CS780: Topics in Computer Graphics

Scalable Graphics/Geometric Algorithms

Sung-Eui Yoon
(윤성의)

Course URL:
http://jupiter.kaist.ac.kr/~sungeui/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**

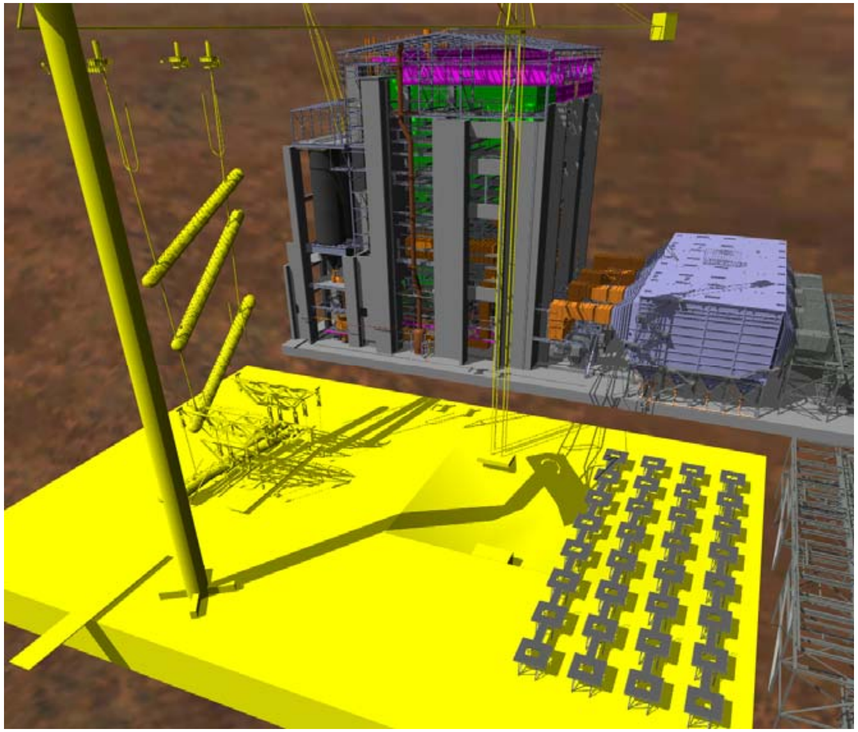
- **Main research focus**
  - **Handling of massive geometric data for various computer graphics and geometric problems**

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:

