HYPERMIX: AN OPEN SOURCE TOOL FOR HYPERSPECTRAL IMAGING

Luis Ignacio Jimenez and Antonio Plaza

Hyperspectral Computing Laboratory,
Department of Technology of Computers and Communications,
University of Extremadura, Caceres, Spain

ABSTRACT

Spectral unmixing has been a popular technique for analyzing remotely sensed hyperspectral images. The goal of unmixing is to find a collection of pure spectral signatures (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*. Over the last years, many algorithms have been presented to address the different parts of the spectral unmixing chain. These algorithms can be categorized in estimation of the number of endmembers, identification of the endmember signatures, and estimation of the endmember's abundances on each pixel. This work presents a tool that integrates many efficient implementations of different methods in order to build more complex processing graphical chains. Also, the tool offers compatibility with the graphical processing unit (GPU), so that algorithms are automatically executed in parallel by the GPU (if available) in order to improve performance.. The tool is available online from http://hypercomphypermix.blogspot.com.es and has been validated with both synthetic and real hyperspectral scenes providing state-of-the-art unmixing results.

***Index Terms*—** Hyperspectral imaging, unmixing, open-source tool

1. INTRODUCTION

Spectral mixture analysis (or *spectral unmixing*) has been an alluring exploitation goal since the beginning of hyperspectral remote sensing [1] until our days [2]. Linear spectral unmixing [3] is a standard technique in spectral mixture analysis that calculates a set of pure spectral signatures, called endmembers [4] [5], and the proportions of these endmembers, called abundances [6], in each pixel. This model assumes that the spectrum collected by the imaging spectrometer can be expressed as a linear combination of endmembers, weighted by its abundances. In last decade an important number of algorithms have been developed to address the automatic and semi-automatic endmember extraction problem from an input image. In this work, we describe a new version of an open-source tool, called HyperMix [7], which includes a collection of efficient implementations of algorithms covering the three main parts of the linear spectral unmixing chain: 1) estimation of the number of endmembers; 2) identification of the endmember signatures; and 3) estimation of endmember abundances; and also several optional image preprocessing steps.

2. HYPERMIX TOOL

The HyperMix tool[1] was born, following the open-source philosophy for Linux and Windows platforms, in order to facilitate the use of hyperspectral unmixing algorithms, and now includes several different algorithms to perform the complete spectral unmixing chain (see Fig. 1). The unmixing chains that can be constructed using the HyperMix tool comprise four main steps: first is the estimation of the number of endmembers; at this point we can perform a dimensionality reduction or image preprocessing. Then we perform the extraction of endmember signatures and finally the abundance maps calculation. According to this structure, HyperMix currently includes the following algorithms implemented in C language: Virtual Dimensionality [8] (VD), Principal Component Analisys [9] (PCA), Spatial PreProcessing [10] (SPP), Orthogonal Subspace Projection [11] (OSP), Iterative Error Analysis [12] (IEA), N-FINDR [13], Vertex Component Analysis [14] (VCA), Image Space Reconstruction Algorithm (ISRA) [15] (ISRA) and Least Squares Unmixing [6] (LSU). The tool also include some methods for displaying the results obtained and conduct spectral unmixing accuracy evaluation that can be helpful in order to measure and compare different unmixing chains over the same image. A database of 100x100-pixel synthetic hyperspectral scenes created using fractals to generate distinct spatial patterns adding noise to the simulated images, has also been included in the HyperMix tool. The use of fractals patterns is due to the similarity that offers regarding to existing in nature scenes like clouds, mountain ranges, coastlines, etc. The images have been generated using a set of randomly selected signatures extracted

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[1] http://sourceforge.net/projects/hypermixtool/?source=navbar

