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Parallel unmixing of remotely sensed hyperspectral images on commodity graphics processing units.

Concurrency Comput. Pract. Exp. 23, No. 13, 1538-1557 (2011).

Summary: Hyperspectral imaging instruments are capable of collecting hundreds of images, corresponding to different wavelength channels, for the same area on the surface of the Earth. One of the main problems in the analysis of hyperspectral data cubes is the presence of mixed pixels, which arise when the spatial resolution of the sensor is not enough to separate spectrally distinct materials. Hyperspectral unmixing is one of the most popular techniques to analyze hyperspectral data. It comprises two stages: (i) automatic identification of pure spectral signatures (endmembers) and (ii) estimation of the fractional abundance of each endmember in each pixel. The spectral unmixing process is quite expensive in computational terms, mainly due to the extremely high dimensionality of hyperspectral data cubes. Although this process maps nicely to high performance systems such as clusters of computers, these systems are generally expensive and difficult to adapt to real-time data processing requirements introduced by several applications, such as wildland fire tracking, biological threat detection, monitoring of oil spills, and other types of chemical contamination. In this paper, we develop an implementation of the full hyperspectral unmixing chain on commodity graphics processing units (GPUs). The proposed methodology has been implemented, using the CUDA (compute device unified architecture), and tested on three different GPU architectures: NVidia Tesla C1060, NVidia GeForce GTX 275, and NVidia GeForce 9800 GX2, achieving near real-time unmixing performance in some configurations tested when analyzing two different hyperspectral images, collected over the World Trade Center complex in New York City and the Cuprite mining district in Nevada.

Keywords: hyperspectral imaging; endmember extraction; abundance estimation; parallel processing; GPUs
doi:10.1002/cpe.1720