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# CS380: Computer Graphics Introduction

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**Sung-Eui Yoon**  
(윤성익)

**Course URL:**  
<http://sglab.kaist.ac.kr/~sungeui/CG>

**KAIST**



# About the Instructor

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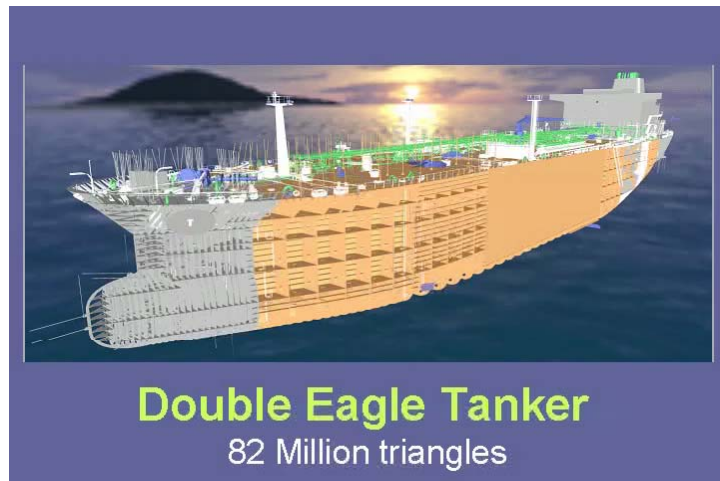
- **Joined KAIST at 2007**
- **B.S., M.S. at Seoul National Univ.**
- **Ph.D. at Univ. of North Carolina-Chapel Hill**
- **Post. doc at Lawrence Livermore Nat'l Lab**
- **Currently IWON associate professor**

# Main Research Focus

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- Handle massive data for various computer graphics and geometric problems
- Paper and video
  - <http://sglab.kaist.ac.kr/papers.htm>
- YouTube videos
  - <http://www.youtube.com/user/sglabkaist>



# Course Information of CS380

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**Instructor:** Sung-eui Yoon  
**Email:** [sungeui@gmail.com](mailto:sungeui@gmail.com)  
**Office:** 3432 at CS building  
**Office hours:** 3:00pm ~ 4:00pm on MW or  
right after class time (or by appt.)  
**Course webpage:**  
<http://sglab.kaist.ac.kr/~sungeui/CG/>  
**Noah discussion page**

# Class Time

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- **Date: every Mon. and Wed.**
  - **Time: 12:40pm ~ 1:55pm**
- **4 credit course**
  - **4 OpenGL courses given by TAs**

# TAs

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- **Bochang Moon (문보창)**
  - Office: 3443
- **JongHyeob Lee (이종협)**
  - Office: 3443
- **Jaepil Heo (허재필)**
  - Office: 4446
- **HyoSeob Park (박효섭)**
  - Office: 3443
- **HaeChan Lee (이해찬)**
  - Office: XXX
- **TA email address**
  - [cs380ta@gmail.com](mailto:cs380ta@gmail.com)

# Prerequisites

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- **Basic knowledge of linear algebra**
  - E.g., matrix multiplication
- **Basic knowledge of programming skill**
  - Preferably with C-like language (e.g., C and C++)
- **If you are unsure, consult the instructor at the end of this class**

# Overview

- We will discuss various parts of computer graphics



**Computer vision** inverts the process  
**Image processing** deals with images



# Application of Computer Graphics

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- Games
- Movies and film special effects
- Product design and analysis
- Medical applications
- Scientific visualization

# Games

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2D game



3D shooting game

# Game Industry at Korea

- One of biggest IT sectors in Korea

창원에 엔씨소프트 프로야구단 생긴다(종합)



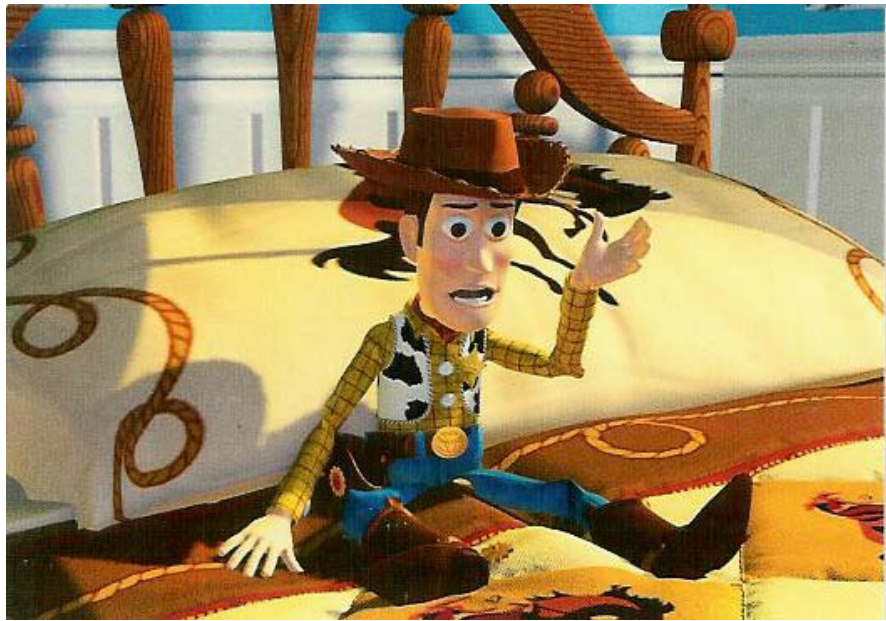
## KBO 이사회 개최

(서울=연합뉴스) 이상학 기자 =11일 오전 서울 강남구 도곡동 야구회관에서 열린 KBO 이사회에서 유영구 총재가 회의를 주재하고 있다. 8개 구단 사장단이 참석한 가운데 열린 이날 이사회에서는 9구단 승인 여부 등을 논의한다. 2011.1.11 leesh@yna.co.kr

