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ТЕМАТИЧЕСКИЙ РЕФЕРАТИВНЫЙ СБОРНИК № 13-1

“Moving Small Target Detection”
(«Обнаружение движущихся малоразмерных целей»)

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"Multiobjective Optimization of OFDM Radar Waveform for Target Detection"

We propose a multiobjective optimization (MOO) technique to design an orthogonal-frequency-division multiplexing (OFDM) radar signal for detecting a moving target in the presence of multipath reflections. We employ an OFDM signal to increase the frequency diversity of the system, as different scattering centers of a target resonate variably at different frequencies. Moreover, the multipath propagation increases the spatial diversity by providing extra "looks" at the target. First, we develop a parametric OFDM radar model by reformulating the target-detection problem as the task of sparse-signal spectrum estimation. At a particular range cell, we exploit the sparsity of multiple paths and the knowledge of the environment to estimate the paths along which the target responses are received. Then, to estimate the sparse vector, we employ a collection of multiple small Dantzig selectors (DS) that utilizes more prior structures of the sparse vector. We use the ℓ1-constrained minimal singular value (ℓ1-CMSV) of the measurement matrix to analytically evaluate the reconstruction performance and demonstrate that our decomposed DS performs better than the standard DS. In addition, we propose a constrained MOO-based algorithm to optimally design the spectral parameters of the OFDM waveform for the next coherent processing interval by simultaneously optimizing two objective functions: minimizing the upper bound on the estimation error to improve the efficiency of sparse-recovery and maximizing the squared Mahalanobis-distance to increase the performance of the underlying detection problem. We provide a few numerical examples to illustrate the performance characteristics of the sparse recovery and demonstrate the achieved performance improvement due to adaptive OFDM waveform design. [J1]

"Tracking Motion Direction and Distance With Pyroelectric IR Sensors"

Passive IR (PIR) sensors are excellent devices for wireless sensor networks (WSN), being low-cost, low-power, and presenting a small form factor. PIR sensors are widely used as a simple, but reliable, presence trigger for alarms, and automatic lighting systems. However, the output of a PIR sensor depends on several aspects beyond simple people presence, as, e.g., distance of the body from the sensor, direction of movement, and presence of multiple people. In this paper, we present a feature extraction and sensor fusion technique that exploits a set of wireless nodes equipped with PIR sensors to track people moving in a hallway. Our approach has reduced computational and memory requirements, thus it is well suited for digital systems with limited resources, such as those available in sensor nodes. Using the proposed techniques, we were able to achieve 100% correct detection of direction of movement and 83.49%-95.35% correct detection of distance intervals. [J2]

"MIMO Radar Moving Target Detection in Homogeneous Clutter"

A multiple-input multiple-output (MIMO) radar approach employing widely dispersed transmit and receive antennas is studied for the detection of moving targets. The MIMO radar transmits orthogonal waveforms from the different transmit antennas so these waveforms can be separated at each receive antenna. For a moving target in colored Gaussian noise-plus-clutter, we quantify the gains from having widely dispersed antennas that allow the overall system to "view" the target simultaneously from several different directions. The MIMO radar performance is contrasted with that of a traditional phased-array approach, which employs closely spaced antennas for this purpose. The MIMO radar approach is well suited to handle targets that have small radial velocities for scenarios in which colocated sensors cannot separate the target from the background clutter. Both a centralized processing and a simple distributed processing form of the MIMO radar approach are developed and studied, and the gains from the centralized version, which come at the price of additional complexity, are clearly demonstrated and explained intuitively. The constant false alarm rate (CFAR) property of an adaptive version of the MIMO moving target detector is also demonstrated for homogeneous clutter. [J3]

"A tutorial overview of anomaly detection in hyperspectral images"

