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Performance Predominance of a New Strategy for CFAR Processors over the N-P Model in Detecting Four Degrees of Freedom χ^2 Fluctuating Targets

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Abstract—Modern radars have adopted adaptive processing techniques to mitigate the deleterious effects of unwanted clutter and jammer. In this situation, the CFAR algorithms play a vital role in achieving the heterogeneous detection of fluctuating targets. In this regard, while the CA-CFAR processor has the top homogeneous performance, the OS and TM techniques have been suggested to provide robust estimates of the threshold in heterogeneous situations. In order to simultaneously exploit the merits of CA and OS or TM processors, some their hybrid versions have been recently introduced. They are termed as CAOS and CATM models. Practically, the frequency diversity between noncoherent sweeps is widespread in actual radar systems. Additionally, the pulse integration strategy is often used in radar systems to improve the target signal-to-noise ratio and correspondingly the system detection performance. For this reason, this paper is focusing on analyzing these new models in the case where the radar receiver noncoherently integrates *M*-pulses to handle its detection. Closed-form expression is derived for their nonhomogeneous performance. The tested as well as the spurious targets are assumed to follow χ^2-distribution with four degrees of freedom in their fluctuations. Our simulation results reveal that the new version CATM exhibits a homogeneous performance that outweighs that of the classical Neyman-Pearson (N-P) procedure, which is employed as a baseline comparison for other strategies in the field of adaptive detectors.

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1. INTRODUCTION

Radar is a particular type of systems that is capable of detecting and tracking moving or fixed targets. Nowadays, besides the importance of radars in warfare scenarios, they also have many civilian applications such as sea and air traffic control, meteorology, and highway security. In this regard, the main function of the radar is to detect objects within its exploration area.

In most cases, owing to the mixing of an interfering component, known as clutter, with the echo signal, the process of detection is often a difficult task. This additional component appears as a result of an echo excited by artificial or natural sources surrounding the object of interest. Thus, the detection of targets of interest and discarding of those that do not concern a particular application constitute the fundamental goal of any radar system. From this point of view, the detection is fairly straightforward. It is accomplished by comparing the signal with a threshold. Therefore, the task of detection is basically dependent upon an appropriate threshold.

In this situation, the threshold is a function of the false alarm rate as well as the probability of detection. In many communication systems, because of the cost associated with a false detection, it is desirable to have a detection threshold that not only maximizes the probability of detection but also holds the probability of false alarm below a preset level [1–5].

There are extensive techniques of how to determine the detection threshold. However, all these classical methods are based on theoretical distributions of clutter and are limited to the white Gaussian noise with known power. In real applications, the noise is often colored and its power is unknown. Additionally, modern radar systems generally operate in non-homogeneous and non-stationary clutter environments. In this situation, the amplitude statistics and the power spectral density of the disturbance are unknown. Therefore, the adaptive versions of the detection algorithms are introduced.

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