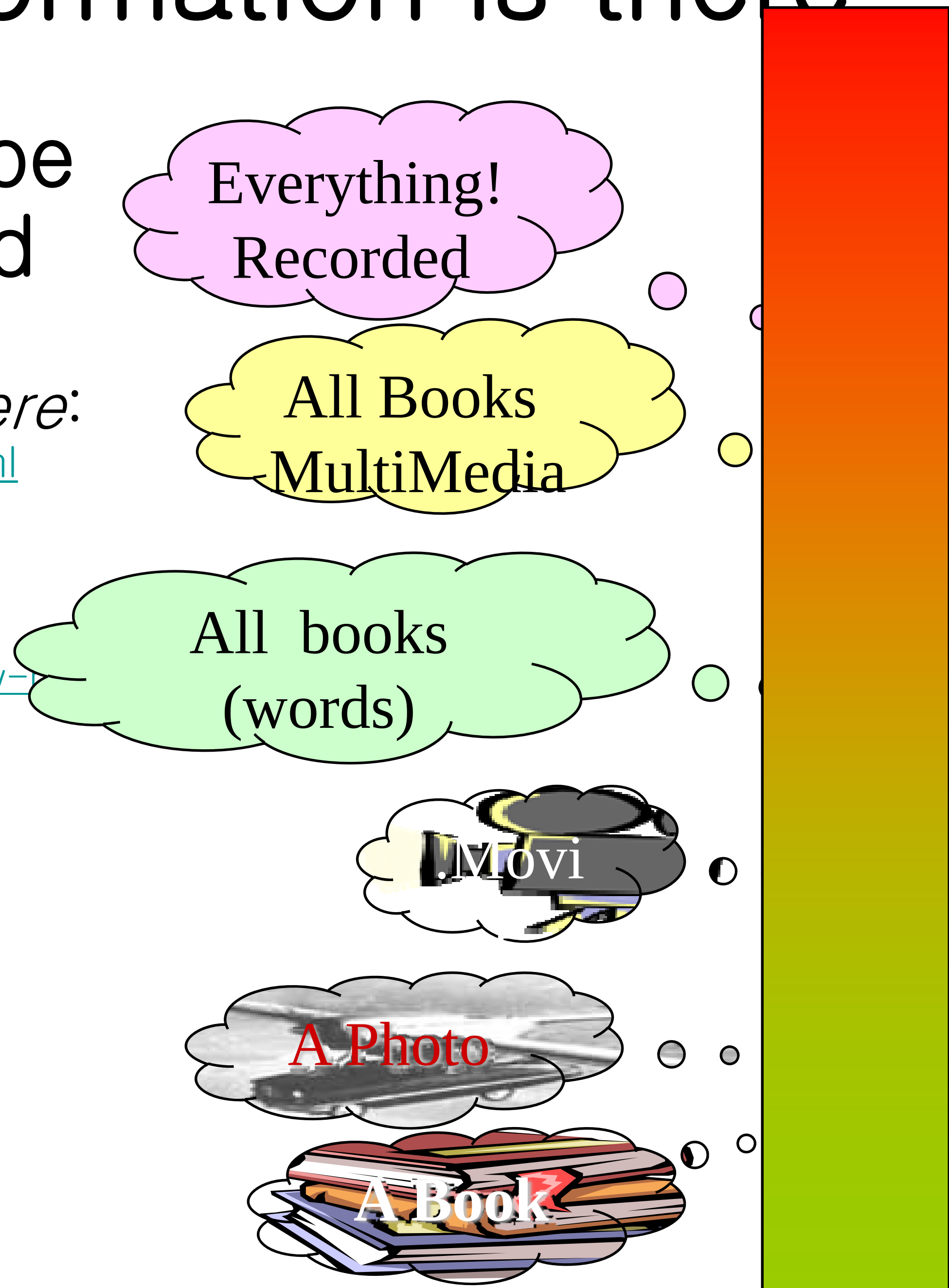
http://www.lesk.com/mlesk/ksg97/ksg.html

See Lyman & Varian:

How much information

http://www.sims.berkeley.edu/research/projects/how-
info/

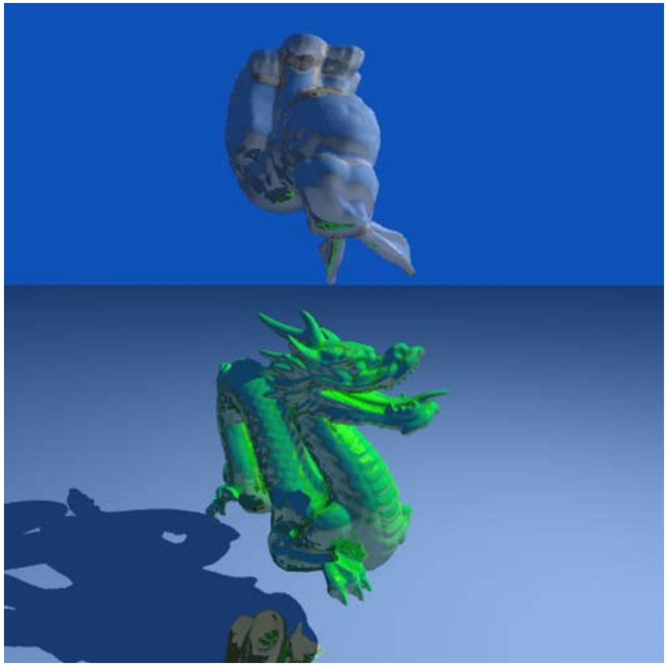
24 Yecto, 21 zepto, 18 atto, 15 femto, 12 pico, 9 nano, 6 micro, 3 milli



