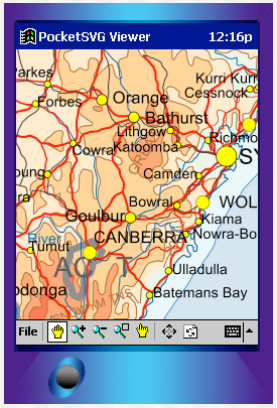
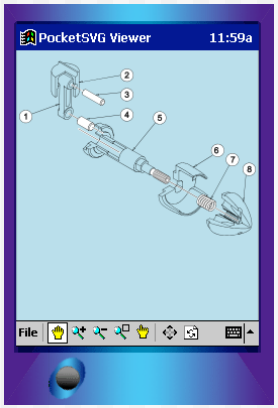
IMGD 4000: Computer Graphics in Games

Emmanuel Agu

Professor Background

- Dr. Emmanuel Agu (professor, “Emmanuel”)
- Research areas
  - Computer Graphics (GPU rendering, mobile graphics, etc)
  - wireless networking and mobile computing
- Advise MQPs, MS and PhD theses





Graphics Trends for Games

- Hardware GPUs
  - Powerful
  - Programmable
  - Geometry shaders
- Capture
- Ray tracing

Trend 1: Graphics Processing Unit

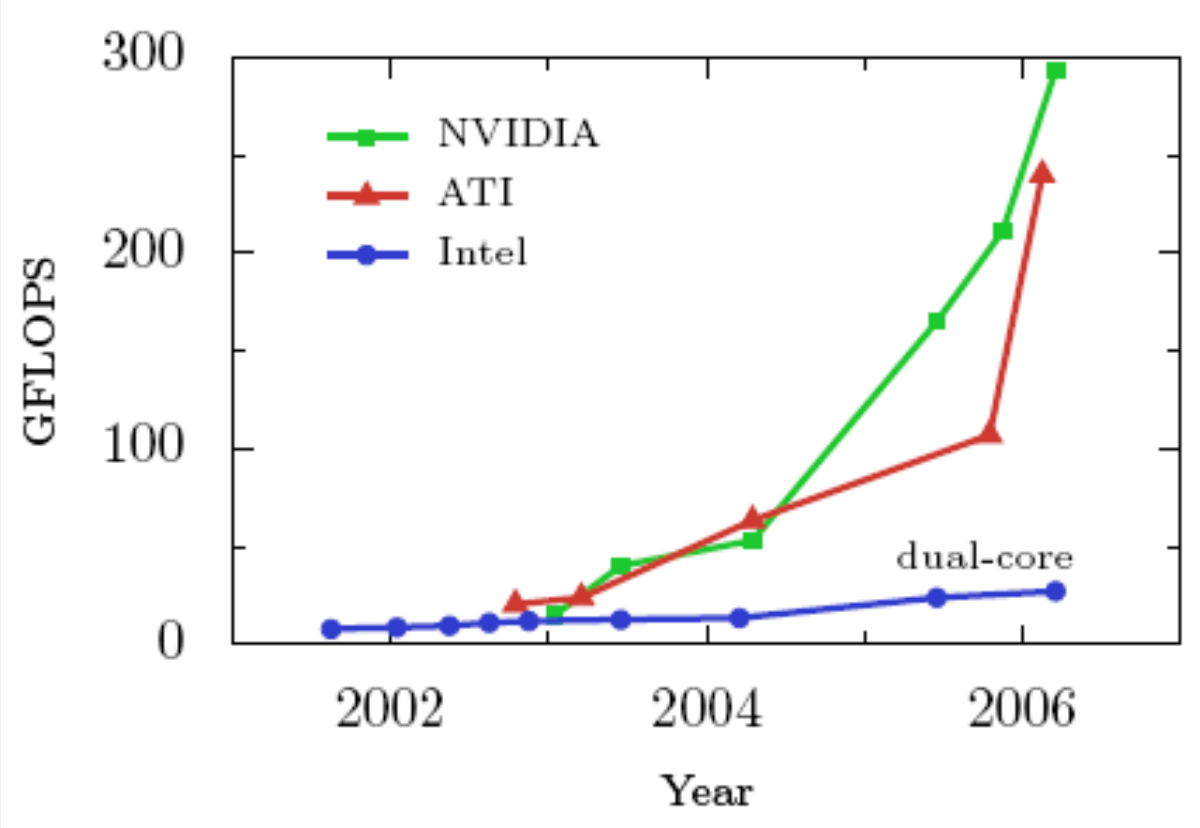
- **OpenGL** and **DirectX** are one of most popular graphics libraries
  - **Current trend:** Implement OpenGL, DirectX on a specialized chip (Graphics Processing Unit (GPU) on your graphics card
- Initially, just hardcode graphics operations onto chip, increase speed
- Powerful, inexpensive, Giga-FLOPS, huge arithmetic ability!
- **Programmable:** in recent 5 - 6 years

