

Maritime surveillance radar

Part 2: Detection performance prediction in sea clutter

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Abstract: Techniques for detection performance prediction for maritime surveillance radars are described, with particular emphasis on the use of the compound K-distribution model for radar sea clutter. The paper first briefly reviews the analytical methods for deriving theoretical detection performance limits using compound models for both clutter and targets. Next, it is shown how the clutter environment is modelled for radar design evaluation, and methods whereby the radar may adapt to this changing environment for optimum target detection performance are described. This is followed by a description of a new method for performance prediction for a cell-averaging CFAR in real clutter, using recorded clutter signals but avoiding lengthy computer simulations. Finally, possible future developments of maritime surveillance radars are discussed.

1 Introduction

Part 1 of this paper [1] describes recent developments which have been made in the understanding and modelling of radar sea clutter. Particular emphasis is placed on the use of a compound form of the K-distribution for describing the amplitude characteristics of the clutter. The purpose of developing this model has not only been to provide a better descriptor of the clutter itself, but also for the design and assessment of improved target detection techniques.

In this paper, it is shown how the clutter models can be incorporated with target models to derive detection performance limits. Further, it is shown how the model can be exploited to investigate the performance of particular signal-processing techniques in a real clutter environment.

Section 2 of the paper describes a generalised approach to theoretical performance prediction based on the standard concepts of optimum threshold settings to achieve required false alarm rates.

Section 3 describes the modelling of the sea clutter

environment and its impact on the design of practical detection signal processing. This is extended to show how the compound K-distribution clutter model can be used to evaluate the detection performance of a cell-averaging CFAR detector using real clutter recordings as a data input.

Finally, Section 4 discusses areas where further improvements in detection signal processing may be expected.

2 Theoretical system performance prediction

The significant improvements in understanding and accuracy of performance evaluation which are achieved through the use of the compound K-distribution model are directly attributable to its compound nature. If the radar detection is based only on the fixed thresholding of a single variate (i.e. a single radar return), then performances can be predicted using a knowledge of the target and clutter probability density functions (PDFs) alone.

If, however, the radar processing involves the use of more than one variate, then the correlation properties of the target and clutter become important. This is so, for example, if the threshold fluctuates because it is derived from other range samples or if many pulse returns are averaged before (or after) thresholding. In these cases, the use of the compound form of the K-distribution provides a more accurate assessment of performance than a model based only on an overall PDF, since it allows correlation properties of the clutter to be accounted for. The target itself may have a PDF and correlation properties which can also be modelled by a compound distribution and this can be combined with the clutter model to produce more accurate detection performance predictions.

2.1 Detection prediction using compound distributions

A generalised approach to detection performance prediction is described here, followed by some examples.

The PDF of clutter can be written, in its compound form, as

$$p(x) = \int_0^\infty p(x|y) p(y) dy \quad (1)$$

For the compound K-distribution model $p(y)$ is the PDF of the local cluster power y , which is gamma distributed, with shape parameter ν and a scale parameter c :

$$p(y) = \frac{c^\nu y^{\nu-1}}{\Gamma(\nu)} \exp(-cy) \quad 0 \leq y < \infty \quad (2)$$

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Surveillance Radar Performance Prediction

Harold R. Raemer



Surveillance Radar Performance Prediction:

Surveillance Radar Performance Prediction Paul Rohan,1983 **Radar Systems Principles** Harold R. Raemer,1996-10-30 In planning a radar system having the proper mathematical modeling of propagation effects clutter and target statistics is essential Radar Systems Principles provides a strong theoretical basis for the myriad of formulas and rules of thumb required for analysis conceptual design and performance evaluation of radar systems Mathematical derivations of formulas commonly used by radar engineers are presented with detailed discussions of the assumptions behind these expressions and their ranges of validity These principles are used in a wide range of radar applications Radar Systems Principles makes it easy to understand the steps in calculating various formulas and when and how these formulas are used A set of problems is provided for each chapter enabling you to check your progress in applying the principles discussed in each section of the text There are more than 170 figures illustrating key concepts Numerous references to well known books on radar for coverage of practical design issues and other specialized topics are given Radar Systems Principles is an ideal textbook for advanced undergraduates and first year graduate students and also makes an excellent vehicle for self study by engineers wishing to enhance their understanding of radar principles and their implication in actual systems Scientific and Technical Aerospace Reports ,1994-03 Target Detection by Marine Radar John N. Briggs,2004-12-03 Radar is a legal necessity for the safe navigation of merchant ships and within vessel traffic services is indispensable to the operation of major ports and harbours Target Detection by Marine Radar concentrates solely on civil marine operations and explains how marine surveillance radars detect their targets The book is fully illustrated and contains worked examples to help the reader understand the principles underlying radar operation and to quantify the importance of factors such as the technical features of specific equipment the weather target reflection properties and the ability of the operator The precision with which targets are positioned on the radar screen and with which their progress is tracked or predicted depends on how definitely they have been detected therefore a whole chapter has been devoted to the issue of accuracy The various international regulations governing marine radar are examined a brief historical background is given to modern day practice and the book does with a discussion of the ways in which marine radar may develop to meet future challenges **RF and Microwave Applications and Systems** Mike Golio,Janet Golio,2018-10-03 This volume RF and Microwave Applications and Systems includes a wide range of articles that discuss RF and microwave systems used for communication and radar and heating applications Commercial avionics medical and military applications are addressed An overview of commercial communications systems is provided Past current and emerging cellular systems navigation systems and satellite based systems are discussed Specific voice and data commercial systems are investigated more thoroughly in individual chapters that follow Detailed discussions of military electronics avionics and radar both military and automotive are provided in separate chapters A chapter focusing on FR microwave energy used for therapeutic medicine is also provided Systems considerations including thermal

