

## Title

Graphics Processing Unit Assisted Thermographic Compositing

## Center Point of Contact

Scott Ragasa, (256) 544-3935, scott.ragasa@nasa.gov

Matthew McDougal, (256) 544-7783, matthew.mcdougal@nasa.gov

Sam Russell, Ph.D., P.E., (256) 544-4411, sam.russell@nasa.gov

## Objective

To develop a software application utilizing general purpose graphics processing units (GPUs) for the analysis of large sets of thermographic data.

## Background

Over the past few years, an increasing effort among scientists and engineers to utilize the GPU in a more general purpose fashion is allowing for supercomputer level results at individual workstations. As data sets grow, the methods to work them grow at an equal, and often greater, pace. Certain common computations can take advantage of the massively parallel and optimized hardware constructs of the GPU to allow for throughput that was previously reserved for compute clusters. These common computations have high degrees of data parallelism, that is, they are the same computation applied to a large set of data where the result does not depend on other data elements. Signal (image) processing is one area where GPUs are being used to greatly increase the performance of certain algorithms and analysis techniques.

## Technical Methodology/Approach

Apply massively parallel algorithms and data structures to the specific analysis requirements presented when working with thermographic data sets.

## Benefits/Payoffs

The end product of this effort is a software application that utilizes general purpose graphics processing units to allow the analysis of large thermographic data sets. This would also allow the use of previously

unavailable computationally intensive analysis techniques, higher resolution thermographic cameras, and larger individual data files.

### Customers

All projects that utilize flash thermography for the inspection of composite aerospace structures.

### 2010 Accomplishments

- Initial research, specifically, determinations of what hardware or software components were limiting factors in the analysis of large thermographic data sets.
- Literature survey to determine what parallel algorithms could be implemented on the GPU to allow for increase analysis capabilities.

### 2011 Accomplishments

- Continued survey of available literature to determine applicable algorithms, optimizations and techniques for increasing the performance of signal processing using the GPU.
- Built a demonstration application to directly compare the performance of corresponding algorithms on the CPU and GPU.



Figure 1 – Proof of Concept Demonstration Application

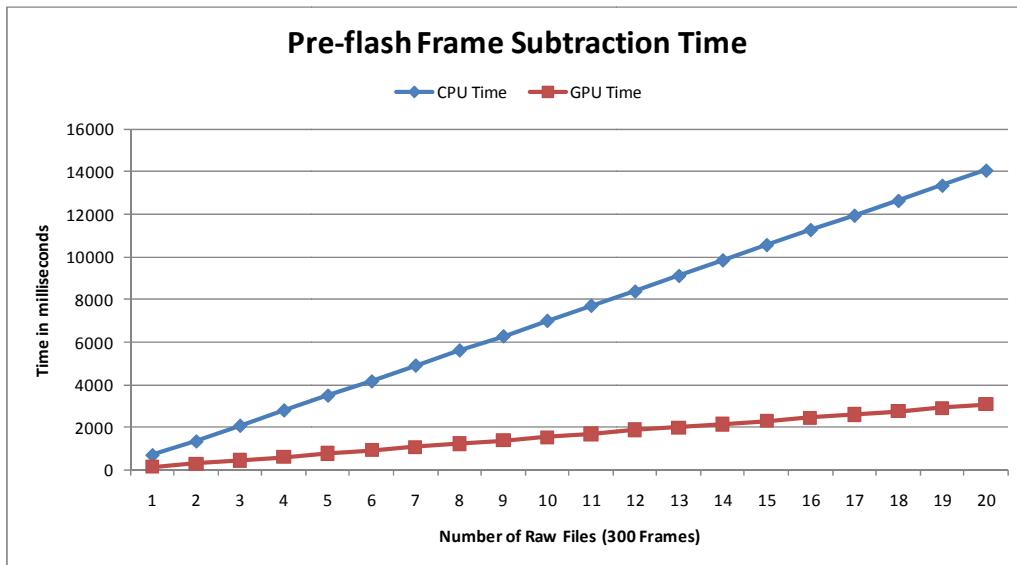


Figure 2 – Comparison of CPU and GPU Image Subtraction Algorithm Implementations

### 2012 Accomplishments

- Built a software application that is capable of visualizing large thermographic data sets in a grid layout, surpassing targeted capability level.

