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ТЕМАТИЧЕСКИЙ РЕФЕРАТИВНЫЙ СБОРНИК № 36-2

“Small Ship Radar Detection”
(«РЛ обнаружение малоразмерных судов»)

Публикации в трудах конференций

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"Comparison of ship detectors for polarimetric SAR imagery"

This paper examines the benefits of using fully polarimetric SAR imagery for ship detection. There are three related aspects to the work. First, RadarSat-2 quad-pol stripmap imagery is used to compare the performance of various ship detection algorithms/methods. The comparison is based on the use of ROC curves. Second, circular spotlight SAR imagery is used to examine how detector performance varies with the azimuth angle. Owing to the small number of available ship samples, this analysis has limitations. Third, again using the circular spotlight SAR imagery, the variation, with respect to azimuth angle, of the elements of the polarimetric covariance matrix of both the ship and the ocean are analysed. The results are as follows. Using the stripmap imagery, it is found that exploiting both polarimetry and spatial correlations greatly improves detection performance. Using the circular spotlight imagery, it is found that detection performance is variable with respect to azimuth angle and trends are hard to discern. Moreover, the performance of the Pauli double bounce detector is generally poor. It is conjectured that ship pitching motion degrades the polarimetric backscatter response in the circular spotlight imagery. Finally, the covariance matrix analysis confirms known trends for the ocean backscatter. The implication of these trends is that the polarimetric covariance matrix is sensitive to changes in azimuth angle and hence detectors based on them are also. The data indicate the extent to which this is the case. [C1]

"A system trade model for the monitoring of coastal vessels using HF surface wave radar and ship automatic identification systems (AIS)"

Coastal nations have an interest in maritime domain awareness for applications in national security, coastal conservancy, fishery and stewardship of the exclusive economic zones (EEZs) along their coastlines. Using our previously developed HF radar and AIS ship detection models we find signal to noise ratio (SNR) as a function of range, including ducted propagation for the AIS radio signals. We use these SNR estimates to find probability of detection Pdand then explore multiple systems and stations at variable spacings along the coast. Our example HF radar has significant power and aperture, similar to the Pisces radar. The AIS model is for high power (12.5 W) AIS and a significantly elevated receiver (≈ 250 ft asl). A combined system of HF radar and AIS shows good capability (Pd> 0.9) to ranges of ≈ 125 km for small ships and to 200 km for large ships. Considering a system of sites separated by 100 km we find that a Pdof > 0.9 can be maintained to a distance off shore of 130 km even for small, 120 ton, ships. [C2]

"Passive bistatic WiMAX radar for marine surveillance"

In this study we investigate the feasibility of using passive bistatic radar to exploit WiMAX communication signals as transmitters of opportunity for marine surveillance. The range and Doppler characteristics of such a system are first assessed through ambiguity function analysis on a typical set of WiMAX data transmission waveforms. Theoretical simulations are then used to investigate the ability of passive WiMAX radar for detecting marine vessels within three busy shipping areas in the UK, and in the presence of noise and interference signals. The initial analysis shows a range resolution of 5.6 m is achievable. Additionally, the simulations demonstrate specific scenarios where WiMAX radar may be used as a low cost surveillance device for detecting both small and large marine vessels in port areas and open waters. [C3]

"Hydro-meteorological disturbaces influence on radar picture investigation"

Integration and correlation functions used in merchant ship radar nowadays increase radar detection possibility of small objects like recreation and fishery boats. These functions improve safety of maritime navigation considerably. For safety of shipping detection possibility of ship borne radars is important mainly during foggy weather, storm and heavy rain. In the article detection possibilities of FM CW and pulse radars were compared. In order to define them, there were registered, during rain and storm weather, radar video signals of two radars installed in the radar laboratory of Gdynia Maritime University located on shore line near south entrance to the port in Gdynia: pulse radar NSC 34 produced by USA Company Raytheon and CW FM radar CRM-203

produced by Telecommunication Research Institute Ltd. Gdansk Division (PIT Ltd). [C4]

"Concurrent use of satellite imaging and passive acoustics for maritime domain awareness"

