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HyperMix: A New Tool for Higher Education of Computer and Remote Sensing Engineers

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Abstract

This paper describes HyperMix, a computer tool that has been specifically designed for the education of computer and remote sensing engineers. The tool is available online (http://hypercomphypermix.blogspot.com.es). HyperMix is an open-source tool that integrates different algorithms for interpreting remotely sensed hyperspectral images collected by Earth-observation instruments. Due to the large size of these images, HyperMix automatically recognizes if the computer in which it is installed has a graphics processing unit (GPU) available, and optimizes the execution of these algorithms in the GPU. This allows for the execution of hyperspectral imaging algorithms in computationally efficient fashion. In this paper, we present a comprehensive survey and analysis of the educational possibilities of the tool, which are based on an exploratory study conducted among users of the tool worldwide. We conclude that HyperMix provides a valuable tool for higher education of a new generation of remote sensing engineers.

Keywords: Remote sensing education; HyperMix; Hyperspectral; Graphics Processing Units (GPUs).

1. Introduction

The education of a new generation of remote sensing engineers is a very important aspect, since the availability of new instruments for Earth observation from airborne or satellite platforms has been growing exponentially in recent years. For instance, recent advances in Earth observation technologies have made possible the development of advanced instruments such as the NASA Jet Propulsion Laboratory's Airborne Visible-Infrared Imaging Spectrometer (AVIRIS), which covers the wavelength range from 0.4 to 2.5 micrometers (visible and near-infrared spectrum) using 224 spectral channels (Green *et al.*, 1998). A hyperspectral data set can be therefore seen as an

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image cube in which each pixel is given by the spectral signature of the materials in that area of the image (see Fig. 1).

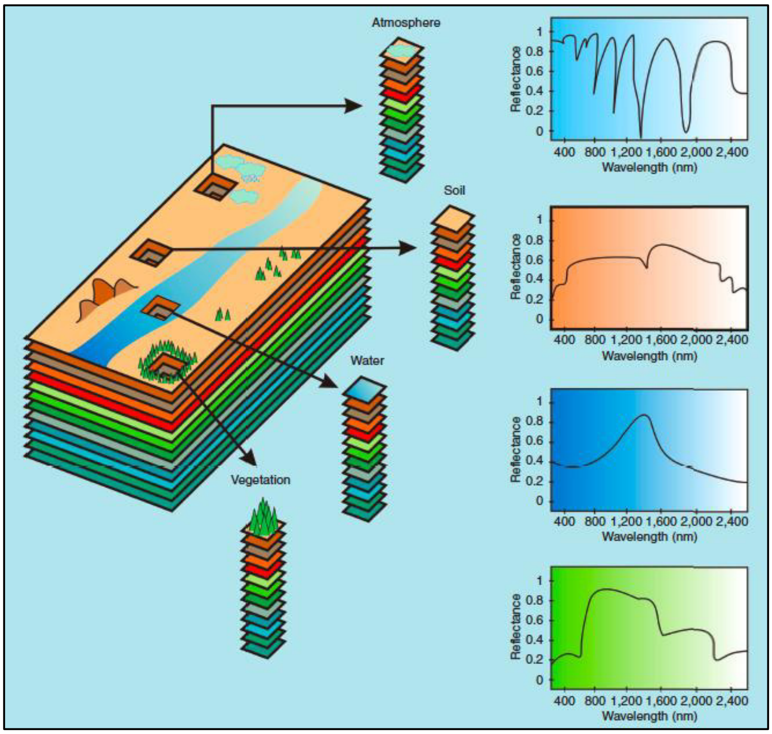

Fig. 1. The concept of remotely sensed hyperspectral imaging.

One of the main issues in the analysis of remotely sensed hyperspectral images is the mixed pixel problem (Bioucas *et al.*, 2012), which depends on the spatial resolution of the data and also on the characteristics of the area that is being imaged. To address this problem, spectral unmixing finds a collection of pure spectral constituents (called *endmembers*) that can explain each (possibly mixed) pixel of the scene as a combination of *endmembers*, weighted by their coverage fractions in the pixel or abundances (Bioucas *et al.*, 2012).

Over the last years, many algorithms have been presented to address the three main parts of the spectral unmixing chain: 1) estimation of the number of endmembers, 2) identification of the endmember signatures, and 3) estimation of the per-pixel fractional abundances (Bioucas *et al.*, 2012). However, the complexity and high dimensionality of the hyperspectral scenes bring computational challenges that make spectral unmixing techniques appealing for implementation in high performance computing systems (Plaza *et al.*, 2011). For instance, graphics processing units (GPUs) have been widely used to accelerate hyperspectral imaging algorithms (Plaza *et al.*, 2011). GPUs are a low-weight and low-cost hardware platform in which it is possible to accelerate operations and methods in order to easily obtain better computational performance. The number of processor cores depends of the architecture and the model of the GPU. The possibilities of these units go beyond their price, and offer an unprecedented potential to accelerate hyperspectral imaging problems. Despite the popularity of hyperspectral unmixing techniques and their high computational demands, to date there is no standardized tool that allows for the computationally efficient execution of spectral unmixing chains in a unified, graphical and fully configurable framework. Such a tool is very important for education of a new generation of remote sensing engineers, who will need to deal with these massive volumes of data in a computationally efficient way.