

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 clutter power y , which is gamma distributed, with shape parameter v and a scale parameter c :

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

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Surveillance Radar Performance Prediction

Nathan Marcuvitz



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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**

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