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Global Unsupervised Anomaly Extraction and Discrimination in Hyperspectral Images via Maximum Orthogonal-Complements Analysis

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Abstract

In this paper we address the problem of global unsupervised detection, discrimination, and population estimation of anomalies of the same type, in hyperspectral images. The proposed approach, denoted as Anomaly Extraction and Discrimination Algorithm (AXDA), detects anomalies via analysis of a signal-subspace obtained by the recently developed Maximum Orthogonal Complement Algorithm (MOCA). MOCA is unique in providing an unsupervised combined estimation of signal-subspace that includes anomalies, and its rank. The main idea of AXDA is to iteratively reduce the anomaly vector subspace-rank, making the related anomalies to be poorly represented. This helps to detect them by a statistical analysis of the $\ell_{2,\infty}$-norm of data residuals. As a by-product, AXDA provides also an anomaly-free robust background subspace and rank estimation. We experimentally show that AXDA performs better than other global anomaly detection techniques, such as the Gaussian Mixture Model-based (GMRX) algorithm and the classical Matched Subspace Detector (MSD), in most of the range of the tested parameters. Since MSD requires prior knowledge of anomaly and background subspaces, which are unknown, the MSD was applied to the anomaly subspace obtained from MOCA and the anomaly-free background subspace obtained from AXDA.

Index Terms

Signal-subspace rank, Maximum Orthogonal-Complements Algorithm (MOCA), Unsupervised Anomaly Detection, Unsupervised Anomaly Discrimination, Hyperspectral Images, Background Modelling.