperture technologies are projected to be very expensive. The current planned radars for smaller ships, although less expensive, are limited in performance. This paper provides a new innovative naval surveillance radar architecture that promises to provide naval surveillance radars with high performance at lower cost. The radar uses a fairly inexpensive line array antenna for transmitting a broad beam and fairly inexpensive planar phased array antenna having digital beamforming in one dimension to form many narrow receive beams. The innovation is to rotate the antennas about 45 degrees on the ship relative to the local horizon so that the multipath and antenna sidelobes for most clutter and targets are minimized. For a mechanically rotating array, a transmitter can be located below deck and the transmission signal can be transferred through a passive rotary joint and passive line array antenna thus providing a simple low cost transmission system. On receive, the receive only phased array antenna can be fairly low cost and digital beamforming of multiple beams along the fan transmit beam can easily be accomplished. For non rotating radars, high power phase shifters would need to be employed in the transmit line array antenna to scan the beam. [C644]

"Signal Detection using the Correlation Coefficient in Fractal Geometry"

Using the Fractal Geometry in Signal processing has been extended nowadays. They have found several applications in signal detection and recognitions. They use the chaotic feature of the noise and clutter and try to distinguish between the noise, clutter and the desired target. Recent works show that lots of clutters like sea and ground clutters have fractal behavior so this kind of approach to the signal detection has been extended these days. In this paper we have used the Box-Counts of a signal rather than the Fractal dimension of a signal as will be defined later in the text. By applying the new defined concept we have developed different methods of signal detection. We use the correlation coefficient of the Box-Count and the time domain range for different ranges. By using the difference in the behavior of these coefficients when we have or don't have a target, we can set statistics from these variables and set up some detectors to determine whether the received signal contains a target or not just by comparing the statistics with some thresholds. One of the applications of the method is in high resolution radars. The received signal contains the Range Profile of the target which is unknown in our point of view. So using matched filters cannot be such helpful. In this paper the proposed detectors can act much better the common detectors of these signals. We have shown the advantage of the new methods. They bring us about 3 db increases in SNR. [C645]

"An Analysis of Measurement Derived Sea Clutter Simulations at Very Low Grazing Angles, in the Presence of Surface Based Ducting"

Sea clutter can have significant performance impacts on shipboard radar systems, particularly against low flying targets. It is essential to the evaluation of shipboard radar system performance, for engineers to have available very accurate sea clutter simulation models, which include the effects of anomalous propagation, as well as rough surface scattering, on the clutter return. In at-sea-tests, sea clutter returns from long ranges have been measured which are larger than the current sea clutter models have predicted. Not only do such large undesirable returns interfere with detection performance, but the presence of strong surface based ducting can result in extended range clutter folding, which may limit the usefulness of clutter mitigation approaches. The importance of the key parameter, grazing angle, in the computation of sea clutter cannot be overstated. Within the horizon the grazing angle is well understood, beyond the horizon grazing angle is a topic of considerable discussion (D.E., Barrick, 1998). The sensitivity of the sea clutter reflectivity models to grazing angle, within the context of trans-horizon ducted propagation is the focus of the issue being raised by this paper. In addition to the trans-horizon grazing angle issue, the difficult decision of selecting the height at which the propagation factor is modeled, is also discussed. [C646]

"Detection in Range-Heterogeneous Weibull Clutter"

The paper deals with detection in range-heterogeneous Weibull clutter. Heterogeneity is defined as a sharp transition from one homogeneous region to another with a different scale and/or shape parameter. The proposed method, firstly, tests the homogeneity of the window. If it is found to be heterogeneous, the transition point is estimated and the threshold is set accordingly. It is known that usual CFAR methods suffer from target masking or increased false alarm rate when operated in non-Rayleigh or range-heterogeneous clutter. The proposed algorithm is shown to perform well in homogeneous or heterogeneous Weibull clutter environment and yield better performance than commonly known methods. [C647]

"Traveling Ionospheric Disturbance Mitigation for OTH Radar"

Deflection of HF propagation paths by traveling ionospheric disturbances (TIDs) remains a troubling cause of coordinate registration errors for over-the-horizon (OTH) radar. Bandwidth and coverage limitations in ionospheric soundings preclude the ability to model TID structure in real time in most cases. It would be useful if TID-induced ray path deflections could be related to radar-measurable quantities like surface-clutter Doppler shift. In studying this possibility, we have considered the relationship between Doppler shift and range rate for point-to-point HF propagation paths in TID environments. The nature of range-rate/Doppler correlation is exposed in three ways: 1) simple theoretical modeling, 2) ray tracing in simulated TID environments, and 3) analysis of OTH radar measurements of a fixed beacon. It is shown that range rate and Doppler shift for fixed-endpoint propagation paths are usually proportional with a ratio that depends on whether ionospheric motion or density changes predominate in the TID environment. A mutual regression prediction of TID-induced range and azimuth ray path deviations based on ionospheric-induced Doppler shifts (as measured by surface backscatter returns) is shown to be an effective way of mitigating apparent wander of OTH targets due to TIDs. [C648]

"A Monte Carlo simulation for two novel automatic censoring techniques of radar interfering targets in log-normal clutter"

In this paper, we present two novel algorithms for automatic censoring of radar interfering targets in log-normal clutter. The proposed algorithms consist of two steps: removing the corrupted reference cells (censoring) and the actual detection. Both steps are performed dynamically by using a suitable set of ranked cells to estimate the unknown background level and set the adaptive thresholds accordingly. The proposed detectors do not require any prior information about the clutter parameters nor do they require the number of interfering targets. The effectiveness of the proposed algorithms is assessed by computing, using Monte Carlo simulations, the probability of censoring and the probability of detection in different background environments. [C649]

"One Base Station Approach for Indoor Geolocation System using RFID"

The proliferation of mobile computing devices and wireless geolocation networks has fostered a growing interest in location-aware systems and devices. Most technologies always use at least three base stations for computing the position of the target objects, including RFID (radiofrequency identification). This paper suggests a novel algorithm, using the RFID-system, to support one reader for localizing target tags amid the clutter of indoor interference environments, based on the metrics of the received signal strength and the time of flight. This algorithm attempts to specify the target tag among four-nearest neighbors as the four-reference tags, and adapt the weighted-center of gravity technique. The method provides a level of accuracy of about 1.07 m as the total error average of positioning 10-target tags in various interference environments that are generated on all sector-

functions. The total error averages of the 3-6 sectors functions are 1.18 m, 0.74 m, 1.6 m, and 0.78 m on one reader in an area of 12 m by 10 m. The effects of interference in the simulation indicated that the accuracy is better for the even-sector-functions as the input-signals' generator for this algorithm. [C650]

"Adaptive ML-CFAR detection for correlated chi-square targets of all fluctuation models in correlated clutter and multiple target situations"

The problem of adaptive CFAR detection of a pulse-to-pulse partially correlated target with 2 K degrees of freedom in a pulse-to-pulse partially Rayleigh correlated clutter and multiple target situations is addressed. The target and the clutter covariance matrices are modeled as first-order Markov processes. The probability of detection for the mean level (ML) detector is shown to be sensitive to the degree of correlation of the target returns and the degree of correlation of the clutter returns as well. [C651]

"Parameter Estimations of SAR Moving Target Based on DPCA-FrFT Algorithm"

The DPCA-FrFT algorithm is used in this paper to realize the localization and velocity estimations in both ground range direction and azimuth direction when it comes to a two-aperture radar system. The moving point target's echo model of two-aperture SAR system is established. Then, the linear frequency-modulated characteristics of moving target's DPCA signal is elaborated. According to this characteristics, fractional Fourier transform is adopted to detect the moving target and estimate parameters. Because of the good capability of DPCA technique for clutter cancellation and the nice effect of FrFT for chirp signal detection, the DPCA-FrFT algorithm can suppress the clutter and realize the localization and velocity estimations well in different signal-to-noise ratio conditions. The simulation results validate the effectiveness of this algorithm. [C652]

"An improved CFAR detector using wavelet shrinkage in multiple target environments"

In constant false alarm rate (CFAR) detection, the noise level in the cell under test (CUT) is estimated by combining the outputs of reference cells. In nonhomogeneous environments, estimator should be immune to the presence of nonhomogeneities among the reference cells. Here, we propose a wavelet CFAR detector that can automatically censors nonhomogeneities of reference cells. This detector is a combination of a pre-processor for denoising of input signal and a conventional CA-CFAR detector. The detection performance of WT-CA-CFAR processor is compared with the CA- and CML-CFAR detectors for homogeneous and multitarget situations. The results show that the WT-CA detector acts like the CA-CFAR in a homogeneous background and performs robustly in presence of interfering targets. [C653]

"Time-orthogonal-waveform-space-time adaptive processing for distributed aperture radars"

Distributed aperture radars represent an interesting solution for target detection in environments affected by ground clutter. Due to the large distances between array elements, both target and interfering sources are in the near field of the antenna array. As a consequence the characterization of both the target and the clutter is complicated, combining bistatic and monostatic configurations. Using orthogonal signaling the receivers can treat the incoming signals independently solving separately bistatic problems instead of the initial multistatic problem. Recent works have demonstrated the benefits of the use of frequency diversity space time adaptive processing for distributed aperture radars. This paper modifies the waveform diversity signal model, resorting to a time orthogonal signaling scheme, which does not present the coherence loss exhibited by frequency diversity. [C654]

"Submillimeter-wave active radar imager"

The authors have developed and demonstrated 3D imaging using a submillimeter-wave FMCW radar with a fast microwave chirp and phase coherent detection. The technique provides an important advantage over more traditional CW RF imaging in that time gating of the return signals allows optimization of the received scene illumination or specific depth reconstruction. This can be used to enhance (or hide) specific objects or greatly reduce background clutter. The system was initially prototyped with available RF components near 600 GHz and a 12.6 GHz chirp producing a 250 MHz/msec sweep yielding a range resolution of 1.2 cm. Lateral resolution on the scene is set by a 20 cm diameter Teflon lens antenna producing approximately 2 cm at 4 m distance. The RF transmit power (generated by a W-band power amplifier and an in-house frequency multiplier chain) is less than 0.5 mW but when coupled with a heterodyne downconverter (in-house developed fundamental balanced Schottky diode mixer, 4000 K DSB noise temperature) yields a measured dynamic range of more than 70 dB. A more compact and higher resolution system is currently under construction and will employ an 18 GHz msec sweep rate microwave chirp for sub-cm range resolution, a 40 cm reflector and a higher power transmitter, dramatically increasing resolution and dynamic range. The talk will cover the system design and some early results we have obtained on test targets at 4 m. [C655]

"A 94GHz FMCW instrumentation radar"

We report on the use of a versatile 94GHz FMCW instrumentation radar to assess optimum hardware configurations for a variety of co-polar and cross-polar target classification studies. Phase noise and sweep linearity are critical parameters in FMCW radars and optimising them is a key objective of any high performance radar system. We have made a systematic comparison of fundamental sources (bias tuned Gunn, varactor tuned Gunn) and multiplied sources (commercial YIG based sweeper, YIG tuned oscillator, permanent magnet YIG tuned oscillator) to ascertain their relative phase noise contributions and FMCW sweep linearities at 94GHz. The radar will also be used to investigate the effect on target return signal coherence as a function of time for different sources. We present details of the calibration against the radar range equation and the effects of variable sweep bandwidth (and hence range resolution). The radar can also be configured for arbitrary polarisation (V, H, +45, -45, RC, LC) and demonstrates high polarisation isolation (33dB) which is required for the accurate assessment of cross-polar radar cross section (RCS), and we will present preliminary results for standard targets and clutter. [C656]

"Waveforms in virtual tomographic arrays"

Distributed sensing systems incorporating RF tomography allow a trade-off between spatial and spectral diversity, however a large number of widely spaced sensors is conventionally thought to be required. A practical method of reducing the number of sensor nodes is introduced via the concept of the virtual tomographic array. Furthermore, the geometry of this virtual array is electronically reconfigurable. Optimal resource allocation is accomplished instantaneously, with dynamic control based upon matching sensing modalities to site specific target and clutter observables. [C657]

"The benefits of matched illumination for radar detection of ground based targets"

This paper compares the radar detection performance of a narrow band rectangular pulse, linear chirp and nonlinear stepped frequency waveform approximating to a matched target illumination against two target types (a farm tractor and a main battle tank) in the presence of clutter (soil/sand, rocks and woodland). [C658]

"Varying FM rates in adaptive processing for distributed radar apertures"

Previous work in waveform diversity for distributed apertures for target detection has focused largely on orthogonal transmissions. This paper investigates an alternative approach; implementing waveform diversity based on differing slopes of the linear FM pulse to the application of target detection for a distributed radar aperture system in the presence of noise and clutter. This paper add develop the required signal model corresponding to the proposed system, accounting for the cross-coupling between the linearly FM pulses. This paper determines whether applying this type of waveform diversity will result in improved performance in the discrimination of the target from noise and interfering sources and compare the performance whether this method is a feasible solution. A crucial step is the optimization of the FM rates using sequential quadratic programming. [C659]

"Long-Range Target Classification in a Cluttered Environment Using Multi-Sensor Image Sequences"