  New operations just added. Possibility to apply to non-graphics application.
- Increasing precision

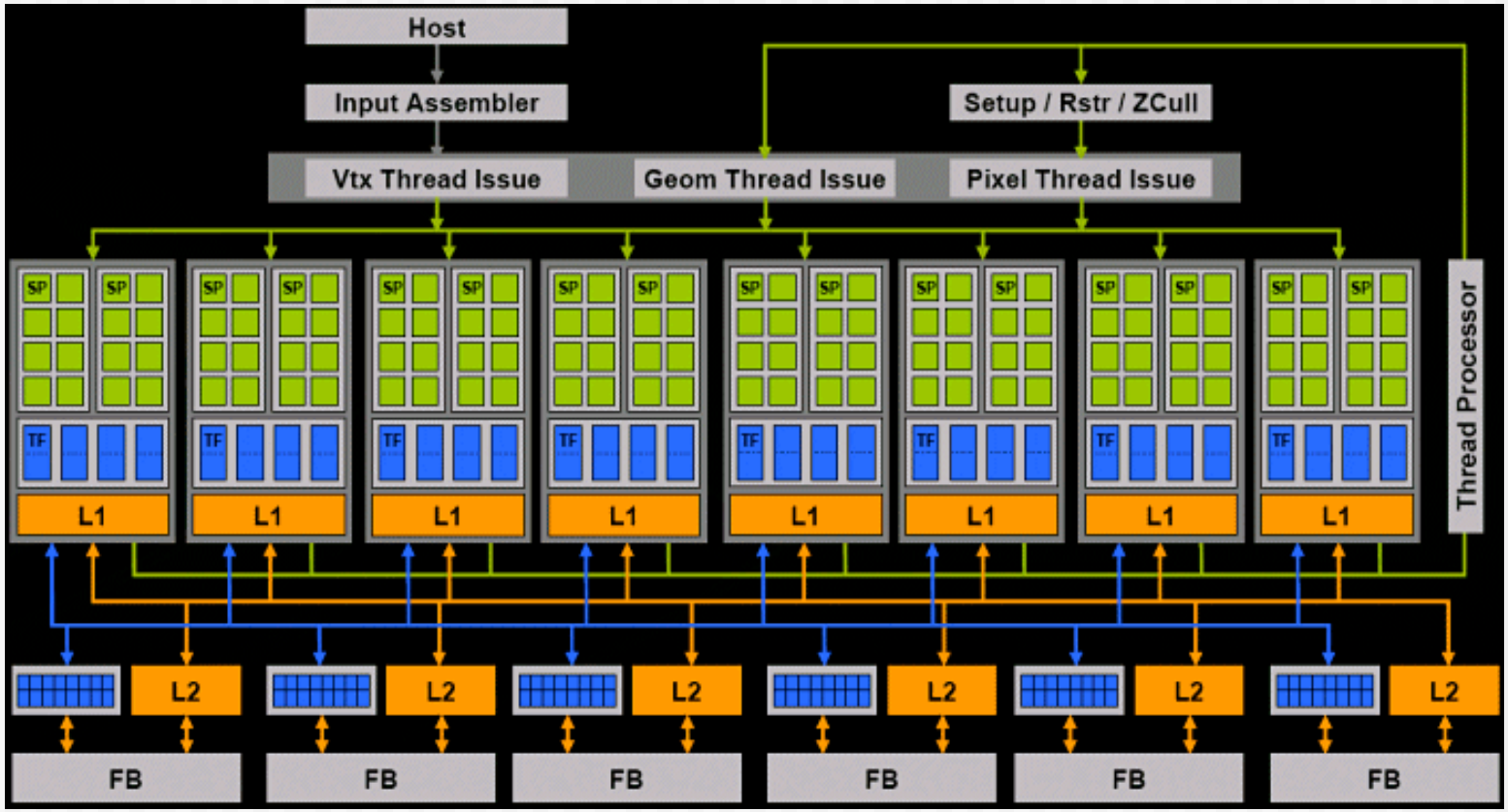
Computational Power

- **NVIDIA** GeForce 9800 GX2 ($550) 1 Tera-FLOPs, 128 GB/sec memory bandwidth;
- **ATI** Radeon HD 3870 X2 ($450) 1 TeraFLOPS
- Dual-core 3.7 GHz **Intel** Pentium Extreme Edition 965.(Around $800) 8.5 GB/sec and 25.6 GFLOPS theoretical peak for the SSE units