In this paper, a tutorial overview on anomaly detection for hyperspectral electro-optical systems is presented. This tutorial is focused on those techniques that aim to detect small man-made anomalies typically found in

defense and surveillance applications. Since a variety of methods have been proposed for detecting such targets, this tutorial places emphasis on the techniques that are either mathematically more tractable or easier to interpret physically. These methods are not only more suitable for a tutorial publication, but also an essential to a study of anomaly detection. Previous surveys on this subject have focused mainly on anomaly detectors developed in a statistical framework and have been based on well-known background statistical models. However, the most recent research trends seem to move away from the statistical framework and to focus more on deterministic and geometric concepts. This work also takes into consideration these latest trends, providing a wide theoretical review without disregarding practical recommendations about algorithm implementation. The main open research topics are addressed as well, the foremost being algorithm optimization, which is required for embodying anomaly detectors in real-time systems. [J4]

"Airborne along-track interferometry for GMTI"

Synthetic Aperture Radar (SAR) Along-Track Interferometry (ATI) has been used extensively to measure ocean surface currents. Given its ability to measure small velocities (-10 cm/s) of relatively radar-dark water surfaces, there is great potential that this technique can be adapted for ground moving target indication (GMTI) applications, particularly as a method for detecting very slow targets with small radar cross-sections. Herein, we describe preliminary results from an ATI GMTI experiment. The SAR data described were collected by the dual-frequency NASA/JPL airborne radar in its standard dual-baseline ATI mode. The radar system imaged a variety of control targets including a pick-up truck, sport utility vehicles, passenger cars, a bicycle, and pedestrians over multiple flight passes. The control targets had horizontal velocities of less than 5 m/s. The cross-sections of the targets were not purposely enhanced, although the targets' reflectivities may have been affected by the existence of the GPS equipment used to record the targets' positions. Single-look and multiple-look interferograms processed to the full azimuth resolution were analyzed. In the data processed to date, all of the targets were observed by visual inspection in at least one of the four combinations of dual-frequency, dual-baseline interferometric data. This extremely promising result demonstrates the potential of ATI for GMTI applications. [J5]

"Positron Emission Tomography-Guided Biopsy With a Dedicated Breast Scanner: Initial Evaluation"

Efforts to create dedicated nuclear medicine breast imaging scanners are maturing as they approach more routine clinical use. These systems promise to improve the detection of small lesions, especially those in breasts that are not definitively imaged with standard methods. Since these techniques lack sufficient specificity for accurate diagnoses of cancer, a method for guiding biopsies with these new devices must be developed. In this investigation, a technique that capitalizes upon the three-dimensional, multi-angle positron emission tomography (PET) breast images created by our new positron emission mammography/tomography imaging and biopsy device (PEM-PET) to guide breast biopsies was tested. Specifically, the accuracy and precision of the needle positioning system was measured for each of the three axes of motion. In addition, a biopsy of a simulated breast lesion was performed under realistic imaging conditions. The results from the positioning tests revealed that the system had very good accuracy and precision in all three axes. The maximum positioning error was plusmn 0.27 mm, sufficient to obtain samples from most lesions detected with PEM-PET. In addition, the simulated biopsy was performed successfully on a single attempt in obtaining a sample from a 5-mm-diameter target sphere. This successful test moves the project closer to the next phase of development, initiation of limited human testing. [J6]

"Along-track interferometry for ground moving target indication"

Synthetic aperture radar (SAR) along-track interferometry (ATI) has been used extensively to measure ocean surface currents. Given its ability to measure small velocities (-10 cm/s) of relatively radar-dark water surfaces, there is great potential that this technique can be adapted for ground moving target indication (GMTI) applications, particularly as a method for detecting very slow targets with small radar cross-sections. Herein, we describe preliminary results from an ATI GMTI experiment. The SAR data described were collected by the dual-frequency NASA/JPL airborne radar in its standard dual-baseline ATI mode. The radar system imaged a variety of control targets including a pickup truck, sport utility vehicles, passenger cars, a bicycle, and pedestrians over multiple flight passes. The control targets had horizontal velocities of less than 5 m/s. The cross-sections of the targets were not purposely enhanced, although the targets' reflectivities may have been affected by the existence of the GPS equipment used to record the targets' positions. Single-look and multiple-look interferograms processed to the full azimuth resolution were analyzed. In the data processed to date, all of the targets were observed by visual inspection in at least one of the four combinations of dual-frequency, dual-baseline interferometric data. This extremely promising result demonstrates the potential of ATI for GMTI applications. [J7]

