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ТЕМАТИЧЕСКИЙ РЕФЕРАТИВНЫЙ СБОРНИК № 35-1

“Helicopter Radar Detection”
(«РЛ обнаружение вертолётов»)

Журнальные публикации

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"Millimeter Wave Circularly Polarized Fresnel Reflector for On-Board Radar on Rescue Helicopters"

The increasing use of millimeter waves for civil radar application, e.g., for automotive or helicopter obstacle detection- requires the development of high gain and low cost antennas in compact form. With this aim, a Fresnel reflector with circular polarization over 5 GHz bandwidth (76-81 GHz) has been designed, fabricated and measured. The gain remains higher than 32 dBi with a peak value of 35 dBi at 79 GHz. For obtaining this performance, specific patches have been designed. They are based on circular rings, rectangular and offset patches. Each of them converts an incident linear electric field into a circular polarized one. [J1]

"Passive bistatic noise radar using DVB-T signals"

This study presents a new approach to passively detect targets using noise-like emitters of opportunity. This method combines the Wiener filtering to achieve clutter rejection and a proposed adaptation to noise-like signals of the amplitude and phase estimation (APES) method. This theoretical approach is confirmed by the detection of a helicopter by a bistatic radar using a digital video broadcasting terrestrial (DVB-T) transmitter. [J2]

"Facet Model of Moving Targets for ISAR Imaging and Radar Back-Scattering Simulation"

A facet model of targets is proposed to simulate inverse synthetic aperture radar (ISAR) images and radar back-scattering of moving targets with rigid and nonrigid motions. Targets are composed of solid objects which are modeled by triangular facets. It is shown that a facet can be treated as an equivalent point-scatterer whose radar cross section (RCS) and position depend on the shape of the triangle, the frequency, and the angle of incidence. A shadowing algorithm is also developed to detect the facets which actually have influence on the signal received by the radar. Besides, a facet division algorithm is implemented to improve the result of the shadowing algorithm and to have at least one facet per resolution cell. Finally, we apply our simulator to obtain the ISAR images of a ship and a helicopter and to calculate the micro-Doppler signature of a human. [J3]

"Radar Signature of a Helicopter Illuminated by a Long LFM Signal"

Helicopters exhibit a very particular Doppler radar signature caused by the movement of rotor blades. This signature can easily be derived using a short-time approximation: the blades are assumed to be static during each pulse. In wideband linear frequency modulated (LFM) radars, however, this assumption cannot be made. The work presented here describes the echo of rotary blades illuminated by LFM radars without the short-time assumption and provides useful information for detection and recognition purposes. [J4]

"The Doppler wheel revisited"

Millimeter-wave radar returns from cylindrical targets, such as artillery shells or helicopter rotor shafts, can be experimentally evaluated with the classic Doppler wheel. This also is a simple autonomous calibration tool for radar development and field testing. However, the less-apparent wheel-return characteristics found in practice must be taken into account. Doppler spectra for speeds up to 3000 rpm measured with a Ka-band radar against a 100 mm-diameter flat cylinder are presented, showing a frequency range from 200 to 4200 Hz. Meaningful signal amplitudes were measured up to the rim-speed Doppler. Frequency components beyond the range defined by the local radial velocity of the illuminated portion were observed up to 2500 Hz. Miniature surface deformations increased the amplitude of the highest frequencies by 5-10 dB. Simulated spectra agreed with measurement results at the higher Doppler frequencies, but a model based on Physical and Geometrical Optics failed to explain the low-frequency components. [J5]

"35 GHz compact radar using fan beam antenna array for obstacle detection"

A 35 GHz, magnetron-based, compact pulse radar is presented. It contains some novel solutions of four

electrically switched slot array antennas having fan beam patterns, solid-state modulator adaptive for the miniature magnetron and digital receiver techniques with advanced processing. It is designed for obstacle and rain detection for collision warning in helicopter applications. [J6]

"Multisensor deployment using PCRLBS, incorporating sensor deployment and motion uncertainties"

Recently, a general framework for sensor resource deployment (Hernandez, et. al. 2004) has been shown to allow efficient and effective utilization of a multisensor system. The basis of this technique is to use the posterior Cramer-Rao lower bound (PCRLB) to quantify and control the optimal achievable accuracy of target state estimation. In the original formulation (Hernandez, et. al. 2004) it was assumed that the sensor locations were known without error. In the current paper, the authors extend this framework by addressing the issues of imperfect sensor placement and uncertain sensor movement (e.g., sensor drift). The crucial consideration is then how these two forms of uncertainty are factored into the sensor management strategy. If unaccounted for, these uncertainties will render the output of the resource manager inaccurate and overoptimistic. The authors adjust the PCRLB to account for sensor location uncertainty, and we also allow for measurement origin uncertainty due to missed detections and false alarms. The work is motivated by the problem of tracking a submarine by adaptively deploying sonobuoys from a helicopter. Simulation results are presented to show the advantages of accounting for sensor location uncertainty within this focal domain of antisubmarine warfare. The authors note that the generic nature of the technique allows it to be utilized within other problem domains, including tracking ground-based targets using unattended ground sensors (UGSs) or unmanned aerial vehicles (UAVs) [J7]

"Use of dynamic radar signature for multistatic passive localisation of helicopter"

