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Statistical Analysis of Ground Clutter from FM Based Passive Radar

A. Bhatta[1*], J. Pidanic[2], and A. K. Mishra[1***]**
[1] *University of Cape Town, Cape Town, South Africa*
[2] *University of Pardubice, Pardubice, Czech Republic*
**ORCID: 0000-0003-4096-4747, e-mail: bhattaabhishek0@gmail.com*
***ORCID: 0000-0003-1948-3818, e-mail: Jan.Pidanic@upce.cz*
****e-mail: amit.mishra@uct.ac.za*

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Abstract—Statistical characterization of ground clutter information for radar systems is a topic that requires a detailed understanding. In this work, we characterize the ground clutter information from data captured by two Frequency Modulation (FM) based passive radar systems placed at different locations in the Czech Republic. Since the target models are statistically defined by the Swerling models, each of which is based on a particular distribution, we attempted to connect the ground clutter with some of the known distributions. The analysis is performed in three steps. The empirical distribution is fitted with some of the well-known distributions. Two different goodness-of-fit tests (named chi-squared test and Kolmogorov–Smirnov test) are performed on the obtained data by comparing the empirical distribution with the fitted distributions to determine which distribution is the best fit. The observations are analyzed and the results are considered in detail.

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1. INTRODUCTION

The performance of ground based radar systems is dependent on multiple factors, one of which is the characteristic of ground clutter information. Aspects of ground clutter have been a topic under study in the design and development of radar systems [1, 2]. The statistical analysis of ground clutter data is necessary to design adequate signal processing algorithms.

In the literature, different techniques for analysis of the ground clutter data are employed by fitting the empirical distribution to some well-known distribution models [3]. An indirect algorithm for estimation and analysis of clutter parameters is presented in [4]. In another analysis technique, the ground clutter data is observed at different range resolutions [5]. The land and sea clutter from a Frequency Modulation (FM) based passive radar is analyzed in [2].

The comparison between Gaussian Mixture Reduction (GMR) and the Expectation Maximization (EM) for clutter mapping is discussed in [6]. Some key properties of radar clutter, such as multivariate Gaussianity, spatial homogeneity, and covariance persymmetry are studied in [7]. Doppler based features are extracted using the maximum-entropy spectral estimate, and the data is analyzed in [8]. In another study [9] the characteristics of radar clutter are analyzed as a Spherically Invariant Random Process (SIRP).

In the current work, we have received complex in-phase and quadrature (IQ) data from two different FM based passive radar systems. The received data is analyzed using three different analysis techniques. First, the empirical distribution function (EDF) of the received data is fitted to some of the well-known probability density functions (PDF). The fitting of the distribution is tested by using two goodness-of-fit tests.

Chi-squared test [10] is used to check the likelihood that a particular point of EDF belongs to the expected PDF. Kolmogorov–Smirnov test [11] is used to check the distance between points on the Empirical Cumulative Distribution Function (ECDF) when compared to the Cumulative Distribution Function (CDF) of the expected distribution.

The two radar systems under study are placed in Pardubice (receiver Rx1) [12] and in Čáslav (receiver Rx2). These radars contain an array of directed dipole antennas oriented towards a particular region of Czech Republic, and in combination these radars provide omnidirectional coverage. Multiple different FM

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ADDITIONAL INFORMATION

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