mechanical reliability power management and safety are discussed in separate chapters Engineering processes are also explored in articles about corporate initiatives cost modeling and design reviews The book closes with a discussion of the underlying physics of electromagnetic propagation and interference In addition to new chapters on WiMAX and broadband cable nearly every existing chapter features extensive updates and several were completely rewritten to reflect the massive changes areas such as radio navigation and electronic warfare

Analysis of Metallic Antennas and Scatterers Branko D. Popović, B. M. Kolundžija, 1994 Describes a novel general entire domain method for the analysis of metallic antennas and scatterers that enables a very wide range of problems to be solved using computers of relatively modest capability The conventional approximation approach requires a large amount of computer storage Of interest to engineers scientists and graduate students engaged in the analysis or design of electrically small and medium sized antennas and scatterers Distributed by INSPEC Annotation copyright by Book News Inc Portland OR

Maritime Surveillance Radar. Part 2 S. Watts, 1990 *Data Fusion for Situation Monitoring, Incident Detection, Alert and Response Management* E. Shahbazian, G. Rogova, P. Valin, 2006-03-02 Data Fusion is a very broad interdisciplinary technology domain It provides techniques and methods for integrating information from multiple sources and using the complementarities of these detections to derive maximum information about the phenomenon being observed analyzing and deriving the meaning of these observations and predicting possible consequences of the observed state of the environment selecting the best course of action and controlling the actions Here the focus is on the more mature phase of data fusion namely the detection and identification classification of phenomena being observed and exploitation of the related methods for Security Related Civil Science and Technology SST applications It is necessary to expand on the data fusion methodology pertinent to Situation Monitoring Incident Detection Alert and Response Management discuss some related Cognitive Engineering and visualization issues provide an insight into the architectures and methodologies for building a data fusion system discuss fusion approaches to image exploitation with emphasis on security applications discuss novel distributed tracking approaches as a necessary step of situation monitoring and incident detection and provide examples of real situations in which data fusion can enhance incident detection prevention and response capability In order to give a logical presentation of the data fusion material first the general concepts are highlighted Fusion Methodology Human Computer Interactions and Systems and Architectures closing with several applications Data Fusion for Imagery Tracking and Sensor Fusion and Applications and Opportunities for Fusion

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Radar Land Clutter J. Barrie Billingsley,2002-04-01 A necessary reference for all radar engineers or analysts including many levels of managers advisors and decision makers in the U S and worldwide radar industry Directly useful in both military DOD and civilian FAA applications The result of 20 years of research at MIT Lincoln Lab this book is of the most significant technological consequence for the industry It actually solves the problem of low angle radar land clutter by showing the reader how to design and predict the performance of radars that operate in situations where land clutter prevalent Radar land clutter constitutes the unwanted radar echoes returned from the earth s surface that compete against and interfere with the desired echoes returned by targets such as aircraft and other moving and stationary targets The ability to accurately predict the effects of land clutter in surface radar has been an unsolved problem for many years This book is comprehensive in addressing the topic containing many interrelated results each important in its own right It unifies and integrates all the results so as to create a comprehensive innovative and unequalled work The results of this book directly enable the reader to predict land clutter effects in surface radar Modern military aircraft deliberately fly low to hide their presence from radars that are also dealing with land clutter Depending on the terrain the performance of the radar varies greatly from very good to very poor This book helps radar engineers provide accurate assessments of ground clutter thus bringing their ability to detect and operate against low flying aircraft to a much higher and much more consistent level

The Record of the IEEE ... International Radar Conference ,1995 **Approximate Boundary Conditions in**

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Radio Direction Finding and Superresolution P. J. D. Gething,1991 Enlarged and revised second edition Modern direction finders capable of measuring elevation angles as well as azimuth angles on the components of multi ray wavefields have become powerful tools for research in ionospheric physics and HF radio propagation The complexity of the problem of resolving closely spaced rays requires the combined use of wide aperture antenna arrays multichannel receiving systems and sophisticated digital processing techniques

Propagation, Scattering and Dissipation of Electromagnetic Waves A. S. Il'inskiĭ,Grigoriĭ IĭAĭkovlevich Slepiaĭn,A. Ya Slepyan,1993 Aimed at physicists and engineers conducting theoretical research or designing microwave and millimetre wave devices this study explores methods of calculating microwave absorption in waveguides resonators and periodic structures

Theory of Nonuniform Waveguides B. Z. Katsenelenbaum,1998 This book presents and develops the mathematical tools required to effectively examine and analyse propagation processes of waves of various natures using the cross section method in artificial and non artificial waveguides These techniques are used in the solution of practical situations in various fields such as plasma heating in nuclear fusion materials processing and radar and satellite communication systems

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