CS780: Topics in Computer Graphics
Scalable Graphics/Geometric Algorithms

Sung-Eui Yoon
(윤성의)

Course URL:
http://jupiter.kaist.ac.kr/~sunteui/SGA/
About the Instructor

- Joined KAIST at July this year
- B.S., M.S. at Seoul National Univ.
- Ph.D. at Univ. of North Carolina-Chapel Hill
- Post. doc at Lawrence Livermore Nat’l Lab

Main research focus
- Handling of massive geometric data for various computer graphics and geometric problems
About the Instructor

- **Contact info**
  - Email: sungeui@cs.kaist.ac.kr
  - Office: 3432 at CS building
  - Homepage: http://jupiter.kaist.ac.kr/~sungeui

- **Office hours**
  - 3:45-4:30pm on Thur. at Room 3432
Some of My Research Results
About the Course

● We will discuss various computer graphics and geometric applications
  ● E.g., rendering, collision detection, path planning, etc

● Main theme
  ● What if we have to deal with massive data or dynamic data for an application on commodity hardware?
Data Avalanche (or Data Explosions)

There are too much data out data!!!

www.cs.umd.edu/class/spring2001/cmsc838b/Project/Parija_Spacco/images/
How much information is there?

• Soon everything can be recorded and indexed

See Mike Lesk:  
*How much information is there:*  
http://www.lesk.com/mlesk/ksg97/ksg.html

See Lyman & Varian:  
*How much information*  
http://www.sims.berkeley.edu/research/projects/how-much-info/  
24 Yecto, 21 zepto, 18 atto, 15 femto, 12 pico, 9 nano, 6 micro, 3 milli

Slide is excerpted from Jim Gray’s talk
Geometric Data Avalanche

- Massive geometric data
  - Due to advances of modeling, simulation, and data capture techniques

- Time-varying data (4D data sets)
Game/Movie: Image Shot from “Cars (2006)"

http://media.movies.ign.com
CAD Model: Power Plant

12 million triangles (1 gigabyte)
CAD Model: Double Eagle Oil Tanker

82 million triangles (4 gigabyte)
CAD Model: Double Eagle Oil Tanker

Image from www.offshore-technology.com
CAD Model: Boeing 777

Ray Tracing Boeing 777, 470 million triangles

Excerpted from SIGGRAPH course note on massive model rendering
CAD Model: Boeing 777

Model data courtesy of Boeing Corp.
Scanned Model: ST. Matthew Model

372 million triangles (10GB)

www.cyberware.com
Turbulence Simulation Data: Richtmyer-Meshkov Instability

Blue Gene/L, World fastest supercomputer, 280 teraFLOPS

2048*2048*1920 grid, 27,000 time step
Over 3 Terabytes of geometric data
Dynamic Model: Cloth Simulation

92K triangles, 94 time steps, 102MB
Other Geometric-related Data

- Images, etc
  - E.g., Giga-pixel projects, Google map, Google Earth
Large-scale Applications

- Entertainment (games/movies)
- Bio, medical, physical simulation/training
- Computer-aided design (CAD) / virtual prototyping
- Geographic information system (GIS)
- Virtual reality
- Robotics and human-computer interaction (HCI), etc
Possible Solutions?

- Hardware improvement will address the data avalanche?
  - Moore’s law: the number of transistor is roughly double every 18 months
Current Architecture Trends

Accumulated growth rates during 1993 – 2004 (log scale)

1.5X 20X 46X 130X

1 10 100 1000

Disk access speed  RAM access speed  CPU speed  GPU speed

Data access time becomes the major computational bottleneck!

Current Architecture Trends: Many-cores

- Employs multi-cores to keep Moore’s law
  - 80 core system in Intel
  - Presents numerous research challenges

- Streaming processors (GPUs) with super Moore’s law
  - Multi stages in parallel

Data access time is getting relatively bigger!
Data Growth

● An observation
  ● If we got better performance, we attempt to produce bigger data to derive more useful information and handle such bigger data

● Amount of data is doubling every 18 ~ 24 months
    www.sims.berkeley.edu/ how-much-info-2003
Ubiquitous Computing

- Uses different computational devices
  - Have relative small main memory and L1/ L2 caches
  - Pose problems even with small models

Google Earth: browsing 3D world
Our Focus in the Course

- Designing scalable graphics and geometric algorithms to efficiently handle massive (static or dynamic) models on commodity hardware
  - Multi-resolution methods
  - Cache-coherent algorithms
  - Culling techniques
  - Data compression
Graphics and Geometric Applications

- Rendering
  - Rasterization, ray tracing, and global illumination

- Interaction
  - Collision detection and proximity queries
  - Path planning & scheduling / robotics

- Time-varying geometry

- Simulation
  - Cloth / light / sound simulations

- Bio-applications
Course Overview

● Half of lectures and half of student presentations

● What you will do:
  ● Choose a topic & read papers related to the topic
  ● Present about two talks explaining the topic to us
  ● Write a short final report on the topic and present it to us
  ● (Neither mid nor final exam)
  ● and, have fun!
Course Overview

● Grade policy
  ● Class presentations: 45%
  ● Report: 45%
  ● Class participation: 10%

● Prerequisites
  ● Undergraduate computer graphics or equivalent
  ● Discuss with me if you are not sure
Presentations & Report

- Provide a survey on a chosen topic
  - Discuss pros and cons of each method
  - You can bring your own research to the course
- Identify problems of existing technique
  - Especially, when we have massive or dynamic models
- Propose ideas to address those problems

- Review service
  - Let’s meet before your in-class presentations
  - I’ll give you comments on your reports
Schedule

● Please refer the course homepage:
Next Time..

- Study two major rendering techniques
  - Rasterization (the technique used in DirectX and OpenGL)
  - Ray tracing
About You

- Please provide the following information to me
  - Your name and email address
  - Your main interest in both general research and computer graphics
  - Your background related to computer graphics
  - Do you plan to take the course?
  - What school you graduated and what stage (e.g., M.S. or Ph.D.) you are in