"Time-frequency method for detecting an accelerating target in sea clutter"

The authors design a time-frequency (TF) method for use in high-frequency surface-wave radar (HFSWR) for detecting a small accelerating target in sea clutter. The clutter is modelled by pseudo targets moving with Bragg velocity towards and away from the radar. The design is based on the Wigner distribution (WD) defined by Chan (type-III WD, in our terminology) rather than the WD defined by Claasen and Mecklenbrauker (1980) (2times type-I WD, in our terminology). Like the type-I WD, the type-III WD also concentrates a chirp signal onto a straight line in the TF plane. The type-III WD has the following advantages: 1) Its range of unambiguously measurable frequencies (RUMF) is [-pi,pi] rad/s, whereas for the type-I WD the RUMF is [-pi/2,pi/2] rad/s. 2) It allows a target separated from the clutter by pi rad/s to be detected, whereas the type-I WD coalesces such a target with the clutter and thereby mask it. An ambiguity function (AF) was defined corresponding to the type-III WD and use it to derive a smoothed type-III WD that mitigates the clutter. The smoothed type-III WD method is applied to real radar data and shown to be superior to the conventional Fourier transform method. The advantages of the type-III WD over the type-I WD are also demonstrated. The design principles laid out in the paper can also be used to develop a TF method for use in air traffic control radar (ATCR) for detecting an accelerating target in land clutter [J8]

"Preventing Damage by Hidden Objects in Vegetation"

The paper presents the experimental radar-based sensor to operate in environment with vegetation cover for detection and discrimination there the small-sized invisible dielectric and metallic objects. This sensor constitutes a vehicle-housed emergency system for surveillance of area with vegetation ahead on the path of moving vehicle to prevent its contact with hidden objects. The emergency system functioning in basically implemented by real-time electromagnetic imaging of the scene of interest and its following image processing to enhance the target responses. The developed and tested experimental radar techniques are under consideration. The results of experimental examinations in field are presented and discussed [J9]

"X-band experimental airborne radar-Phase II: synthetic aperture radar and ground moving target indication"

Defence Research and Development Canada, Ottawa, has completed Phase II of a multifunction X-band wideband experimental airborne radar. The system consists of a high average power transmitter, a digital waveform generator, two wideband 8-bit channels for synthetic aperture radar (SAR)/inverse synthetic aperture radar and two narrowband 14-bit channels for ground moving target indication (GMTI). The reflector antenna uses a novel multimode feedhorn to derive two phase centres displaced in azimuth. 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. Highlights of the data collection capabilities, include a swath width 16 K points wide in the single-channel SAR modes, 8 K points wide in the two-channel integrated SAR-GMTI modes and 4 K points wide in the GMTI surveillance modes. The architecture of the radar, its modes of operation with respect to the SAR and GMTI data collection capabilities, the MATLAB-based GMTI processor, and the real-time kernel developed for the SAR processor are discussed; and results from its high resolution stripmap, landspot, seaspot and GMTI modes are presented from trials in July 2003. [J10]

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"GMTI along-track interferometry experiment"

Synthetic aperture radar (SAR) along track interferometry (ATI) has been used extensively to measure ocean surface currents. Given its ability to measure small velocities (10 cm/s) of relatively radar-dark water surfaces, there is great potential that this technique can be adapted for ground moving target indication (GMTI) applications, particularly as a method for detecting very slow targets with small radar cross-sections. In this paper we describe preliminary results from an ATI GMTI experiment. The SAR data described herein were collected by the dual-frequency NASA/JPL airborne radar in its standard dual-baseline ATI mode. The radar system imaged a variety of control targets including a pickup truck, sport utility vehicles, passenger cars, a bicycle, and pedestrians over multiple flight passes. The control targets had horizontal velocities of less than 5

m/s. The cross-sections of the targets were not purposely enhanced, although the targets' reflectivities may have been affected by the existence of the GPS equipment used to record the targets' positions. Single-look and multiple-look interferograms processed to the full azimuth resolution were analyzed. In the data processed to date, all of the targets were observed by visual inspection in at least one of the four combinations of dual-frequency, dual-baseline interferometric data. This extremely promising result demonstrates the potential of ATI for GMTI applications. [J12]