# Movies and Film Special Effects

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**Toy story**



**Matrix**

# 3D Movies

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**Avatar**

# 3D TV

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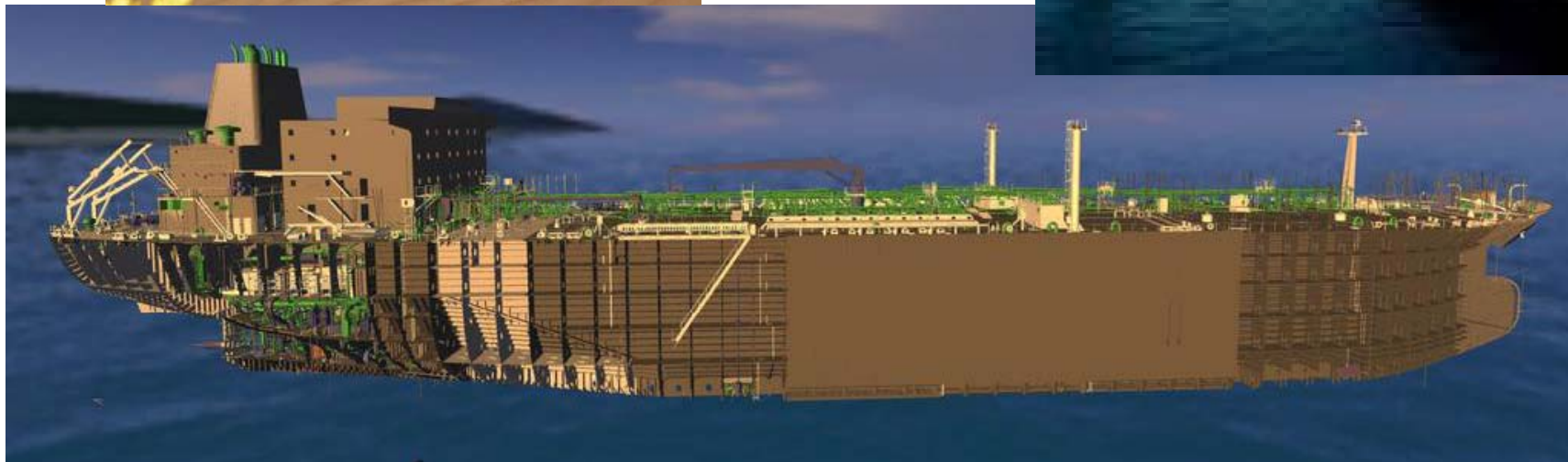
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**Samsung 3D TV**

# Product Design and Analysis

- Computer-aided design (CAD)

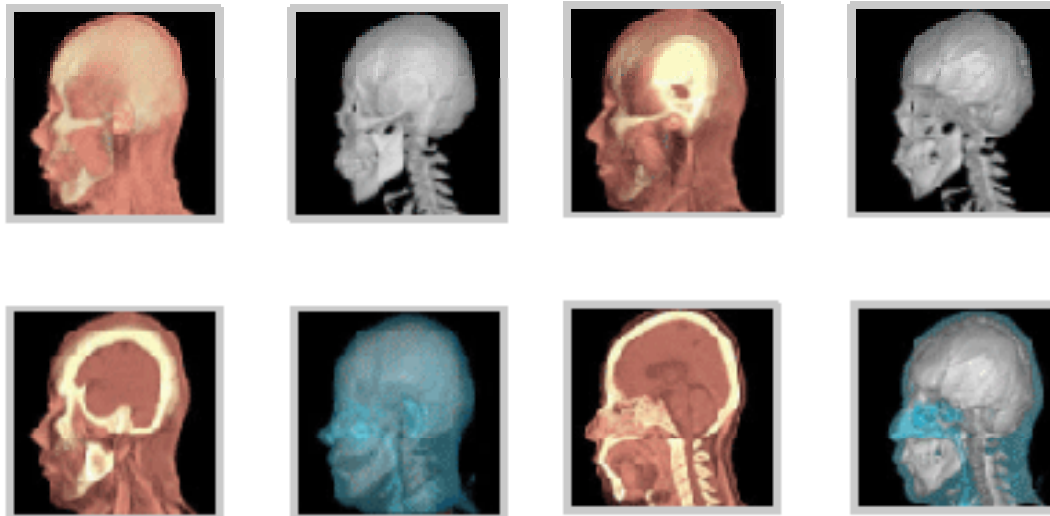


# Medical Applications

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- Visualizing data of CT, MRI, etc



Rapidia homepage



# Medical Applications

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- Visualizing data of CT, MRI, etc