The research being conducted in the Center for Secure and Resilient Maritime Commerce (CSR), a DHS National Center of Excellence for Port Security examines some basic science issues and emerging technologies to improve the security of ports and inland waterways, as well as coastal and offshore operations. This research follows a layered approach utilizing above water and underwater surveillance techniques. The investigated layers include satellite-based wide area surveillance; HF Radar systems providing over-the-horizon monitoring; and nearshore and harbor passive acoustic surveillance. Integration of these systems is aimed at achieving vessel detection, classification, identification, and tracking. In this paper, we present the results of sea tests where satellite imagery was combined with concurrent passive acoustic surveillance. The wide area sensing was provided by the University of Miami CSTARS facility's electro-optical (EO) and synthetic aperture radar (SAR) satellite imaging capabilities. Satellites detected the ships using a panchromatic EO sensor FormoSat-2 and SAR from the COSMO-SkyMed constellation. The Stevens Passive Acoustic System was used for detecting sound produced by the same ships that were detected by satellites. Concurrent Satellite-Acoustic measurements provide the following advantages: 1. Increasing the probability of small vessel detection and decreasing false alarms. 2. The joint systems can provide redundant detection and classification in conditions where one of the systems fails. For example, EO satellite imaging does not work at night and in fog and cloudy conditions while acoustic detection has limits during stormy weather due to ambient noise. SAR imaging can detect vessels in all weather, but provides less detail about a specific vessel. 3. Acoustics can provide target classification and bearing and satellites can give target localization and heading. SAR data can be used to estimate vessel speed in some cases. 4. Satelli--te imaging is helpful for the acoustic detection of an underwater target in cases when satellite information allows separation of surface and underwater targets. 5. Joint measurements provide more data (information) for target classification. Several tests were conducted in New York Harbor, where the satellite images and acoustic signatures of the same boats were recorded. The satellite registered a number of small boats. The small boats were acoustically detected at distances up to 4 km and the signal generated by a passenger ferry was observed at a distance up to 7 km. [C5]

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

The protection of military harbours is a complex task. A force protection system integrates several sensors and databases for ashore and waterside surveillance: • passive sensors (acoustic, magnetic, CCTV, IR, FO fence) • active sensors (Radar, Diver Detection Sonar) • remote / autonomous vehicles for inspection and surveillance • chart database • information database Additionally a network-based waterside security application should integrate several additional sources and services e.g.: • WEB based Automatic Identification System (AIS) • Satellite based AIS • Access to online databases e.g. weather information, ship register data • C4I data e.g. MCCIS (NATO C4I system) or JoCIS (EADS export C4I system) Also, new technical possibilities of modern multi touch HMI approaches and aspects of user centric man machine interface design will be discussed. [C6]

"Oil Spill statistics from SAR images in the North Eastern Baltic Sea ship route in 2007-2009"

A large number of illegal oil pollutions impose considerable threat to marine environment especially in marginal seas like the Baltic Sea. Illegal spills are mainly detected on essential navigation routes. The monitoring of Oil Spills (OS) using remote sensing imagery (SAR data) was performed on the northeastern Baltic Sea ship route. The pre-analyzed satellite images for detecting marine pollution were provided to marine surveillance agency in Estonia. Out of 137 detected potential pollutions 76 were confirmed by aerial surveillance missions within two-year period. OS were mainly of low confidence, had small area, low contrast with surrounding water and smeared edges. The entrance to the Gulf of Finland was classified as the area where illegal spills of oil and bilge water take place, mainly. Between 30-50% of actual oil pollutions are not detected by SAR. [C7]

"An innovative spaceborne radar concept for global maritime surveillance: Description and performance demonstration"

The paper describes an alternative concept to conventional SAR instruments for ship detection over all ocean surfaces. The concept is specifically oriented for ship detection, and not for land or sea imaging. It allows wide swath coverage (as high as 1000 km). It exhibits high detection performances of small ships even in adverse sea states conditions. Its power consumption is reduced allowing a permanent operation all along the orbit. At least, it uses already developed and low cost technologies. [C8]

"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. [C9]

"Utilization of ASAR wave mode data for shipping safety"

Safety of shipping is a growing concern. The causes of shipping casualties are various, while over 30% of the casualties are due to bad weather. Heavy sea state and severe weather conditions have caused the loss of more than 200 large cargo vessels within 20 years between 1981 and 2000. Remote sensing techniques, particularly the active microwave radar provides global sea surface observations for detecting heavy sea state and bad weather independent of clouds and sunlight and therefore it can contribute to shipping safety. A dataset of synthetic aperture radar (SAR) images spans nearly two decades since the launch of ERS-1 in 1991 for operational observations. When no other operations are requested, ERS-1, 2 SAR and ENVISAT ASAR can collect data as small images of 10 km times 5 km size every 200 km or 100 km along the satellite's orbit. This kind of data is called SAR wave mode data and can be acquired continuously and globally over the sea surface. Using the integral wave parameters derived from SAR wave mode data, global sea state statistics can be carried out. In the present paper, significant wave height and zero upcrossing wave periods derived from ASAR wave mode data using the CWAVEENV empirical algorithm are compiled into a global wave atlas. Wave steepness is a crucial parameter for shipping safety. By using integral wave parameters derived from ASAR wave mode data, wave steepness is calculated and compiled to the global wave atlas as well. [C10]

