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Multitarget Analysis of CFAR Detection of Partially-Correlated χ^2 Targets

Mohamed B. El Mashade
Al-Azhar University, Cairo, Egypt
e-mail: elmashade@yahoo.com

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Abstract—The goal of this paper is to treat the problem of detecting the partially-correlated χ^2 fluctuating targets with two and four degrees of freedom. We analyze the detection performance in general terms of the more generalized version, which is known as GTM, of the CFAR processors when the operating environment is contaminated with outlying target returns and the radar receiver carries its processing based on post-detection integration of *M* exponentially correlated pulses. Analytical formulas for the detection and false alarm probabilities are derived, in the absence as well as in the presence of spurious targets which are assumed to be moderately fluctuating following χ^2 target models. A performance assessment by numerous numerical examples, which has considered the role that each parameter can play in the processor performance, is given. The obtained results show that the processor performance enhances, for weak SNR of the primary target, as the correlation coefficient ρ_s increases and this occurs either in the absence or in the presence of extraneous targets. As the strength of the target return increases, the processor tends to invert its behavior. The well-known Swerling models embrace the correlated target cases in the situation where the correlation among the target returns follows χ^2 fluctuation models with two and four degrees of freedom and this behavior is common for all GTM based detectors.

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1. INTRODUCTION

As addition to sensory equipment, radar represents an important agent which genuinely affords 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 not be distinguished with the naked 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 unknown in the past. It can also measure the instantaneous speed of such an object toward or away from the observing station. The superiority of radar to ordinary vision lies in the greater distances at which seeing is possible with radar, in the ability of radar to work regardless of light condition and of obscuration of the object being seen, and in the lightness with which target range and its rate of change can be measured.

Radar systems use modulated waveforms and directive antennas to transmit electromagnetic energy into a specific volume in space to search of targets. Objects within a search volume will reflect portions of this energy (radar returns or echoes) back to the radar. These echoes are processed by the radar receiver to extract target information such as range, velocity, angular position, and other target identifying characteristics. The primary functions of any radar system are detection, tracking and imaging. The detection process represents the main fundamental concern of the radar because based on it, it will decide to continue or stop any further processes.

In attempting to sense the presence of a target through the detection of its returned signal, the radar may have to contend with clutter, jamming, and various interference signals as well as noise. Since both the target signal returns and the radar noise background result from random processes, the detection is a statistical process. This process is accomplished by comparing the received signal amplitude with a threshold level. This threshold is usually set to exclude most noise signals. If the noise power is assumed to be constant, then the detection process becomes a simple problem since the detection threshold is held fixed.

In practice the system noise level may change due to changing atmospheric conditions, component temperatures or varying noise background from jamming or other interference. In the case of external clutter and jamming signals, the changes in the noise level and the resulting rate of false alarm may be dramatic. To