GPU Computational Power Growth



Nvidia 8800



Block diagram of the GeForce 8800. Source: NVIDIA

681 million transistors 1.35GHz 128 stream processors

Programmable GPU?

- GPGPU: General-Purpose Computation on GPU. Non-graphics application
- Programmable: hack non-graphics applications onto GPU
- Program applications as collection of shaders **OR**
- New GPGPU programming languages for non-graphics people (Nvidia's CUDA, AMD's CAL, Rapidmind)
- GPGPU applications:
  - Physically based simulation: fluid Dynamics; Cloth simulation,
  - Signal and Image Processing
  - Medical imaging
  - Database query/data mining
  - Global illumination algorithms: Ray tracing, photon mapping

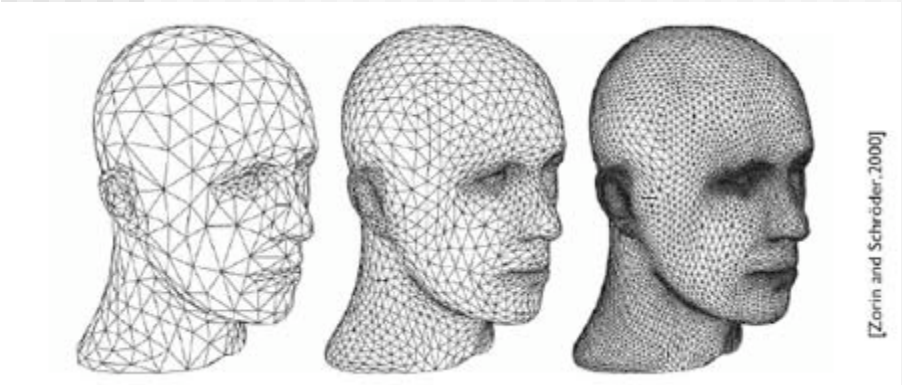
Why are GPUs getting so fast?

- **Arithmetic intensity:** use more transistors for computation and less for decision logic.
- **Economics:** Demand is high thanks to multi-billion dollar game industry.
  - More chips produced => lower price

- AMD + ATI => Fusion chips….Cool idea?

Geometry Shaders

- New shader unit, can generate new vertices, primitives from original set
- Tesselation and simplification algorithms on GPU
- Real-time LoD management in game



Computer Graphics in Games

- **Elements?**
  - Model geometry
  - Apply colors, shading
  - Shadows
  - Texture mapping
  - Fog
  - Transparency and blending
  - Anti-aliasing

Courtesy: Madden NFL game

Trend 2: Capture

- Old way: write models, equations to model:
  - Object geometry, lighting (Phong), animation, etc
- New way: capture parameters from real world
- Example: motion in most sports games (e.g. NBA 2K live) is captured.
  - How? Put sensors on actors
  - Let them play game
  - Capture their motion
  - Put motion in a database
  - Replay database when real players play game

How is capture done?

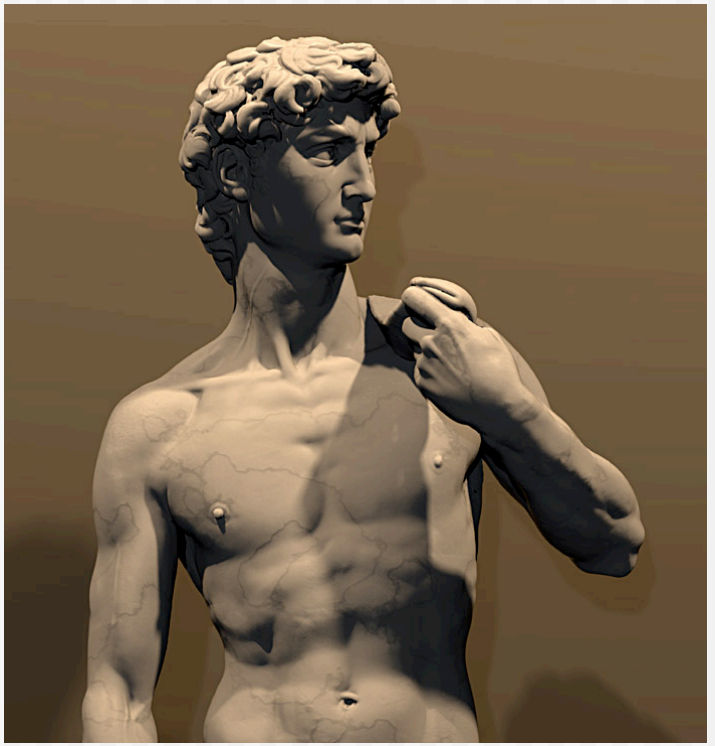
- **Capture:**
  - Digitize real object geometry and attributes
  - Use cameras, computer vision techniques to capture rendering data
  - Place data in database, many people can re-use
- **Question:** What is computer vision?