"Cluster-Based Split-Window Radon Transform Algorithm for Ship Wake Detection"

The purpose of this article is to present a novel algorithm for ship wake detection in synthetic aperture radar (SAR) images. The main originality of our work is that splitting the image with small window before conventional Radon transform to make the illumination has stronger consistency in each window and adopting clustering algorithm to select real wakes form disturbing lines. Experimental result on real SAR image is presented and compared to that obtained using conventional approaches. [C11]

"An Improved Automatic Ship Detection Method in SAR Images"

This paper provides an improved automatic ship detection algorithm, which uses two-parameter CFAR algorithm based on Gauss-distribution to process the homogeneous imaging local area, and uses two-parameter CFAR algorithm based on K-distribution to process the heterogeneous imaging local area again. This improved 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. [C12]

"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. [C13]

"Using HF surface wave radar and the ship Automatic Identification System (AIS) to monitor coastal vessels"

We compare the ship detection capabilities of the automatic identification system AIS (installed on some ships) and coastal, surface wave HF radars, showing how to use both systems together to enhance ship detection performance in coastal regions. Practical reasons to want better real-time awareness of the location, velocity and type of vessels along coasts include vessel safety, protection of the coastal environment and national security. Our model for the HF radar aspect uses an example radar with significant power and aperture, similar to the Pisces radar. The AIS model is for the high power (12.5 W) AIS unit and a significantly elevated receiver (~ 250 ft asl). The HF system show good capability to ranges of ~ 150 km for small ships to 250 km for large ships. The AIS system shows excellent capability out to a typical horizon of ~ 50 km with irregular coverage beyond using ducted propagation to several hundred km and more. Use of both systems allows monitoring of both AIS and

non-AIS equipped ships and enhances probability of detection for situations where both systems are functional. [C14]

"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. [C15]

"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. [C16]

"Multiple scattering of HF skywave radar signals: Physics, interpretation and exploitation"

HF radar signals rely on the ionosphere to achieve over-the-horizon surveillance, but this is obtained at the expense of subjecting the signals to a diverse range of scattering and modulation phenomena. Many of these effects are associated with multiple scattering, both in the ionosphere and near the earthpsilas surface. This paper reviews a variety of multiple scattering phenomena and shows how an understanding of the physics enables the radar echoes to be interpreted so as to extract information about targets and the environment. Particular attention is focussed on (i) scattering from small scale plasma irregularities, which can be used to classify propagation modes and thus improve target tracking, and (ii) scattering from the sea surface, which can be exploited for optimising radar ship detection performance as well as a range of remote sensing applications. [C17]

"The effects of sea clutter on the performance of HF Surface Wave Radar in ship detection"

This paper presents a study of the effects of sea clutter on the performance of HF surface wave radar (HFSWR), operating in the band between 3 and 5 MHz, in the detection of two classes of ships: large freighters with gross registered tonnage (GRT) in the order of several tens of thousands of tons and small vessels with a GRT of about 1000 tons. The radar returns from both large and small ships are estimated from the measured returns from the Canadian Coast Guard Ship (CCGS) Teleost, based on the differences of their radar cross section (RCS) estimated in [10]. The estimated returns are then extrapolated in range using the propagation attenuation calculated for the sea condition under which the measured returns were obtained. These extrapolated returns were compared with the sea echoes measured from the same radar to assess the detection capability of the radar. The conclusions of the study are that, in the detection of large ships, the radar performance is independent of sea state, but in the detection of small ships, the radar performance is dependent on sea state. It is shown that if a radar employing conventional linear beamforming methods is to maintain the detection capability for the small ships, then the aperture of the receive array cannot be reduced from its current value. [C18]

"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. [C19]

"High Resolution Radar Imaging of the Sea Surface"