"A novel application of a microaccelerometer for target classification"

This paper presents a novel method of target classification by means of a microaccelerometer. Its principle is that the seismic signals from moving vehicle targets are detected by a microaccelerometer, and targets are automatically recognized by the advanced signal processing method. The detection system based on the microaccelerometer is small in size, light in weight, has low power consumption and low cost, and can work under severe circumstances for many different applications, such as battlefield surveillance, traffic monitoring, etc. In order to extract features of seismic signals stimulated by different vehicle targets and to recognize targets, seismic properties of typical vehicle targets are researched in this paper. A technique of artificial neural networks (ANNs) is applied to the recognition of seismic signals for vehicle targets. An improved back propagation (BP) algorithm and ANN architecture have been presented to improve learning speed and avoid local minimum points in error curve. The improved BP algorithm has been used for classification and recognition of seismic signals of vehicle targets in the outdoor environment. Through experiments, it can be proven that target seismic properties acquired are correct, ANN is effective to solve the problem of classification and recognition of moving vehicle targets, and the microaccelerometer can be used in vehicle target recognition. [J13]

"Ship detection based on coherence images derived from cross correlation of multilook SAR images"

A new simple technique is presented to extract ships from synthetic aperture radar (SAR) images. The procedure is to compute the cross-correlation values between two images extracted by moving windows of a small size from the multilook SAR intensity (or amplitude) images. A coherence image, consisting of the cross-correlation values of the intensity images, is then produced. Ships are deterministic targets, so that their interlook subimages possess higher degree of coherence than the uncorrelated random images of the surrounding sea surface. The main advantage of this method over the conventional constant false-alarm rate is its ability to detect, under favorable conditions, "invisible" images of ships embedded in the speckled image of the sea surface. The technique is tested using a RADARSAT-1 image in which one known and several unknown ships are present. The use of complex images and the exploitation of short decorrelation times of small-scale ocean waves to obtain an extra look are also discussed. [J14]

"Target detection trials with a millimeter wave radar system"

Unobstructed, large RCS targets, similar radar targets surrounded by moving foliage, and small targets in severe clutter have been used as test cases for two pre-processing algorithms and several threshold levels in an experimental millimeter wave radar system. The rather conventional "six-out-of-eight" pulse radar selection method with binary output has been compared to an algorithm that accepts a target if the pre-defined trigger level is crossed by the average of the eight consecutive pulses. In this case, however, the output is an analog value corresponding to the relative average video amplitude. In terms of plotted video, this process seems to give a slightly better combination of false alarm rate and detection probability. Large targets are easier to detect from foliage clutter with the conventional method. [J15]

"X-band wideband experimental airborne radar for SAR, GMTI and maritime surveillance"

Defence Research and Development Canada-Ottawa has completed Phase I in the development of a new multimode X-band wideband experimental airborne radar (XWEAR) to support studies in synthetic aperture radar (SAR) imaging, inverse SAR (ISAR), ground moving target indication (GMTI) radar and maritime surveillance radar with particular focus on small target detection and long-range surface surveillance. Specific areas of interest include research into SAR imaging techniques for fixed and moving targets, time-frequency analysis of ocean and land moving targets, space-time adaptive processing for application to GMTI, investigation into the electromagnetic backscatter properties of the ocean surface, generation of signatures for automatic target recognition and feature extraction, and analysis on the immunity of wide bandwidth systems against electronic countermeasures. Phase I culminated with the flight trialling of the SAR and maritime surveillance modes. Phase II will see the trialling of the wide area surveillance GMTI (WAS GMTI) and integrated SAR-GMTI modes. A description of the experimental radar is given along with an overview of its data collection capability. Distinguishing features include operation at X-band, single-channel operation for SAR and maritime surveillance,

and two-channel operation for WAS-GMTI and integrated SAR-GMTI. The new radar maximises the use of an existing digital scan converter as a controller, and commercially available components including the transmitter, A/D converters and computer boards. The timing circuitry, waveform generator, single- and dual-channel receivers are custom built [J16]

"Techniques for improving STAP performance in high PRF applications"