Slide is excerpted from Jim Gray's talk

Geometric Data Avalanche

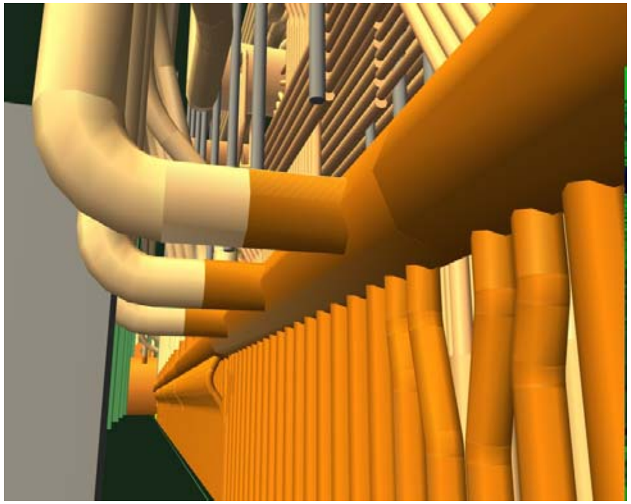
- **Massive geometric data**
  - **Due to advances of modeling, simulation, and data capture techniques**
- **Time-varying data (4D data sets)**



Game/Movie: Image Shot from "Cars (2006)"