Applications are reviewed of high resolution radar sea surface imagery to remote sensing, wide area surveillance, target detection and tracking. The limitations imposed by sea surface motion on SAR imaging are discussed and illustrated, along with methods to exploit the motion such as along track interferometry. Ships on the sea are subject to roll, pitch and yaw motions, which defocus SAR imagery; analysis and signal processing to characterise and overcome the difficulties are described. Real aperture images of the sea are shown to contain detailed information on the propagation of surface waves, which may be used in algorithms to detect anomalies such as small surface vessel; these are also described and demonstrated [C20]

"Target Detection Based on The Artificial Neural Network Technology"

As it is difficult to detect small ship targets from complex background in an IR image because of the impact of kinds of noises, complex background and the smallness of the target, this paper puts forward a method of background prediction utilizing the neural network. The method estimates the background of the input image nonlinearly, gains the residual error image, and detects the target. By comparison, NARX whose hidden layer transfer function utilizing L-M algorithm can achieve more excellent target detection than other neural networks like BP in training speed and stability, thus it is research valuable in the field of small target detection in complex background [C21]

"Sub-aperture Behavior of SAR Signatures of Ships"

First Page of the Article [C22]

"Verification of the Radar Visibility of Small Objects"

Minimal and maximal distances of radar visibility and tracking of small objects were measured in different weather conditions in the Gulf of GdaГ‚Вїsk and at high sea on big tanker ship and s/v "Dar MГ‚ВїodzieГ‚Вїy". Radars working in S and X band were used. Different small objects, including buoys, hydrofoil boats and high-speed crafts, were observed and tracked on different radars in different weather conditions. Results of these experiments will be presented in this paper. [C23]

"Radar Detection of Small Sailing Yachts"

Paper describes measurements in the real sea conditions of the maximum radar detection and tracking distances of small sailing yachts without radar reflectors and equipped with different types of radar corners by contemporaneous ship and shore based radar equipment. Researches were conducted on order of the Maritime Office in Gdynia. [C24]

"A Multivariate Approach to Iceberg and Ship Classification in HH/HV ASAR Data"

First Page of the Article [C25]

"Naval radar in a littoral environment"

The changed political situation in the world forces navies to reconsider their roles and missions. As a consequence, the naval operation areas shift from warfare on the open sea to littoral warfare. In modern scenarios full scale, multiple engagements attack on a naval convoy is less likely. Instead, the threat is more likely to come from weapons launched from the land or small, high-speed ships. Additionally, detection and tracking of surface targets becomes a more important sensor function. This paper discusses the impact of littoral warfare on the design of naval radar. The main aspects discussed in this paper are the benefit of accurate Doppler information, high radar stability, use of Doppler-polarimetry and sensor flexibility. [C26]

"Electromagnetic interactions between a high frequency surface wave and a ship"

In this paper, we assess the capability of a HFSW radar to detect a small fast boat moving behind a ship, the dimensions of which are comparable to the wavelength. We show that, in the HF band, the scattered field in the shadow region of the large ship is significant enough to induce strong coupling between the two vessels. This results in fluctuations in the values of the RCS of the small boat of about 12 dB. [C27]

"Oil slick detection by SAR imagery using Support Vector Machines"

Spaceborne Synthetic Aperture Radar (SAR) is well adapted to detect ocean pollution independently from daily or weather condition. In fact, oil slicks have specific impact on ocean wave spectra. Initial wave spectra may be characterized by three kinds of waves, big, medium and small, which correspond physically to gravity and gravity-capillary waves. The increase of viscosity is due to the presence of oil damps gravity-capillary waves. This induces a damping of the backscattering to the sensor, but also a damping of the energy of the wave spectra. Thus, local segmentation of wave spectra may help oil slick detection. It can be achieved by the segmentation of a multiscale decomposition of the original SAR image. In this work, a supervised oil slick detection is proposed by using Support Vector Machines into the wavelet decomposition of a SAR image. It performs accurate detection with no consideration to signal stationarity nor to the presence of strong backscatters (such as ship). Moreover, when using normalized SAR images, the kernel expansion may be generalized from one image to an other to make a near unsupervised detection scheme. The algorithm has been applied on Envisat ASAR images. First experiments yield accurate segmentation results with a very limited number of false alarms. [C28]

"A simulation study of a noncoherent radar signal processing for oil slick detection"