A novel beamforming architecture is presented in which space-time adaptive processing (STAP) for clutter suppression in airborne radar is implemented with tap delays of multiple PRIs. The resulting output is combined with the unadapted output. This can result in improved detection performance for targets obscured by clutter that covers only a small proportion of the unambiguous Doppler extent, as often occurs in high PRF modes [J17]

"Detecting small moving objects using temporal hypothesis testing"

This paper addresses the problem of detecting small, moving, low amplitude objects in image sequences that also contain moving nuisance objects and background noise. We formulate this problem in the context of a hypothesis testing procedure on individual pixel temporal profiles, leading to a computationally efficient statistical test. The technique assumes we have reasonable deterministic and statistical models for the temporal behavior of the background noise, target, and clutter, on a single pixel basis. Based on these models we develop a generalized likelihood ratio test (GLRT) and perfect measurement performance analysis, and present the resulting decision rule. We also propose a parameter estimation technique and compare its performance to the Cramer Rao bound (CRB). We demonstrate the effectiveness of the technique by applying the resulting algorithm to real world infrared (IR) image sequences containing targets of opportunity. The approach could also be applicable to other image sequence processing scenarios, using acquisition systems besides IR imaging, such as detection of small moving objects or structures in a biomedical or biological imaging scenario, or the detection of satellites, meteors or other celestial bodies in night sky imagery acquired using a telescope [J18]

"Strengths and limitations of the Fourier method for detecting accelerating targets by pulse Doppler radar"

The Fourier transform method has been generally used in pulse Doppler radar for detecting targets that are moving with acceleration, despite the phenomenon known as Doppler smearing which limits the performance of the method. Examples of accelerating targets are manoeuvring aircraft and missiles. The authors quantify the effects of Doppler smearing. In using a pulse Doppler radar to detect a nonaccelerating target in additive white Gaussian noise and to estimate its radial velocity, the Fourier method provides an output signal-to-noise ratio (SNR) that increases linearly with the number of pulses. When the target is accelerating, the Fourier method may still be used to detect the target and estimate its median velocity, provided the acceleration is small enough in the sense described. For a given acceleration, when the number of pulses is increased, the output SNR of the Fourier method varies as a concave function, increasing to a maximum and then decreasing, before the method fails catastrophically. Thus the number of pulses and the acceleration have to be matched to achieve optimum performance. Empirical formulas for the dependence of the optimum SNR and the optimum number of pulses on the acceleration are given. The results are shown to be relevant to the design of generalised likelihood ratio test detectors that apply a search over a grid [J19]

"Airborne GMTI radar position bias estimation using static-rotator targets of opportunity"

In target tracking systems: using GMTI (ground moving target indicator) radars on airborne platforms, the locations of these platforms are available from GPS-based estimates. However, these estimated locations are subject to errors that are, typically, stationary autocorrelated random processes, i.e., slowly varying biases. In situations where there are no known-location targets to estimate these biases, the next best recourse is to use targets of opportunity at fixed but unknown locations. Such targets can be, e.g., static rotators (ground-based radars with rotating antenna), which yield detections in moving target indicator (MTI) radars. It is shown that these biases can be estimated in such a scenario, i.e., they meet the complete observability condition. Following this, the achievable accuracy for a generic scenario is evaluated. It is shown that accurate georegistration can be obtained even with a small number of measurements [J20]

"JointSTARS and GMTI: past, present and future"

The concept of airborne surveillance of enemy ground forces with a Ground Moving Target Indicator [now called GMTI] radar capable of detecting moving ground vehicles and helicopters was proposed in 1968 and resulted in a DoD program to realize its potential. This article traces the program history starting with the Army's Stand Off Target Acquisition System [SOTAS] as it evolved through the Small Aerostat Surveillance System [SASS] and the Assault Breaker/Pave Mover programs into the currently fielded Joint Surveillance and Target Attack System

[JointSTARS], which, in prototype form, more than proved its worth in the 1991 Gulf War. New developments and trends in GMTI radars are also discussed together with other potential platforms [J21]

"Measurements of L-band inland-water surface-clutter Doppler spectra"