Wikipedia

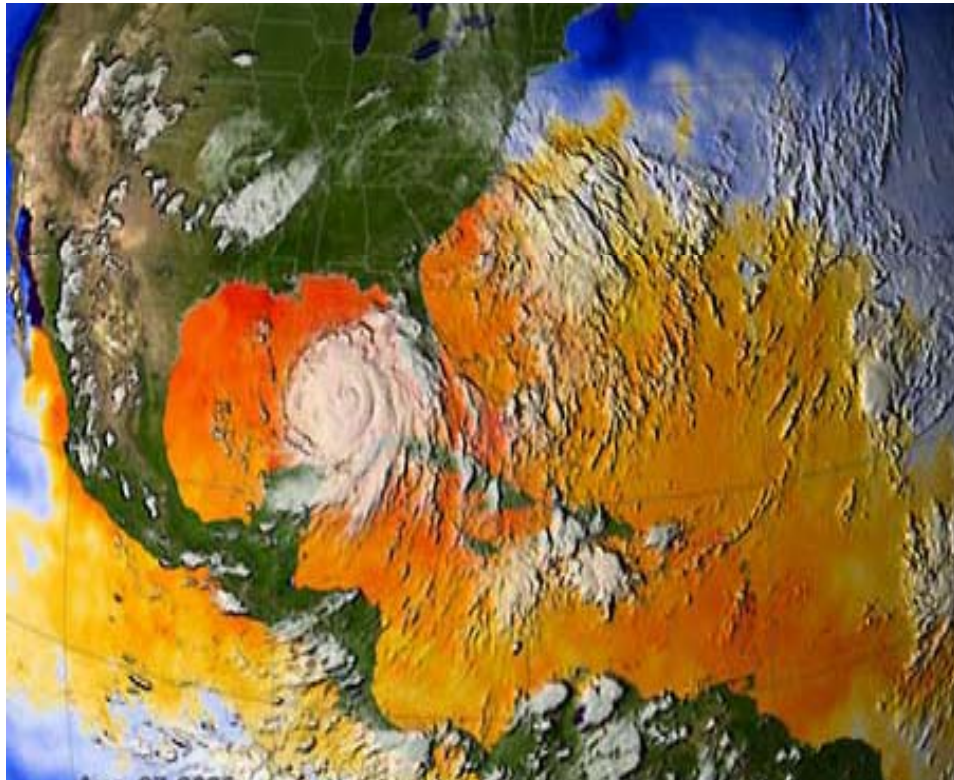
**Mouse skull (CT)**

# Scientific Applications

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- Weather visualization



LLNL

# Topics

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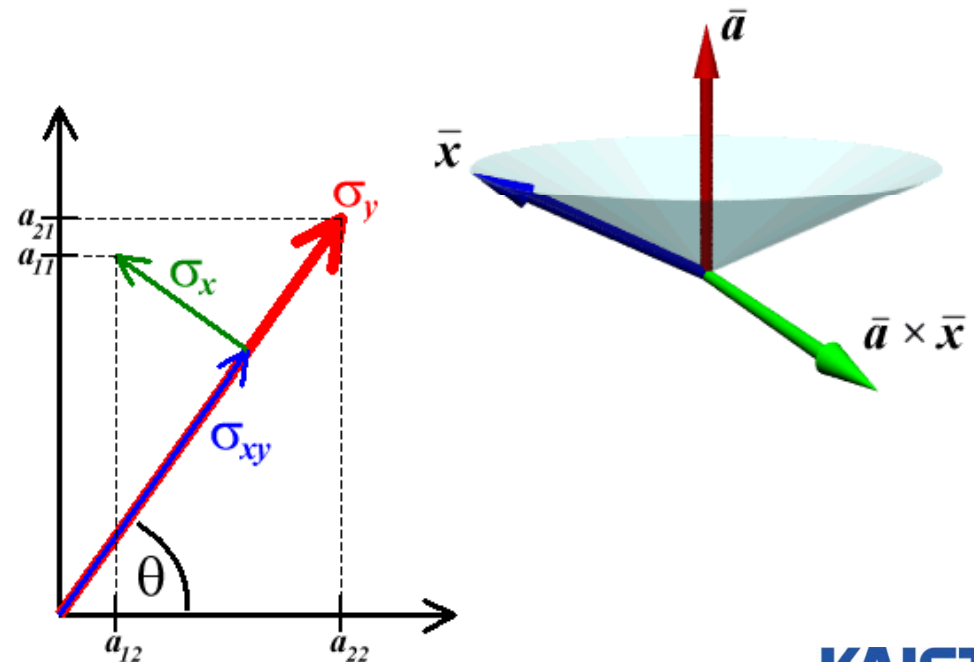
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- **Mathematical tools**
- **3D models and interaction**
- **Hidden surface removal**
- **Rasterization**
- **Lighting and shading**
- **Shadows**
- **Texture mapping**
- **Ray tracing**
- **Global illumination**
- **Curves and surfaces**
- **Simplification and levels of detail**
- **Collision detection**
- **Graphics hardware, etc**

# Mathematical Tools

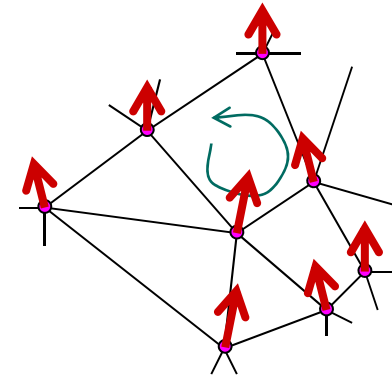
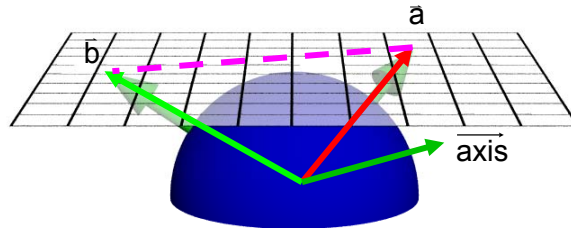
- Homogeneous coordinates
- Vectors
- Planes
- Frames
- Transformations

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$



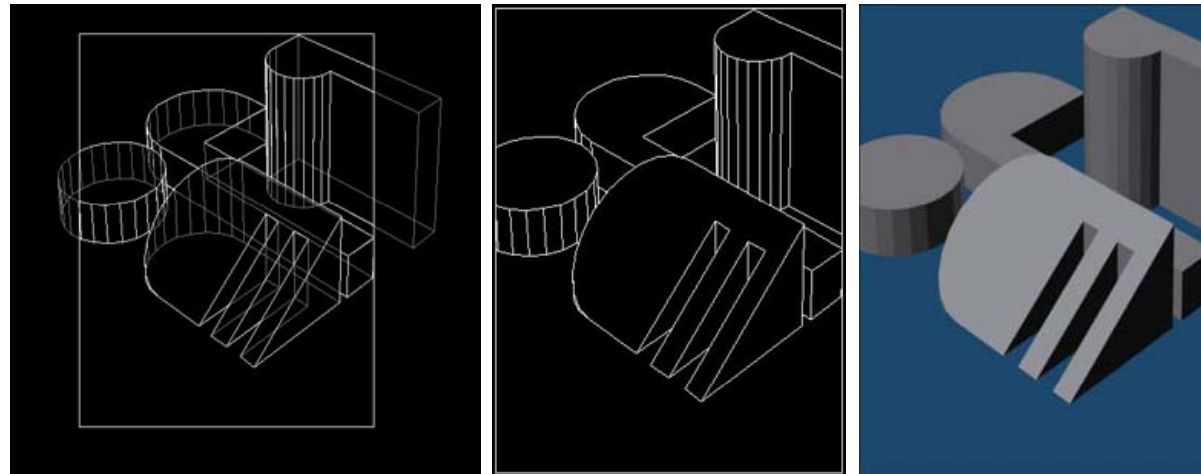
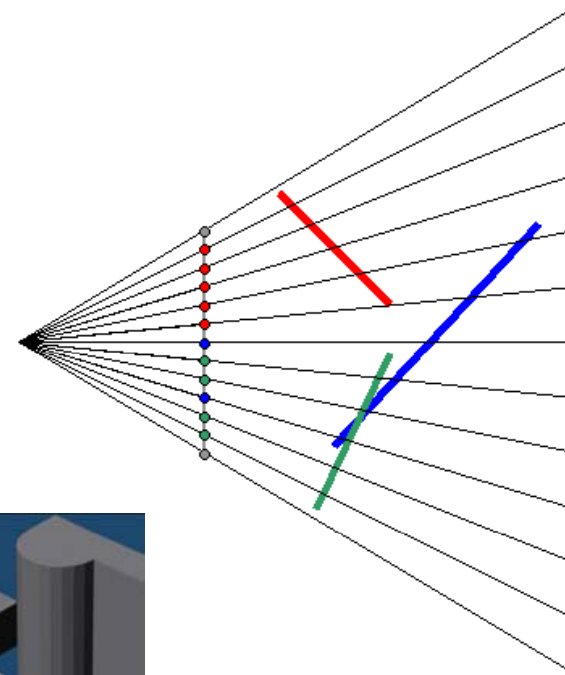
# 3D Models and Interaction

- Loading and view models
- Picking and selection
- Modeling a trackball
- Virtual reality (VR) is all about interaction



