Chapter XVI

Hyperspectral Image Classification with Kernels

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Abstract

The information contained in hyperspectral images allows the characterization, identification, and classification of land covers with improved accuracy and robustness. However, several critical problems should be considered in the classification of hyperspectral images, among which are (a) the high number of spectral channels, (b) the spatial variability of the spectral signature, (c) the high cost of true sample labeling, and (d) the quality of data. Recently, kernel methods have offered excellent results in this context. This chapter reviews the state-of-the-art hyperspectral image classifiers, presents two recently proposed kernel-based approaches, and systematically discusses the specific needs and demands of this field.
Introduction to Remote Sensing

Materials in a scene reflect, absorb, and emit electromagnetic radiation in different ways depending on their molecular composition and shape. Remote sensing exploits this physical fact and deals with the acquisition of information about a scene (or specific object) at a short, medium, or long distance. The radiation acquired by an (airborne or satellite) sensor is measured at different wavelengths, and the resulting spectral signature (or spectrum) is used to identify a given material. The field of spectroscopy is concerned with the measurement, analysis, and interpretation of such spectra (Richards & Jia, 1999; Shaw & Manolakis, 2002). Figure 1 shows the application of imaging spectroscopy to perform satellite remote sensing.

Hyperspectral sensors are a class of imaging spectroscopy sensors acquiring hundreds of contiguous narrow bands or channels. Hyperspectral sensors sample the reflective portion of the electromagnetic spectrum ranging from the visible region (0.4-0.7 \( \mu \text{m} \)) through the near infrared (about 2.4 \( \mu \text{m} \)) in hundreds of narrow contiguous bands about 10 nm wide.\(^1\) Hyperspectral sensors represent an evolution in technology from earlier multispectral sensors, which typically collect spectral information in only a few discrete, noncontiguous bands. The high spectral resolution characteristic of hyperspectral sensors preserves important aspects of the spectrum (e.g., shape of narrow absorption bands), and makes the differentiation of different materials on the ground possible. The spatially and spectrally sampled information can be described as a data cube (colloquially referred to as “the hypercube”), which includes

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\(^1\) Each pixel is defined in a N-dimensional space, in which each dimension represents a wavelength or frequency, and is used to identify the material contained in the pixel.
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