Visual surveillance has been an active research area in computer vision and image processing, due to its crucial role in helping military intelligence and law enforcement agencies to fight against crime and terrorist activities. The goal of a visual surveillance system is to detect abnormal object behaviors and to raise alarms when such behaviors are detected. After moving objects are detected, it is essential to classify them into predefined categories, so that their motion behaviors can be appropriately interpreted in the context of their identities and their interactions with the environment. Consequently, object classification is a vital component in a complete visual surveillance system. RADAR (Radio Detection and Ranging) images are often undesirable in military applications because they reveal the location of the imaging system. So we explore visible and infrared images of ships which are generally more consistent than RADAR images and for which it is easier to compensate for environmental effects. Recent advances in visible and IR imaging technology improves its ability to observe objects at very long distances, but it is still militarily desirable to stay away as far as possible from potential enemy ships, which may be observed at different viewing angles. Several methods have been described in literature to perform the automatic classification of big ships (e.g. aircraftcarriers, combat ships, transportation ships, etc) from images, but none of them are based on small boat classification. A Principal Component Analysis (PCA) based target classification system is implemented for visible and IR small boat images which are captured in a highly cluttered background environment. Two robust segmentation algorithms were implemented,

Graph-cut for grayscale IR small boat images, and Adaptive Progressive Thresholding (APT) for visible small boat images. These algorithms are tested for images captured in a highly cluttered background. [C660]

"De-cluttering with Integrated Probabilistic Data Association for Multisensor Multitarget ACC Vehicle Tracking"

In the field of automotive environment perception, the state estimation problem of other road users with sensors like video, radar, lidar, or combinations of them has been solved for years now. However, driver assistance systems like ACC are only available for restricted environments like highways and rural roads today. Especially in complex environments, the uncertainty of target existence induced from missing and false detections becomes the dominating error source. Traditional approaches for track verification are rule based systems and trained classifiers. In this contribution, we present an automotive application of the integrated probabilistic data association (IPDA) filter superseding additional validation modules by modeling the probabilistic knowledge about both, state and existence, as temporal Markov chains and computing filter estimates for both issues. The temporal evolution and measurement update models for state and existence estimation are presented for the vehicle tracking problem as well as results from a sensor fusion setup with video and multibeam lidar. [C661]

"Antenna Array Detection in Highly Cluttered Environment Using Time Reversal Method"

This paper concerns a method of target detection in a cluttered environment where a significantly large number of highly reflective scattering objects exists. With the conventional Radar detection, the detection of a target additional to this highly scattering environment would suffer greatly in their detection dynamic range. In this paper, we present a novel time reversal method that enables automatic destructive interference of the field-probing electromagnetic wave on the reflective scatters of the environment such that the cluttered environment becomes virtually transparent. The experiment in lab tree-scattering environment demonstrates that this time reversal clutter-nulling scheme substantially enhances the detection dynamic range and the signal-to-noise ratio, significantly raising target detectability. [C662]

"Retrodirective Radar for Small Projectile Detection"

Retrodirective systems are of growing interest because of their unique functionality and relative simplicity compared to phased-array and synthetic-aperture approaches. Retrodirective communications has been investigated the most and is now emerging in commercial systems. Retrodirective radar is a more recent development, starting with basic research on retrodirective noise correlating radar (RNC). This presentation summarizes recent research on a much more robust retrodirective radar approach that provides the wide search and autofocus capabilities of the RNC radar, but with far better capability to measure the bearing of small, fast-moving targets in the presence of clutter. [C663]

"Synthetic Aperture Radar Ghost Image Cancellation Using Broadband Time Reversal Averaging Techniques"

In this paper, we present a time reversal averaging scheme for removing ghost images which occur in synthetic aperture radar (SAR) target imaging in a rich scattering environment. In the highly cluttered environment, the ghost images due to secondary scattering significantly deteriorate the quality of conventional SAR image. The time reversal (TR) method enables focusing on the target, significantly enhancing signal-to-noise ratio. By averaging TR-SAR images produced using different probing angles, the target image is coherently enhanced and the ghost images due to secondary scattering are significantly reduced. The effectiveness of the scheme is demonstrated via both computer simulation analysis and experimental measurements. [C664]

"Doppler-Polarimetric Approach to Microwave Remote Sensing of Precipitation"

This study has shown that considered Doppler and polarization parameters of radar signal contain information on rain microstructure and turbulence intensity in weather object. The differential Doppler velocity of raindrops carries the important information on microstructure of rain and can be used in order to measure the rain intensity. However turbulence decreases this effect and should be taken into consideration as well. Application of independent turbulence-related variables can improve the reliability and accuracy of radar measurements in rain. Measurements of weather objects by Doppler-polarimetric radar can be very useful to solve wave propagation problems for the tasks of microwave remote sensing, communications and the radar's ability to detect targets embedded in high clutter background. [C665]

"Electromagnetic Diversity and EMI Implications for Multiple Co-sited Radars and Targeting Applications"

Real-time fusion of data collected from a variety of co-located radars that acquire information in a cooperative manner from multiple perspectives and/or different frequencies, is being shown to provide a more accurate and effective way of tracking complex targets in a multi-target scenario. This is more advantageous than employing a single radar or a group of radars operating independently. This paper describes a cooperative multi-sensor approach in which multiple radars operate together in a non-interference limited manner. A three-fold approach is presented: (i) applying multiobjective joint optimization algorithms to set limits on the operational parameters of the radars to preclude electromagnetic interference; (ii) measuring and processing radar returns in a shared manner for target feature extraction based on electromagnetic diversity principles in conjunction with target scattering cross sections; and (iii) employing feature-aided track/fusion algorithms to detect, discriminate, and follow real targets from clutter noise. The results of computer simulations are provided that demonstrate the advantages of this approach. [C666]

"Polarization Diversity for Detecting Targets in Heavy Inhomogeneous Clutter"

Polarization diversity has proved to be a useful tool for radar detection, especially when discrimination by Doppler effect is not possible. In this paper, we address the problem of improving the performance of polarimetric detectors for targets in heavy inhomogeneous clutter. First, we develop a polarimetric detection test that is robust to inhomogeneous clutter. We run this polarimetric test against synthetic and real data to assess its performance in comparison with existing polarimetric detectors. Then, we propose a polarimetric waveform-design algorithm to further improve the target-detection performance. A numerical analysis is presented to demonstrate the potential performance improvement that can be achieved with this algorithm. [C667]

"Target Detection Using HF Radar Data"

High frequency (HF) radar systems have a potential to detect targets which are located beyond the optical horizon on the sea surface. Unfortunately sea clutter may be strong enough to prevent such detection. In this work we present results of applying space-time adaptive processing (STAP) to this problem. Real, registered signals were used for numerical experiments. [C668]

"CFAR Matched Detector of Signals in Autoregressive Noise"

The generalized likelihood ratio test (GLRT) for detecting a target signal in autoregressive (AR) noise whose covariance matrix is unknown is presented. We proposed a new constant false alarm rate (CFAR) matched detector whose structure does not depend on noise covariance matrix and level and its performance penalty is small. The evaluation of its performance shows that the loss measured with respect to the corresponding optimum structure with known noise covariance matrix is kept within a few dBs. [C669]

"Maximizing Detection Performancewithwaveform Design for Sensing in Heavy Sea Clutter"

In this paper, we consider a radar system capable of adaptively adjusting its transmitted waveform to mitigate the effect of the environment and improve detection performance. We thus bring the potential of waveform agility to bear on the challenging problem of target detection in heavy sea clutter. Using a two-stage procedure, we first estimate the statistics of the sea clutter in the vicinity of a predicted target. A phase-modulated waveform is then designed and transmitted so as to maximize the generalized likelihood ratio at the predicted target location, thus improving the signal-to-clutter ratio (SCR). Employing the compound-Gaussian (CG) model, we exploit a subspace-based approach to further mitigate sea clutter and deliver improved detection performance. Simulations illustrate the effectiveness of our method. [C670]

"Experimental results on moving target detection by focusing in UWB low frequency SAR"

The main objective of this paper is to present and evaluate a method to detect moving targets in Ultra Wideband (UWB) low frequency Synthetic Aperture Radar (SAR). Moving target detection at low radar frequencies is associated with long integration time and has to handle azimuth focusing for reliable detection. The examined method tests different hypotheses on relative speeds in the area of interest. The optimum step size between the hypotheses is found from a point target approximation. Experimental results show that the ability to detect moving targets increases significantly. In this study, the improvement of the Signal-to-Clutter Noise Ratio (SCNR) is up to approximately 20dB using a single antenna. The focusing method allows initial estimates in speed of moving targets. The SAR data, which is used in our experiments, was collected by the airborne UWB low frequency CARABAS-II system. [C671]

"The effect of land clutter statistics on automatic gain control"

Modern radars are rarely able to sample the full dynamic range of observed land clutter. Therefore designers

must employ gain control to make best use of the receiver hardware. This paper considers suitable land clutter models for use in the development of automatic gain control for high-resolution radar. The clutter statistics observed by the radar also have an impact on other areas including detection and target classification, but this paper concentrates on the problem of controlling the front-end gain of the radar receiver. [C672]

"Maximum likelihood CFAR for lognormal clutter with censored samples"

In this paper the structure of Maximum Likelihood (ML) CFAR for lognormal clutter is derived assuming that some reference samples are censored to avoid destructive effect of interfering targets. It is shown that under some acceptable approximations we will achieve in a simple structure for this detector which is suitable for real time processing. The proposed detector is compared with non censored ML CFAR (i.e. logt CFAR) via simulation. It is shown that while the proposed detector is a little weaker than logt CFAR in homogeneous clutter, in non homogeneous clutter it outperforms the logt CFAR. [C673]

"GLRT based adaptive detection for MIMO radars"

In this paper, the problem of adaptive target detection using temporal coherent pulse train in presence of clutter is considered for MIMO radars. We have formulated this problem as a hypothesis test. For clutter with unknown statistics two adaptive decision rules have been developed using two-steps generalized likelihood ratio test (GLRT). The performances 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. [C674]

"Performance of multichannel parametric detectors with MCARM data"

We consider the problem of detecting a multichannel signal in the presence of spatially and temporally colored disturbances. The parametric Rao and GLRT detectors, recently developed by exploiting a multichannel autoregressive (AR) model for the disturbance, have been shown to perform well with limited or even no range training data. In this paper, we evaluate the detection performance of the parametric Rao and GLRT detectors using airborne radar data obtained from the Multi-Channel Airborne Radar Measurement (MCARM) database. The data contain typical clutter found in airborne radar systems, and cover a variety of scenarios including dense-target or heterogeneous environment. Experimental results with the MCARM data show that the parametric Rao and GLRT detectors can provide good detection performance with limited or even no range training data in real radar environments. As such, these detectors offer useful solutions to detection problems in dense-target or heterogeneous environments. [C675]

"Optimisation of bistatic HF surface wave radar configurations"

HF surface wave radars are increasingly being deployed in bistatic configurations, usually via the mechanism of overlapping the coverage of two monostatic radars and sharing signals, but sometimes as intrinsically bistatic radar designs. In either case, the advantages which may attach to bistatic scattering geometries may easily be compromised by suboptimum positioning of the transmitting and receiving systems. Here we address the problem of finding the optimum spatial configuration for a given palette of radar missions, taking account of target signatures, clutter, noise, propagation and geographical constraints on the siting of the radar facilities. [C676]

"Moving target detection for synthetic aperture radar via shadow detection"

In this paper a novel technique is presented for detecting moving targets in SAR imagery by tracking the shadow of the target over multiple looks instead of using the target direct energy return. Unlike the SAR image of a moving target that is blurred and displaced, the shadow of the target is displayed at the true target location. The detection performance using shadow is primarily independent of the target radar crosssection and depends upon the clutter to noise signal level. A change detection method is developed that provides detection via identification of the target shadow as an outlier from a background distribution. The background is inferred from a sequence of SAR images. It is shown that simple temporal averaging by alignment of the image for estimating the background works reasonably well with SAR images offering good shadow contrast. The technique was successfully demonstrated initially using real radar data from a short range spotlight SAR system. Results against weaker shadow signals at longer stand-off range have also proved very encouraging showing a moving target being detected at 10 km standoff range. [C677]

"Design and development of a signal and data processor test bed for a passive radar in the FM

band"

This paper describes the design and development of the signal and data processing chain required by a Passive Covert Radar (PCR) exploiting a single non co-operative frequency modulated (FM) commercial radio station as its transmitter of opportunity. The processing chain is proved to: 1) efficiently remove interference and clutter from the received signal, 2) detect targets and extract their bistatic range, bistatic Doppler and azimuth, 3) track targets in the Cartesian domain via the use of particle filtering. The whole processing sequence has been tested using emulated FM radio signals and scenarios as an input to receiving channels. Detection and tracking performance of the passive radar have been assessed comparing the performance of the signal and data processor test bed to the truth data feeding the test bed itself. [C678]

"Regularisation methods for covariance matrix estimation in low sample support stap"

The interference covariance matrix in space time adaptive processing is usually estimated from training data that is drawn from adjacent range gates to the cell under test. The sample support required to achieve good detection performance may not be available in practice due to many factors such as system design or clutter heterogeneity. In this paper, we address this problem by proposing and evaluating a number of covariance matrix regularisation methods that attempt to reduce the bias of the eigenvalues of the estimated covariance matrix and hence improve the signal detection performance. [C679]

"Modelling sea clutter temporal correlation in detection calculations"

The calculation of target detection performance in a combination of K-distributed sea clutter and radar system noise has, to date, been limited to the case where the clutter speckle component is independent from pulse to pulse (as sometimes occurs with frequency agility). Recent advances in computational techniques reported here allow the speckle and noise to have different correlation times, thereby allowing fixed frequency and limited frequency agility radars to be modelled at all ranges and at all clutter to noise ratios. [C680]

"Polarisation filtering for small target discrimination in ground clutter"

