Abstract

Hyperspectral images (HSI) provide data rich information in both the spatial and spectral domain. The special properties of hyperspectral data have significantly expanded the domain of many analysis techniques, including supervised and unsupervised classification, spectral unmixing, compression, target, and anomaly detection which are of importance in hyperspectral image exploitation in defense and security applications. The main purpose of this research is to develop a robust library for hyperspectral image processing that perform efficiently on Graphics Processing Units (GPU), considerably improve the algorithm throughput, and facilitated rapid prototyping of HSI-analysis systems. This library is intended to be released as an Open Source project which will be available to the hyperspectral image processing community in different application domains. This undergraduate research project is a continuation of the work on HSI target detection on GPUs from last year.

Technical Approach

- Analyze and select parallelizable algorithms from the MATLAB Hyperspectral Image Analysis Toolbox (HIAT)[1]
- Determine detectors to be implemented[2]
- Develop library containing the selected algorithms

Previous Work

HIAT

Detectors

- Full Pixel
- Matched Filter
- RX Detector

Pre-Post Processing

Unsupervised Classification

Supervised Classification

Feature Extraction/Selection

- Principal Component Analysis
- Singular Value Decomposition
- Discriminant Analysis

Classifiers

- Euclidean Distance
- Fisher Linear Discriminant
- Mahalanobis Distance
- Maximum Likelihood

Abundance Estimators

- Non negative sum to one
- Non negative least square

Technical Approach

- Identify and remove proprietary code in the detectors
- RX Detector uses Cholesky Decomposition from Intel’s MKL[3]
- \( A = LL^T \)
- Remove proprietary code from PCA and SVD
- Both use SVD routine from CULA[4]
- \( M = U \Sigma V^T \)
- Explore open source alternatives such as MAGMA[5]
- Replace proprietary dependency’s
- Thorough testing of all implementations
- Benchmarking
- Use extensive sets of Hyperspectral data
- Create documentation, tutorials, and examples

Accomplishments Through Current Year

- Analysis of detection algorithms and their structure.
- Proprietary code within algorithms detected in target detection code.
- Selection of detection code to be ported to GPU.
- Identified which algorithms are amenable to GPU and which are not.

Future Work

- Finish Reed-Xiaoli (RX), Principal Component Analysis, and Singular Value Decomposition incorporating MAGMA. Test thoroughly and document for the library.

Opportunities for Transition to Customer

- GPU implementation of detection algorithms may be incorporated in standoff and portal explosive detection systems that require high throughput.

References

2. Trigueros Espinoza, Blas; Rosario-Torres, Samuel; Vélez-Reyes, Miguel; Santiago Santiago, Nayda Grisell, “GPU Implementation of Target Detection Algorithms for Explosive Material Detection using Hyperspectral Imaging and NVIDIA® GPUs”
4. CULA - GPU Accelerated Linear Algebra http://www.culatools.com/
5. MAGMA - Matrix Algebra on GPU and Multicore Architectures http://icl.cs.utk.edu/magma/