Geometry Capture: 3D Scanning

- **Capturing geometry trend:** Projects on precise 3D scanning (Stanford, IBM,etc) produce very large polygonal models
- Some models too large to be loaded by most machines

Model: David

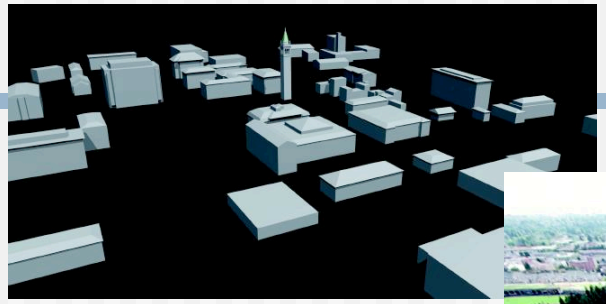
Largest dataset Size: 2 billion polygons, 7000 color images!!



Courtesy: Stanford Michael Angelo 3D scanning project

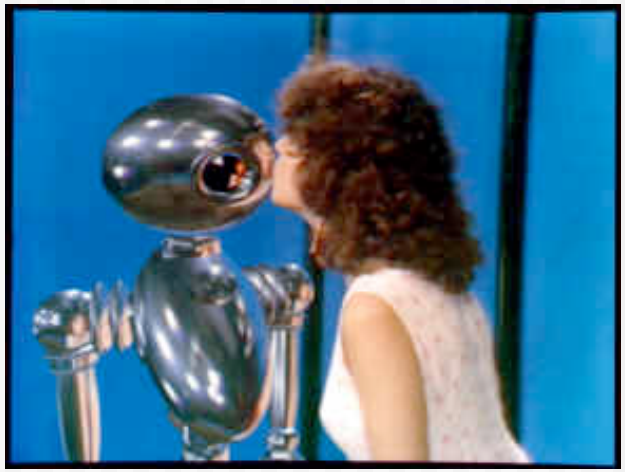
Exactly What Can We Capture?

1. Appearance (volume, scattering, transparency, translucency, etc)

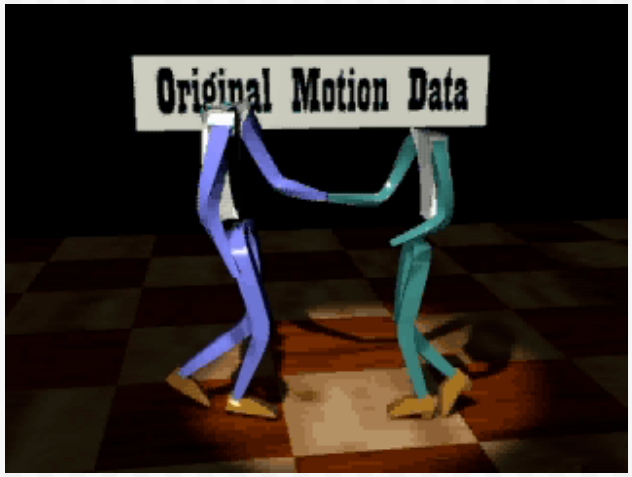


2. Geometry

3. Reflectance & Illumination



4. Motion



Light Probes: Capturing light

Amazing graphics, High Dynamic Range?

Why effort to capture?

- **Big question:** If we can capture real world parameters, what advantages does **computer graphics** have**?**

Trend 3: Raytracing in Games

- Raytracing: A global illumination rendering
  - Reflection / refraction / shadow