Uncontrolled oil slicks have become a serious problem in recent decades. Big scale disastrous situation can be monitored by satellite SAR systems. On the contrary local, small scale oil slicks can be monitored by traditional radar systems mounted on the sea shore, off-shore oil platforms or ships. Design of an appropriate signal processing needs an effective signal simulation because real signals are rarely available and not in sufficient amount. A simulation algorithm of an oil slick backscattered signal and results of a study of the simulated signal processing for oil slicks detection are presented. [C29]

"Unsupervised oil slick detection by SAR imagery using kernel expansion"

Spaceborne synthetic aperture radar is well adapted to detect ocean pollution independently from daily or weather condition. In fact, oil slicks have specific impact on ocean wave spectra. Initial wave spectra may be characterized by three kinds of waves, big, medium and small, which correspond physically to gravity and gravity-capillary waves. The increase of viscosity due to the presence of oil damps gravity-capillary waves. This induces a damping of the backscattering to the sensor, but also a damping of the energy of the wave spectra. Thus, local segmentation of wave spectra may be achieved by the segmentation of a multiscale decomposition of the original SAR image. In this work, an unsupervised oil slick detection is proposed by using kernel-based novelty detection into the wavelet decomposition of a SAR image. It performs accurate detection with no consideration to signal stationarity nor to the presence of strong backscatters (such as ships). The algorithm has been applied on ENVISAT ASAR images. It yields accurate segmentation results, even for small slicks, with a very limited number of false alarms. [C30]

"Signatures of vessels in ENVISAT AP-mode imagery"

A series of ENVISAT AP mode data has been collected over the Nome field off the coast of central Norway. An oil production vessel has been imaged with different ASAR beams and polarisations to study how its signature changes with varying imaging parameters. Cross-polarised data gives better contrast for automated detection compared to co-polarised data, when the incidence angle is small. [C31]

"Ship echo discrimination in HF radar sea-clutter"

HF radar can provide over the horizon detection of ships on very large oceanic areas. Normally, the Doppler shift produces by ships is small, of the same order of magnitude as the Doppler shift of the sea clutter. Consequently, it is not always easy to discriminate a ship line from a sea clutter line. In this paper the coherence of sea clutter is considered in the context of a radar interferometer. It is shown that the coherence function can be useful to discriminate between a ship line and sea clutter spectral peaks. The dependence of the coherence value with the signal to clutter ratio is also studied. [C32]

"CFAR techniques for over-the-horizon radar"

Since the OTHR background noise is too strong, the target echoes would be embedded in sea clutter and environment noise. In order to detect targets such as ships or aircrafts from radar returns, a range Doppler CFAR schemes is presented, the identical Doppler frequency resolution cells over adjacent range or azimuth resolution cells are used to form a sliding window for targets detection. Since the OTHR range resolution cells is very large and so do the azimuth resolution cells, the total number of range Doppler resolution cells that forms sliding window is limited in order to guarantee stationary. Some CFAR algorithms such as CA, CM, TM, BLU and QBW methods that are suitable for OTHR are compared and analyzed versus different total range or azimuth resolution cells number. If the total range Doppler resolution cells number is small (less than 12), CA-CFAR is preferred in order to get the good detection performance. In multiple targets situation, CM-CFAR or TM-CFAR are suggested which trims the largest samples that possibly be interfering targets. [C33]

"Oceans 2002 Conference and Exhibition. Conference Proceedings (Cat. No.02CH37362)"

First Page of the Article [C34]

"Small ship detection with high frequency radar using an adaptive ocean clutter pre-whitened subspace method"

We propose a novel scheme for using high frequency ocean surveillance radar (HFOSR) to detect slow weak target echoes embedded in temporally correlated sea clutter having a continuous spectrum. General Doppler processing CFAR detection of ships in ocean surveillance radar is usually inhibited by the continuous high order sea clutter. Conventional subspace methods can be utilized to enhance the detection, but they deteriorate dramatically in the presence of correlated sea clutter. In our paper an adaptive sea clutter filtering is introduced which improves the threshold and accuracy of the subspace detection method. Both simulated and real ship targets are used to verify the effectiveness of our proposed method. [C35]

"Ship detection and tracking using HF surface wave radar"

The Canadian Department of National Defence (DND) conducted a joint trial involving multiple sensors in the detection and tracking of ships in the Grand Banks of Canada in March 2000, including the HF surface wave radar (HFSWR) system at Cape Race, Newfoundland. One objective of the trial was to evaluate the detection and tracking capabilities of the HFSWR system. Three co-operative ships were used: a Canadian Navy patrol frigate named Ville de Quebec and two small fishing vessels named Anne S. Pierce and Arctic Pride. We present some results of the detection and tracking of these co-operative ships using the HFSWR. The radar had difficulties tracking ships near Bragg lines, i.e., the first-order sea echoes of the radar. A revised algorithm is also presented to detect ships near Bragg lines. [C36]

