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A discriminant analysis-based automatic ordered statistics scheme for radar systems

A.J. Onumanyi [a,*], H. Bello-Salau [b], A.O. Adejo [a], H.O. Ohize [c], M.O. Oloyede [d], E.N. Paulson [a], A.M. Aibinu [e]

[a] Department of Telecommunication Engineering, Federal University of Technology, Minna, Nigeria
[b] Department of Computer Engineering, Ahmadu Bello University, Zaria, Nigeria
[c] Department of Electrical and Electronics Engineering, Federal University of Technology, Minna, Nigeria
[d] Department of Information and Communication Science, University of Ilorin, Ilorin, Nigeria
[e] Department of Mechatronics Engineering, Federal University of Technology, Minna, Nigeria

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ABSTRACT

The ordered statistics (OS) scheme is an effective constant false alarm rate (CFAR) technique deployed in many radar systems. It is widely deployed because of its simplicity and effectiveness under conditions of both homogeneous and non-homogeneous radar returns. However, the problem of inaccurate censoring typically degrades its performance since it is often difficult to accurately determine the actual number of interfering targets and clutter edges in the reference window per time. In this article, we address this problem based on the principle of discriminant analysis (DA) towards automatically and effectively estimating the k^{th} rank ordered element of the OS scheme. Our scheme, termed the DA-OS scheme, works without requiring *a priori* knowledge about the statistical characteristics of the input radar returns. The results obtained via Monte Carlo simulation indicate that the DA-OS scheme achieves a small CFAR loss of about 0.392 dB relative to the cell averaging (CA) scheme under conditions of homogeneous radar returns at a probability of detection of 0.5. It outperforms other notable traditional schemes, including the CA, smallest-of CA, greatest-of CA, and the fixed OS schemes under conditions of non-homogeneous radar returns. Finally, it provides a number of desirable qualitative characteristics as against other existing censoring techniques.

1. Introduction

Radar systems are highly useful in many remote sensing applications, for example, they are invaluable in the recent fourth industrial revolution, which encompasses the control of industrial robots to sense and avoid collision [1], for speed control of mobile industrial machines, monitoring of industrial environments for fault identification, location and security purposes [2], as well as for object and proximity detection [3], and in covert communications [4,5]. Other classic areas concerned with radar usage include the weather [6], agriculture [7], military, geological [8], civil [9], and aviation industries [7], to name but a few. These automotive application areas depend on radar sensors integrated with processors and controllers designed to improve the detection, safety, forecasting, security, and productivity of these respective industries [10,11]. However, in order to guarantee the effectiveness of radar systems, it is imperative to deploy effective constant false alarm rate (CFAR) schemes within such radar systems towards ensuring that their false alarm rates are kept below a predefined value to prevent erroneous operation.

There are some classic and simple CFAR schemes that can be deployed in the above-mentioned radar application areas. For example, the cell averaging (CA), smallest-of cell averaging (SOCA), greatest-of cell averaging (GOCA) are fundamental methods deployed pervasively across many radar systems [12]. Most other schemes are often derived or based on the CA and its variants [13–15]. However, the CA has a key limitation in its performance under non-homogeneous conditions, where radar returns within the reference cells contain multiple interfering targets and/or clutter returns. Under such non-homogeneous conditions, the CA scheme incurs increased false alarm rates at clutter edges as well as target masking in the presence of interfering targets. The SOCA scheme was proposed to resolve the problem of target masking under conditions of multiple interfering targets, however, it presents very high false alarm rates at clutter edges.

* Corresponding author.
E-mail addresses: adeiza1@futminna.edu.ng (A.J. Onumanyi), bellosalau@gmail.com (H. Bello-Salau), achonu@futminna.edu.ng (A.O. Adejo), henryohize@futminna.edu.ng (H.O. Ohize), tahir.oloyede@gmail.com (M.O. Oloyede), enpaulson2@gmail.com (E.N. Paulson), maibinu@gmail.com (A.M. Aibinu).

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