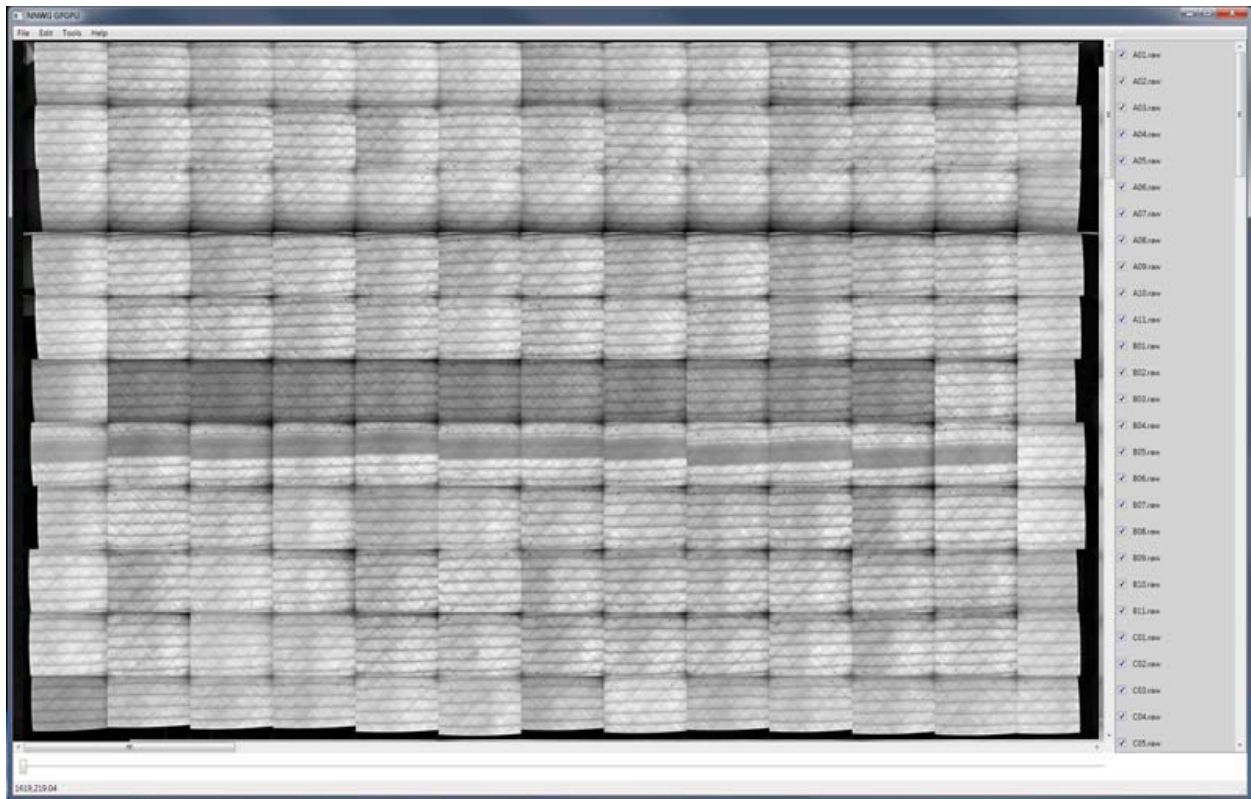


Figure 3 – Mosaic Visualization Application

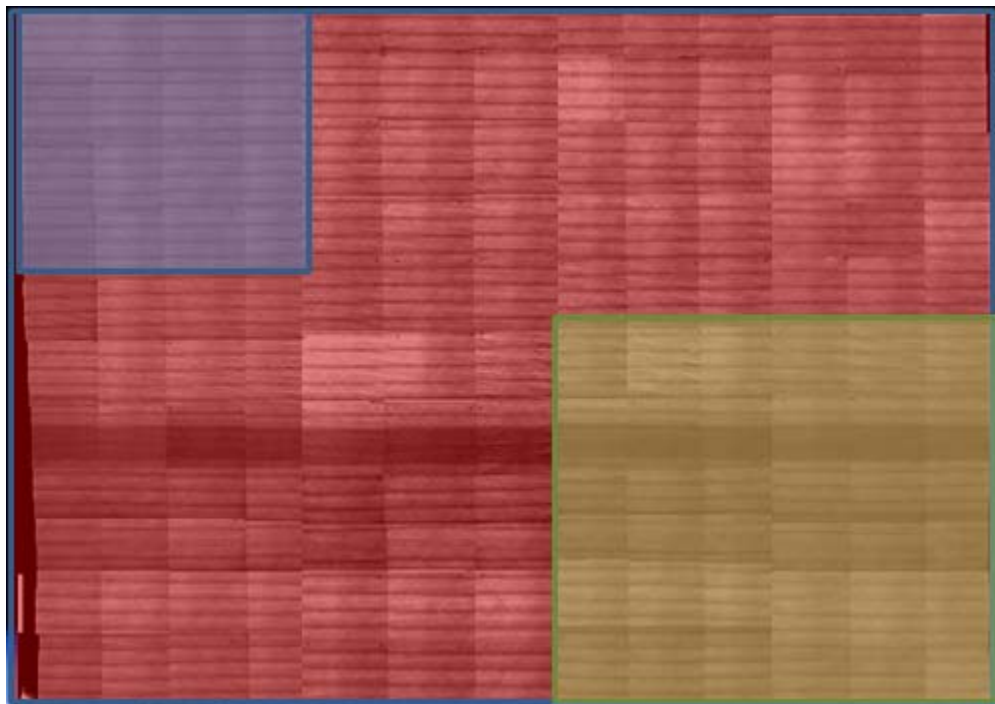


Figure 4 – Comparison of Visualization Capabilities

Note: The blue area denotes the capabilities of the current analysis software, the green area denotes the goal capabilities of this project, and the red area denotes what was achieved – the full mosaic of 143

images.

- Built a MATLAB®-based application capable of performing principal component analysis (PCA) on thermographic data sets with support for the GPU.

