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*Antenna-Based Signal Processing Techniques for Radar Systems (Artech House Antenna Library) [Alfonso Farina] on www.nxgvision.com *FREE* shipping on qualifying offers. This book brings the reader up-to-date on all aspects concerning ECCM at the antenna level.*

The targets are modeled as subspace random signals having zero mean and given covariance matrix. Different target classes are discriminated based on their different signal subspaces, which are specified by their covariance matrices. Performance is investigated by means of numerical analysis and Monte Carlo simulation in terms of probabilities of false alarm, detection and classification. The extra signal-to-noise power ratio necessary to pre-classify a target once a detection has occurred is also derived. Greco graduated in Electronic Engineering in and received the Ph. From December to May she joined the Georgia Tech Research Institute, Atlanta, USA as a visiting research scholar where she carried on research activity in the field of radar detection in non-Gaussian background. In she joined the Department of? Her general interests are in the areas of statistical signal processing, estimation and detection theory. In particular, her research interests include cyclostationarity signal analysis, bioacoustic signal analysis, clutter models, spectral analysis, coherent and incoherent detection in non-Gaussian clutter and CFAR techniques. Fulvio Gini - Dept. In he joined as the Department of? From July through January , he was a visiting researcher at the Department of Electrical Engineering, University of Virginia, Charlottesville. He has been session chairman at international conferences. He has given lectures at universities in Italy and abroad, and has given a tutorial entitled "Coherent detection and fusion in high resolution radar systems" at the International Conference on Radar May , Brest and the tutorial "Advanced Radar Detection and Fusion" at the International Radar Conference May , Washington D. His general interests are in the areas of statistical signal processing, estimation and detection theory. In particular, his research interests include non-Gaussian signal detection and estimation using higher order statistics, parameter estimation and data extraction from multichannel interferometric SAR data, cyclostationary signal analysis, and estimation of nonstationary signals, with applications to communication and radar processing. He is the author of more than 80 peer reviewed publications. In he joined Selenia, now Alenia Marconi Systems, where he is a manager since May ; since one year he is a member of the Chief Technical Office. Recently he has been appointed Scientific Director. He has provided leadership in many projects? He is the author of more than peer reviewed publications and the author of books and monographs: Radar Data Processing Vol. He has written the Chapter 9 on? Skolnik of Naval Research Laboratory. He has been session chairman at many international radar conferences. He uses to lecture at universities and research centres in Italy and abroad; He also frequently gives tutorials at the Intl. Radar Conferences on signal, data and image processing for radar; in particular on multi-sensor fusion, adaptive signal processing, space time adaptive processing STAP and detection. He is the co-recipient of the prestigious best paper award, entitled to Mr.

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Chapter 2 : Antenna-based Signal Processing Techniques for Radar Systems - Alfonso Farina - Google Bo