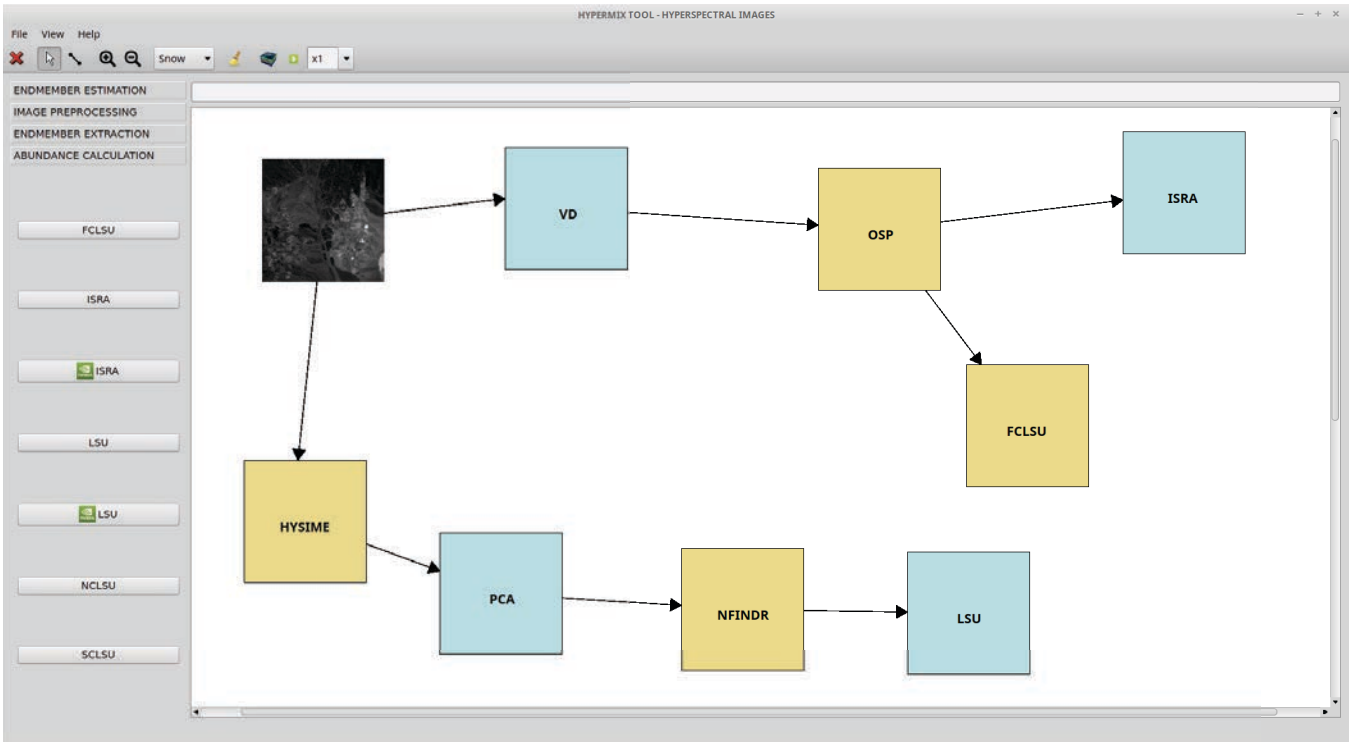

Fig. 1. Example of a the process of building a complete unmixing chain in our new version of the HyperMix Tool.

from a spectral library compiledby the U.S. Geological Survey (USGS) and made up of a total of 420 signatures. We also have include some real popular scenes used in the field, like the well-known AVIRIS Cuprite data set.

3. NEW FEATURES

Here we describe the new features incorporated to the HyperMix tool. With the ultimate goal of developing a user-friendly tool, we added some new features which extend considerably its funcionalities and make it distnguishable from other similar applications:

- An important new feature of the tool is the new way to prepare the operation which is going to be executed by means of dynamic and fully customizable flowchart diagrams (see Fig. 1). In this way, an inexperienced user can easily learn and manage complete hyperspectral unmixing chains in graphical form. The tool offers a short description of all operators included and the parameters needed for each of them. The number of possible chains that an user can build is enormous, following the spectral unmixing chain structure described above and its logic. Moreover this graphical representation allows to perform experiments with different images in a simple and straightforward way.

- Perhaps the main new feature added in this version of the tool is the possibility to include parallel operators which can use an NVidia graphic processing units (GPU) if the machine in which the tool is installed has one has one. The tool is capable to recognize the GPU and perform parallel executions of the unmixing chain. These parallel operators are represented in different colors in order to differentiate them from the iterative ones. In the current version of HyperMix we include some implementations of the algorithms listed before, developed using the NVidia Compute Unified Device Architecture (CUDA). This point allows us to compare the accuracy and performance obtained between both, parallel and iterative versions of the same algorithms, thus simplifying the development process of these algorithms greatly.