The Electronic Warfare and Radar Division (EWRD) of the Defence Science and Technology Organisation (DSTO) has initiated a number of studies investigating the exploitation of polarimetric analysis for the detection of small targets in strong ground clutter. This paper presents the results of experimental trials and associated signal processing research where an understanding of the scattering mechanisms present is used to design discrimination filters in the polarisation domain. It is shown that these physics-based filters provide highly efficient detection and identification of a variety of manmade targets immersed in strong clutter environments. [C681]

"HF radar ship detection and tracking using WERA system"

High frequency (HF) radars are capable to detect and track targets at extremely long ranges. 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 ship detection and tracking problem in a complex HF radar signal environment. It uses a conventional constant false-alarm-rate (CFAR) detection procedure but the thresh-olding scheme is based on regression analysis of power spectrum values along range and Doppler cells. The ship tracking scheme includes the model in polar coordinates that uses tracking state vector consisted of range, azimuth and velocities and fixed-coefficient filter parameters to get smoothed tracks. The proposed detection and tracking schemes have been tested using real HF radar data from WERA system. [C682]

"The dependence of radar target detectability on array weighting function"

This paper assesses the dependence of target detectability in the presence of clutter on the transmitting and receiving antenna array weighting functions for airborne, medium pulse repetition frequency radar. Target detectability is best for functions which result in the lowest average sidelobe levels. [C683]

"Automatic Censoring Detection Using Binary Clutter-Map Estimation for NonGaussian Environments"

In this paper, we propose an automatic censoring detector using binary clutter map estimation, for multiple target situations and compound dominated-clutters. The proposed censoring procedure dynamically discards the unwanted samples by implementing an adaptive pre-thresholding, for the incoming clutter echoes. Thus, the obtained decisions are sent serially into a shift register to form the binary clutter map (BCM) estimation. Finally,

the logical states of the clutter map register are used to yield the background level estimation. To show the robustness of the clutter map-based detection scheme, the effects of speckle correlation and interfering targets on the censoring efficiency are analyzed. [C684]

"A Performance Comparison of Two Time Diversity Systems using TM-CFAR Detection for Partially Correlated Chi-Square Targets in Nonuniform Clutter and Multiple Target Situations"

In automatic detection, performance of time diversity systems is proved to be sensitive to how the multiple-pulse sample echoes, from commonly encountered nohomogeneities, are accumulated within the same receiver. Based upon the "non conventional time diversity system"(NCTDS), we derive exact expressions for the probabilities of false alarm and detection of a pulse-to-pulse partially correlated chi-square target with 2K degrees of freedom for the trimmed mean constant false alarm rate (TM-CFAR) detector. Because of the complex mathematics induced by the "conventional time diversity system" (CTDS), detection performance of this system is carried out using Monte Carlo simulations. The obtained results show that, while the NCTDS achieves a better nonuniform clutter resilience than the CTDS, the latter outperforms the former in multiple target situations. Hence, when both nonhomogeneities are concomitantly present, the two systems performances become nearly similar. [C685]

"Rapid-fluctuating Radar Signal Detection with Unknown Arrival Time"

We study the rapid-fluctuating radar signal detection, where the arrival time of the received signal, i.e., the range cell index of the target, as well as the complex amplitude of the signal and the noise are unknown. We show that even in additive white gaussian noise (AWGN) environment, uniformly most powerful invariant (UMPI) test does not exist. Instead, the UMPI detector in known SNR is used as an upper performance bound for performance evaluation of any invariant detector performance. In addition, we derive generalized likelihood ratio (GLR) detectors for this signal in AWGN with unknown noise variance and also in clutter with unknown covariance matrix. The GLR test statistic for AWGN represents the ratio of the maximum power over all cells to the total power. The GLRT for a clutter environment is also a power ratio which is the maximum over all range cells of the Euclidean norms of the spatially whitened observed sequence. Simulation results demonstrate that the performance of the proposed GLR test in AWGN is very close to the upper bound performance, i.e., to the UMPI test in known SNR. [C686]

"Optimized implementation of a parallel DSP architecture for real time stacked beam radar signal processing"

This paper presents a parallel processing architecture, based on four TMS320C44 VME-bus DSP boards, for real time implementation of six clutter map constant false alarm rate (CM-CFAR) detectors together with a height finding extractor. The latter is based on a centroidal interpolation of the angular location of the target. The optimal processing speed has been achieved by fully exploiting the capacity of the 'C44 processor. The implemented configuration is well adapted for two dimension stacked beam surveillance radar. The overall parallel processing scheme interconnections and the real time implementation results are presented and discussed. [C687]

"The spectrum of scattered radar signals from complex ground targets"

This paper records the spectrum of some types of radar pulses scattered by complex ground based targets. A frequency-domain full wave Electromagnetic (EM) model of targets reveals significant distortion of the spectrum of the scattered signal in relation to that of the incident signal in many cases. Scattering is examined in monostatic cases only. The results lead into a deeper understanding of the scattering mechanisms and the quantification of echoes of complex ground targets. This can lead one to categorise ground targets differently from other features such as surface clutter and target shadows. [C688]

"Cooperation between tracking and radar resource management"

This paper will discuss closely integrating the Tracker and Radar Resource Management processes within phased array radar. Several techniques are discussed and, where possible, basic analyses and figures of merit are given. In particular an analysis of time-agile track initiation in land clutter suggests significant benefits for slow moving targets. [C689]

"Range Doppler correlation for time-orthogonal distributed aperture radars"

Distributed aperture radars represent an interesting solution for target detection in environments affected by clutter. Due to the large distances between array elements, both target and interfering sources are in the near field of the antenna array. Recent works have demonstrated the benefits of combining frequency diversity and

space time adaptive processing for distributed aperture radars. Using orthogonal signaling the receivers can treat the incoming signals independently, solving several bistatic problems instead of the initial multistatic problem. However, a well known problem in bistatic radar is the dependency of the clutter Doppler center on range. We analyze the benefits of joint use of waveform diversity and adaptive techniques to counteract the non-stationarity of the clutter Doppler. [C690]

"The architecture and operating characteristics of a multi-frequency HF surface wave radar-part two"

The HFSWR described in part one of this paper [1] uses simultaneous multi-frequency operation to obtain robust performance during its normal operation. To examine the nature of the radar and its environment, the high quality multi-frequency data generated and then stored, is analysed in more detail, particularly to generate measured target HF RCS profiles which are presented in this paper. The results suggest there is an ability in part to distinguish different target categories. This, and the supporting evidence, is commented on. [C691]

"Recognition of convoys with airborne adaptive monopulse radar"

A technique for recognition of extended targets on the ground, in particular convoys, by air- or spacebased radar is presented. The technique is based on adaptive monopulse in conjunction with space-time adaptive processing for clutter and interference rejection. It is demonstrated that the standard deviation of the azimuth and radial target velocity estimates of the space-time adaptive monopulse can be exploited to recognise a potential spatial extension of a moving target. [C692]

"TR-SAR: Time Reversal Target Focusing in Spotlight SAR"

We develop time reversal spotlight synthetic aperture radar (TR-SAR) for target focusing and ghost images removal in SAR. Conventional SAR is not designed for imaging targets in a rich scattering environment. In this case, ghost images due to secondary reflections appear in the SAR images. We show in this paper, how, from a rough estimate of the target location obtained from a conventional SAR image and using time reversal, TR-SAR focuses on the target with improved resolution, and reduces or removes ghost images. Verification with experimentally measured electromagnetic data demonstrates the success of TR-SAR. [C693]

"Improving Detection in Sea Clutter using Waveform Scheduling"

In this paper, we propose a method to exploit waveform agility in modern radars to improve performance in the challenging task of detecting small targets on the ocean surface in heavy clutter. The approach exploits the compound-Gaussian model for sea clutter returns to achieve clutter suppression by forming an orthogonal projection of the received signal into the clutter subspace. Waveform scheduling is then performed by incorporating the information about the clutter into the design of the next transmitted waveform. A simulation study demonstrates the effectiveness of our approach [C694]

"A new signal detection with unknown doppler in an unknown background using spectrogram"

The current methods of detecting targets operate based on interference, clutter, noise, parameters and/or on signal Doppler specifications. There is no optimum detector for a general environment in unknown Doppler shifts. In this paper based on the combination of tolerance interval technique and time-frequency signal analysis, a new method is presented to introduce a new detector. The method is non-parametric, signal is analyzed in time-frequency domain by its spectrogram and the time interval of signal presence is determined. Finally, the adaptive thresholding is utilized and signal detection is fulfilled. [C695]

"Non-Linear Prediction of Inverse Covariance Matrix for Stap"

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. In this paper, we propose a new approach of applying non-linear prediction theory to address the range dependency problem in bistatic airborne radar systems. This technique uses a non-linear function to obtain an estimate of the range-dependent inverse covariance matrix. Simulation results suggest a non-linear fit for the model (nonlinear relationship between the inverse covariance matrices) and show an improvement in processor performance as compared to conventional STAP methods. [C696]

"GLRT-Based Adaptive Doppler Processing for HF Radar Systems"

High frequency skywave and surface-wave over-the-horizon (OTH) radars are required to detect targets in the

presence of powerful clutter and interference from man-made and natural sources. However, the received disturbances may be highly structured in the time domain (i.e. pulse-to-pulse) within the coherent processing interval (CPI). This provides scope for adaptive Doppler processing to enhance detection performance with respect to conventional FFT-based methods. This paper proposes a generalized likelihood ratio test (GLRT) based detector that not only possesses the valuable constant false alarm rate (CFAR) property invariant to disturbance scale-change, but also exhibits distinct advantages over the adaptive coherence estimator (ACE) and adaptive subspace detector (ASD) when unwanted signals are present. Here, we present the first experimental results for this detector in a HF surface wave radar Doppler processing application. [C697]

"Concurrent Tracking and Detection of Slowly Moving Targets using Dynamic Logic"

We describe a new approach for combining range and Doppler radar data to perform multi-target detection and tracking. The algorithm framework is based upon dynamic logic, a biologically-inspired neural architecture, which yields advantages over conventional multi-target tracking algorithms by reducing the computational complexity during data association by several orders of magnitude. The algorithm is tested on experimental range-plus-Doppler radar data, and the results demonstrate a surprising degree of robustness in the presence of nonhomogeneous clutter and uncertainty in the number of targets [C698]

"A new method of ship and chaff polarization recognition under rain and snow cluster"

In Warfare on the sea, passive interferences include not only chaff but also surrounding atmosphere such as rain and snow, these factors will influence final recognition of targets. This paper solves the problem by polarization theory. This method is based on the radar which can receive both left and right circularly polarized wave and obtain the full polarization information of echoes. Firstly, the path influence of rain and snow from polarization power matrix is eliminated in order to correct the power matrix of targets. Secondly, the distinguishing rate of targets from chaff is increased employing non-linear polarization transformation to increase the polarization range ratio of echoes. Finally, Simulation experiments show the method is effective. [C699]

"Future Surface Radar technology: From Air Defence to Air and Missile Defence"

This paper describes how Air Defence radars are evolving from general Air Defence missions (single-mission radar) to Air and Missile Defence missions (multi-mission radar) in order to cope with news threats for Homeland Defence and External Theatre Defence. After a description of the radar requirements for general Air Defense and Missile Defence, Missile Defence impacts on radar sensors are explained. It is shown that conventional Air Defence radar cannot completely meet at the same time both Air Defence and Missile Defence requirements. The present multi-mission, multifunction MASTER A developed by Thales is described. The final parts explain the Thales portfolio evolution from MASTER A to M3R and the related S Band product policy. [C700]

"Resource Management for Airborne Surveillance Radars"

This paper will discuss the radar resource management research currently being undertaken at Thales Aerospace. A detailed simulation of a radar resource manager and the associated environment and target models has been produced in order to investigate resource management and its integration with tracking, as well as its application to an airborne surveillance radar and related scenarios. Several potential benefits may be predicted through the use of such a system as compared to a conventional track-while-scan (TWS) radar, including increased detection range, reduced track initiation time, and the ability to more intelligently consider secondary sources of information such as digital terrain elevation data and a clutter map when making decisions. Several example problems are discussed in this paper, with simulation results presented, including the use of adaptive track update times for the case where two or more tracks mix, the use of a target likelihood function to schedule additional looks for targets in a clutter environment and so reduce track initialisation time, and operator interface considerations. [C701]

"A New Differential Clutter Map Processing in Modern Surveillance Radars"

In this paper we propose a new differential clutter map processing to reduce the false alarms from stationary ground clutter, sea clutter and improve the detection probability of the slow moving target with low Doppler frequency shift. The proposed clutter map is a scan to scan processing which receives the echo signal from Doppler filter bank tuned at lowest Doppler frequency, processes it and delivers the processed signal to the CFAR processing. The simulation results show that the false alarm rate is reduced by more than -30 db. The Clutter map also increased the probability of detection of low speed target, slower than 100 Km/hr. [C702]

"Detection and classification of urban structures based on high-resolution SAR imagery"

In this paper, several advanced methods for detecting and classifying urban structures in high-resolution SAR imagery are presented. The detection of man-made structures resp. the suppression of clutter, for example natural surfaces, can be accomplished by a coherent time-frequency analysis. These techniques can detect targets in the scene that behave like point-scatterers (such as edges, poles, etc.) by their high degree of correlation across sub-apertures of the scene. If polarimetric data are available, this approach can be extended by taking into account the frequently anisotropic polarimetric backscattering of man-made targets. As a third approach, a simple but powerful operator for detecting urban structures by analysing texture inhomogeneity in SAR images is developed. A second objective of this paper is the segmentation and classification of the detected urban structures. Based on the detected man-made structures, the characteristic structure size is investigated, using several approaches, to distinguishing between residential areas, industrial areas and dense city centres. The methods are evaluated using several real airborne SAR datasets. [C703]

