Medical Imaging on the GPU Using OpenCL

Master projects by: Erik Smistad\textsuperscript{a} and Thor Kristian Valderhaug\textsuperscript{a}
Supervisors: Drs. Anne C. Elster\textsuperscript{a} & Frank Lindseth,\textsuperscript{ab}
a: Norwegian University of Science and Technology, Trondheim, Norway
b: SINTEF Medical Technology, Trondheim, Norway

3D Surface Extraction

**Marching Cubes** is an algorithm for extracting a 3D surface from a set of sampled scalars. The algorithm is used extensively for visualizing and analyzing medical data (X-ray, MR) and the result of 3D segmentation.

**Implementation on the GPU**
Marching Cubes is a completely data-parallel algorithm. Each cube in the voxel grid can be calculated independent on the other cubes, hence well suited for running on the GPU

**Challenge:** How to store the result of each cube in memory in parallel on the GPU?

In the serial implementation this is simple, just use a stack and add the vertex data to the stack.

**Solution:** Stream reduction using Histogram Pyramids\textsuperscript{[1]}

**Histogram Pyramids**\textsuperscript{[1]}
A data structure that:
- Filters out cubes that has no triangles (stream reduction)
- Returns the total sum of triangles
- Provides each cube with an index for memory storage
- Can be efficiently used by means of textures yielding large speedup

![Histogram Pyramids](image)

**Results**

![Image](image)

![Speedup](image)

[HPC-Lab](http://research.idi.ntnu.no/hpc-lab)

3D Ultrasound Reconstruction

Continuation of work done by Ludvigsen et. al 2010

**Challenges**
- Calculate 64 million voxels from ca 400 b-scans
- Used under surgery, so fast reconstruction time is important
- Keep cost down

**Solution**
- Exploit the the parallelism in the problem by utilizing the parallel power of the community GPUs

![VNN algorithm](image)

**Results**

Achieve a reconstruction time of 1.29 sec on GPU compared to 29.81 sec on a CPU

Thanks to Holger Ludvigsen for pictures and CPU timing

Acknowledgments

We would like to thank AMD and NVIDIA for their hardware contributions to Dr. Elster’s research lab and the staff SINTEF Medical Technology at Trondheim for all their help.