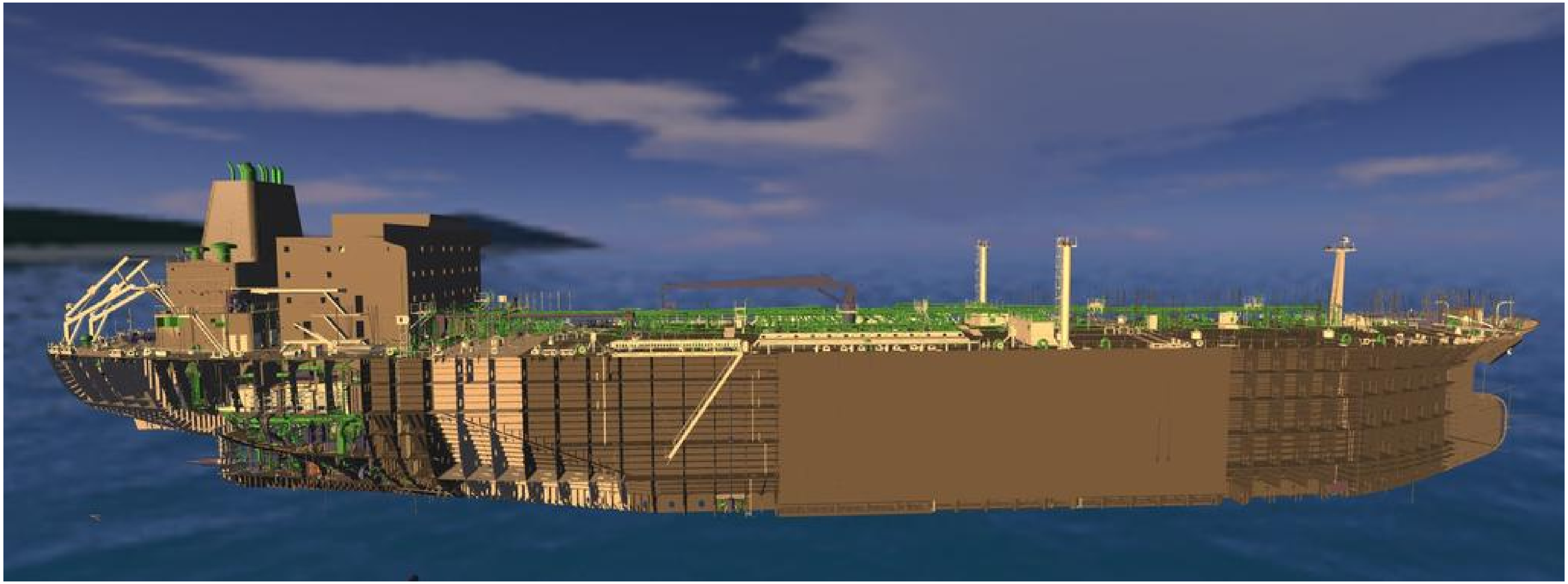
http://media.movies.ign.com

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

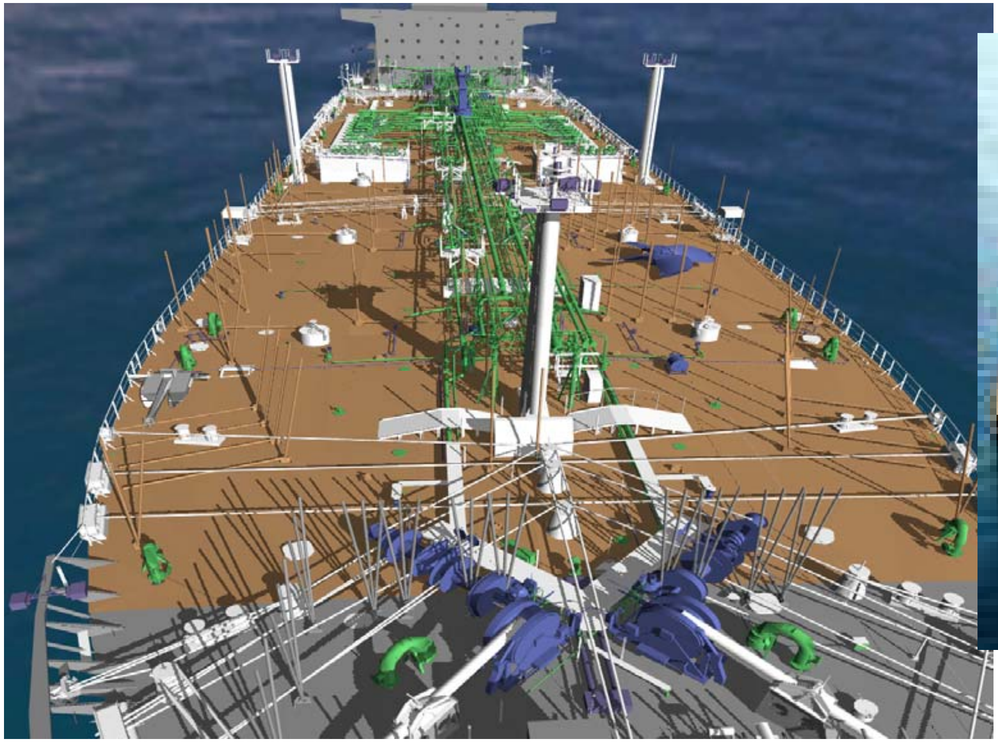
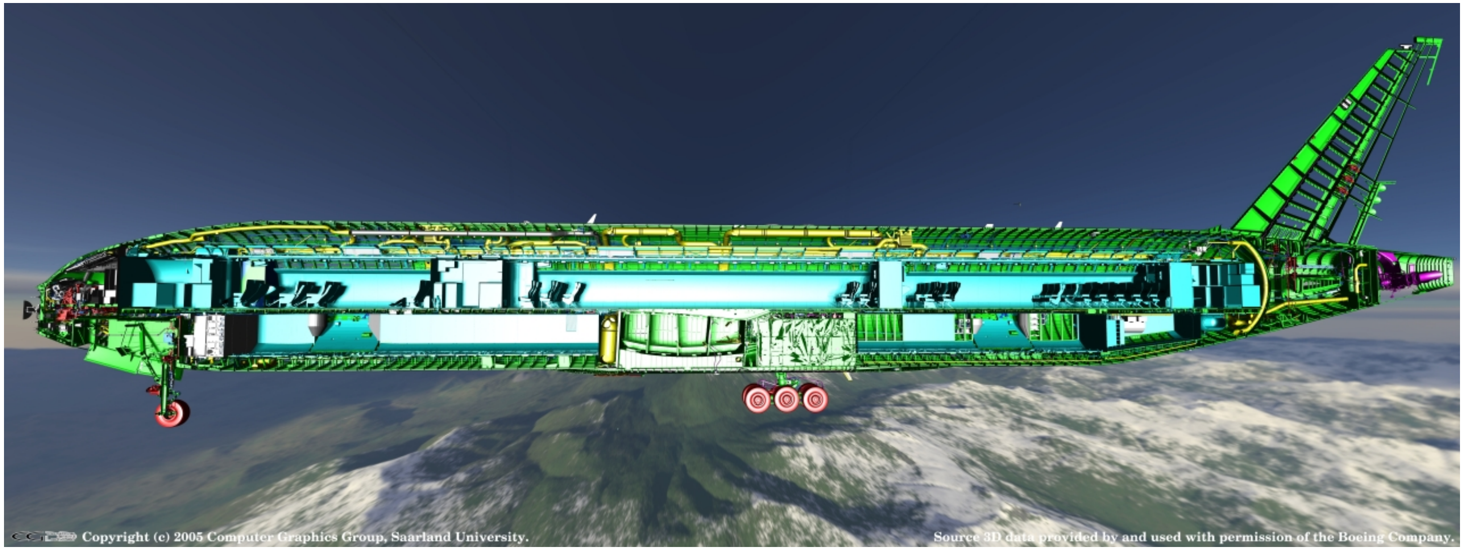


