Scout: Case Studies

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Overview

• “Pandora’s Box”
  - Ray casting Example

• Simple heat diffusion application
  - Compute and visualization in one program

• Large data, multiple GPUs, etc...
Pandora’s Box

• What’s in the CT scanned box?
  - Original data set is 2048x2048x1024…
  - We’ve down sampled to 512x512x256
  - Simple raycasting approach - maximum intensity…

```cpp
// Maximum intensity example.
raycast with (shapeof(density)) {
  float maxVal = density;
  // For each ray-cell intersect keep tabs on
  // the maximum density.
  intersect() {
    where (density > maxVal)
      maxVal = density;
  }

  // Finally assign the pixel values...
  image = rgba(maxVal, maxVal, maxVal, 1.0);
}```
Pandora’s Box...
Heat Transfer

• How does heat propagate through an object
• Need to solve the heat diffusion equation

\[
\frac{\partial T}{\partial t} = k \left( \frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} \right)
\]

• We’ll use an finite differences approach...
Heat Diffusion

• Problem configuration
  - Heat source(s) in red
    • Uneven heating
  - Heat sinks in blue
  - Multi-material
    • Grayscale

SkamCo Fermangulator #42
float:shapeof(temp) new_temp; // time step result goes here...

// Data parallel computation of the diffusion...
compute with(shapeof(temp)) {
    // Don’t compute over boundary conditions ...
    where(mask > 0) {
        float temp_x;
        temp_x = (alpha/(dx*dx))*(temp[i+1][j]-2*temp[i][j]+temp[i-1][j]);
        temp_y = (alpha/(dy*dy))*(temp[i][j+1]-2*temp[i][j]+temp[i][j-1]);
        new_temp = dt* (temp_x + temp_y) + temp[i][j];
    } else {
        new_temp = temp; // boundary conditions stay constant..
    }
}

// New temperatures need to become our initial conditions for
// the next pass.
temp = new_temp;
High Level Code Structure

```
// Simulation loop ...
for(float time = 0.0; time <= SIM_TIME; time += dt) {
    // Data parallel compute block.
    compute with(shapeof(temp)) {
        ...
    }

    // Render the results of current time step.
    render with(shapeof(temp)) {
        image = ...;
    }
}
```

CPU Loop

Compute pass

Render pass

GPGPU
Heat Diffusion Example

• Results for 512x512
  - 3,482 time steps (0.3 sec.)
  - CPU (2.2 GHz Opteron) with -O3: 92.8 sec.
  - GPU (GeForce 7800): 6.7 sec.
    • For compute and render...
Large Data - Texture Paging

- GPUs have a lot of memory - still not enough!
- What to do?
  - Manage texture paging on your own...
  - Page/stream data through the GPU one subset at a time
Texture Paging - Parallelism

- Stepping stone for parallelism
Issues

• For some computations boundaries must be shared. Distributed memory...
• What about arbitrary indexing?
Parallel Scout

• Dual PCI-E, GPU clusters
  - Work in progress - collaboration with UC Davis
  - MPI based
  - Basic support will be part of source release
  - Stay tuned to gpgpu.org for details!

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