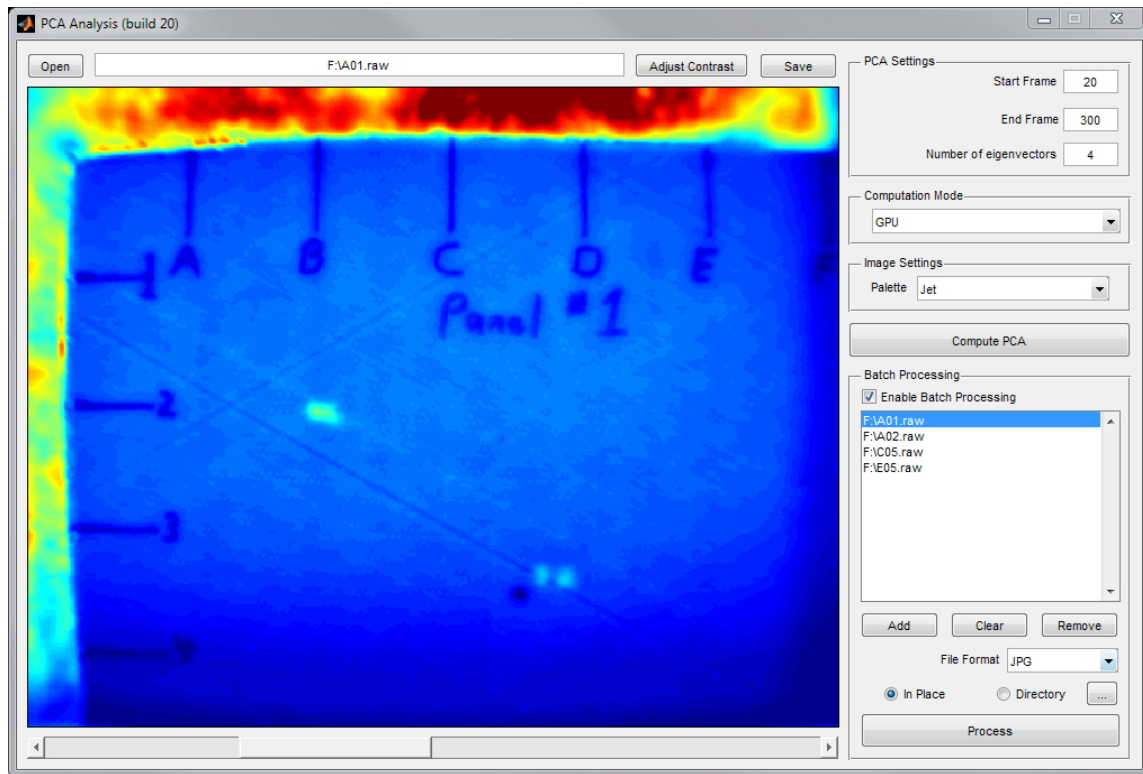


Figure 5 – MATLAB®-based PCA Application

The software application supports both CPU and GPU execution modes so it is able to run on both conventional PCs as well as GPU workstations. When compared to previous implementations of principal component analysis on thermographic data, the GPU-assisted software exhibits not only increased performance on a per-file basis, but also more stable processing performance