"Ship detection by SAR interferometry"

In order to extend the capabilities of synthetic aperture radar (SAR) imagery to the detection of small ships on an agitated sea surface, even with low incidence angles, a new method based on SAR interferometry and coherence techniques has been developed. The use of phase instead of intensity allows even small ships, with low backscattering, coefficients to be detected, since the returned signal from a ship should have higher phase coherence than the surrounding sea [C37]

"Track classification in a naval defence radar using fuzzy logic"

The track extractor for a naval defence radar must be capable of the early formation of tracks on small radar cross section targets against a background of clutter (e.g. tracks on sea skimming missiles); other targets of interest may be aircraft or ships. A radar that is sensitive enough to detect small RCS targets will, as a consequence, return plots from a wide variety of clutter sources, such as land, sea and birds. A track extractor that provides early target detection on weak targets, combined with a very low false track rate from the uncorrelated clutter and noise, will still be left with a track picture containing targets such as birds that, while perfectly genuine, are unwanted by a weapons system or display. This paper describes and demonstrates a method, using fuzzy logic, of identifying the type of each track, in order to suppress the output of these unwanted tracks. It illustrates the process by considering the identification of unwanted bird tracks [C38]

"COBRA GEMINI radar"

With the end of the cold war, measurement and signature intelligence (MASINT) data collection requirements have changed. Formerly, the primary MASINT task was to collect information on foreign strategic missile

systems. Today's data collection problem is to collect information on proliferating and emerging tactical ballistic missile capabilities in a number of rest-of-world (RoW) countries. The optimum solution to this data collection problem is an airborne phased array radar. However, this solution is expensive and time-intensive to implement. Therefore, key and consistent recommendation of studies addressing the RoW data collection problem has been to develop a small, transportable imaging radar. This paper presents details of a transportable dual (S and X) band radar development program, named COBRA GEMINI, to provide this collection capability. The program is being managed by the Air Force's Electronic Systems Center (ESC), with support from MIT/Lincoln Laboratory and the MITRE Corporation [C39]

"Detection and localization of lost objects by SAR technique"

Containers and pallets are often lost from ships. A system based on a micro satellite weighting less than 100 kg, embracing a small SAR (Synthetic Aperture Radar) sensor; a transponder installed in the container and one or more ground stations is described. When a container drops in the water a floating housing is unhooked and the internal transponder is switched-on. Initially it works in a low power consumption status and then, when activated by the small satellite beacon, starts full power operations. The azimuth localization is performed by a synthetic aperture or Doppler analysis processing. In the range direction a short pulse is used. The radar transmitted frequency is shifted inside the transponder, maintaining the coherence. This avoids any problem of time ambiguities in the radar because the receiver chain operates at a different frequency from the transmitter. The micro satellite should be equipped with GPS system for determining its position along the orbit. The received signals are preprocessed on board and then transmitted to the satellite control station. A requirement of four/five days can be met by a single satellite while up to four's are needed for one day revisit time. This paper deals with the description of such innovative system, its dimensioning and possible implementation solutions for the micro satellite radar and the electronics contained into the transponder [C40]

"Fractal detection of radar weak targets"

Radar weak target detection is a very difficult problem. The fractal information of radar targets may provide a new way to enhance the performance of conventional detection methods. A new approach to detect ship targets from sea clutter has been developed. The approach is based on the use of the fractal signature difference between the ship target and sea clutter, which is manifested in the backscattered radar signal from different objects. The fractal signatures are estimated by using the box counting method. In the case of a small number of sampling points, the computation of the fractal dimensions is considered [C41]

"Feature extraction for radar ship target recognition using compactly supported wavelets"

In this paper, we are mainly concerned with the application of orthogonal discrete wavelet transform in feature extraction for incoherent radar ship target recognition, based on the Daubechies' wavelets (1988). Experiments are carried out for the proposed method with practical video-echo data of four kinds ,and the corresponding results indicate that the computational complexity of the new method is small and the extracted features are typical with high data compression. In the last, a new detection approach to the odd video-echo of radar ship target is proposed [C42]

"Application of the Dempster-Shafer Algorithm to the Detection of Sar Ship Wakes"

First Page of the Article [C43]

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