The passive radar concept is very attractive with regard to the covertness and detectability of a low-altitude flying target by use of low-frequency opportunistic signals. Detection performances are described in a large number of published papers showing the feasibility of passive detection. Accurate localisation of a target is more problematic, because it requires appropriate opportunistic signals for range compression as well as a large receiving antenna for accurate angular measurement. The introduced concept considers the exploitation of the dynamic signatures returned by helicopters to facilitate their localisation. A multistatic configuration with at least three receivers is considered. Flash echoes observed on each of the bistatic radars are detected and processed in a coherent manner to derive a set of angles used to triangulate the target position. Simulations are described including an approximate modelling of the bistatic radar cross-section. Analysis of different multistatic configurations is carried out. Further possible improvements of the concept are also introduced. [J8]

"On the scattering mechanism of power lines at millimeter-waves"

The radar signature of power lines is of high importance in the design of systems for helicopter collision avoidance. Laboratory measurements have been reported previously, but field measurements at millimeter waves are missing. The present contribution describes measurements done in ground-based configuration with a real aperture scanning-beam radar operating simultaneously at 35 and 94 GHz. By scanning, an aspect angle interval of 60° was covered, including the broadside aspect. The narrow beam width allowed to discriminate between different wires separated horizontally. While these measurements were done under a very shallow incidence angle, assisting measurements were done with the same radar mounted into an aircraft using synthetic aperture radar techniques. The results for shallow and steep incidence are compared and show the significant influence of this parameter on the signature of the power line. Additionally the measurement results are compared with those from model calculations. [J9]

"Optimizing time-frequency kernels for classification"

In many pattern recognition applications, features are traditionally extracted from standard time-frequency representations (TFRs). This assumes that the implicit smoothing of, say, a spectrogram is appropriate for the classification task. Making such assumptions may degrade classification performance. In general, ana time-frequency classification technique that uses a singular quadratic TFR (e.g., the spectrogram) as a source of features will never surpass the performance of the same technique using a regular quadratic TFR (e,g., Rihaczek or Wigner-Ville). Any TFR that is not regular is said to be singular. Use of a singular quadratic TFR implicitly discards information without explicitly determining if it is germane to the classification task. We propose smoothing regular quadratic TFRs to retain only that information that is essential for classification. We call the resulting quadratic TFRs class-dependent TFRs. This approach makes no a priori assumptions about the amount and type of time-frequency smoothing required for classification. The performance of our approach is demonstrated on simulated and real data. The simulated study indicates that the performance can approach the Bayes optimal classifier. The real-world pilot studies involved helicopter fault diagnosis and radar transmitter

identification [J10]

"Radar-assisted collision avoidance/guidance strategy for planar flight"

We propose a radar-assisted collision avoidance/guidance strategy (RACAGS) for flight vehicles on low altitude missions. The task of obstacle avoidance and guidance are integrated in a single collision avoidance/guidance strategy. The avionic aids and computational requirements are modest as the strategy mainly depends on range-map and inertial system information. The strategy is first implemented in a planar scenario and then extended to three-dimensional and nominal trajectory following flight scenarios. Several simulation studies are presented for illustration [J11]

"Extraction of power line maps from millimeter-wave polarimetric SAR images"

Radar backscatter of power lines has lower values than those of the surrounding ground clutter when the power line is oriented at an off-normal direction with respect to the radar line of sight. For power lines, the traditional detection algorithms that are commonly based on the statistics of the backscatter power of the clutter and target result in excessive false-alarm rates due to very low signal-to-clutter ratio. The application of a statistical polarimetric detection algorithm that significantly improves the signal-to-clutter ratio is demonstrated. The coherence between the co- and cross-polarized backscatter components is used as the detection parameter. This statistical detection parameter can be applied to any extended targets such as a suspended cable in clutter background. Detection criteria based on clutter backscattering coefficients, power line size, and aspect angle, as well as the number of independent samples are obtained. The performance of the algorithm for mapping power lines in SAR images is demonstrated using a number of low-grazing incidence polarimetric SAR images at 35 GHz [J12]

"Matched subspace CFAR detection of hovering helicopters"

A constant false alarm rate (CFAR) strategy for detecting a Gaussian distributed random signal against correlated non-Gaussian clutter is developed. The proposed algorithm is based on Scharf's matched subspace detector (MSD) and has the CFAR property with respect to the clutter amplitude probability density function (apdf), provided that the clutter distribution belongs to the compound-Gaussian family and the clutter covariance matrix is known to within a scale factor. Analytical expressions of false alarm and detection probabilities are derived. An application to the problem of detecting hovering helicopters against vegetated ground clutter is reported [J13]

"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 [J14]

"Flight test evaluation of a 35 GHz forward looking altimeter for terrain avoidance"

Honeywell has conducted a series of flight tests of a 35 GHz digital microprocessor controlled forward looking radar altimeter. A Bell 206L Jet Ranger helicopter was used to evaluate the capability of the sensor as a detector of various types of terrain collision hazards. The sensor was composed of a covert, spread spectrum radar altimeter processor driving a 35 GHz converter and antenna assembly mounted on a steerable platform. Excellent correlation between predicted performance and observed performance was obtained [J15]

"Pulse Doppler signature of a rotary-wing aircraft"

Field measurements of a modified Sikorsky S-55 helicopter target were carried out to investigate rotary-wing aircraft Doppler radar signature phenomenology. The results of the data analysis with regard to classification and identification of the aircraft based on its signature are presented. It was found that using the Doppler radar return and appropriate feature extraction techniques, the helicopter's design features can be estimated. Target backscatter from the main rotor blades, tail rotor blades, or hub can be used for target detection, acquisition, and classification as a rotary-wing aircraft. The extraction of configuration and blade count features can further define the helicopter for identification [J16]

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