- A third main improvement in this version of HyperMix is more orientated to extend its life and relevance in the community. It consists of the possibility to add our own operators to the tool only dragging the executable file, compiled by the user in a specific folder, and using some very simple rules for identifying this executable in the tool and include it in the graphical operations. By this way, an user can easily use HyperMix in his/her own development process by turning it in an useful tool for including new implementations related to spectral unmixing problems.

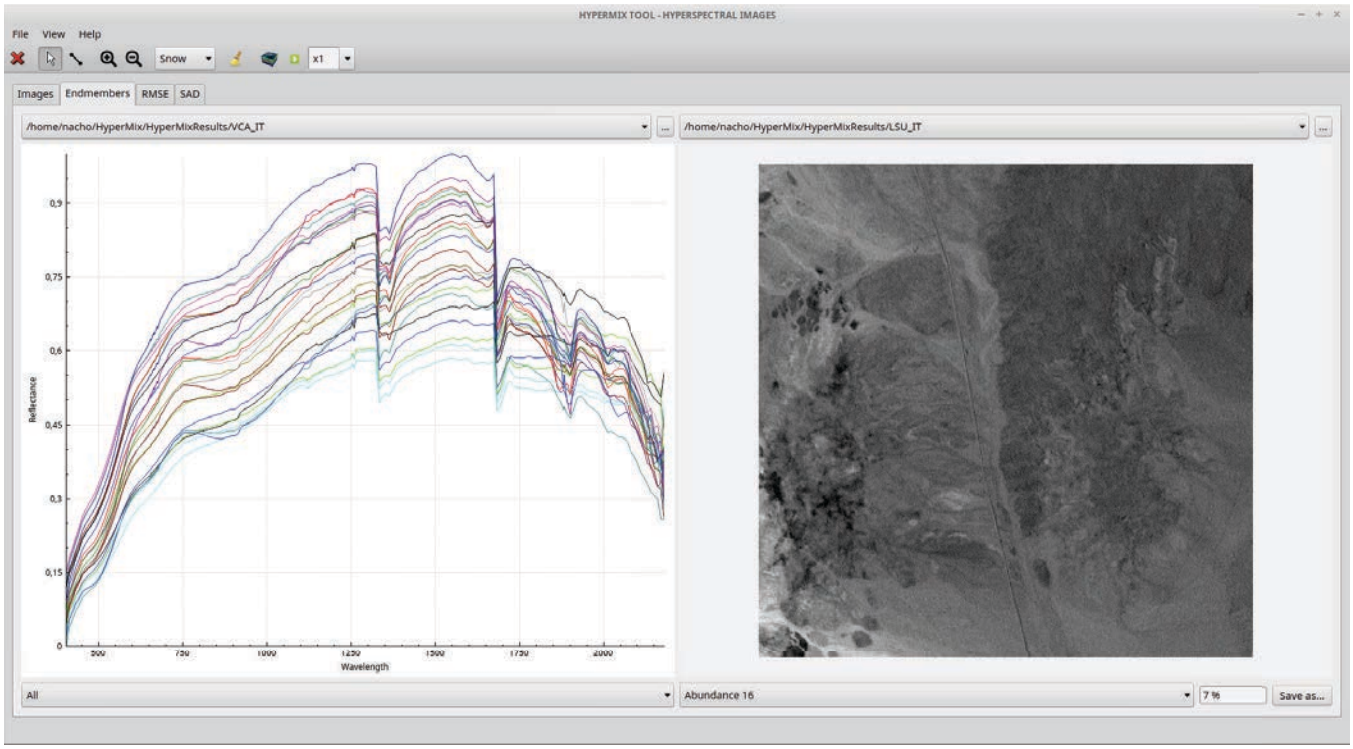

Fig. 2. HyperMix Tool displaying some resulst obtained.

Along with this new version of HyperMix, we have created a blog[2] to inform of updates and new releases of the tool. Also this blog will be used as a line of communication with users, to receive their suggestions and answer possible doubts.

4. CONCLUSIONS

In this work, we have presented a new version of the HyperMix tool (implemented following open-source principles) for executing full hyperspectral unmixing chains. Specifically, we have significantly extended the functionality of the tool including more algorithms and options, as well as an interactive way to build the unmixing chains and evaluate the algorithms. Last but not least, we have included a parallel GPU execution mode that automatically recognizes GPU hardware in the system and executes the unmixing chains in parallel mode.

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