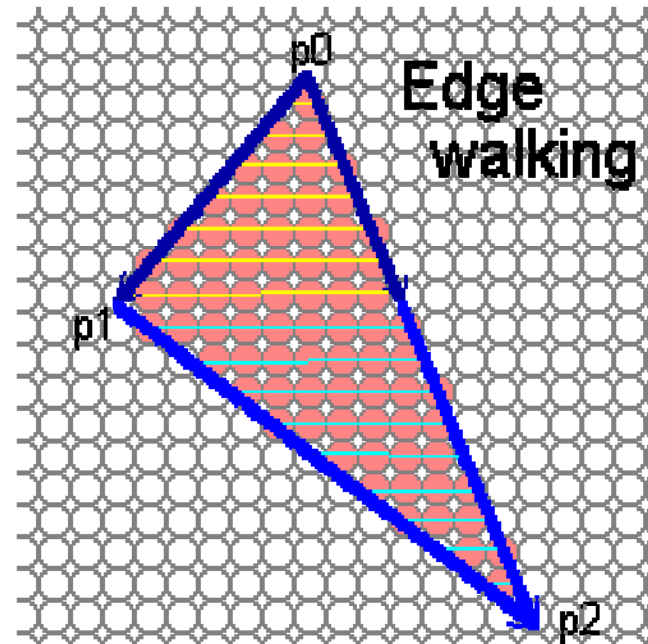
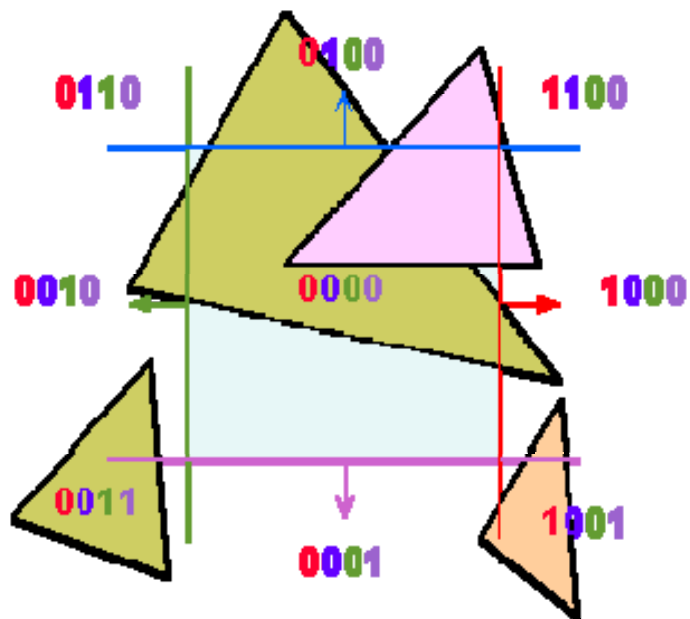
# Hidden Surface Removal

- Classic problem
- BSP trees
- Ray casting
- Depth buffering



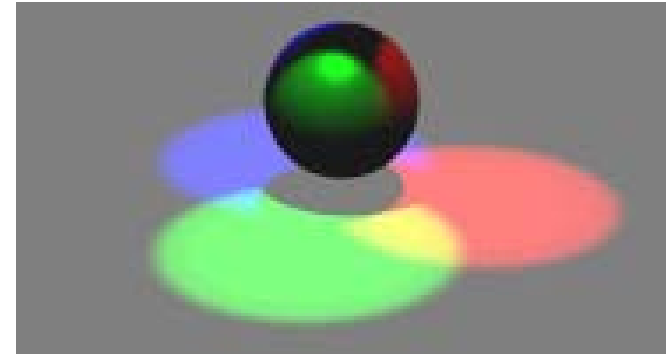
# Rasterization

- Clipping
- Scan conversion

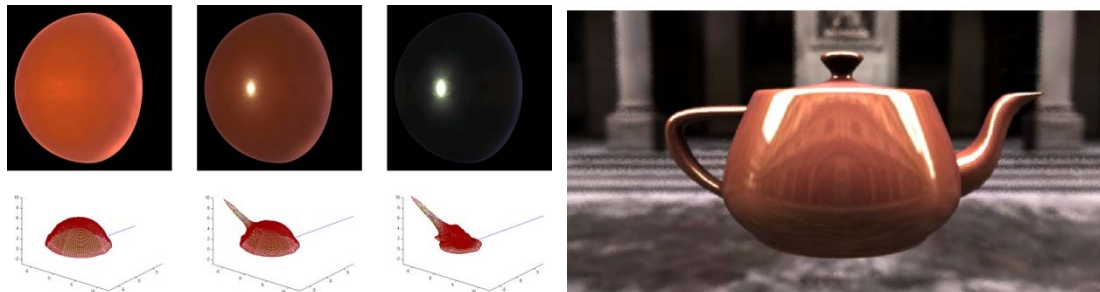
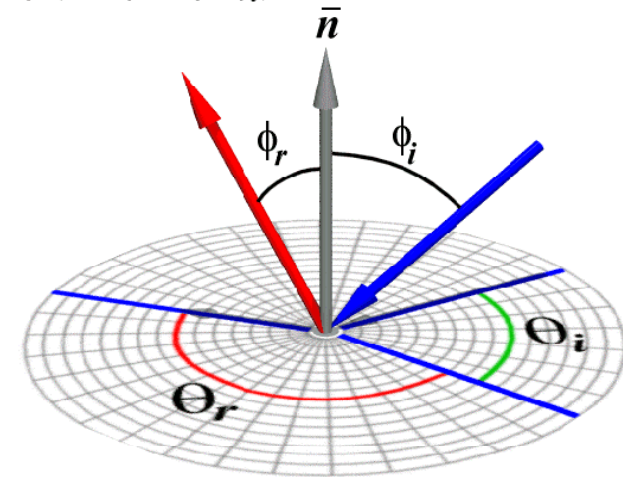


# Lighting and Shading

- Flat, gouraud, and phong shading
- Empirical and physically-based illumination models
- BRDFs



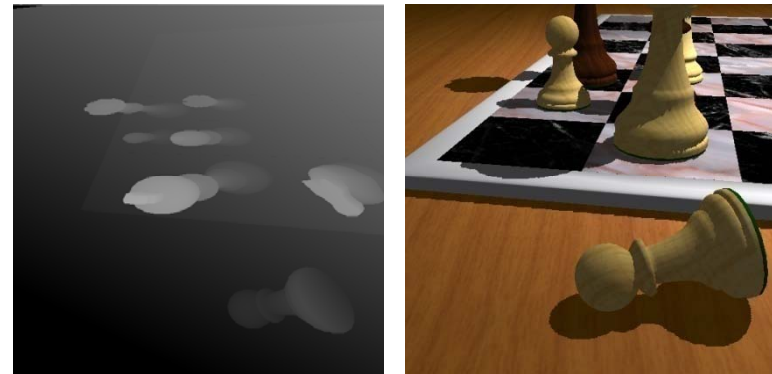
$$\rho(\theta_r, \phi_r, \theta_i, \phi_i)$$