Image from www.offshore-technology.com

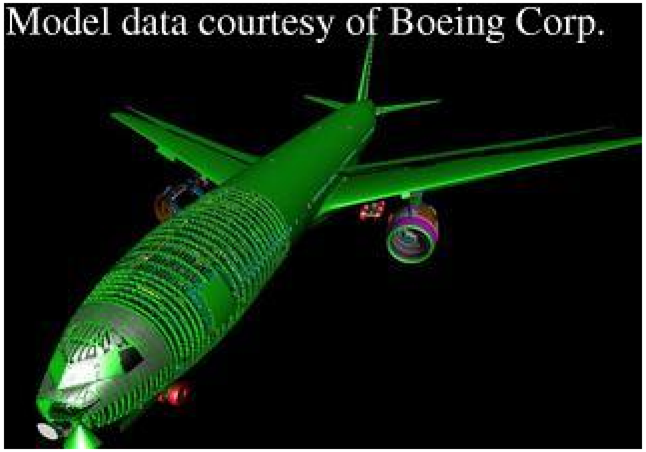
CAD Model: Boeing 777

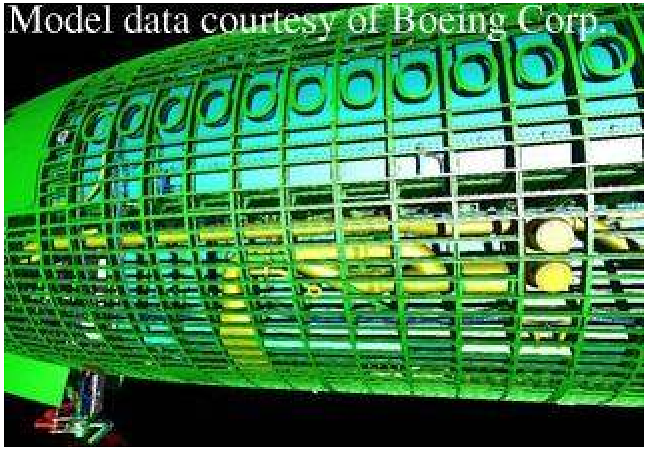


Ray Tracing Boeing 777,
470 million triangles

Excerpted from SIGGRAPH course note on massive model rendering