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 Abstract We consider the selection of an antenna array configuration, composed of a small number of omnidirectional elements, to be exploited for passive radar sensors. Based on properly identified pattern characteristics and design criteria for practical applications, a suitable planar configuration is selected that allows both angular selectivity and direct signal attenuation. The selected configuration is further optimized in terms of sidelobe level by resorting to appropriate amplitude tapering. Moreover, three different approaches are investigated for antenna-based adaptive disturbance cancellation, and a comparative performance analysis is carried out. Simulation results show that an effective clutter suppression is obtained if the direct signal from the transmitter is attenuated by means of spatial adaptive cancellation, and the multipath echoes from stationary obstacles are removed by means of temporal adaptive cancellation. In particular, the approach based on the Sidelobe Canceller is shown to yield good performance while requiring a limited system complexity. The main advantages of bistatic radar are that the receiver is far less vulnerable to electronic counter measures ECM and that bistatic operation has counter stealth properties. Moreover, passive radar systems have much lower cost, as they do not need a dedicated transmitter [1 â€” 3]. In spite of all these advantages, which make passive radar attractive for a broad range of applications, they must cope with the use of nonoptimized waveforms and with a strong direct signal from the transmitter of opportunity that typically operates in continuous wave CW mode. Directive antennas, characterized by a high Front-to-Back Ratio FBR , are usually employed to attenuate the direct signal. Its residuals are then typically removed by means of temporal adaptive clutter cancellation together with the clutter contribution [4 â€” 6]. However, the use of a directive antenna provides only a limited angular coverage for the radar surveillance and does not allow to cover a very wide air space region. This drawback can be avoided by using an antenna array composed of a set of omnidirectional elements in the plane, in place of a dedicated directive surveillance antenna [7 â€” 9]. As long as the elements are properly spaced, a directive pattern may be synthesized by jointly processing the signals received at each element. This also allows the beam to be electronically steered in all directions or, better, a set of directional beams to be generated that globally cover the whole air space of interest. Obviously this would require the availability of multiple coherent receiving channels. However, in this case the same array might be used to collect the transmitted signal by synthesizing a beam pointed toward the transmitter of opportunity. This represents a viable solution if several dislocated illuminators of opportunity should be exploited. To keep the system cost and its complexity low, proper array configurations should be designed and able to provide good performance using a limited number of elements [10]. In this paper, we describe effective criteria to identify a suitable antenna array configuration for passive radar. According to the proposed strategy, the array is designed so that it yields reasonable characteristics for the resulting antenna pattern 3? The benefits of antenna-based spatial adaptivity have been shown in the literature with reference to different passive radar applications. A clear demonstration of potentiality of the spatial adaptivity is reported in [11] for a GSM-based passive radar for medium range surveillance, in [12] for an FM radio-based passive radar, and in [13] for a specific passive radar application in the HF frequency bandwidth. In [14], the space-time adaptive beamformer based on constrained least mean squares algorithm has been exploited. Even for the reference signal recovery, adaptive techniques can be used to protect the system against multipath contributions. For example, in [15] the joint exploitation of spatial and temporal degrees of freedom is considered to obtain a multipath-free version of the reference signal. Therefore, in this paper, we investigate different techniques for antenna-based adaptive disturbance cancellation to be applied before the standard temporal cancellation filter. The comparative analysis allows to identify the main benefits of the different approaches and to select the most suitable space-time processing scheme. Specifically, the simulation results, obtained for an FM radio-based passive radar case, show that the approach based on the Sidelobe Canceller followed by the temporal extensive cancellation algorithm ECA [4] yields good performance while requiring a limited system complexity. The paper is organized as follows. In Section 2 , the array design strategy is described, and a suitable antenna array configuration is selected by trading off the achievable performance for the expected system complexity and cost. The selected array configuration is further optimized in Section 3 where a proper amplitude tapering strategy is adopted to control the sidelobe level of the resulting pattern. Section 4 briefly summarizes the considered techniques for antenna-based adaptive disturbance cancellation; moreover, an effective approach is introduced for the synthesis of the reference antenna beam that is exploited to collect the signal from the transmitter. The comparative performance analysis is presented in Section 5 where the results are reported for an FM radio-based passive radar scenario. Finally, our conclusions are drawn in Section 6. Antenna Array Configuration Analysis The first step of our work consists in identifying an appropriate configuration for the array of antennas that provides good performance using a limited number of elements to keep the low cost characteristic. Specifically, we refer to 2-dimensional planar array configurations. A reasonable criterion to select a planar array configuration may involve the evaluation of some significant pattern parameters, such as the 3? It is also reasonable to restrict the choice to those configurations, for which the expected angle estimation performance does not depend on the Direction of Arrival DoA of the signal. In particular, it is possible to refer to the estimation accuracy achievable by the Generalized Likelihood GL estimation. GL DoA Estimation and Its Accuracy Let us consider a planar array of elements and let be the coordinates and the azimuth pattern of the th element, respectively, being the angle formed with the positive -axis. Then, the target steering vector can be written as where is the wavelength of the received signal. The signals received at a given time by the elements of the array may be collected in an -element column vector , called snapshot, and given by where is the signal DoA, is the complex amplitude of the received signal, which does not include the antenna gain, and is the disturbance. The DoA of a monochromatic signal, whose complex amplitude is unknown, may be estimated by maximizing the Generalized Likelihood, as in where the operators denote the Euclidean norm of vector , while the notation for which is minimum. In particular, it can be shown that the resulting estimation accuracy is given by see, e. Omnidirectional Antennas and Symmetry Conditions In case all the antennas are omnidirectional, for example, the target steering vector and its first-order derivative with respect to may be rewritten as.