"Robust radar detection of moving ground targets with STAP"

Airborne radar sensors are able to detect small and slow moving ground targets using short dwell times by distinguishing the weak target signature from the dominant ground clutter signal. The capability of a Ground Moving Target Indication (GMTI) sensor is principally governed by the Probability of Detection (PD). Other capabilities such as geolocation, tracking and recognition are derived from these detection data. One method used to enhance the PD for platforms with multiple phase centres is Space Time Adaptive Processing (STAP). In this paper we report an experimental assessment of a robust STAP algorithm [1, 5, 6] using the QinetiQ Enhanced Surveillance Radar (ESR) data. From our results it is apparent that robustness may be introduced if a selective training methodology is employed to estimate the data covariance. Results are given for both Pre- and Post-Doppler STAP [C704]

"A Study for a Space-Based Passive Multi-Channel SAR"

This paper deals with the potentialities obtained by splitting the passive antenna of a space-based bistatic SAR into multiple sub-apertures. A preliminary analysis is performed in order to identify the main orbital and system design parameters for a satellite equipped with a multichannel passive radar sensor. The effectiveness of the resulting bistatic system is investigated paying particular attention to the assessment of the achievable MTI capabilities. In particular the conceived system is shown to allow: (i) clutter cancellation and detection of slowly moving ground targets for surveillance purpose, and (ii) relocation of moving targets in high resolution SAR images. [C705]

"Bistatic JDL-STAP for ground moving target detection"

Optimum STAP requires knowledge of the true interference covariance matrix. In practice, this matrix is not known and is estimated from training data that must be target-free and statistically homogeneous with respect to the test data. These conditions are often not satisfied, which degrades the detection performance. Single-data-set algorithms have been proposed to circumvent this problem, which works solely on the test data. In this paper, we study the issues associated with applying reduced-dimension techniques to these algorithms in a bistatic radar system. Simulation results show an improved detection performance against conventional STAP algorithms in heterogeneous environments. [C706]

"Space-Time Adaptive Processing in the presence of non-Gaussian sea clutteR"

Space-Time Adaptive Processing (STAP) is an optimum technique for target detection in the presence of Gaussian clutter [1,2]. However, for high resolution sea surveillance radar, clutter statistical properties are different [5]. Therefore classical STAP must be redefined. It can be done in the framework of the theory of Spherically Invariant Random Process (SIRP). In this paper a simple method of improving STAP performance in the presence of non-Gaussian clutter is proposed. Results are validated using simulated data. [C707]

"A rare event approach to the detection of target-like signals in CFAR training data"

A new method based on the existence of rare events (RE) is proposed to detect the presence of nonhomogeneous samples in a set of Constant False Alarm Rate (CFAR) training data. Two RE schemes designated as the mean-to-mean ratio (MMR) and the variance-to-variance ratio (VVR) tests are proposed. No a priori knowledge of the nonhomogeneity topology is assumed. Analysis using Monte-Carlo method based on Rayleigh clutter and Swerling I target models is presented. Target-like interferences which seriously degrade the detection performance of the cell-averaging CFAR detector can be detected with a higher probability by RE detectors. [C708]

"Multiple Target Tracking Using Maximum Likelihood Probabilistic Data Association"

The maximum likelihood-probabilistic data association (MLPDA) target tracking algorithm is effective in tracking very low observable targets. A key limitation of MLPDA is that it is restricted to tracking a single target. We derive and implement a multiple target version of MLPDA called Joint MLPDA (JMLPDA). While the JMLPDA implementation presented in this paper is focused on a two-target case, this algorithm is extensible to any number of targets. The MLPDA and JMLPDA algorithms are combined to form a multi-target MLPDA tracking algorithm. Performance of the JMLPDA and the multi-target MLPDA algorithms are compared to a probabilistic multi-hypothesis tracker (PMHT) for two crossing targets, focusing on track management/update. Simulation results show that under conditions of heavy clutter, the multi-target MLPDA outperforms PMHT in terms of reduced track errors and longer track life. [C709]

"Detecting and Tracking Moving Objects in Sequences of Color Images"

A statistical change detector, implemented as a zero-latency finite-memory filter, is used to identify anomalies in temporal pixel statistics. An F-distributed test statistic is computed for each pixel and used in a hypothesis test. The tracker, with automatic track initiation and termination, uses a low-complexity pairwise joint probabilistic data association (JPDA) algorithm, which has been restricted to consider clusters (sub-problems) containing no more than two tracks. The track state and clutter model are augmented to include color. The detector and tracker are used to process sample video data [C710]

"SAR Processor based on a CFAR Signal or Interference Subspace Detector Matched to Man Made Target Detection in a Forest"

This paper deals with two new SAR processors based on CFAR subspaces detector. These two algorithms aim at improving man made target detection performances in a forest clutter by using electromagnetic scattering models. The implementation of the two detectors is described. An application on simulated data shows the interest of the two methods [C711]

"Evaluation of Knowledge-Aided STAP Using Experimental Data"

Recent advances in knowledge-aided space-time adaptive processing (KA-STAP) have resulted in significant performance improvements for ground moving target indication (GMTI) radar systems. In particular, the use of prior knowledge including terrain, clutter discretes, and previously detected targets has been shown to be effective for mitigating the poor performance often encountered when operating in heterogeneous clutter environments. This paper provides an evaluation of KA-STAP techniques based on extensive processing of experimental data. Two major performance issues are addressed: high false alarm rates due to under-nulled clutter discretes and target cancellation due to corruption of the STAP training data by other targets in the scene. Each of these problems is demonstrated using experimental multi-channel X-band radar data. Methods for using prior knowledge to improve performance are presented and processing results using the experimental data are provided that show how KA-STAP can lead to significantly improved detection performance relative to conventional STAP processing. [C712]

"A Monte-Carlo Approach for Tracking Mobile Personnel"

In this paper, we propose a Monte-Carlo method based on the particle filter framework to track footfall locations generated by mobile personnel using seismic arrays. While the particle proposal function follows a simple bootstrap approach, the novelty in our algorithm comes from a unique weighting strategy that takes into account the sparse nature of the seismic footfall signal and is robust against missed detections and clutter which could appear in the form of other impulsive sources or other walkers. Our weighting strategy automatically makes use of the wavefront shape, either planar or circular, and assigns weights in x-y space. Data association is built into the system, eliminating the need to explicitly associate the received footfall impulses with different walkers. Hence our algorithm is ideal for tracking multiple mobile personnel. We also demonstrate the fusion of our system with range information available by means of radar. Fusion with radar improves x-y tracking when range resolution is lost due to a large distance between the target and the seismic array leading to planar wavefronts. [C713]

"Online Multisensor-Multitarget Detection and Tracking Using Variable Rate Particle Filters"

In this paper we present an online approach for joint detection and tracking for multiple targets using variable rate particle filters (VRPFs). Unlike conventional models and particle filters, the proposed method utilises the applied forces (tangential and radial components) to model target motions and does not assume the hidden state to change at the same rate as the observations. In effect not only does the proposed method enable us to model

parsimoniously the manoeuvring behaviours of targets with a single dynamical model but it also provides a more efficient framework for recursive estimation of the targets' positions since much fewer states will be estimated. In addition, a target detection/termination module will be integrated in the proposed method in which a track initiation, termination, or maintenance move is randomly executed using Bayesian Monte Carlo methods. To model a more realistic observation environment Poisson process is chosen for all target originating and spurious measurements. Unlike other observation models, the proposed model does not require extensive computation for data association between active targets and observations, prior to target state estimation, as a result. To improve the quality of the particles we adopt a data-dependent importance sampling strategy in which the latest observations are involved when new particles are updated. This enables the target states to be updated as new observations arrive while keeping the number of states sufficiently low to track the manoeuvres of the targets. Computer simulations demonstrate the potential of the proposed method for detecting and tracking multiple highly manoeuverable targets in a hostile environment with high clutter density and low detection probability. [C714]

"A novel ground moving target detector in dual-channel SAR images based on the covariance matrix"

Concerning the detection of ground moving targets in dual-channel SAR images, a novel detector based on sample covariance matrix is proposed. The method makes use of the principle of orthogonal projection, for obtaining the component of the sample covariance matrix energy vector that is perpendicular to the clutter covariance matrix energy vector, then construct effective metric by this orthogonal component. Compared with traditional DPCA, this new metric can achieve better clutter rejection, eliminate influences from moving targets' sidelobes, set threshold more easily and get lower false alarm probability. The simulated results prove the effectiveness of this metric. [C715]

"Change detection of concealed targets using repeat-pass SAR images"

This paper proposes a novel change detection algorithm for locating target concealed by foliage using multi-pass low-frequency SAR images. Having registered the image pair, an intensity ratio detector is used to detect the potential changes due to disturbance in local mean backscatters with an computed threshold according to a given probability of false alarm. Once a local change is reported, CFAR detection is used to confirm it. The background estimation is operated on one of the local patch pairs according to the change style. Finally, the algorithm is tested on the benchmark image pairs from CARABAS-II data collected during the flight campaign in Vidsel 2002, which has show good performance in detection the arrival targets and departure targets while keep a rather low false alarm rate. The algorithm is also less time consuming. [C716]

"A new channel equalization method for airborne multi-channel SAR-GMTI system"

This paper investigates the channel equalization problem of airborne multi-channel SAR-GMTI system. A key problem for ground moving target indication is clutter suppression, which is sensitive to the correlation of channels. For the multi-channel system, there are differences among the characteristic of two channels and also the antenna amplitude patterns (phase as well as gain), which worsen the correlation of channels. This paper proposes a channel equalization method to improve the clutter suppression ratio. Theoretical analysis is illustrated with experimental airborne SAR data. [C717]

"A novel approach to three-channel SAR-GMTI channel equalization and moving target detection and location based on real data"

Aiming at airborne three-channel SAR-GMTI system and its real data, a novel channel equalization method is presented, furthermore, in virtue of the method's good performance on compensating the clutter differences between different channels, a technique for moving target detection (MTD) and location is further proposed. This method first realizes signal equalization between inner channels utilizing the leaking signals, then implements range and azimuth time calibration and compensates the channel differences via iteration after range compression, after that, it realizes MTD by clutter cancellation and imaging, finally obtains target parameters by estimating moving target doppler shift. The technique proved its good performance in real data processing with the advantages of high channel equalization precision, little computations, good clutter cancellation and MTD performances and easiness to implement. [C718]

"An effective SAR-GMTI technique based on eigen-decomposition of the covariance matrix"

An effective multi-channel SAR-GMTI technique based on eigen-decomposition of the covariance matrix is proposed. The variation of the sum of small eigenvalues of the covariance matrix is used to detect moving

targets which can avoid clutter suppression. The radial velocity of the moving target is estimated by two steps. Firstly, using the interferometric phase of two SAR images to get the coarse radial velocity estimation, then the more precise radial velocity is obtained by searching the space-domain steering vector of the moving target. It overcomes the sensitivity of the interferometric phase to clutter and noise. The performance of the approach is analyzed in detail. The merit of the presented technique is demonstrated by simulated and measured SAR data. [C719]

"Moving target detection in airborne SAR by a combined wigner-STFT transform"

The detection and the motion parameters estimation of the moving targets is a key problem in imaging the moving target for Synthetic aperture radar (SAR). In this paper, a new method based on the combination of the Wigner-Ville distribution (WVD) and the short-time Fourier transform (STFT) has been proposed and applied to moving target detection for airborne SAR. It is demonstrated that the proposed method can eliminate the cross-terms of the WVD and improve the time-frequency resolution of the STFT simultaneously. Its performance is demonstrated by both simulation and experimental examples. Our results suggest that the proposed method provides a efficient technique in detecting the moving target for airborne SAR. [C720]

"Moving target location of VSAR based on maximum likelihood method"

Based on the pixel vector sampled among multi-images, VSAR may effectively suppress the strong ground clutter and realize the moving target detection and locating. In this paper, the Cramer-Rao bounds (CRBs) are derived for the estimation of a proposed VSAR model parameters, as well as the azimuth locations of moving targets, and the maximum likelihood (ML) methods are further proposed to reach these CRBs. Finally, some detailed numerical experiments are also provided to show the effectiveness of the proposed methods. [C721]

"Radar resources optimization by adaptive serch domains priority assignment based on most threatening trajectories computation"

The main challenge of future phased array multifunction radar will be to optimise the radar time budget to avoid deleterious overload effects. For this purpose, we propose a new technique for priority assignment of Search Domains. Then, we have developed new algorithms for most threatening trajectories computation based on Calculus of Variations approach developed for "shortest path computation" in image processing. [C722]

"Track management and PMHT"

PMHT algorithm, as proposed, promises high performance multi target tracking in clutter with (relatively) modest computational resources. However, when applied to practical target tracking situations, a number of problems need to be overcome. PMHT assumes fixed number of tracks, and furthermore it assumes that all tracks are true tracks. No track quality measure is provided within PMHT to enable false track discrimination. In this paper we add the probability of target existence to PMHT processing, and accommodate a variable number of tracks. [C723]

"Gaussian mixture cardinalized PHD filter for ground moving target tracking"

The cardinalized probability hypothesis density (CPHD) filter is a recursive Bayesian algorithm for estimating multiple target states with varying target number in clutter. In particular, the Gaussian mixture variant (GMCPHD) for linear, Gaussian systems is a candidate for real time multi target tracking. The present work addresses the following three issues: (i) we show the equivalence between the GMCPHD filter and the standard Multi Hypothesis Tracker (MHT) in the case of single targets; (ii) using a Gaussian sum approach, we extend the GMCPHD filter by employing digital road maps for road constraint targets. The utilization of such external information leads to more precise tracks and faster and more reliable target number estimates; (iii) we model the effect of Doppler blindness by a target state dependent detection probability, leading to more stable target number estimation in the case of low Doppler targets. [C724]