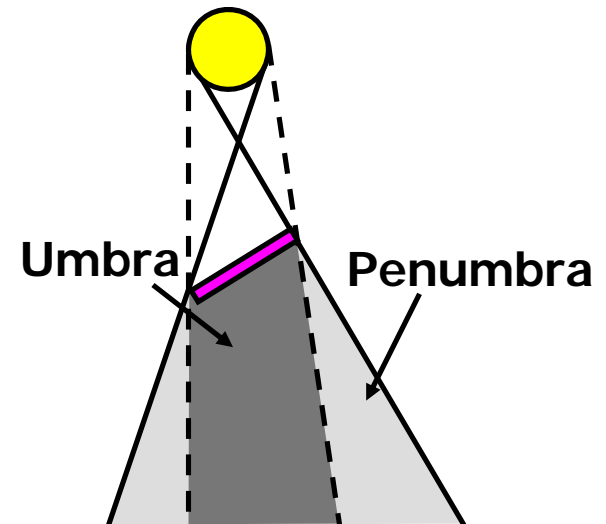
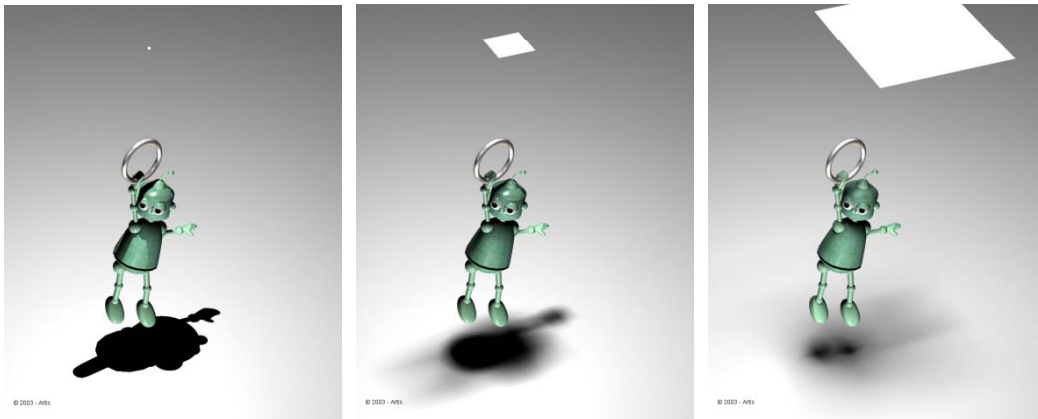


# Shadows

- Shadow volumes
- Shadow maps

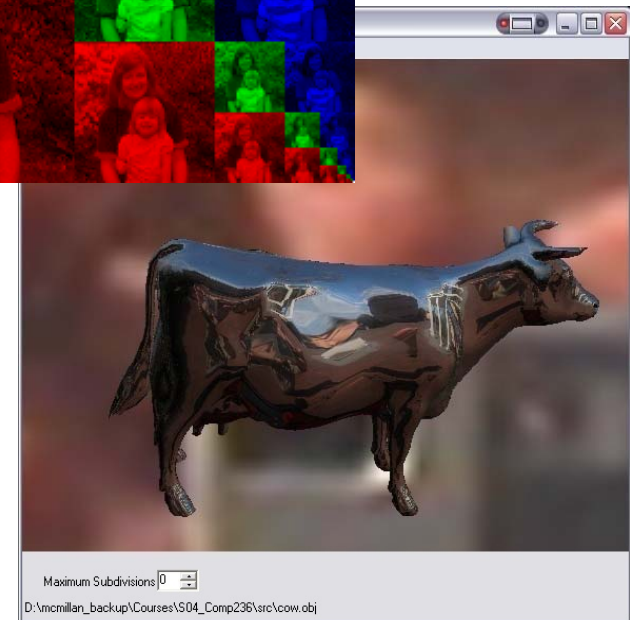
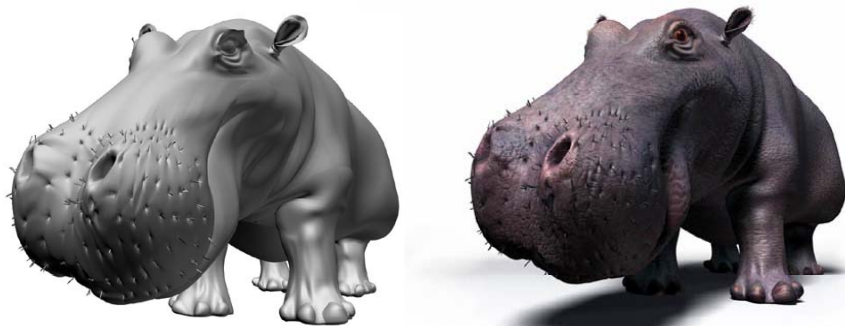


Images courtesy of Stamminger and Drettakis 02



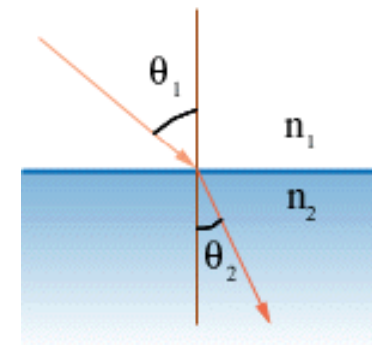
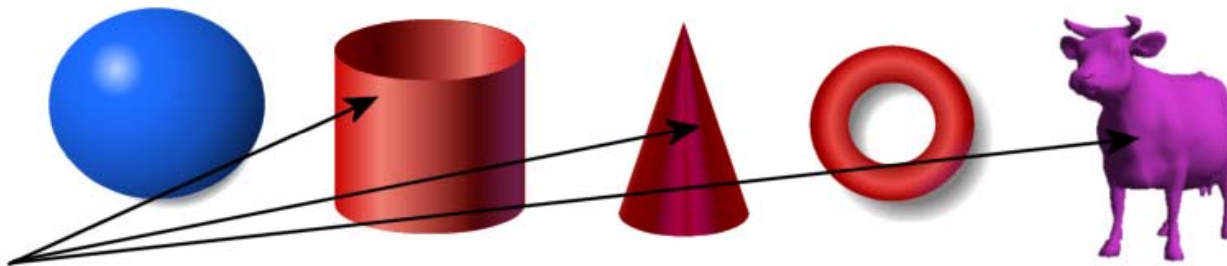
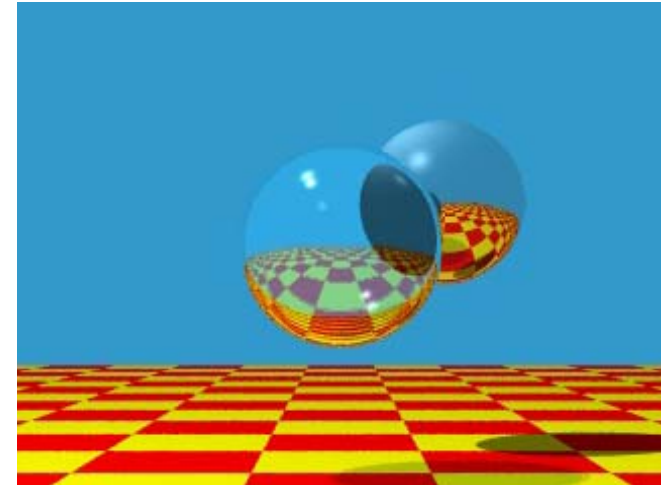
# Texture Mapping

