Analyzing the Use of GPUs for Hyperspectral Image Processing

Yajaira González
Advisor: Nayda G. Santiago
Electrical and Computer Engineering Department
University of Puerto Rico at Mayagüez

Abstract

Spectral Unmixing is a process by which the constituent’s members of a pixel scene are determined and the fraction of the abundance of the elements is estimated. Several algorithms have been developed in the past in order to obtain abundance estimation from hyperspectral data. In particular, from our research group, the constraint positive matrix factorization algorithm was developed for unsupervised spectral unmixing. However, this algorithm as well as additional ones are characterized by being highly computational and time consuming due to the magnitude of the data involved. In this research we analyze the use of Graphic Processing Units (GPUs) as computing platform in order to reduce computation time related to abundance estimation of hyperspectral images. Our implementation is being developed in C using NVIDIA® Compute Unified Device Architecture (CUDA™). As first step in the direction of providing the building blocks for more complex algorithms developed in our group, we are implementing the Hyperspectral Image Analysis Toolbox (HIAT) for processing hyperspectral and multispectral data. Some of these algorithms will be used for the implementation of the Constraint Positive Matrix Factorization (CPMF). Preliminary results of the implementation of the Principal Component Analysis (PCA) algorithm will be presented.

PMF

PMF is an unsupervised algorithm that solves the following equation [7]:

\[ X = \arg \min_{A,S} \| X - AS \|_F \]

Where \( A \) is the abundance matrix and \( S \) the endmember matrix.

Parallelism with CUDA

- Directly use GPU's processing power.
- Single Instruction, Multiple Data(SIMD).
- Blocks are further organized into “grids”.
- Multiple kernels can be executed in parallel.

Technical Approach

Principal Components Analysis (PCA) is used for dimensionality reduction and spectral decorrelation of data.

\[ \frac{1}{M} \sum_{i=1}^{M} \left( \frac{1}{N} \sum_{n=1}^{N} x_{ni} \right) \]

\[ \frac{1}{M} \sum_{i=1}^{M} \left( \frac{1}{N} \sum_{n=1}^{N} (x_{ni} - \mu_i)^2 \right) \]

Previous implementations of PCA in CUDA were not found available [10-11].

Partial Implementation of PCA

Table 2: Results of Partial Implementation of PCA in CUDA

Future Work

Our future work includes implementation of the additional algorithms such as Discriminant Analysis, Singular Value Decomposition, and the Information Divergence Algorithms as well as the rest of the HIAT routines in order to use them to complete the PMF algorithm.

References


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