Chapter 3 : Alfonso Farina - Wikipedia

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To our knowledge, this is the first time that the statistical MIMO is being proposed for radar. The fundamental di erence between statistical MIMO and oth The fundamental di erence between statistical MIMO and other radar array systems is that the latter seek to maximize the coherent processing gain, while statistical MIMO radar capitalizes on the diversity of target scattering to improve radar performance. Coherent processing is made possible by highly correlated signals at the receiver array, whereas in statistical MIMO radar, the signals received by the array elements are uncorrelated. Radar targets generally consist of many small elemental scatterers that are fused by the radar waveform and the processing at the receiver, to result in echoes with fluctuating amplitude and phase. It is well known that in conventional radar, slow fluctuations of the target radar cross section RCS result in target fades that degrade radar performance. By spacing the antenna elements at the transmitter and at the receiver such that the target angular spread is manifested, the MIMO radar can exploit the spatial diversity of target scatterers opening the way to a variety of new techniques that can improve radar performance. In this paper, we focus on the application of the target spatial diversity to improve detection performance. An optimal detector invariant to the signa Lee Swindlehurst, Petre Stoica , " We consider robust and computationally efficient maximum likelihood algorithms for estimating the parameters of a radar target whose signal is observed by an array of sensors in interference with unknown second order spatial statistics. Two data models are described, one that uses the target directi The resulting algorithm requires two 1-D searches rather than a 2-D search, as with previous approaches for the structured case. If a uniform linear array is used, only a single 1-D search is needed. A generalized likelihood ratio test for target detection is also derived under the unstructured model. Show Context Citation Context Maximum likelihood ML approaches have not been extensively considered for this problem, mainly because they are perceived to be too computationally complex, and because ther Vorobyov, Senior Member , " The new technique enjoys the advantages of MIMO radar without sacrificing the main advantage of phased-array radar which is the coherent processing gain at the transmit The new technique enjoys the advantages of MIMO radar without sacrificing the main advantage of phased-array radar which is the coherent processing gain at the transmitting side. The essence of the proposed technique is to partition the transmitting array into a number of subarrays that are allowed to overlap. Then, each subarray is used to coherently transmit a waveform which is orthogonal to the waveforms transmitted by other subarrays. Coherent processing gain can be achieved by designing a weight vector for each subarray to form a beam towards a certain direction in space. Moreover, the subarrays are combined jointly to form a MIMO radar resulting in higher resolution capabilities. The substantial improvements offered by the proposed phased-MIMO radar technique as compared to previous techniques are demonstrated analytically and by simulations through analysis of the corresponding beampatterns and achievable output signal-to-noise-plus-interference ratios. Both analytical and simulation results validate the effectiveness of the proposed phased-MIMO radar. We propose a new technique for multiple-input multiple-output MIMO radar with colocated antennas. Each subar-ray is used to coherently transmit a waveformwhich is or Each subar-ray is used to coherently transmit a waveformwhich is orthog-onal to the waveforms transmitted by other subarrays. Coher-ent processing gain can be achieved by designing a weight vector for each subarray to form a beam towards a certain direction in space. Simulation results show the substantial improve-ments offered by the proposed technique as compared to pre-vious techniques that validate its effectiveness. Ultra wideband multiple-input multiple-output radar by Hammad A. The utilization of ultra wideband UWB signals enables the radar designer to solve the most important problems of radar target observation. The extremely wide bandwidth enables greater information to be obtained due to high time resolution and the frequency dependence of the scattering centers over The extremely wide bandwidth enables greater information to be obtained due to high time resolution and the frequency dependence of the scattering centers over this large bandwidth. Recently there have been many advances in multiple-input multiple-output MIMO antenna systems in communications. These diversity systems have been shown to have the potential to dramatically improve the performance of the communications systems. Unlike the traditional beamforming approach, which uses highly correlated signals of an array of transmitting or receiving antenna elements to collimate a beam towards a certain direction in space, MIMO capitalizes on the independence between signals from different transmitters and on the diversity of target scattering to improve the information received from the response. The analysis of such radars has been carried out to demonstrate its promising features in terms of better target identification and improved signal to noise ratio SNR. Ansarray of radar elements is used with highly correlated signalssto form a controllable beam, which can be collimated in ascertain direction to scan the desired space. Such radars aresknown as phas Abstractâ€"We address the problem of detecting a signal of interest in the presence of noise with unknown covariance matrix, using a set of training samples. We consider a situation where the environment is not homogeneous, i. A knowledge-aided Bayesian framework is proposed, where these covariance matrices are considered as random, and some infor-mation about the covariance matrix of the training samples is available. Within this framework, the maximum a priori MAP estimate of the primary data covariance matrix is derived. It is shown that it amounts to colored loading of the sample covariance matrix of the secondary data. The MAP estimate is in turn used to yield a Bayesian version of the adaptive matched filter. Numer-ical simulations illustrate the performance of this detector, and compare it with the conventional adaptive matched filter. Index Termsâ€"Bayesian detection, heterogenous environments, knowledge-aided processing, maximum a posteriori estimation. In the Gaussian case, when the covariance matrix of the noise in the CUT is known, the optimal processor consists of a whitening step followed by matched filtering [2]. However, the statistics of th

