Improving Mars Rover Image Compression Via GPUs and Genetic Algorithms – S0133

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Overview

- Mars Rover Images
- Image Compression using Wavelets
- Genetic Algorithms
- AccelerEyes' Jacket with Matlab
- Improvements
- Results
- Future work
Death Star Blueprints

Noticed possible vulnerability with the exhaust port
Mars Images
Wavelet Image Compression

Original Image

Forward Wavelet Transform

Quantizer

Encoder

Decompressor

Dequantizer

Decoder

Lossy Image

Inverse Wavelet Transform

10011
Multiresolution Analysis

Original Image

Decomposition at level 2
Mars Rover Challenges

- No on-site tech support
- 35 MIPS 33 MHZ IBM RAD 6000 Processor
- 128 MB of memory
- Noisy environment requires Error Detection and Correction (EDC)
- 12,000 bits/sec modem
- Need low complexity, EDC and compression
Genetic Algorithms
Genetic Algorithms

- Solutions are made up of 50 circles
- X-position
- Y-position
- Radius of circle
- Color of circle

![Diagram showing chromosome and gene structure](https://via.placeholder.com/150)

<table>
<thead>
<tr>
<th>$x_{11}$</th>
<th>$x_{12}$</th>
<th>...</th>
<th>$x_{1j}$</th>
<th>...</th>
<th>$x_{2j}$</th>
<th>...</th>
<th>...</th>
<th>$x_{ij}$</th>
</tr>
</thead>
</table>

**chromosome**

**gene**
Genetic Algorithms

Crossover

A

B

Mutation

7 11 3

11 2 8

7 2 8

7 3 8
Genetic Algorithms
Magnified Region

Original – Wavelet – Evolved
High Level vs. Low Level Language

Program was originally in C++ and took 3 days to do a run

Ported to Matlab by a collaborator

Many people can write better CUDA and underlying functions than I can

Working with students and professors who are already using Matlab
Matlab GA

- GA are embarrassingly parallel
- Biggest cost is usually the fitness calculation
- Previously ran on a supercomputer at Fairbanks, AK using Matlab in parallel
- GPU is a natural fit for GA and GPUs
- Accelereye's Jacket
Acclereyes' Jacket

- Easy to change code – double to gdouble
- GFORs have lots of restrictions but can improve speed
- CONV2 used a lot in Wavelet DWT and accelerated in Jacket
Techniques

- GFOR can't have nested loops or IF statements
- Rewrite Wavelet Toolbox code to remove loops and IF statements
- Many IF statements for special cases of wavelets – can be ignored
- 2-5 times speed up
Memory Considerations

- We are constrained by the memory on the GPU
- Memory transfers are a big hit
- The GFOR allows us to tile the problem on the GPU and on the Tesla and use up to 100 fitness calculations on a 512 x 512 image
Speed up versus # of images

Jacket 2.1 GTX 560 TI vs. Intel Quad Core Q95550 2.83Ghz

Number of images

Speed up

Graph showing speed up versus number of images for Jacket 2.1 GTX 560 TI vs. Intel Quad Core Q95550 2.83Ghz. The graph compares different image resolutions: 512x512, 256x256, and 1024x1024.
Future Work

- Test on Multi GPU Tesla system
- Accelerate ICER scheme which uses a modified lifting format
- Island GA model where the DWT and GA is done completely on the GPU
- Extending to cloud based GPUs through Amazon Web Services
- Fairbanks is getting Fish (a GPU supercomputer)
Conclusions

- GPUs can be used to accelerate wavelet based image compression
- Jacket allows high level code changes in Matlab
- Allows for faster fitness calculations and larger GA populations
- Wavelets can be evolved that improve the image quality of reconstructed Mars Rover images
- Archived data from Rovers can be used to improve images and increase science content
Thanks

- AccelerEyes - John, James, Scott
- JPL – especially Aaron B Kiely and Matt
- Frank Moore and Kenrick Mock at UAA
- Link to Genetic Algorithm art: http://www.cosc.brocku.ca/~bross/JNetic/
- ARSC Supercomputing at University of Alaska, Fairbanks
- NASA EPSCoR