when run in batch mode. The performance results are summarized in Figure 6.

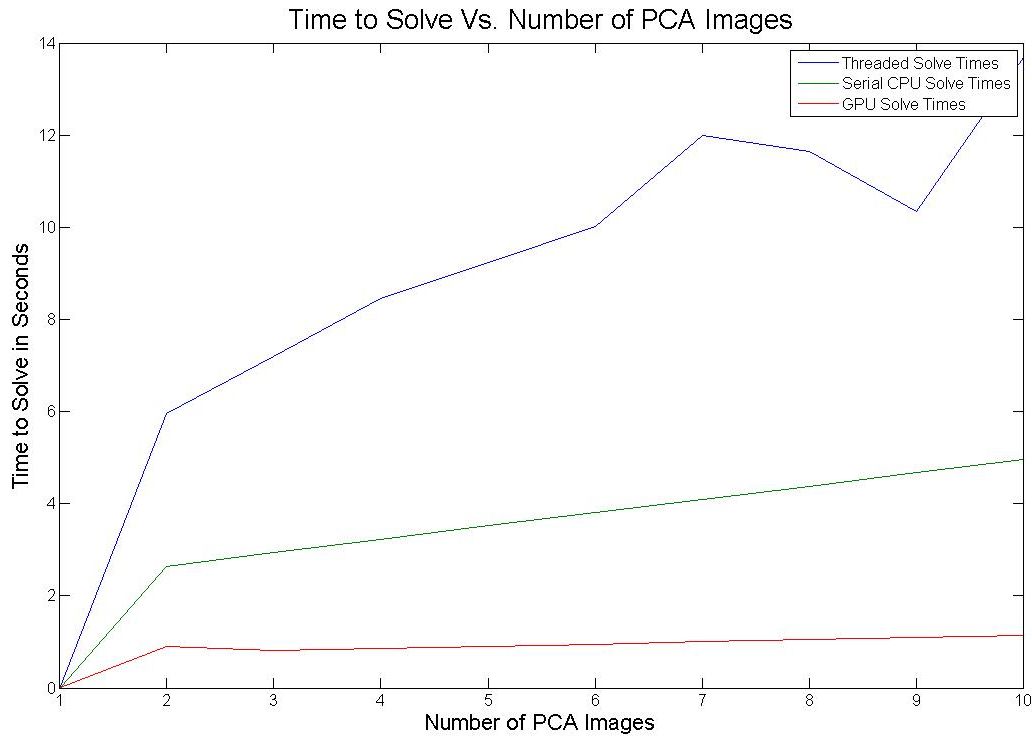


Figure 6 – Comparison of CPU and GPU Processing Performance

### Status

The task is complete. Several additional areas of nondestructive evaluation were identified that could benefit from GPU-accelerated software including ultrasonic analysis and data fusion visualizations should additional funding opportunities become available.

