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Anomaly Subspace Detection Based on a Multi-Scale Markov Random Field Model

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Abstract

In this paper we introduce a multi-scale Gaussian Markov random field (GMRF) model and a corresponding anomaly subspace detection algorithm. Natural clutter images, often appear to have several periodical patterns of various period lengths. In such cases, the GMRF model may not sufficiently describe the clutter image. The proposed model is based on a multi-scale wavelet representation of the image, independent component analysis, and modeling each independent component as a GMRF. Anomaly detection is subsequently carried out by applying a matched subspace detector to the innovations process generated by the presumed model. The robustness of the proposed approach is demonstrated with application to automatic target detection in synthetic and real imagery. A quantitative performance analysis and experimental results demonstrates the advantage of the proposed method in comparison to competing methods.

I. Introduction

During the last decade, there has been a remarkable progress in random field models and their applications. Random field modeling has been applied extensively to texture synthesis [1], [2], image segmentation [3], [4], [5], and target detection [6], [7]. Most random field models are based on the spatial interaction of pixels in local neighborhoods. The noncausal autoregressive (NCAR) model represents each pixel as a linear combination of pixels at nearby locations, and an additive white noise variable (innovations process). Chellappa and Kashyap [1], [8] proposed an iterative estimation method and synthesis algorithm for the 2-dimensional NCAR model. They illustrated the usefulness of the NCAR models for synthesis of textures resembling several real

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