Although radar surface-clutter reflectivities from terrain are generally much greater than those from water, strong Bragg resonances at low but non-zero Doppler frequencies in backscatter from small inland bodies of water might potentially cause false alarms for moving target indicator (MTI) or other Doppler signal-processing techniques designed for target detection in ground clutter. To provide data for investigating this concern, measurements of L-band radar backscatter were recorded from the surface of a small inland freshwater reservoir in central Massachusetts. These measurements were of unusually high system stability and spectral purity so as to provide up to 80 dB of available spectral dynamic range. Strong Bragg spikes occurred in the clutter Doppler spectra from the reservoir at low (3 to 4 Hz) but non-zero Doppler frequencies. This strong Bragg resonance was persistent in time and space throughout the measurements. Spectral results are presented for all four combinations of linear polarization. Comparison with tree clutter spectral results indicates that, when an occasional water body comes under surveillance at vertical polarization in otherwise generally forested terrain, water clutter spectral density is expected to exceed surrounding-terrain tree clutter spectral densities in the Bragg-offset Doppler vicinity by large amounts [J22]

"An extended track-before-detect algorithm for infrared target detection"

Track-Before-Detect (TBD) approaches have important applications such as the detection of small, dim targets in a long-range Infrared Detection and Tracking (IRDT) system. The movement model of target limited by TBD is extended to that of target with constant acceleration in this work. An algorithm based on linear variant-coefficient difference equation for moving target indication is proposed. Moreover, based on parametric models of target and background, this paper presents an analysis of its optimal signal-to-noise ratio (SNR) gain versus target and background characteristics as well as the sensitivity of this gain to mismatch. [J23]

"Simulation studies of moving-target detection: a new approach with Wigner-Ville distribution"

The authors discuss the application of Wigner-Ville distribution (WVD) for moving-target detection (MTD) in a typical ground-based radar. The proposed technique enhances the target-detection capability using the fact that the sidelobe levels in the Wigner spectrum are very small in magnitude. This in turn facilitates the realisation of the Doppler-filter bank by the WVD without resorting to additional weighting to reduce the sidelobes, unlike in the current MTD-I system (FFT-based). The MTD scheme proposed exhibits good performance capabilities, by providing higher detection probabilities, lower false-alarm rates and an additional 10 dB gain in the improvement factor, for ground plus weather clutter, over MTD-I. This novel approach to MTD serves as a simple and superior alternative to the MTD-II and MTD-III schemes, which have similar performance capabilities over MTD-I. Computer-simulation results are presented to support the superiority of the proposed approach [J24]

"Carrier-free signal design for look-down radars"

The detection of low flying targets with small radar cross section (RCS), known as low observables, such as cruise missiles and stealth airplanes adds a new dimension to radar signal design and radar signal processing. A high resolution look-down radar is very attractive since it takes advantage of target shape to overcome difficulties encountered with small RCS. The look-down geometry, however, imposes three requirements: 1) the radar should detect targets with small relative velocities from almost zero to about the velocity of sound with no blind speeds, 2) it should minimize ground clutter by using short pulses, and 3) the radar signal must have a thumbtack ambiguity function. We investigate a look-down radar that eliminates time side lobes of compressed signal correlation functions to improve range resolution, reduces ground clutter to enhance receiver dynamic range, and uses thumbtack resolution function to resolve moving low observable targets from the surface of the Earth. The side lobe elimination technique transforms the correlation function of a coded waveform, based on complementary codes, to the correlation function of a single pulse. Features of side lobe elimination technique along with clutter cancellation circuits are presented in terms of blind speeds and range-velocity resolution function [J25]

"Phase aberration correction on two-dimensional conformal arrays"

