COMPUTATIONAL INTELLIGENCE FOR OPTIMIZATION AND ANALYSIS OF HIGH DIMENSIONAL SPECTRAL IMAGERY

by

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ABSTRACT

While modern hyperspectral sensors acquire plentiful of spectral and spatial data from a scene, the huge volume of acquired data poses a challenge to traditional data processing techniques. This dissertation investigates the potential of computational intelligence methods for extracting useful information from high dimensional spectral imagery. Artificial neural networks were utilized due to its powerful function approximation capabilities. Particle swarm optimization was studied for its characteristic of fast convergence to the global optimum region. The basic swarm optimizer was extended to deal with the problem of selecting optimal features from hyperspectral image data. Two original applications for hyperspectral imagery were proposed. In the biomedical field, a novel visualization system for computer-aided surgery was proposed. The aim of the system was to deliver clearer visualizations under a layer of blood and assist the surgeon during surgeries. An image processing method using artificial neural networks to enhance visualization of blood-covered regions was developed. By tuning optical filters to interesting wavelengths, a multi-spectral system for this specific task was designed. An unsupervised feature extraction method was proposed using entropy and texture. In the field of remote sensing, an artificial neural network-based approach to model chemical contents in soybean fields was developed. In this case, the objective was to predict the crops' quality non-destructively, helping the farmer to determine the best time for harvest. The effect of preprocessing the hyperspectral data using derivative analysis was examined. A feature selection method using two particle-swarms was proposed, and compared with principal components analysis. A spectral analysis scheme was proposed exploring the linear models obtained using artificial neural networks, and the features selected by the particle swarms with linear and non-linear models. Using the proposed framework, the significance of spectral regions on the performance of the specific applications could be indicated.

Dedicated to my grandmother, Fute Takahashi,
who first initiated this Brazil-Japan affair more than 70 years ago.