Noise-Robust Spectral Signature Classification in Non-resolved Object Detection using Feedback Controlled Adaptive Learning

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Accurate spectral signature classification is key to reliable nonresolved detection and recognition of spaceborne objects. In classical signature-based recognition applications, classification accuracy has been shown to depend on accurate spectral endmember discrimination. Unfortunately, signatures are corrupted by noise and clutter that can be nonergodic in astronomical imaging practice. In previous work, we have shown that object class separation and classifier refinement results can be severely corrupted by input noise, leading to suboptimal classification. We have also shown that computed pattern recognition, like its human counterpart, can benefit from processes such as learning or forgetting, which in spectral signature classification can support adaptive tracking of input nonergodicities.

In this paper, we model learning as the acquisition or insertion of a new pattern into a classifier's knowledge base. For example, in neural nets (NNs), this insertion process could correspond to the superposition of a new pattern onto the NN weight matrix. Similarly, we model forgetting as the deletion of a pattern currently stored in the classifier knowledge base, for example, as a pattern deletion operation on the NN weight matrix, which is a difficult goal with classical neural nets (CNNs). In particular, this paper discusses the implementation of feedback control for pattern insertion and deletion in lattice associative memories (LAMs) and dynamically adaptive statistical data fusion (DASDAF) paradigms, in support of signature classification. It is shown that adaptive classifiers based on LNN or DASDAF technology can achieve accurate signature classification in the presence of nonergodic Gaussian and non-Gaussian noise, at low signal-to-noise ratio (SNR). Demonstration involves classification of multiple closely spaced, noise corrupted signatures from a NASA database of space material signatures at SNR > 0.1:1.