"Data association for target tracking by several passive sensors"

In recent years, there has been considerable interest within the tracking community in the approach to data association based on the assignment algorithm. The focus of this paper is to describe a new dynamic S-D assignment algorithm. In the presence of clutter, missed detections, the new method incorporates the image intensity information into the dynamic assignment cost coefficient. To reasonably utilize the special feature of IR sensors, the association becomes more accurate and, at mean time, the complexity of the algorithm has not obviously increased. The simulation results show that the proposed approach has better performance than traditional approaches. [C725]

"A Real-time signal processing method for air-born three-channels GMTI"

In this paper, we briefly introduced the performance of several GMTI systems at first. After that, we prompted a method based on CSI algorithm for air-born three-channels GMTI signal processing, gave out the processing diagram of this method, analyzed the principle of cluster suppress, present an adaptive phase compensation method for each channel based on the minimum power criterion and analyzed the locating and velocity-estimation problem of moving targets. The presented method, which has been applied in actual furnishment, turned out to be efficient. [C726]

"Optimal polarimetric interferometry coherence analysis in detection and location of moving target with SAR"

This paper mainly deals with the problem of the optimal polarimetric interferometry coherence in detection and location of moving target with SAR. The coherence is closely related with the estimated accuracy of the interferometric phase between the residual images which are obtained from clutter cancellation. A novel method for improving the estimated accuracy of the interferometric phase is presented. Using the echo model of moving target, the procedure of clutter cancellation in frequency domain is derived. The optimal polarimetric interferometry processing for residual images is proposed with detailed analysis. Finally, the interferometric coherences of the residual images with different polarization are analyzed by simulation to validate the theory. [C727]

"Channels equalizing and calibration technology of moving target detection for multi-phase centers receive system"

With the rapid developing of synthetic aperture radar (SAR) in recent year, multi-channel receive technology is widely applying in wide-swatch SAR, high resolution SAR, GMTI, InSAR, multi-band and multi-polarization SAR. In this paper, have a deeply discussion on equalizing between channels in wideband multi-receive aperture system when amplitude imbalance and phase non-uniform. Take a three receive aperture GMTI system as example, detail process is present, step by step from GMTI system design block diagram to final processing result. Measured data processing results validate effectiveness of the method. [C728]

"Automatic target recognition based on SAR images and Two-Stage 2DPCA features"

2-dimensional principal component analysis (2DPCA) has received more and more attentions in recent years, since it can evaluate the covariance matrix more accurate than PCA in extracting features from 2-dimensional images. However, a drawback of 2DPCA is that it needs more features than PCA because 2DPCA only eliminates the correlations between rows. In this paper, two-stage 2DPCA is proposed to extract features from synthetic aperture radar (SAR) images to further compress the dimension of features and decrease the recognition computation. Experimental results based on MSTAR data indicate that two-stage 2DPCA can decrease feature dimensions significantly, and the target recognition performance can be improved at the same time. [C729]

"SAR azimuth antenna pattern estimation using a strong point target"

An alternative method to estimate the SAR azimuth antenna pattern (AAP) is presented in this paper. By applying time-frequency analysis to the echoes from a strong point target, the azimuth ambiguous problem can be solved and the algorithm is less affected by the background clutter. The method we proposed is not only much cheaper but also avoids the trouble of deploying and maintaining extra transponders, provided a strong point target, like a corner reflector, is already deployed in the calibration site. Finally, simulation experiment confirms that our method is correct and feasible. [C730]

"An algorithm of SAR GMTI in the presence of blanketing jamming"

Jamming and clutter must be effectively suppressed for moving target detection. A method of detecting slow-moving ground targets based on three-aperture synthetic aperture radar (SAR) in the presence of blanketing jamming is presented. It uses two-aperture cancellation method to suppress SAR jamming to target then to detect the moving ground targets. Firstly, spatial geometry model and echo signal model of three-antenna SAR were built, then an algorithm of SAR moving target detection based on clutter suppression interferometer (CSI) was derived, and the realization steps were presented. Finally, computer simulation results validate its effectiveness. [C731]

"Ridgelet transform with application in ground penetrating radar processing"

Ridgelet is the new development of wavelet dealing with line singularities in signals. In goundpenetrating radar (GPR) signal, the direct wave is a strong noise which has line singularity. In time-space domain, the useful information in GPR signal is badly polluted by strong direct wave so that the underground targets can not be recognized correctly. Ridgelet overcomes the disadvantages of wavelets in dealing with high dimensions that it can effectively represent singularities along lines or hyperplanes. Concerning the characteristics of GPR signals, the ridgelet transform is employed to remove the background noise and separate the direct wave. The simulation results for real GPR signals demonstrate its effectiveness. [C732]

"Design of GMTI combining networks"

Multichannel radar systems are of choice for ground moving target indication (GMTI) since they allow for a joint space-time processing of the received data that enables an efficient suppression of ground clutter returns. The design of the receiving sensor group is driven by the performance specifications of the intended GMTI modus, which usually requires the sensor array to consist of a few hundred up to a few thousand elements. Though desirable, a full digital processing of all receiving channels is practically not feasible due to both hardware constraints and computational load. The formation of sub-arrays using a proper combining network before A/D conversion reduces the number of processing channels while maintaining the advantages of the full array. In this paper the impact of the combining network design on the GMTI performance of a simulated airborne multichannel radar system is investigated. [C733]

"Space-based moving target positioning using radar with a switched aperture antenna"

Ground moving target indication (GMTI) by space based radar can effectively only be performed with a multi-aperture / multi-channel system or a satellite cluster [1]. To keep weight, power consumption, data rate and costs low, the technique of switching subapertures from pulse to pulse has been proposed. While the detection performance using STAP (space-time adaptive processing) has been analysed in several publications, the estimation performance and the mechanisms leading to good or bad aperture switching strategies, have not yet been treated sufficiently. In fact, aperture partitions well suited for detection must not necessarily be good for estimation. This paper is thought as a contribution to fill the knowledge gaps concerning repositioning algorithms and performance analysis. [C734]

"Polarimetric feature fusion in GPR for landmine detection"

A polarimetric multi-feature framework for the detection of antipersonnel landmines with ground penetrating radar (GPR) is suggested. The features result from independently acquired and processed GPR measurements in co- and cross-polar configurations. The initial detection in the confidence maps is made independently after which the coordinates of the detected targets are co-located. The marginal feature distributions are normalized via Johnson's transform prior to the fusion process and a Maximum Likelihood based linear-quadratic classifier is used as a fusion rule. The framework makes use of secondary data acquired from an open test site to train the classifier. The framework performance is illustrated on the data acquired over a specifically designed test- site. [C735]

"MTI processing based on dual frequencies-dual apertures spaceborne SAR"

Based on dual frequencies-dual apertures spaceborne SAR (synthetic aperture radar), a new SAR operation mode with four receiving channels is presented in this paper. High resolution imaging and moving target indication (MTI) are studied with this new mode. The coherent accumulation (CA) method, which combines dual channels data, is used to enhance the range resolution. With the data from all channels, the two aperture interferometric processing is executed to implement clutter cancellation. A pair of the clutter suppressed data are employed to implement double carrier frequency conjugated processing (DCFCP), then MTI processing is completed, followed by moving target imaging. The simulation results show the validity of the signal processing method and the feasibility of this new SAR mode. [C736]

"An airborne GMTI radar simulator based on space-time adaptive processing"

Space-time adaptive processing (STAP) has proved to be one of the best techniques capable of detecting weak moving targets in strong clutter environment and has been widely applied in airborne ground moving target indication (GMTI) radar. This paper introduces our work on establishing an airborne GMTI radar simulator, which can be used to test and evaluate existing STAP algorithms and develop new algorithms. Currently, the basic functional frame of simulator has been completed. In practical application, many necessary real-world refinements to the model are discussed and analyzed based on the simulation results. [C737]

"Ground slow-moving target adaptive processing for Airborne Radar"

Airborne fire-control radar is mainly equipped with forward looking antenna, which is characterized by high flight velocity, short wavelength and low PRF. Consequently, on one hand, ground clutter of airborne fire-control radar is non-homogeneous in range and multi-ambiguous in Doppler frequency; on the other hand, Doppler frequency spectrum of the clutter varies quickly with the cone angle and the bandwidth of the mainlobe is much spread. We focus on the features of the clutter and the ground slow-moving target for airborne fire-control radar at first Then it is pointed out that the mainlobe clutter is the most important factor which influences the detection performance. Finally, an adaptive processing algorithm, which is named FS-AMTI, is presented based on the frequency shift of the center of mainlobe clutter by adopting segmentation strategy. Experimental results with real data illustrate the good detection performance for slow-moving target of the proposed algorithm. [C738]

"A new wall compensation algorithm for through-the-wall radar imaging"

The signal will encounter refraction, changing in speed and get attenuated as passing through the wall in the through-the-wall radar. In this paper, by analyzing the echo signal model, the relationship among the transmit signal, target position function and the wall system function in view of the system concept will be achieved, a new wall compensation algorithm based on the inverse system and a method of estimating the wall system function using the real data will be proposed. Proof of concept is provided using real data collected in a laboratory environment. The results show that the new wall compensation algorithm can eliminate the effects of unknown wall parameters very well. [C739]

"Man-made target discrimination based on scattering mechanism identification and spectral correlation property analysis of POLSAR images"

In this paper, a novel discrimination method is proposed to automatically discriminate man-made targets in diverse natural clutter environments of polarimetric synthetic aperture radar (POLSAR) images .The novel method, which makes fully use of the difference between man-made target and natural clutter on scattering mechanism type and spectral correlation property, permits to obtain a clear and credible target discrimination effect .The validity of our novel method is verified by fully polarimetric L-band POLSAR data acquired by DLR 's airborne E-SAR system. [C740]

"Multiresolution feature extraction in target detection of UWB SAR"

This paper firstly analyzes the difference between high-frequency synthetic aperture radar (SAR) and low-frequency ultra-wide band synthetic aperture radar (UWB SAR) in extraction of multiresolution feature. And then we establish the equivalent models of target and trunk clutter in UWB SAR images and analyze the differences of multiresolution characteristic between target and trunk clutter as image resolution is varied from fine to course. Two forms of first-order autoregression (AR) model are introduced to model multiresolution sequences, and a two-dimensional (2-D) definition of generalized likelihood ratio (GLR) is presented to improve the robustness of multiresolution feature extraction. At last a feature extraction experiment of multiresolution based on region of interest (ROT) is accomplished. The results of experiment testify that the multiresolution feature is effective to improve the performance of UWB SAR target detection. [C741]

"Spatial decorrelation evaluation for interferometric SAR"

SAR interferometry based on image pairs acquired by different antennas enables the topographic mapping and ground moving target indication. Both the generated DEM accuracy and the clutter suppression performance are determined by the coherence of SAR image pairs. The baseline perpendicular to the SAR trajectory is one of the most important factors that affect the coherence, which varies with the property of the terrain. In this paper, the geometry between the perpendicular baseline and the terrain is researched, and the effect of terrain on coherence is presented. Then a more accurate formula for calculating the correlation coefficient is deduced in combination with the frequency characteristic of radar signals. The calculation results conform to the simulation results. [C742]

"Signal-Clutter-Noise Power Ratio of Airborne Wideband Radar"

Received power of signal and clutter for airborne wideband radar is developed. Signal-clutter power ratio (SCR), signal-noise power ratio (SNR), clutter-noise power ratio (CNR), signal-clutter plus noise power ratio (SCNR) respectively for narrowband radar and wideband radar are given. Computer simulation shows, under the same conditions, wideband radar can provide better SNR, SCR and SCNR performance in one range resolution cell than narrowband radar, so wideband signal will be of more benefit to a target detector. [C743]

"Design of the High-powered Clutter Suppression System Based on ADSP-TS203"

The paper studies the design to implement moving target indication (MTI) and moving target detection (MTD) based on a piece of ADSP-TS203. Digital signal processor (DSP) provides great flexibility for the design of the software. After pulse compression, the radar echoes including clutter, noise and targets are transmitted to DSP for MTI and MTD. The system mainly adopts the arithmetic of three-pulse elimination to realize MTI. MTD can be completed by using a narrow-band-Doppler-filter group in frequency domain. At last, it's verified that this system can restrain clutter and distinguish the targets effectively, which has been tested on the hardware. Meanwhile, the improvement factor is also improved. The system can be widely used in radar signal processing. [C744]

"A Robust Method for Censoring the Interference-targets"

To avoid target signal cancellation, which decreases the output signal-to-interference-plus-noise ratio (SINK) of space-time adaptive processing (STAP) significantly, it is necessary to eliminate the data vectors contaminated by interference-targets from the training data vectors set. There often exist errors between the actual steering vector and the assumed desired one for interference-targets (outliers) signals in nonhomogeneous clutter environments. The errors can cause distortion of main beam pattern, which leads the conventional reiterative censoring adaptive power residue (RAPR) method to degrade significantly in performance or even completely fail. An enhanced robust effective methodology is presented here, which first suppresses the mainlobe distortion to censor the strong interference-targets by diagonal loading the covariance matrix of training data vectors with a large value; and then eliminates the weak interference-targets coaligned with the desired signal vector. In addition, the new method achieves low computational complexity due to the recursive updating for inverse of covariance matrix. The computer simulation results show that the enhanced method is superior to the conventional RAPR method. [C745]