Chapter 4 : Poster Detection and tracking of ballistic target

This text delivers an accurate description of working principles, processing schemes and performance evaluation techniques. In addition, it provides engineering details on the newest digital techiques for sidelobe jamming cancellation and digital beamforming (DFB).

First experiments[edit] As early as , German physicist Heinrich Hertz showed that radio waves could be reflected from solid objects. In , Alexander Popov , a physics instructor at the Imperial Russian Navy school in Kronstadt , developed an apparatus using a coherer tube for detecting distant lightning strikes. The next year, he added a spark-gap transmitter. In , while testing this equipment for communicating between two ships in the Baltic Sea , he took note of an interference beat caused by the passage of a third vessel. In his report, Popov wrote that this phenomenon might be used for detecting objects, but he did nothing more with this observation. In , he demonstrated the feasibility of detecting a ship in dense fog, but not its distance from the transmitter. He also got a British patent on September 23, [10] for a full radar system, that he called a telemobiloscope. His system already used the classic antenna setup of horn antenna with parabolic reflector and was presented to German military officials in practical tests in Cologne and Rotterdam harbour but was rejected. Through his lightning experiments, Watson-Watt became an expert on the use of radio direction finding before turning his inquiry to shortwave transmission. Requiring a suitable receiver for such studies, he told the "new boy" Arnold Frederic Wilkins to conduct an extensive review of available shortwave units. Across the Atlantic in , after placing a transmitter and receiver on opposite sides of the Potomac River , U. Hoyt Taylor and Leo C. Young discovered that ships passing through the beam path caused the received signal to fade in and out. Taylor submitted a report, suggesting that this phenomenon might be used to detect the presence of ships in low visibility, but the Navy did not immediately continue the work. Eight years later, Lawrence A. Hyland at the Naval Research Laboratory NRL observed similar fading effects from passing aircraft; this revelation led to a patent application [13] as well as a proposal for further intensive research on radio-echo signals from moving targets to take place at NRL, where Taylor and Young were based at the time. Hugon, began developing an obstacle-locating radio apparatus, aspects of which were installed on the ocean liner Normandie in In total, only Redut stations were produced during the war. The first Russian airborne radar, Gneiss-2 , entered into service in June on Pe-2 fighters. More than Gneiss-2 stations were produced by the end of Full radar evolved as a pulsed system, and the first such elementary apparatus was demonstrated in December by the American Robert M. Page , working at the Naval Research Laboratory. Watson-Watt in Great Britain. Wilkins returned a set of calculations demonstrating the system was basically impossible. When Watson-Watt then asked what such a system might do, Wilkins recalled the earlier report about aircraft causing radio interference. This revelation led to the Daventry Experiment of 26 February , using a powerful BBC shortwave transmitter as the source and their GPO receiver setup in a field while a bomber flew around the site. Work there resulted in the design and installation of aircraft detection and tracking stations called " Chain Home " along the East and South coasts of England in time for the outbreak of World War II in This system provided the vital advance information that helped the Royal Air Force win the Battle of Britain ; without it, significant numbers of fighter aircraft would always need to be in the air to respond quickly enough if enemy aircraft detection relied solely on the observations of ground-based individuals. Also vital was the " Dowding system " of reporting and coordination to make best use of the radar information during tests of early deployment of radar in and Given all required funding and development support, the team produced working radar systems in and began deployment. This fact meant CH transmitters had to be much more powerful and have better antennas than competing systems but allowed its rapid introduction using existing technologies. Radar in World War II A key development was the cavity magnetron in the UK, which allowed the creation of relatively small systems with sub-meter resolution. Britain shared the technology with the U. Later, in , Page greatly improved radar with the monopulse technique that was used for many years in most radar applications.