Two-dimensional conformal arrays are proposed to enhance low contrast lesion detection deep in the body. The arrays conform to the body maintaining good contact over a large area. To provide full three-dimensional focusing for two-dimensional imaging, such arrays are densely sampled in the scan direction (x) and coarsely sampled in the nonscan direction (y), i.e., the arrays are anisotropic. To illustrate reduction in slice thickness with increased array length in y, a two-dimensional array is synthesized using a one-dimensional, 128 element

array with a 3.5 MHz center frequency. A mask is attached confining transmission and reception of acoustic waves to 2 mm in y. Using a mechanical scan system, the one-dimensional array is moved along y covering a 28.16 mmЧ20.0 mm aperture. Accordingly, the synthetic array has 128 elements in x and 10 elements in y. To correct for geometric irregularities due to array movement, a gelatin based phantom containing three-dimensional point targets is used for phase aberration correction. Results show that elevational beam quality is degraded if small geometric errors are not removed. Emulated conformality at the body surface and phase aberrations induced by spatial inhomogeneities in tissue are further imposed and shown to produce severe beam-forming artifacts. Two-dimensional phase aberration correction is applied and results indicate that the method is adequate to compensate for large phase excursions across the entire array. To fully realize the potential of large, two-dimensional, conformal arrays, proper two-dimensional phase aberration correction methods are necessary [J26]

"Detection of small moving objects in image sequences using continuity filter"

A new continuity filter method for detecting small moving targets with unknown trajectories in image sequences of a high noise environment is presented [J27]

"Target course recognition using nonsinusoidal look-down radars"

The target signature of an airplane as viewed by a nonsinusoidal look-down radar is obtained analytically as a function of target shape, azimuth orientation, look-down angle, and transmitted pulse duration. The information contained in the target signature can be used for detection of stationary and moving targets in heavy clutter, as well as the recognition of target shape and orientation. The relation between target signature and target azimuth orientation shows that pulse lengths shorter than airplane length are required to perform target recognition at all azimuth angles. Target course recognition in the radar ground plane is the process of determining the azimuth angle by selecting from the database the target signature that is most similar to the observed one. The effect of look-down angle on the target signature is also analyzed. At small look-down angles, target shape information is obtained with pulse lengths shorter than aircraft length. However, at large look-down angles pulse lengths much shorter than the airplane length are required. The variation of the target signature with azimuth and look-down angles are utilized for determining two-dimensional target course recognition. Cruise missile radars operating in a lookdown mode can utilize the very-high-resolution nonsinusoidal radar to enhance target shape recognition in addition to target course recognition [J28]

"Analysis of the digital MTI filter with random PRI"

Modulation of the radar pulse repetition interval (PRI) is a conventional technique used to improve the target velocity coverage in a moving target indicator (MTI) filter. Typically, a given pattern of interpulse intervals is periodically repeated (staggered PRI). Additionally, the staggered PRI gives some protection against PRI analysis in an electronic intelligence environment. The paper presents an analysis of the digital MTI for two types of PRI random generation. In the first type, small deviations with respect to a mean PRI are randomly generated (random deviation method, RDM). In the second type, the intervals themselves are randomly selected (random interval method, RIM). The author derives for both cases, the relationship between the velocity-dependent gain factor and the probability density function (PDF) of the corresponding random variables. This allows one to predict the influence of the PDF on the expected performance. Specific design strategies that take into account practical constraints, like the maximum unambiguous range and the dwell time, are also proposed for each method [J29]

"Target motion compensation by spectrum shifting in synthetic aperture radar"

Target motion can severely distort the image in a conventional synthetic aperture radar (SAR) by causing targets having even small components of radial velocity to be lost or to appear with enormous along-track errors. The presence of moving targets in the image can be detected from the spectral characteristics of the data samples contained in the synthetic aperture sequences being processed. By isolating the spectra of the moving targets and translating them to a point near the origin before carrying out conventional SAR processing, the moving targets can be made to appear as their correct locations in the final image. The theoretical basis for the correction procedure is developed and simulation results for a typical system are presented [J30]

"A localized adaptive MTD processor"

The problem of achieving the optimum moving target indicator (MTI) detection performance in strong clutter of unknown spectrum when the set of data available to the estimation of clutter statistics is small due to a severely nonhomogeneous environment is studied. A new adaptive implementation, called the Doppler domain localized generalized likelihood ratio processor (DDL-GLR), is proposed, and its detection performance is studied in detail.

It is shown that the DDL-GLR is a data-efficient implementation of the high-order optimum detector and has several advantages of practical importance over the adaptive processors [J31]

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