"Neural Modeling Fields for Multitarget/Multisensor Tracking"

We describe a new approach for combining range and Doppler data from multiple radar platforms to perform multi-target detection and tracking. In particular, we assume azimuthal measurements are either coarse or unavailable, so that multiple sensors are required to triangulate target tracks using range and Doppler measurements only. The algorithm framework is based upon neural modeling fields, a biologically-inspired neural architecture, which yields advantages over conventional multi-target tracking algorithms by reducing the computational complexity during data association by several orders of magnitude. The algorithm is tested on synthetic multi-sensor data, and the results demonstrate that accurate tracks can be estimated by exploiting spatial diversity in the sensor locations. These results are promising, and demonstrate a surprising degree of robustness in the presence of nonhomogeneous clutter and uncertainty in the number of targets. [C746]

"Adaptive Multi-Sensor Waveform Design for RF Tomographic Sensors"

Distributed sensing systems incorporating RF tomography allow a trade-off between spatial and spectral diversity, however a large number of widely spaced sensors is conventionally thought to be required. A practical method of reducing the number of sensor nodes is introduced via the concept of the Virtual Tomographic Array. Furthermore, the geometry of this virtual array is electronically reconfigurable. Optimal resource allocation is accomplished instantaneously, with dynamic control based upon matching sensing modalities to site specific target and clutter observables. [C747]

"UWB measurement, complex-amplitude texture, and Walled-LTSA array in plastic landmine visualization"

We describe the importance of ultra wideband (UWB) reflection measurement in the adaptive target visualization. We use a complex-valued self-organizing map (CSOM) to deal with complex-amplitude texture obtained by stepped-frequency UWB reflection measurement. We distinguish targets from clutter by paying attention to the difference in texture in space and frequency domains. In the technique, a wideband measurement is desirable to obtain precise texture. We employ a newly developed antenna, walled LTSA, with which we can construct a wideband, dense array for high-resolution imaging. [C748]

"Radar Polarimetry for Target Discrimination"

Discrimination of targets vs. clutter is critical to many radar identification problems. For the purpose of Improvised Explosive Device (IED) detection, radar range profiles and images are valuable to capture the target of interest; it remains a big challenge to differentiate the target from the surrounding man-made clutter. The goal is to reduce the clutter. It is well-known that vector wave scattering is sensitive to both wave polarization and target

orientation. This work makes use of ultra-wide-band (UWB) radar technology and polarization diversity to characterize targets with polarimetric signatures. The results were based on both radar measurement and electromagnetic simulation. This research demonstrated the effectiveness of radar polarimetry for improved target identification. [C749]

"Conditional and constrained joint optimization of RADAR waveforms"

In this paper we describe a methodology of jointly designing waveforms for a semi-cooperative, distributed radar system. Some radars have waveforms which are fixed and cannot adapt. The remainder of the group must optimize their emanations conditioned on the existence of the non-cooperative radars. We term this 'conditional joint optimization.' A special case is termed constrained joint optimization examines the problem when the RADAR configuration is completely cooperative. Only classic constraints such as phase-only, finite energy, etc. are considered. The overall metric that is used in the optimization is signal to interference plus noise ratio (SINR). We will show the results of a number of empirical experiments based on canonical spectra and knowledge aided sensor signal processing for expert reasoning (KASSPER) simulated data that show that a joint conditional design will outperform a non-cooperative, individually optimized RADAR network. [C750]

"Polarization diversity for detecting targets in inhomogeneous clutter"

Polarization diversity has proved to be a useful tool for radar detection, especially when discrimination by Doppler effect is not possible. In this paper, we address the problem of improving the performance of polarimetric detectors for targets in heavy inhomogeneous clutter. First, we develop a polarimetric detection test that is robust to inhomogeneous clutter. We run this polarimetric test against synthetic and real data to assess its performance in comparison with existing polarimetric detectors. Then, we propose a polarimetric waveform-design algorithm to further improve the target-detection performance. A numerical analysis is presented to demonstrate the potential performance improvement that can be achieved with this algorithm. [C751]

"Experimental HF radar trial of real-time STAP"

An alternative multi-static HF radar architecture, known as the Forward-Based Receiver Augmentation (FBRA) system, has been developed and tested by the Defence Science and Technology Organization [1]. The experimental system has performed beyond expectations in a number of trials involving targets of interest. This is not only due to the impressive hardware capabilities, but also the advanced signal processing for clutter and interference mitigation, particularly STAP which was shown to be indispensable for the successful operation of the system. This paper describes the real-time STAP algorithm in the FBRA system, and demonstrates its experimental detection performance on a cooperative aircraft target with flight path "ground truth" data available from on-board GPS logging equipment. [C752]

"Computationally efficient waveform diversity"

In this paper, a new signal processing approach referred to as simultaneous range-Doppler (SRDreg) is presented. It applies fractional Fourier transforms in a manner that yields projections and slices of the cross-ambiguity function (CAF). Waveform diversity (WD) techniques often require extensive processing resources, thus precluding WD from smaller, more mobile systems, or applications with limited resources. By employing SRDreg, the feasibility of WD in these applications is greatly increased. The projection and slice processing is used to detect targets and estimate their unambiguous range and Doppler in the CAF range-Doppler space. SRDregdetects peaks of the CAF in a processor-efficient manner, thereby reducing the computational load associated with traditional approaches since computing the entire CAF is avoided. The number of required operations is reduced to O(Nlog2(N)) as opposed to O(N2log2(N)). Since SRD* processing load is insensitive to waveform modulation and coding, orthogonal waveforms can be exploited to confer temporal, spatial, and spectral diversity to a sensor system, without incurring any processing penalty. Fundamentally, SRDregoffers waveform flexibility and increased processing efficiency, which can be applied to broaden the scope of applicability of WD to sensor systems. [C753]

"Study of Detection Technique Simulation of High Resolution Radar Based on BP Neural Network"

Technology applying neural network to detection of high resolution radar is advised. Firstly, it analyses the principle of detection technique of high resolution radar and the conception of "distance corridor". Secondly, it introduces the basal principle of BP algorithm. The principle and structure of three layers BP neural network is analysed. Thirdly, the detection technology and algorithm of high resolution radar based on BP neural network is researched. The result of research of target detection technology based on BP neural network possesses superperformance, which is in view of four distance corridor and ten distance corridor, which are the neural network that possesses four input neurons and ten input neurons. At last, the research is carried out by Matlab,

the result are visible and understandable. [C754]

"Canonical Framework for ATI and DPCA"

The topic of moving-target detection in clutter has been extensively studied, there are many methods, such as along-track interferometric (ATI) phase, displaced phase center antenna (DPCA) method, space-time adaptive processing (STAP), or some other metrics. A canonical framework is proposed that encompasses ATI and DPCA. The statistical test metric for ATI and DPCA is established in an simple form, via the definition of the complex central Wishart distribution, deduces the statistics of the test metric, the probability distribution of the test metric for ATI and DPCA have the complex central Wishart distribution of 1times1 case, namely the chi2-distribution. The theory foundation offers the possibility to construct the united multi-channel SAR GMTI detector, and derive the constant false-alarm rate (CFAR) detector tests for separating moving targets from clutter. [C755]

"A new method to create a virtual third antenna from a two-channel SAR-GMTI system"

Two-channel SAR-GMTI systems are suboptimal for moving target motion parameter estimation. Indeed, the ATI phase estimate of the across-track velocity component for a moving target is biased to lower values depending on the target signal to clutter ratio and the target across-track velocity. Additional antenna diversity can introduce additional degrees of freedom that can eliminate the bias problem. Aperture switching is an accepted method to virtually increase the number of channels without adding new hardware. One such mode is the RADARSAT-2 toggle mode (S. Chiu and C. Gierull, 2006). This paper proposes a new processing method to create a similar effective phase center configuration as the RADARSAT-2 Toggle mode from already recorded two-channel SAR data. This is achieved by delaying and combining the recorded two-channel measurements. The combination operation manifests not only a third phase center halfway between the phase centers of the two-channel system, but also a different antenna length of the virtual third antenna which requires a modification of the DPCA-ATI processing algorithm. The DPCA-ATI performance of the new mode is assessed and compared to ATI from the original two-channel mode. [C756]

"Multi-range and multi-pulse radar detection in correlated non-Gaussian clutter"

This work presents a multi-range cell and multi-pulse approach to radar detection problem. The derived detector performs clutter estimation using the neighboring range cells, clutter cancellation, threshold setting simultaneously and it eliminates the need for a separate CFAR operation. The radar clutter is modeled as compound-Gaussian and assumed to have fully-correlated unknown texture among the range cells in the window of interest. The target signal is composed of an unknown complex return and known Doppler steering vector. Generalized likelihood ratio test (GLRT) is derived by means of estimating the clutter texture parameter and complex target return. Performance of the detector is investigated by means of numerical analysis and Monte-Carlo simulations. [C757]

"Performance analysis of RADARSAT-2 multi-channel MODEX modes"

It has been recognized that a two-aperture approach to ground moving target indication is sub-optimum and that target parameter estimation is often compromised by clutter interference or poor signal-to-clutter ratios. This paper investigates the Ground Moving Target Indication (GMTI) performance of several virtual channel concepts proposed for the RADARSAT-2 moving object detection experiment (MODEX). These are capable of increasing the spatial diversity of RADARSAT-2 by exploiting its very flexible antenna programming capabilities and allowing the two-channel SAR system to operate like a three or four channel radar. A high fidelity space-based radar moving target indication simulator (SBRMTISIM) is used to generate virtual channel raw GMTI data for analysis. Moving targets are detected using a combination of the Factored Space-Time Adaptive Processing (Factored STAP) and the cell-averaging constant false alarm rate (CA-CFAR) detector. The detection performance of virtual multi-channel MODEX modes are analyzed and compared with those of the standard two-channel MODEX mode and a true three or four channel space-based radar system. [C758]

"Multi-range and multi-pulse radar detection in correlated non-Gaussian clutter"

This work presents a multi-range cell and multi-pulse approach to radar detection problem. The derived detector performs clutter estimation using the neighboring range cells, clutter cancellation, threshold setting simultaneously and it eliminates the need for a separate CFAR operation. The radar clutter is modeled as compound-Gaussian and assumed to have fully-correlated unknown texture among the range cells in the window of interest. The target signal is composed of an unknown complex return and known Doppler steering vector. Generalized likelihood ratio test (GLRT) is derived by means of estimating the clutter texture parameter and complex target return. Performance of the detector is investigated by means of numerical analysis and Monte-Carlo simulations. [C759]

"Distributed adaptive CCAWCA CFAR detector"

In the sense of likelihood ratio test (LRT), a new type of distributed constant false alarm rate (CFAR) scheme-CCAWCA(censored cell-averaging -R-weighted cell averaging) CFAR detector is presented Its characteristic is that censored cell-averaging (CCA) CFAR algorithms are used in local processors to form the estimation of SNR of local observations, and then the estimation transmitted to the data fusion center (DFC). Finally, the fusion center makes the final decision based on the weighted cell averaging (WCA). Since the weights are adjusted according to different SNR adaptively, the proposed detector can be available in the case that the target echo and noise/clutter have different level for every sensor. In addition, it does not need a priori knowledge about the interference in order to perform well. Furthermore, unlike the OS-CFAF the tolerance of interfering targets is restricted in appointed k value's. Under Swerling 2 assumption, the analytic expression of detection probability and false alarm probability are derived. [C760]

"Continuous-discrete filtering for dim manoeuvring maritime targets"

Real radar data containing a small manoeuvring boat in sea clutter is processed using a grid based finite difference implementation of continuous-discrete filtering. Both two dimensional diffusion and four dimensional constant velocity models are implemented using Gaussian and Rayleigh sea clutter models. Superior performance is observed for the constant velocity model and significant sensitivity is noted due to mismatches between actual clutter characteristics and Gaussian and Rayleigh models. A simple likelihood ratio thresholding technique is shown to provide a significant performance improvement. [C761]

"Target existence based resource allocation"

Assume an ESA (electronically steered antenna) radar. In between the surveillance mode operations (where the radar completes one scan of the surveillance area), this radar has spare time for (at least one) additional mode which could be optimized for various special requirements. The optimization is often translated to the choice of the next track to update. In this paper we propose a resource allocation scheme designed to minimize the time to confirmation of tracks following new targets, as well as to minimize the time to terminate tracks whose targets are lost or have disappeared from the view. The resource allocation cost is a function of the probability of target existence of individual tracks. Simulation results show that resource allocation based on this cost significantly increases the number of targets that can be reliably tracked in the sense of them being quickly followed by confirmed tracks upon arrival, and of their tracks being quickly terminated when the targets themselves disappear. The penalty of this approach is an increase in the root mean square target trajectory estimation errors of confirmed true tracks, as they are not updated as often. [C762]

"Adaptive censored cell-averaging CFAR detection in distributed sensor networks"

This paper present a new distributed CFAR (constant false alarm rate) detector based on the adaptive censored cell-averaging CFAR technique. In the scheme, every local decision of individual detector, resulting from the comparison between its sample in test cell and the estimate of clutter power level of its reference samples, takes the value zero or one. In local processor, the CCA-CFAR (censored cell-averaging) technique is utilized to get the local decision, Then, the fusion center makes the global decision based on the total local decisions, which are transmitted from each local sensor. The overall decision, which is zero or one, is obtained at the data fusion center grounded on "k/N" fusion rule. The results show that for the nonhomogeneous background caused by multiple interfering targets, this approach is more reality. Particularly in multiple target situations, it exhibits robustness than MOS (maximum order statistic), mOS (minimum order statistic), and OSOR (ordered statistics), ORAND in distributed sensor networks. Under Swerling 2 assumption, the analytic expression of false alarm and detection probability are derived. [C763]

