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Performance of Novel Versions of CFAR Detection Schemes Processing M-Correlated Sweeps in Presence of Interferers

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Abstract—The detection of moving target (MTI) against clutter background represents one of the most important goals of a radar system. To achieve this objective, it is necessary to suppress or cancel the clutter returns with as small suppression of the target signal as possible. In this regard, MTI radar is capable of detecting such type of targets in the presence of interferers. Radar MTI is of great interest in civil and military applications, where it reduces the returns from stationary or slowly moving clutter. Additionally, in order to make decisions on the target presence, the MTI processing may be applied with automatic detection. In this situation, the CFAR detection is a common style of adaptive algorithms employed in radar systems to detect target returns against a background of noise, clutter and interference. However, the presence of MTI complicates the analysis of the detection system performance since its output sequence is correlated even though its input sequence may be uncorrelated. Our goal in this paper is to analyze the performance of a radar signal processor that consists of a nonrecursive MTI followed by a square-law integrator and a new version of CFAR circuit detection; the operation of which is based on the hybrid combination of CA and TM algorithms. The processor performance is evaluated for the case where the background environment is assumed to be ideal (homogeneous) as well as in the presence of spurious target returns amongst the contents of the reference cells. The numerical results exhibit that the processor performance can be enhanced through either increasing the number of incoherently integrated pulses or decreasing the correlation among consecutive sweeps, given that the rate of false alarm is keeping constant.

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1. INTRODUCTION

The general task of primary radars, used in air or vessel traffic control, is to detect all targets inside the observation area and if an aircraft is found (detected), it extracts its information such as bearing, range, speed, etc. Hence, the detection represents the fundamental task based on which, the radar receiver will decide to continue or stop its processing.

In real applications, clutter is a complicated time and space variant stochastic process. It is the major problem for outdoor radar operations and there is no standard measure to reject it. The nature of clutter varies with application and radar parameters because of many users and the over-crowding of the spectrum. In this regard, electromagnetic interference is a common occurrence with current communication and electronic equipments. Hence, avoidance or elimination of such interference is of primary concern of the radar designer.

One of the most efficient methods for doing this is to exploit the Doppler shift in reflections from moving targets. This is called moving target indication (MTI), and it is used in many radar applications today. Ideally, clutter components will be removed by the MTI process, leaving receiver noise and reflection from targets at the output. The MTI signal exhibits spatial correlation between clutter samples. The correlation is concluded to be the reason for performance degradation, as detection on clutter appears as targets [1–5].

Automatic detection may be combined with MTI processor in order to make decisions on target presence. The target detection scheme would be an easy task if the echo signal was observed before an empty or statistically completely known noise or clutter signal background. In this regard, all received echo signal amplitudes would be compared with a fixed threshold, which is based on the noise and clutter statistic only, and targets are detected in all cases when this threshold is exceeded by the echo signal inside a cell under test

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ADDITIONAL INFORMATION

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REFERENCES

1. G. M. Dillard, J. T. Rickard, "Performance of an MTI followed by incoherent integration for nonfluctuating signals," *Proc. of IEEE Int. Radar Conf.*, 28-30 Apr. 1980, San Diego, USA (IEEE, 1980), pp. 194–199.
2. M. B. El Mashade, "Performance analysis of the OS family of CFAR schemes with incoherent integration of M-pulses in the presence of interferers," *IEE Proc. Radar*, *Sonar Navig.* **145**, No. 3, 181 (June 1998). DOI: 10.1049/ip-rsn:19981607.
3. Jose Raul Machado-Fernandez, Norelys Mojena-Hernandez, J. C. Bacallao-Vidal, "Evaluation of CFAR detectors performance," *Iteckne* **14**, No. 2, 170 (2017). DOI: 10.15332/iteckne.v14i2.1772.
4. M. B. El Mashade, "M-correlated sweeps performance analysis of mean-level CFAR processors in multiple target environments," *IEEE Trans. Aerospace Electronic Systems* **38**, No. 2, 354 (Apr. 2002). DOI: 10.1109/TAES.2002.1008971.
5. Md. Maynul Islam, Mohammed Hossam-E-Haider, "Detection capability and CFAR loss under fluctuating targets of different Swerling model for various gamma parameters in RADAR," *Int. J. Advanced Computer Sci. Applications* **9**, No. 2, 90 (2018). DOI: 10.14569/IJACSA.2018.090214.
6. M. B. El Mashade, "M-correlated sweeps performance analysis of adaptive detection of radar targets in interference-saturated environments," *Ann. Telecommun.* **66**, No. 11-12, 617 (2011). DOI: 10.1007/s12243-010-0236-5.
7. W. Q. Wang, *Radar Systems: Technology*, *Principles and Applications* (Nova Science Publishers, Inc, 2013).
8. Ajay Kumar Yadav, Laxmi Kant, "Moving target detection using VI-CFAR algorithm on MATLAB platform," *Int. J. Advanced Research Computer Science and Software Engineering* **3**, No. 12, 915 (Dec. 2013).
9. Chang J. Kim, "A new formula to predict the exact detection probability of a generalized order statistics CFAR detector for a correlated Rayleigh target," *ETRI J.* **16**, No. 2, 15 (1994). DOI: 10.4218/etrij.94.0194.0022.
10. Dejan Ivković, Milenko Andrić, Bojan Zrnić, "A new model of CFAR detector," *Frequenz* **68**, Nos. 3-4, 125 (Mar. 2014). DOI: 10.1515/freq-2013-0087.
11. Amritakar Mandal, Rajesh Mishra, "An adaptive clutter suppression technique for moving target detector in pulse Doppler radar," *Radioengineering* **23**, No. 1, 84 (Apr. 2014). URI: https://www.radioeng.cz/fulltexts/2014/14_01_0084_0095.pdf.
12. Yuhua Qin, Huili Gong, Ting Liu, "A new CFAR detector based on automatic censoring cell averaging and cell averaging," *TELKOMNIKA* **11**, No. 6, 3298 (2013). DOI: 10.11591/telkomnika.v11i6.2686.
13. Subhankar Shome, Rabindra Nath Bera, Samarendra Nath Sur, Rabi Adhikary, "Moving target detection and Doppler extraction using digital spread spectrum radar," *Int. J. Intelligent Systems Applications* **6**, No. 10, 47 (2014). DOI: 10.5815/ijisa.2014.10.07.
14. M. B. El Mashade, "Heterogeneous performance evaluation of sophisticated versions of CFAR detection schemes," *Radioelectron. Commun. Syst.* **59**, No. 12, 536 (2016). DOI: 10.3103/S0735272716120025.
15. M. B. El Mashade, "Heterogeneous performance analysis of the new model of CFAR detectors for partially-correlated $\chi 2$-targets," *J. Systems Engineering Electronics* **29**, No. 1, 1 (Feb. 2018). DOI: 10.21629/JSEE.2018.01.01.