CS 380 - GPU and GPGPU Programming
Lecture 2: Introduction, Pt. 2

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Reading Assignment #1 (until Aug 28)

Read (required):

- Orange book, chapter 1 (*Review of OpenGL Basics*)
- Orange book, chapter 2 (*Basics*)
What Are GPUs?

*Graphics* Processing Units

But evolved toward

- Very flexible, massively parallel floating point co-processors
- But not entirely programmable!
- Fixed-function parts have definite advantages (e.g., texture filtering, z-buffering)

We will cover both perspectives

- GPUs for graphics
- GPU computing (GPGPU – general purpose computation on GPU)
Peak Performance

Theoretical GFLOP/s

- NVIDIA GPU Single Precision
- NVIDIA GPU Double Precision
- Intel CPU Double Precision
- Intel CPU Single Precision

- GeForce 780 Ti
- GeForce GTX TITAN
- GeForce GTX 680
- Tesla K40
- Tesla K20X
- Tesla C2050
- Tesla C1060
- Harpertown
- Westmere
- Bloomfield
- Sandy Bridge
- Ivy Bridge
- GeForce 8800 Ultra
- GeForce 7800-GTX
- GeForce 6800-Ultra
- Woodcrest
- Pentium 4
- Aug-03
- Feb-05
- Oct-06
- Mar-08
- Jul-09
- Nov-10
- Apr-12
- Aug-13
- Dec-14
GPU Architectures Over the Years

GPU Roadmap

- **Volta**: Stacked DRAM
- **Maxwell**: Unified Virtual Memory
- **Kepler**: Dynamic Parallelism
- **Fermi**: FP64
- **Tesla**: CUDA

Y-axis: DP GFLOPS per Watt
X-axis: 2008 to 2014
Example: Fluid Simulation and Rendering

- Compute advection of fluid
  - (Incompressible) Navier-Stokes solvers
  - Lattice Boltzmann Method (LBM)
- Discretized domain; stored in 2D/3D textures
  - Velocity, pressure
  - Dye, smoke density, vorticity, …
- Updates in multi-passes
- Render current frame

Courtesy Mark Harris
Example: Volumetric Special Effects

- NVIDIA Demos
  - Smoke, water
  - Collision detection with voxelized solid (Gargoyle)

- Ray-casting
  - Smoke: direct volume rendering
  - Water: level set / isosurface

Courtesy Keenan Crane
Example: Particle Simulation and Rendering

- NVIDIA Particle Demo
Example: Level-Set Computations

- Implicit surface represented by distance field
- The level-set PDE is solved to update the distance field
- Basic framework with a variety of applications
Example: Diffusion Filtering

De-noising

- Original
- Linear isotropic
- Non-linear isotropic
- Non-linear anisotropic
Example: Linear Algebra Operators

Vector and matrix representation and operators

- Early approach based on graphics primitives
- Now CUDA makes this much easier
- Linear systems solvers

Courtesy Krüger and Westermann
Glift: Generic, Efficient, Random-Access GPU Data Structures

- "STL" for GPUs
- Virtual memory management

Courtesy Lefohn et al.
What’s in a GPU?

Lots of floating point processing power

- Stream processing cores
  - different names: stream processors, CUDA cores, ...
  - Was vector processing, now scalar cores!

Still lots of fixed graphics functionality

- Attribute interpolation (per-vertex -> per-fragment)
- Rasterization (turning triangles into fragments/pixels)
- Texture sampling and filtering
- Depth buffering (per-pixel visibility)
- Blending/compositing (semi-transparent geometry, ...)
- Frame buffers
Thank you.