"Tracking a moving target with multiple doppler sensors using an artificial neural network"

Tracking of human movements using radar in a high-clutter environment or even through walls is a problem of current interest. Example applications include law enforcement, disaster search-and-rescue and urban military operations. One approach to human tracking is to use wideband waveforms. Such system is capable of high range localization, but the cost of the hardware tends to be high. Doppler-based sensors, on the other hand, offer an inexpensive way to detect moving targets in the presence of stationary clutter. However, target location information is not possible, unless frequency or spatial diversity is incorporated. In this work, we investigate the use of a collection of spatially diverse Doppler sensors to derive the location information of a moving target. This problem has been investigated previously by Armstrong and Holeman in the context of tracking a baseball in 3D using a number of speed guns. In that work, a local search method was employed for the maximum-likelihood estimation of target parameters (position and velocity) from the measured Doppler shifts. However, the results

can be very dependent on the initial guess so that the parameter estimation may not be robust. In this paper, an artificial neural network is proposed to estimate the target parameters using Doppler information measured by a set of spatially distributed sensors. The neural network is trained to relate the nonlinear relationship between the observed Doppler information and the target parameters. For the training, point scatterer data generated by simulation are used. Some preliminary measurement data are collected using a toy car that runs a round track. Its trajectory and velocity are estimated by the neural network. The simulation and measurement results are reported. [C764]

"Identification of Hidden Mines"

This paper reviews the state of knowledge concerning the identification of buried mines and unexploded ordnance using techniques based on the singularity expansion method, supplemented by symmetry. It includes a list of important references which, in turn, give a very large list of references. This is supplemented by some more recent specific references. [C765]

"Cross-Channel Interference in Multi-User Radar Systems"

In this paper we evaluate the impact of the presence of interfering radar on the target direction of arrival (DOA) monopulse estimation performed by the reference radar. The importance of the use of codes in multi-user radar system is highlighted in a simple scenario of two cooperating radars. [C766]

"A new formulation for coherent backscattering from distributed targets"

A new formulation for backscattering from distributed targets has been developed that expresses the backscattered signal received by the radar as a weighted coherent sum involving the antenna spatial spectrum and the backscattered radiation. While the general formulation is applicable to scatterers in the antenna Fresnel zone, the specific focus in this study was on the far field region. [C767]

"Performance analysis of RADARSAT-2 multi-channel MODEX modes"

It has been recognized that a two-aperture approach to ground moving target indication is sub-optimum and that target parameter estimation is often compromised by clutter interference or poor signal-to-clutter ratios. This paper investigates the ground moving target indication (GMTI) performance of several virtual channel concepts proposed for the RADARSAT-2 moving object detection experiment (MODEX). These are capable of increasing the spatial diversity of RADARSAT-2 by exploiting its very flexible antenna programming capabilities and allowing the two-channel SAR system to operate like a three or four channel radar. A high fidelity space-based radar moving target indication simulator (SBRMTISIM) is used to generate virtual channel raw GMTI data for analysis. Moving targets are detected using a combination of the factored space-time adaptive processing (factored STAP) and the cell-averaging constant false alarm rate (CA-CFAR) detector. The detection performance of virtual multi-channel MODEX modes are analyzed and compared with those of the standard two-channel MODEX mode and a true three or four channel space-based radar system. [C768]

"UWB FSR for air targets detection: Preliminary analysis"

This paper is dedicated to the preliminary analysis of the utilisation of an ultra wideband (UWB) signal in forward scattering radar (FSR) for air target detection. Some advantages of the wide spectrum ranging signal use are shown: ground clutter reduction, target resolution, altitude and direct target position evaluation. [C769]

"A new bearings-only tracking algorithm for ground moving targets constrained to roads"

We propose a new recursive algorithm for tracking ground moving targets from multiple bearings-only measurements in clutter, collected by a ground moving observer. The scenario represents a target moving along a realistic road network with junctions, roads branching or crossing, where the probability of having measured the line-of-sight bearing, among the multiple observed ones, is less than the unity. This constrained motion estimation is performed using particle filters. Realistic simulations are presented to support our findings. [C770]

"Evaluation of the single and two data set STAP detection algorithms using measured data"

Traditional space time adaptive processors for radar target detection require a training data set which is usually drawn from adjacent range gates. Clutter heterogeneity, however, can severely limit the available training sample support and consequently degrade the detection performance. The SDS algorithms, on the other hand, overcome this problem by operating solely on the test data without recourse to training data. In this paper we evaluate both of these approaches, in particular the AMF and MLED, using the MCARM data set. We illustrate

the performance degradation of the AMF that results from the clutter heterogeneity and the corresponding advantage of the MLED. We also show that a calibration step of the spatial steering vectors results in significant performance improvement of all of the algorithms considered here. [C771]

"Statistical Modeling and ML Parameter Estimation of Complex SAR Imagery"

Accurate statistical models for the complex pixels forming fine-resolution synthetic aperture radar (SAR) images are needed for several engineering applications, including coherent signal detection in SAR clutter, automatic target recognition, and automatic SAR RCS calibration without calibration targets. We derive the maximum likelihood estimator for the parameters of a complex generalized Gaussian distribution and show that it can be efficiently computed. Applying this to fine-resolution SAR images representing a wide variety of scene contents, we show that this model very accurately captures both the central regions and tails of the data distribution. [C772]

"Knowledge-Aided Space-Time Adaptive Processing"

A fundamental issue in knowledge-aided space-time adaptive processing (KA-STAP) is to determine the degree of accuracy of the aprioriknowledge and the optimal emphasis that should be placed on it. In KA-STAP, the a priori knowledge consists usually of an initial guess of the clutter covariance matrix. This can be obtained either by previous radar probings or by a map-based study. In this paper, we consider a linear combination of the aprioriclutter covariance matrix with the sample covariance matrix obtained from secondary data, and derive an optimal weighting factor on the aprioriknowledge by a two-step maximum likelihood (ML) approach. The performance of the two-step ML approach is compared with that of the convex combination (CC) approach and is evaluated using the KASSPER data. [C773]

"A Net Track Solution to Pose-Angular Tracking of Maneuvering Targets in Clutter with HRR Radar"

Maintaining track continuity is a challenging task for large area persistent surveillance with high target density, rapid target maneuvering, and low target-to-clutter ratio. When the sensor revisit interval is long, measurement-to-track association becomes rather difficult. Although maneuvering targets can be discriminated via Doppler processing, clutter still masks moving targets at certain aspect angles. This creates a blind zone for GMTI (ground moving target indicator) radar, which may extend as large as 25% of the azimuth angles. For high-value targets that may undergo evasive maneuvers, a net track solution coordinating multiple looks from a netted set of sensors is set forth in this paper to ensure continuous monitoring. Target visibility therefore needs to be factored into netted radar platform coordination and sensor systems management. For ground targets, their heading is mostly aligned with the longitudinal axis. The target pose thus carries kinematic information about the direction of velocity vector that can be used to assist tracking of maneuvering targets. In this paper, the range profiles of high range resolution (HRR) radar are used for pose angular estimation of maneuvering targets in clutter. A pose-sensitive classifier provides matching scores that are converted into likelihoods and updated over time in a probabilistic manner. Pose angular tracking from individual sensors in the network is fused to cover the blind zone encountered by individual sensors. A software simulation environment that produces range profiles based on the RF signatures of moving targets is used in the study. Simulation results for pose angular tracking in clutter are presented to illustrate the net track solution concept and its performance. [C774]

"Real-time PRF selection for medium PRF airborne pulsed-doppler radars in tracking phase"

This paper proposes a new method to select optimal pulse repetition frequency (PRF) sets for use in tracking mode of medium PRF airborne pulsed-Doppler radar. Neural networks algorithm is used to map from engagement variables to the optimal PRF set. On-line computation during flight can be made real-time after off-line training of the neural network. The training sets for the neural network need to be generated by selecting optimal PRF set for the possible engagement scenarios from which range-Doppler clutter map is calculated to check the decodability and detectability for all PRF candidates. The PRF sets generated by the method must guarantee the maximum detectability inside the target tracking window as well as maintaining good decodability. Simulation result shows that the proposed method has much better range-Doppler detection performance compared to the previous algorithms by applying different optimal PRF set to different engagement scenarios and target positions. [C775]

"In Situ Adaptive Feature Extraction for Underwater Target Classification"

This research compares the performance improvements of image-based sonar target classification algorithms when they are adapted to changing clutter environments. The distribution of seabed pixels in the sonar imagery is modeled as a correlated, K-distributed random variable allowing for a quantitative representation of seabed

environments in the various testing scenarios. Parameterized environments comprising various target-like seabed textures are generated synthetically and used to examine adaptive classification performance. Results demonstrate that optimizing classifier parameters respective to specific environments improves overall classification performance compared to optimizing classifier parameters against a pooled dataset that includes all possible environments. [C776]

"Multichannel parametric detectors for airborne radar applications"

We consider the problem of detecting a multichannel signal in the presence of spatially and temporally colored disturbances. The parametric Rao and GLRT detectors, recently developed by exploiting a multichannel autoregressive (AR) model for the disturbance, have been shown to perform well with limited or even no range training data. The performance of the parametric detectors, however, has been evaluated through the limited computer simulations. The disturbances were generated to follow the exact multichannel AR processes and independently from each other with the same distribution whereas the disturbances in an airborne radar environment do not follow the exact multichannel AR model. In this paper, we evaluate the detection performance of the parametric Rao and GLRT detectors using airborne data obtained from the multi-channel airborne radar measurement (MCARM) database. This data contain typical clutter found in airborne radar systems, and cover a variety of scenarios including dense-target or heterogeneous environment Numerical results show that the parametric Rao and GLRT detectors work well with limited or even no range training data in an airborne radar environment. [C777]

"An approach for interference detection and rejection from other sensors by using Hough Transform and image processing"

This paper presents some results of studies on radar interference rejection using a Hough-Transform-based technique and image processing. If target detection is done by comparing the magnitude of each bin with a threshold produced by a CFAR algorithm, a number of radar systems operating at the same frequency band can cause reciprocal interference, thereby affecting detection and increasing false alarm probability. In this work we will refer to this interference as to "other sensor interference" (OSI). The goal of this work is the definition of methods to detect and remove the interference patterns from radar raw video images. We show that the substitution of interferences with samples estimated from cells (cross range samples) in close proximity of the OSI-affected samples allows CFAR algorithms performance to be improved. [C778]

"Distributive Target Tracking in Wireless Sensor Networks under Measurement Origin Uncertainty"

This paper addresses the problem of tracking a single target under measurement uncertainty due to clutters and missed detections in wireless sensor networks. By adopting the particles' representation of the probability density function of target state, this paper develops a particle filter (PF) and probabilistic data association filter (PDAF) hybrid tracking algorithm, name as PF-PDAF. PF-PDAF extends the well-known PDAF to the general nonlinear system. Based on the hierarchical sensor network architecture, the distributive PF- PDAF is also implemented. Moreover, the posterior Cramer-Rao lower bound (PCRLB) is computed to provide a theoretical bound on the tracking performance of the developed algorithms. Simulation results are provided. [C779]

"Adaptive Sensing of Dynamic Target State in Heavy Sea Clutter"

We propose an adaptive estimation method for the spatio- temporal covariance matrix of sea clutter. The motivation is to enable adaptive detection approaches that rely on accurate estimation of this matrix. The method involves vectorization of the equations for the dynamical system model governing the temporal evolution of the clutter matrix followed by a multiple particle filtering approach to deal with the high dimensionality of the formulation. The estimated sea clutter covariance matrix is applied to the problem of detection of a small target in heavy clutter; effectiveness is demonstrated via simulations. [C780]

"Wavefront Adaptive Sensing for Radar Spread Clutter Mitigation"

In spatially inhomogeneous, Doppler-spread radar environments, adaptive processing is often precluded because neither the target wavefront is sufficiently known nor is signal-free training data available. This paper presents a new clutter mitigation method designed to overcome these challenges by combining minimum variance (MV) adaptive beamforming and blind source separation (BSS) for distributed sources. Wavefront adaptive sensing (WAS) is a hybrid adaptive beamforming approach which uniformly maximizes gain against clutter by avoiding MV signal cancellation due to mismatch at high SNR and poor BSS threshold performance at low SNR. Simulation results are presented for target detection in a multi-mode spread-Doppler over-the-horizon radar scenario. [C781]

"Discrete Suppression with ΣΔ-STAP"

This paper presents the hybrid algorithm of SigmaDelta-STAP and direct data domain(D3) which is robust to the discrete interferer. SigmaDelta-STAP provides high performance result with the relatively low complexity of calculation. It also requires small number of training sample to estimate covariance matrix. However this algorithm is vulnerable to the discrete interferer which is target-like interferer with high SNR. This paper shows that SigmaDelta-STAP can suppress discrete interferer signal in conjunction with direct data domain (D3) method which is an effective method to eliminate non-correlated interference such as discrete interferer in the non-homogeneous environment. [C782]

"Morphological Component Analysis and STAP Filters"

STAP is an adaptive filtering algorithm that works on space-time radar data to suppress the effects of clutter and jamming and achieve both target identification and parameter estimation in airborne and space based radar [1][2]. The signals to which STAP processes are applied consist of three basic parts, target, clutter and jamming. In morphological component analysis (MCA) [3] the component signals are separated by assuming that each signal component can be sparsely represented in some suitable dictionary. It is assumed that expansions of a given signal component in the dictionaries of the other signal components are non-sparse. The MCA algorithm seeks a solution through an optimization method that implements this sparse-representation idea. This approach was applied to the analysis of ISAR images in [4]. In this paper we consider the basic STAP equations as a problem in multi-channel morphological component analysis (MMCA) [5] [6] [7]. The method is illustrated by application to the KASSPERI datacube. [C783]