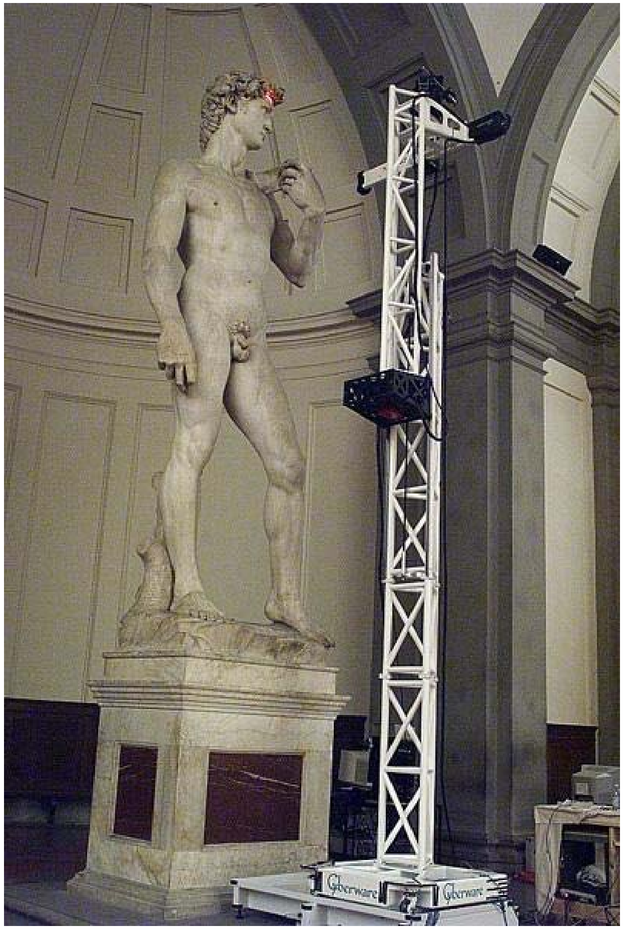
CAD Model: Boeing 777





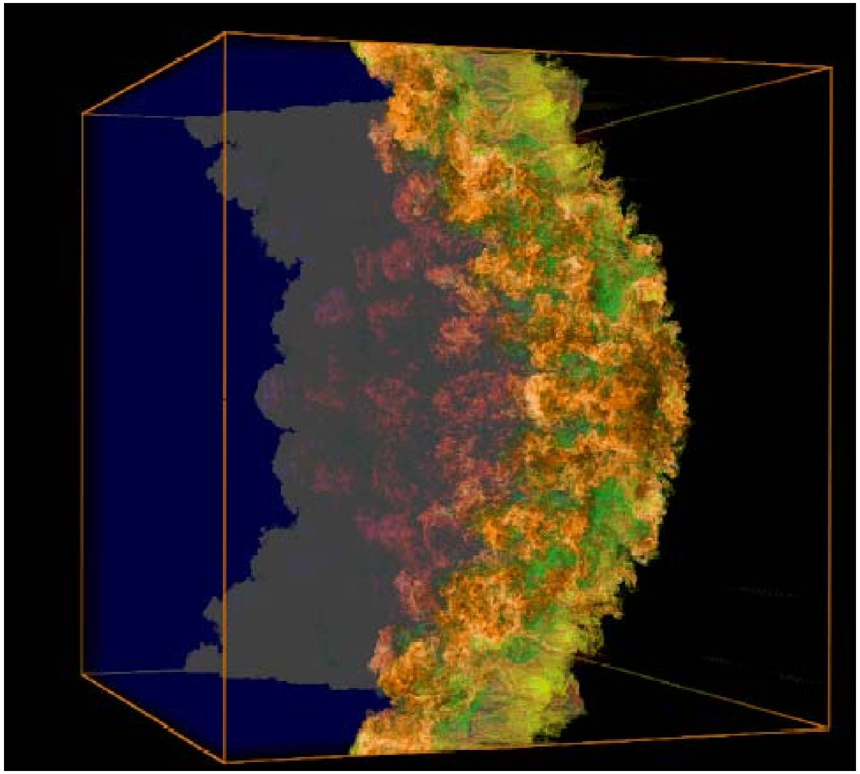
Scanned Model: ST. Matthew Model

372 million triangles (10GB)



www.cyberware.com

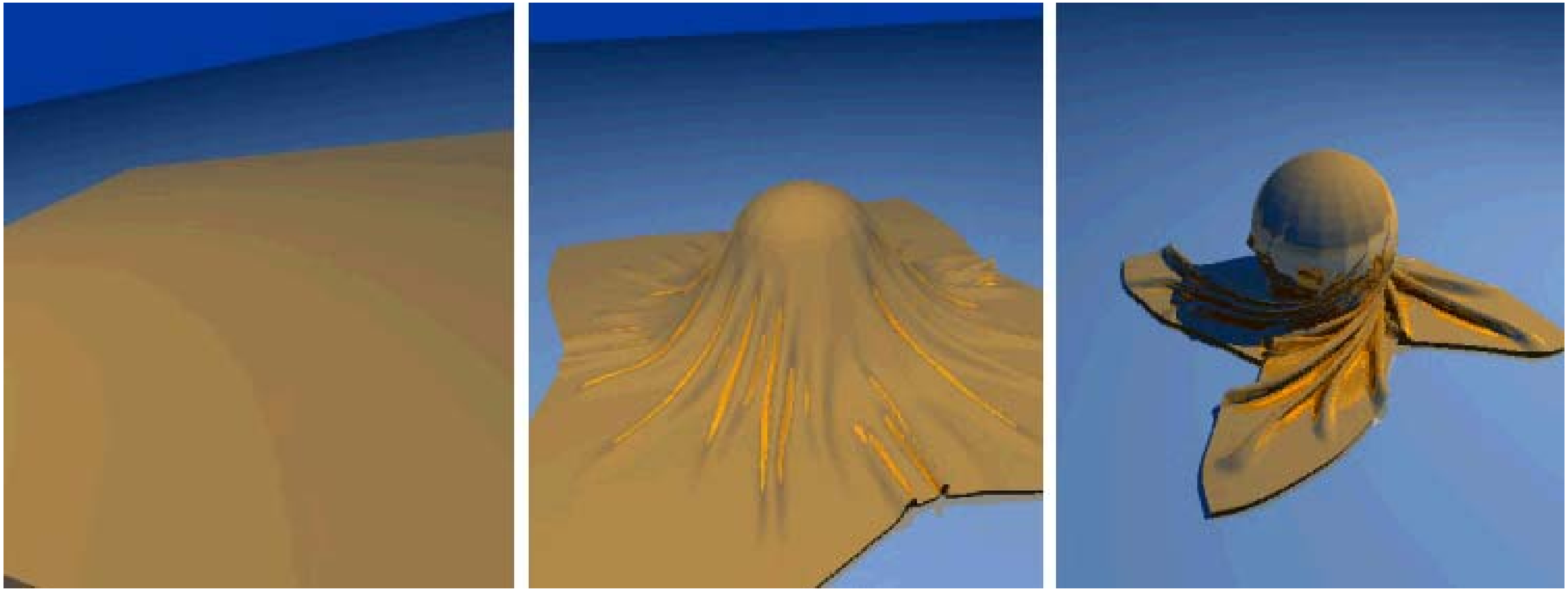
Turbulence Simulation Data: Richtmyer-Meshkov Instability



