ISSN 0735-2727, Radioelectronics and Communications Systems, 2016, Vol. 59, No. 12, pp. 536–551. © Allerton Press, Inc., 2016.
Original Russian Text © M.B. El Mashade, 2016, published in Izvestiya Vysshikh Uchebnykh Zavedenii, Radioelektronika, 2016, Vol. 59, No. 12, pp. 14–32.

Heterogeneous Performance Evaluation of Sophisticated Versions of CFAR Detection Schemes

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Received in final form March 4, 2016

Abstract—The detection of radar targets in a background, the statistical parameters of which are unknown and may not be stationary, can be effectively achieved through CFAR processors. The CA-CFAR scheme performs optimally for homogeneous and exponentially distributed clutter observations. However, it exhibits severe performance degradation in the presence of outlying target returns in the reference set or in regions of abrupt change in the background clutter power. The OS-CFAR processor has been proposed to solve both of these problems. Although this processor may treat target multiplicity quite well, it lacks effectiveness in preventing excessive false alarms during clutter power transitions. The TM-CFAR algorithm, which implements trimmed averaging after ordering, can be considered as a modified version of OS technique. By knowingly trimming the ordered samples, the TM detector may actually perform better than the OS processor. To simultaneously exploit the merits of CA, OS, and TM schemes, two combinations namely CAOS and CATM have been suggested. Each one of these versions optimizes good features of two CFAR detectors, depending on the characteristics of clutter and searched targets, with the goal of enhancing the detection performance under constant level of false alarm. It is realized by parallel operation of two standard types of CFAR schemes. Our goal in this paper is to analyze these two developed versions in heterogeneous situations, to show to what extent they can improve the behavior of the conventional CFAR processors.

DOI: 10.3103/S0735272716120025

1. INTRODUCTION

Radar is an invention that can be considered as an addition to man's sensory equipment which affords genuinely new facilities. It enables a certain class of objects to be seen, that is detected and located, at distances far beyond those at which they could be distinguished by the unaided eye. This seeing is unimpaired by night, fog, cloud, smoke, and most other obstacles to ordinary vision. Additionally, radar permits the measurement of the range of the objects it sees with a convenience and precision entirely unknown in the past. Furthermore, it can measure the instantaneous speed of such an object toward or away from the observing station in a simple and natural way. The superiority of radar to ordinary vision lies in the greater distances at which seeing is possible, in its ability of working regardless of light condition and of obscuration of the object being seen, and in the unparalleled ease with which target range and its rate of change can be measured [1–5].

Detection of targets represents one of the most fundamental tasks of a radar system. This task is associated with the process of examining the radar data to see if it is regarded as interference only, or interference plus echoes from a target of interest. Once a target is detected, the system can turn its attention to processing the target information. Depending on the type of radar application, the system might be concerned with estimating the radar cross section (RCS) of the target, measuring and tracking its position or velocity, imaging it, or providing fire control data to direct weapons at the target.

From the detection point of view, radars are increasingly required to detect small targets in the presence of strong clutter while simultaneously maintaining a low, and preferably constant, level of false alarm. Two key radar subsystems for achieving this goal are the Doppler filter, for suppressing clutter as far as possible, and the automatic detector, for deciding which of the filtered returns represent targets.

Since the false alarm rate is very sensitive to the setting of the detection threshold, changes in radar characteristics with time (ageing) and changes in the target background characteristics mean that a fixed detection threshold is not practical. Additionally, the operational environments of radar systems have different sources of noise that deteriorate their performance. Moreover, thermal noise generated by the radar

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