"Wavefront Adaptive Raymode Processing for Over-the-Horizon HF Radar Clutter Mitigation"

Detection of surface targets using over-the-horizon radar (OTHR) is extremely challenging due to ionospherically-induced Doppler spread clutter. In particular, low Doppler targets are often masked by ground clutter arriving via multipath propagation at different elevation angles, each with a different ionospheric Doppler shift. The wavefront adaptive raymode processing (WARP) approach presented here exploits the azimuthally distributed nature of the clutter return and adaptively estimates the "crinkly" spatial wavefront arriving on each raymode by using its distinct Doppler spectral characteristics. Rather than the plane-wave beamwidth of the array aperture, the raymode resolution of WARP is limited by the wavenumber-extent-spatial-aperture (WESA) product of the clutter return. Thus it is possible to spatially separate clutter raymodes using limited array apertures. Using simulated radar data, WARP is shown to provide a signal-to-clutter-plus-noise ratio (SCNR) improvement of as much as 30 dB over conventional processing for targets buried in Doppler spread clutter. [C784]

"Comparison of Radar-Based Human Detection Techniques"

Radar offers unique advantages over other sensors in the human detection problem, such as remote operation during virtually all weather and lighting conditions. Many radar-based human detection systems today employ Fourier analysis, such as spectrograms. However, spectrograms perform poorly in high clutter environments. Also, an inherent SNR loss is caused by the implicit assumption of linear target phase. In this paper, human modeling is used to derive a more accurate non-linear approximation to the true non-linear target phase and the likelihood ratio is optimized over unknown parameters to enhance detection performance. Performance is compared both analytically and through MATLAB simulations. [C785]

"Adapting to Change: The CFAR Problem in Advanced Hyperspectral Detection"

Newer, realistic models of targets and backgrounds used in hyperspectral detection do not always lend themselves to a CFAR (constant false alarm rate) formulation. Several advanced techniques are considered here. It is found that incorporating a particular empirically validated method of target evolution permits an exact CFAR version of a large class of advanced detectors based on elliptically contoured distributions. Other validated detectors are considered, for which no closed form normalization exists to convert them to CFAR form. For these a geometrical approach to achieving approximate CFAR performance is described and analyzed. [C786]

"Bistatic foliage penetration modelling"

This paper aims at presenting a model able to study the impact of the target presence under vegetation and to assess the detection feasibility. In a first part the model is described. We will then get at the analysis of results for several set of radar configurations to illustrate the potentiality of detection by means of shadows. [C787]

"Point target interferometry for natural and artificial scatterers"

The Coherent Targets Monitoring technique is providing superior ground deformation mapping compared with standard interferometry based on one pair of Master/Slave scenes. This is because using a larger data set it is possible to estimate and correct for additional phase error sources. Also the point targets detected as coherent targets are generally characterized by stronger signal that provides more accurate phase information than the clutter present in the rest of the scene. This paper reviews previous work in SAR noise estimation and shows the advantages of point targets versus distributed targets. Results from the Turtle Mountain/Frank Slide site show that the measured phase/deformation errors at the point target positions are within the estimated range. Corner reflectors with a high SNR are expected to improve the accuracy of the method. [C788]

"Distributed target detection in SAR images using improved chaos-based method"

Detection of distributed targets such as internal wave or ship wake on sea surface in Synthetic Aperture Radar (SAR) images is an important application of ocean microwave remote sensing. The chaotic characteristic of sea clutter gives some clues to targets detection on sea surface. Speckle, the inherent noise of SAR image, will affect the predictive accuracy of sea clutter adversely and reduce the detection performance of radar. In order to apply the chaotic characteristic of sea clutter to targets detection in SAR images more effectively, an improved chaos-based detection method is proposed in this paper. First, speckle noise is suppressed by undecimated wavelet transform (UWT), and then targets are detected on the basis of the chaotic characteristic of sea clutter from the denoised SAR images. Experimental results prove that the method proposed in this paper is effective for the distributed targets detection in SAR ocean images. [C789]

"Research on Multi-mode Fusion Tracking of OTHR Based on Auction Algorithm"

In OTHR's tracking system, we will estimate the state of a discrete-time, linear stochastic system whose observation process consists of a finite set of known, non-linear measurement models. MPDA is capable of exploiting multipath target signatures arising from discrete propagation modes that are resolvable by the radar, but it is very time-consuming and will bring multipath tracks. In this paper, a multi-mode fusion tracking of OTHR based on auction algorithm (A-MFT) is proposed, which effectively solve the problem of multi-mode measurements. When tracking a single and non-maneuvering target with four possible measurements, simulations in clutter environment show that the computing speed of the algorithm proposed in this paper is greatly higher than that of MPDA, and the tracking precision just a little lower than that of MPDA, further more, A-MFT will not bring multipath tracks and do not need consequent track association. [C790]

"A normalized Fractionally lower-order moment algorithm for Space-Time Adaptive Processing"

A new space-time adaptive processing algorithm is proposed for clutter suppression in phased array radar systems. In contrast to the commonly used normalized least mean square (NLMS) algorithm which uses the second order moments of the data for adaptation, the proposed method uses the lower order moments of the data to adapt the weight coefficients. The normalization is also performed based on the data sample dispersion rather than the variance. Processing results using simulated and measured data show that the proposed algorithm converges faster than the NLMS algorithms in Gaussian and non-Gaussian clutter environments. It also provides better clutter suppression than the NLMS algorithm under heavy-tailed, impulsive, non-Gaussian environments. It in turn improves the target detection performance. [C791]

"Collaborative Multi-Target Detection in Radar Sensor Networks"

In many military and civilian applications, estimating the number of targets in a region of interest plays a primary role in performing important tasks such as target localization, classification, recognition, tracking, etc. Such an estimation problem is however very challenging since the number of targets is time-varying, targets' states are fluctuating, and various kinds of targets might appear in the field of interest. In this paper, we develop a framework for estimating the number of targets in a sensing area using Radar Sensor Networks (RSN): (1) the multi-target detection problem is formulated; (2) signals, interference (e.g., clutter, jamming, and interference between radars), and noise at radar sensors are modeled; and (3) a Maximum Likelihood Multi-Target Detection (ML-MTD) algorithm is proposed to combine received measurements and estimate the number of targets present in the sensing area. We evaluate multi-target detection performance using RSN in terms of the probability of miss-detection Pmd and the root mean square error (RMSE). Simulation results show that multi-target detection performance of the RSN is much better than that of single radar systems. [C792]

"Experimental consideration on the synthetic range-profile processing by stepped-frequency radar"

In radar system, separation of the target from the background clutters requires high range and cross-range

resolution. To improve the range resolution, shorter pulses and wideband-FM pulses are utilized. However, they tend to complicate system architecture and to increase implementation cost due to the necessity of a wideband receiver. The synthetic range-profile (SRP) processing has been proposed to realize high range resolution without using the wideband receiver. The principle of the processing is that the echoes of stepped-frequency pulses are synthesized by IDFT in the frequency domain. This enables us to obtain short pulses in the time domain. This paper proposes the SRP radar composed of high-speed wideband exciter, which generates the stepped-frequency pulses. Through experiments, effectiveness of the proposed system is verified. [C793]

"Wrapper approach for feature subset selection using GA"

In this paper, wrapper based approach is presented to feature subset selection of ground penetrating radar (GPR) echo signal using genetic algorithm in conjunction with constructive learning algorithm. GPR echo signal inherently has the non- stationary characteristic and the target echo signal is deteriorated by the clutter. Firstly, WP-based preprocessing algorithm is used to clutter reduction and feature extraction. Then wrapper based approach is adopted to find optimal feature subset, and at meanwhile obtain the result of classification. Experiment result based on GPR landmine data shows the feasibility and advantage of the presented algorithm. [C794]

"Region feature extraction based on improved regularization method in SAR image"

The noise existed in synthetic aperture radar (SAR) image weakens the detailed features of region of interest (ROI) such as target and shadow. It also leads to the serious performance reduction of subsequent target detection, classification and recognition. The conventional regularization method could enhance target features in SAR image; however, the high computation complexity limits the real-time application of it. An improved regularization method is introduced in this paper, which increases processing speed of region feature extraction for SAR image significantly. It is theoretically proved that, by optimizing SAR projection operator, computation complexity could be reduced from O(M3N3)to O(MN) without ability losing of the region-based feature enhancement. MSTAR SAR image data is employed for algorithm experiment. The result shows that our method can increase target-to-clutter ratio significantly while restraining the noise in ROI, and then extract target and shadow from background clutters in SAR image more accurately. [C795]

"Clutter analysis of high resolution millimeter-wave SAR-data in the spatial and wavelet domain"

This paper presents the analysis of high resolution millimeter SAR clutter data, measured in a joint Swiss-German flight campaign. The generalized Gaussian function and the Kolmogorov-Smirnov test are considered to test the hypothesis of Gaussian clutter process. 35 GHz and 94 GHz data are compared. The results are presented in the time and wavelet domain, as the wavelet domain is an import transform domain for the development of terrain classification, target recognition and data compression algorithms. [C796]

"Design, Simulation and Implementation of UWB Antenna Array and it's Application in GPR Systems"

Most of the shallow buried object detection techniques by ground penetrating radar (GPR) use a monostatic type radar system. The shallow target is difficult to be detected by the conventional GPR due to its low range resolution. Recently, we have developed GPR system based on single-plate monopole antennas operating in the frequency range between 1 GHz and 20 GHz. A total of seven monopole elements have been used to form an antenna array. The antenna and the array have been designed and simulated using CST microwave studio. Their impedance and radiation characteristics have also been simulated and measured. By using the designed antenna array, the GPR system has been constructed. The developed GPR system is able to acquire, save and analyse the data measured in frequency domain. Common source or wide-angle reflection and refraction (WARR) technique has been used for acquiring and processing the data. This technique is effective for the rejection of the ground surface clutter. The system has been tested in the laboratory. It shows its ability to detect metallic objects by using A-scan technique. Furthermore, we could localize a mine-like target buried in dry soil by applying the B- scan technique. Further details of the antenna simulation results and the application of the system in buried object detection will be discussed. [C797]

"Extracting information from shadows in SAR imagery"

The presence of speckle noise presents considerable challenges in interpreting SAR imagery. Despite the very high resolution that is on offer with modern SAR systems, the extraction of reliable intelligence from SAR imagery in an automated and robust manner has faced considerable difficulties. Shadow regions in SAR imagery are unique in terms of absence of speckle and any distortion from imaging artefacts. This paper presents a series of work that has aimed at exploiting the information in SAR shadows. Earlier work looked at combining

shadow features with target features obtained with single look imagery. This provided for better target classification and led to a technique for estimating heights for urban structures. However, it is with multiple perspective imagery that SAR shadows have proved really effective. Using shadow delineation alone, information from different look angles over a sequence of SAR images is combined together to provide very reliable and unambiguous estimates of building dimensions. Another remarkable success has been the detection of moving targets from their shadows over a sequence of SAR images. The images of moving targets are blurred and distorted making it difficult, if not impossible, to detect the moving targets in SAR imagery. However, the target shadows are undistorted. Initial results with short-range data have been successfully replicated with detecting moving targets at much longer ranges. In all of these cases performance will be affected where clutter background is weak, dynamic range is poor or shadows from different objects overlap. Nevertheless, this paper has highlighted a range of applications from target detection and location to urban scene analysis where SAR shadows have been shown to provide a highly effective way of extracting information from the imagery. [C798]

"A Clutter Reduction Technique for Microwave Reconstruction of Shallow Underground Targets"

This paper presents a signal pre-processing technique for the stepped-frequency ground penetrating radar that is aimed at suppressing clutter related to antenna effects and variation of the ground surface response. Both the ground bounce and the clutter can obscure shallow underground objects such as landmines making difficult their detection. At the preprocessing stage, the measurement system has been calibrated using a free space and metal sheet as standards. Both the modulus and the phase of the signal obtained for metal sheet have been approximated by polynomials, and this synthetic signal is used to derive approximate transfer functions of the antenna. This technique utilizes calibration measurement for only one position of the metal sheet and yet reduces clutter related to the antenna effects. Besides, the calibration simplifies further subtraction of the ground surface response. The 2-D image of the subsurface is built then using B-scan data from which the ground bounce is eliminated. The performance of the method is demonstrated in several examples employing the frequency-domain data collected by a transmitting-receiving antenna pair. [C799]

"Improvements of radar clutter classification in air traffic control environment"

The use of adaptive technologies may prove useful in the processing of radar signals. The proposed radar clutter classificator is aimed to improve the detection of snow clutter presence in data acquired by a ground radar system in an air traffic control environment. Each plot detected in the radar image is processed in order to extract a series of features which are then used to discriminate between targets or snow clutter. The data set used in simulations has been extracted from a measurement campaign carried out in presence of snow in Italian airports, with the help on an expert operator who manually classified a set of plots as target, or clutter. Two sets of features have been tested, one of which is derived from moments of inertia, and the second one is a specifically designed feature vector, which has been selected as to follow the reasoning scheme of a trained human observer. Three different classifiers have been tested and compared in the final stage: a Bayes classifier, a multilayer perceptron and a radial basis function network. Results indicate the best configuration exhibits a correct classification rate of about 95%. [C800]

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