- Surface parameterization
- Mipmaps and filtering
- Reflection and environment mapping



# Ray Tracing

- Object intersection
- Reflection and refraction
- Depth-of-field, motion blur, glossy reflections, soft shadows

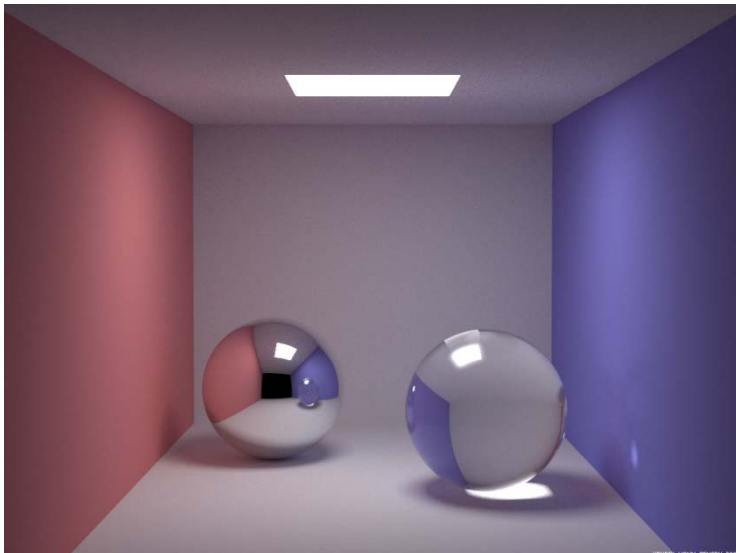


# Global Illumination

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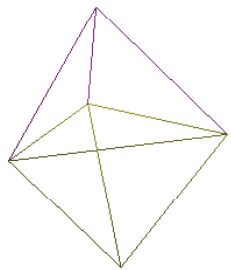
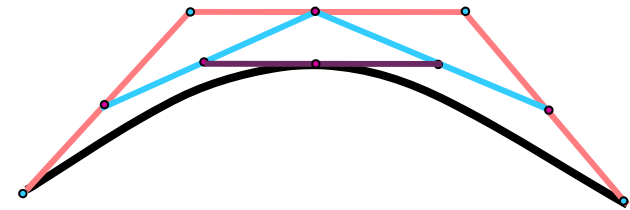
- Rendering equation
- Path tracing, photon mapping, radiosity



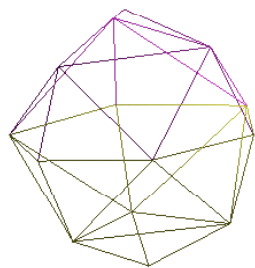
Images courtesy of Caligari ([www.caligari.com](http://www.caligari.com))

# Curves and Surfaces

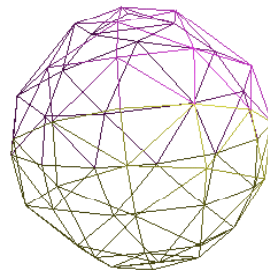
- Bezier curves and B-splines
- NURBS and subdivision surfaces
- Parametric solids



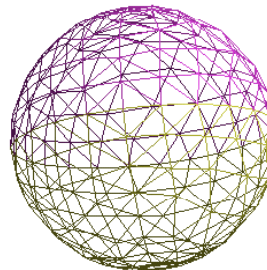
*0-levels*



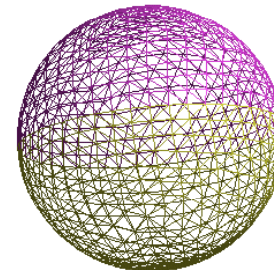
*1-level*



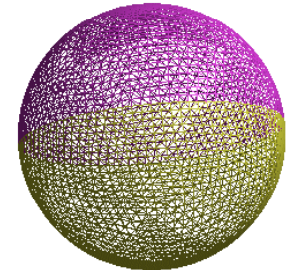
*2-levels*



*3-levels*



*4-levels*



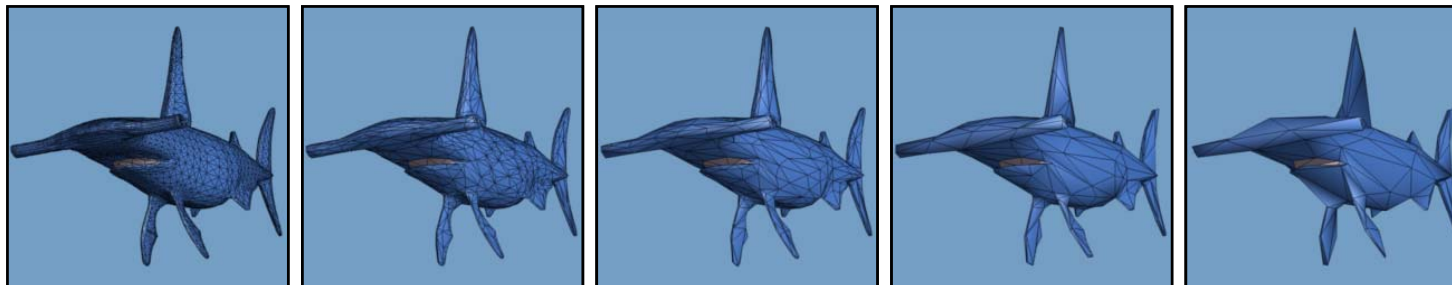
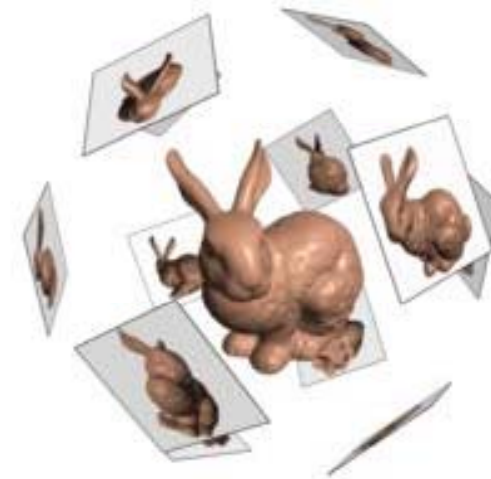
*5-levels*