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

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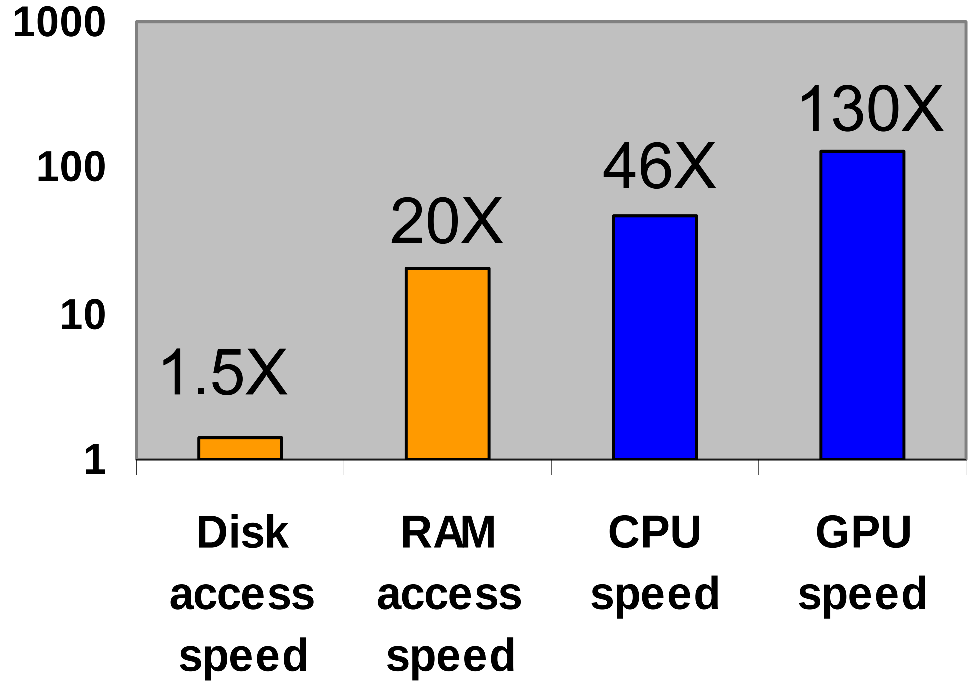
Possible Solutions?

- **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)



Courtesy: Anselmo Lastra, http://www.hcibook.com/e3/online/moores-law/

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!

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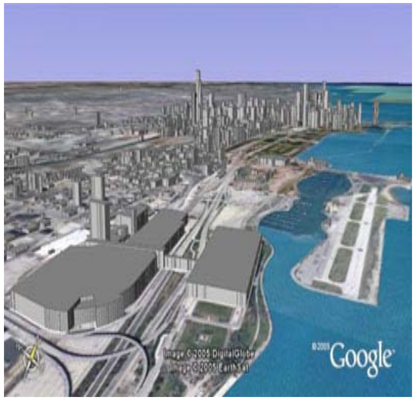
Data Growth

- **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**
  - ***"How Much Information," 2003. Lyman, Peter and Hal R. Varian.,*** **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

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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!**

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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:
  - http://jupiter.kaist.ac.kr/~sungeui/SGA/

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**

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