### Future Work and Applications

Research performed during the completion of this task was instrumental in the creation of a software application that will be used to analyze data acquired by the automated scanning system constructed to perform thermographic and ultrasonic nondestructive evaluation of the Space Launch System Payload Fairing manufacturing demonstration article. Demonstration testing of the automated scanning system will encompass the nondestructive inspection of a one-sixth segment of the Payload Fairing shown in Figure 7. Estimations for the thermographic data collected are approximately one thousand data sets. Using the conventional analysis techniques and software, interpretation and reporting of results would require a significant amount of time. As a result, a new, general purpose graphics processing unit assisted software application was developed to dramatically decrease the analysis time.

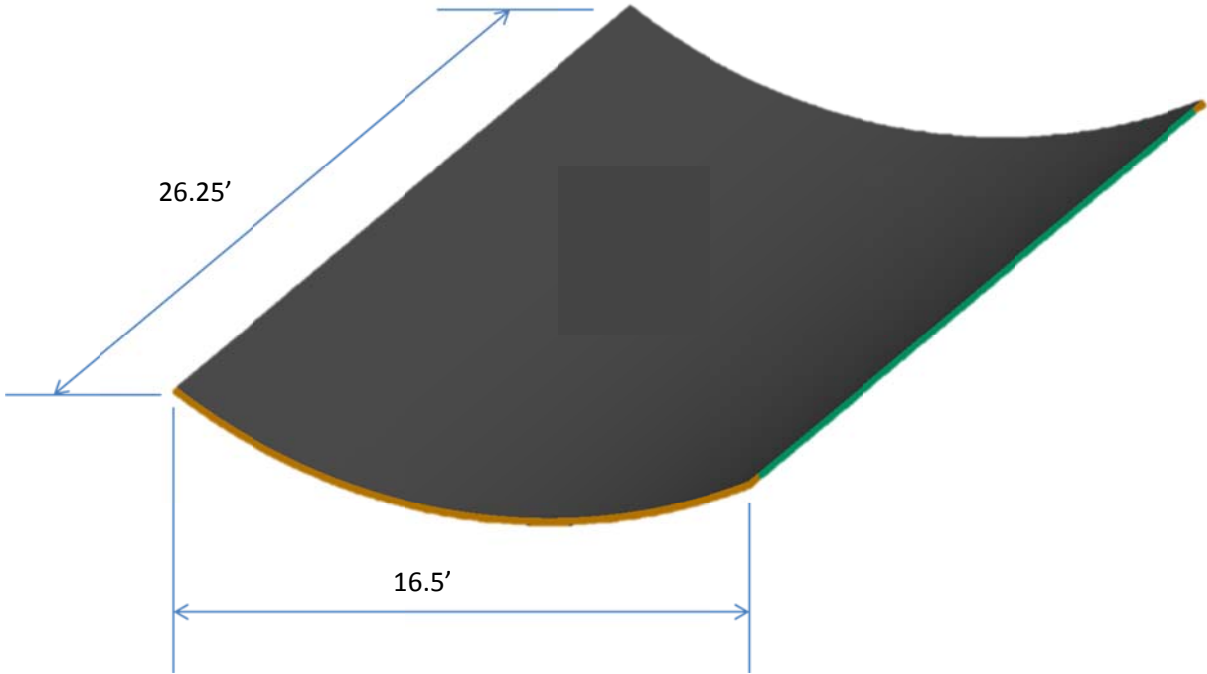


Figure 7 – 1/6<sup>th</sup> Segment Payload Fairing

### Conclusion

The payoff of this research effort is already visible in the creation and deployment of GPU-accelerated inspection software. By applying the lessons learned from this research effort and the first real-world deliverable to other nondestructive evaluation techniques and analysis, additional benefits are possible.