# Simplification and LOD

- Levels of detail
- Progressive meshes



82 million triangles

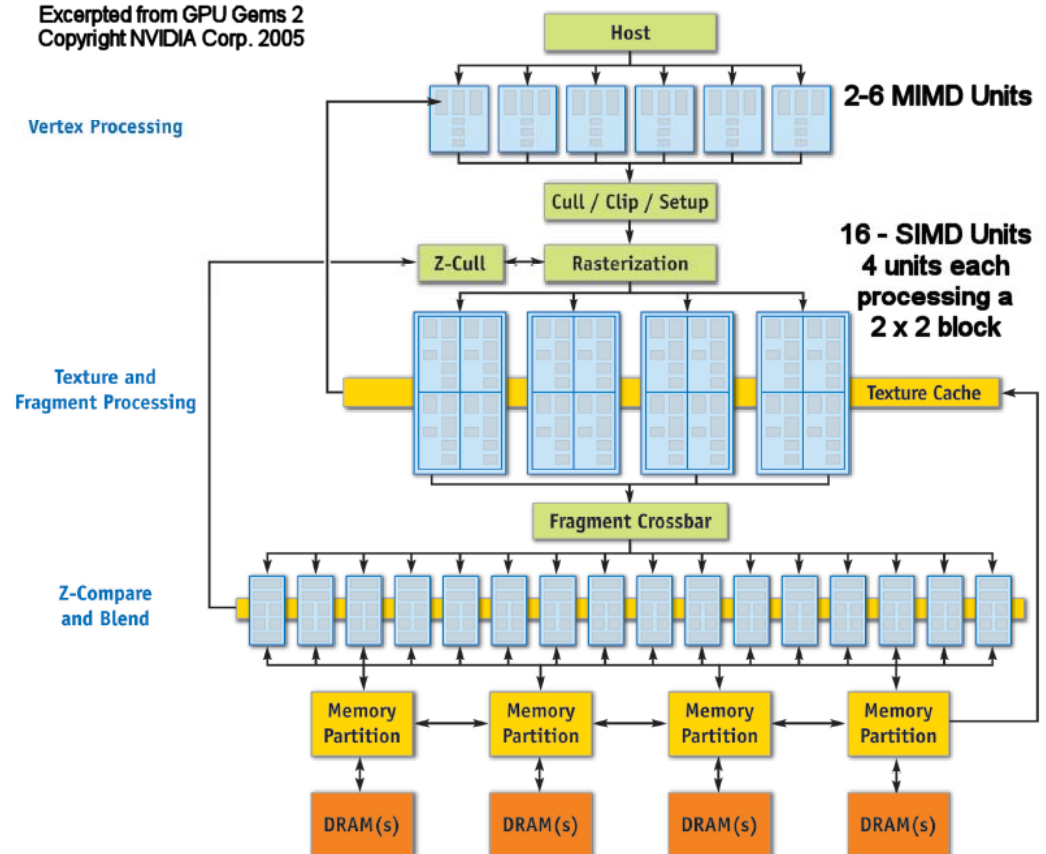


# Graphics Hardware

- History
- Architecture
- Shading languages
- Future



Excerpted from GPU Gems 2  
Copyright NVIDIA Corp. 2005

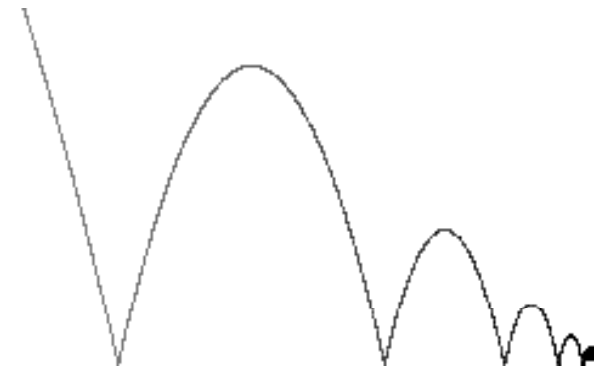
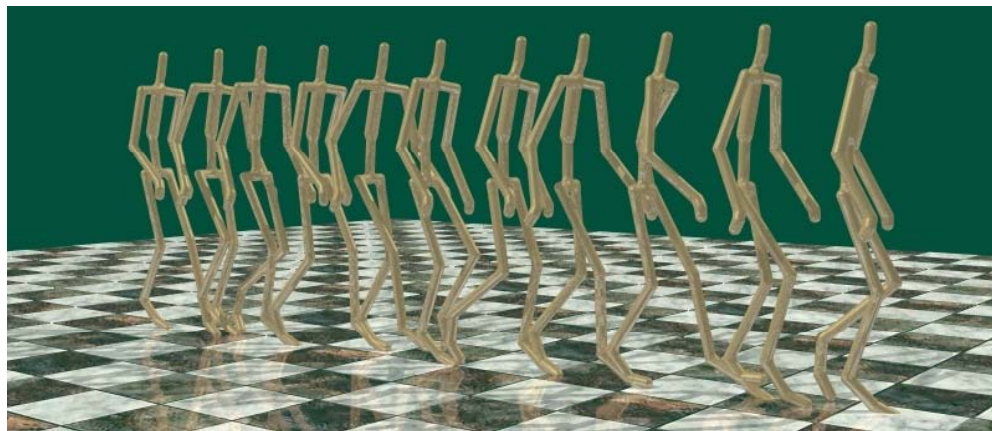


# Animation

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- Keyframing
- Parameteric splines
- Motion capture
- Simulation