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Applications[edit] Commercial marine radar antenna. The rotating antenna radiates a vertical fan-shaped beam. The information provided by radar includes the bearing and range and therefore position of the object from the radar scanner. It is thus used in many different fields where the need for such positioning is crucial. The first use of radar was for military purposes: This evolved in the civilian field into applications for aircraft, ships, and roads. The first commercial device fitted to aircraft was a Bell Lab unit on some United Air Lines aircraft. Military fighter aircraft are usually fitted with air-to-air targeting radars, to detect and target enemy aircraft. In addition, larger specialized military aircraft carry powerful airborne radars to observe air traffic over a wide region and direct fighter aircraft towards targets. In port or in harbour, vessel traffic service radar systems are used to monitor and regulate ship movements in busy waters. It has become the primary tool for short-term weather forecasting and watching for severe weather such as thunderstorms , tornadoes , winter storms , precipitation types, etc. Police forces use radar guns to monitor vehicle speeds on the roads. Smaller radar systems are used to detect human movement. Examples are breathing pattern detection for sleep monitoring [32] and hand and finger gesture detection for computer interaction.

Chapter 5 : Poster A multiple hypotheses testing approach to radar detection and pre-classification

By spacing the antenna elements at the transmitter and at the receiver such that the target angular spread is manifested, the MIMO radar can exploit the spatial diversity of target scatterers opening the way to a variety of new techniques that can improve radar performance.

Subsequently, the kinematic model of the ballistic target is derived; it includes the main forces acting on it, namely: On the basis of these two models it is possible to determine the detection probability of a notional L-band radar during the target flight and to build up an interactive multiple model IMM for target tracking. The performance evaluation of the design IMM tracking algorithm is obtained via Monte Carlo simulation. In particular, highly manoeuvring aircraft and ballistic target in the boost phase are used to check the capability of the IMM. In he joined Selenia, now Alenia Marconi Systems, where he is a manager since May ; since one year he is a member of the Chief Technical Office. Recently he has been appointed Scientific Director. He has provided leadership in many projects â€" also conducted in the international arena â€" in surveillance for ground and naval applications, in airborne early warning and in imaging radar. He is the author of more than peer reviewed publications and the author of books and monographs: Radar Data Processing Vol. Skolnik of Naval Research Laboratory. He has been session chairman at many international radar conferences. He uses to lecture at universities and research centres in Italy and abroad; He also frequently gives tutorials at the Intl. Radar Conferences on signal, data and image processing for radar; in particular on multi-sensor fusion, adaptive signal processing, space time adaptive processing STAP and detection. He is the co-recipient of the prestigious best paper award, entitled to Mr. In he joined Selenia S. His working interests span from the area of synthetic aperture radar image formation and moving target detection and imaging , to space-time adaptive processing for AEW and ground-based radar, to parallel processing architectures with VLSI and COTS devices. He is presently involved in the areas of adaptive signal processing, detection and estimation with application to tri-dimensional ground and ship based phased array radar. He is the author of several peer reviewed papers also invited on journals and conference proceedings. He is the co-author of three tutorials on adaptive array and space-time adaptive processing presented at the intl. In she entered Selenia now AMS , working on e. Later, she operated in the field of Synthetic Aperture Radar, processing recorded live data, setting up algorithms for motion compensation, and use of polarimetric and multifrequency SAR data fusion for speckle reduction. The field of interest is the development of computer models and simulations for radar performance prediction and site test analysis. Her present areas of investigation are oriented towards phased arrays and adaptive signal processing, detection, estimation and tracking filtering. He then attended a specialization course by the Ministry of Posts and Telecommunications and served for military duty in the Italian Navy Ministry, department of Operations Research. He has been working with all the main antenna and radome projects for different missile and radar systems. In the topics of his experience, he has authored several national and international technical papers and cooperated to several European research joint programs. Her research interests are numerical techniques, software development and computer-aided design in applied electromagnetics, both in low and high frequency ranges. She is currently working in Electromagnetic simulation of antenna and target modelling for radar, missile and telecommunication systems. He developed a thesis entitled: His working interests span from phased arrays to adaptive signal processing, detection, estimation and tracking filtering. He is the co-author of two papers on conference proceedings.

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Advanced signal processing techniques for pulsed-doppler radar Master of Science Thesis KARIM OUNISSI Department of Signals and Systems Division of Signal Processing and Antennas.

Chapter 9 : Antenna-based Signal Processing Techniques for Radar Systems : A. Farina :

We consider the selection of an antenna array configuration, composed of a small number of omnidirectional elements, to be exploited for passive radar sensors. Based on properly identified pattern characteristics and design criteria for practical applications, a suitable planar configuration is selected that allows both angular selectivity and direct signal attenuation.