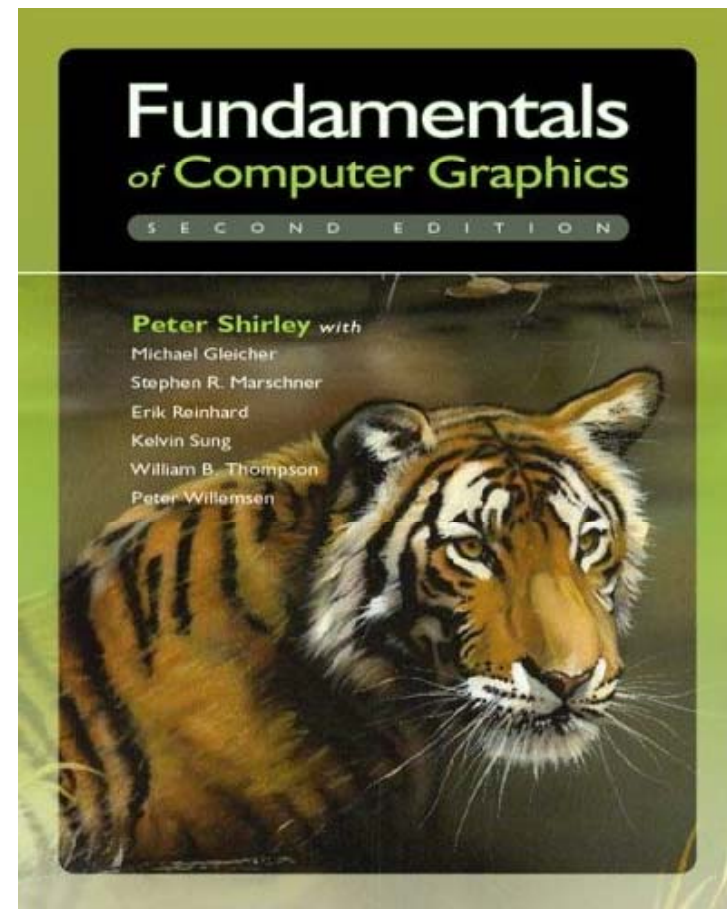


# Textbook

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- **Fundamentals of Computer Graphics**
  - 1<sup>st</sup> Edition
  - 2<sup>nd</sup> Edition
  - 3<sup>rd</sup> Edition
  - Peter Shirley et al.
  - AK Peters
  
- **Ordered in KAIST bookstore & library**



# Textbook – OpenGL

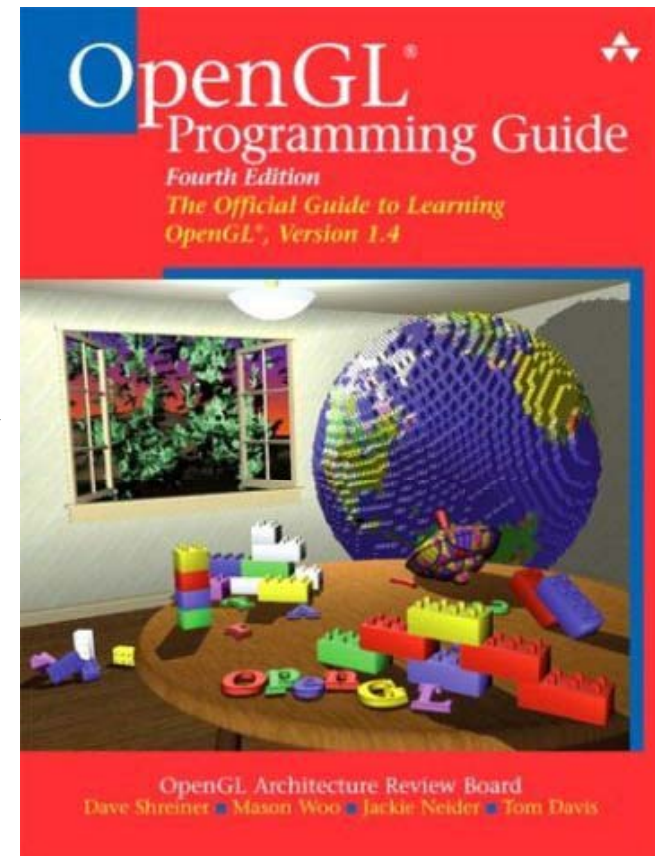
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- OpenGL Programming Guide
  - Addison-Wesley Professional
- Version 1.1 is available at internet

<http://www.glprogramming.com/red/>

- Reference book is also available

<http://www.glprogramming.com/blue>



# Other Reference

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- Technical papers
  - Graphics-related conference (SIGGRAPH, etc)
  - <http://kesen.huang.googlepages.com/>

- Course homepages
- Google or Google scholar

Google™



# Program Assignments (PAs)

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- **PAs (broken into 7 parts)**
  - Viewing and manipulating 3D models with OpenGL
  - Rasterization and clipping
  - Texture mapping and lighting
  - Raytracing
  - Etc.
- **My philosophy**
  - The load of each PA should not be too high, but these assignments cover most major parts of the course

# Grading

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- Mid-term: 20%  
Final-term: 30%  
Quiz and assignments: 50%
- Late policy
  - No score for late submissions
  - Submit your work before the deadline!

# Class Attendance Rule

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- Late two times → count as one absence
- Every two absences → lower your grade (e.g., A- → B+)
- To check attendance, I'll call your names or take pictures
- If you are in situations where you should be late, notify earlier

# Honor Code

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- Collaboration encouraged, but *assignments must be your own work*
- Cite any other's work if you use their codes
  - If you copy someone else's codes, you will get F
  - We will use a code copy checking tool to find any copy

# Official Language in Class

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- **English**
  - I'll give lectures in English
  - I may explain again in Korean if materials are unclear to you
  - You are also recommended to use English, but not required



# Other Related Courses

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- **CS580 (Graduate-level introductory CG, Spring semester)**
  - Will be given by me in the next spring semester, 2013
  - Focus on high quality rendering, which will be briefly touched at the end of CS380
  - Undergraduate students can take the course
  - Given alternatively between me and Prof. Jinah Park
- **CS380 (Spring semester)**
  - Given alternatively between me and Prof. Jinah Park
- **CS482 (Fall semester)**
  - Focus on animation

# Any Questions?

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- **Come up with one question on what we have discussed in the class and submit at the end of the class**
  - 1 for already answered questions
  - 2 for typical questions
  - 3 for questions with thoughts
  - 4 for questions that surprised me

# About You

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- Name
- Your (non hanmail.net) email address
- What is your major?
- Previous graphics experience
- Any questions

# Homework for Each Class

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- **Go over the next lecture slides before the class**
  - **Just 10 min ~ 20 min for this should be okay**

# Homework

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- **Watch 2 SIGGRAPH Videos**
  - Write their abstracts and submit at the beginning of every Wed. class
- **Example of an abstract**
  - Just one paragraph for each abstract

**Title: XXX XXXX XXXX**

**Abstract: this video is about accelerating the performance of ray tracing. To achieve its goal, they design a new technique for reordering rays, since by doing so, they can improve the ray coherence and thus improve the overall performance.**

# Next Time...

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- Screen & world space
- Basic OpenGL usage

