CS380: Computer Graphics
Introduction

Sung-Eui Yoon
(윤성의)

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

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About the Instructor

- **Main Research Focus**
  - **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**

About the Instructor

- **Notable recognitions**
  - **Co-chairs at ACM Symp. on Interactive 3D Graphics and Games**
  - **Best paper award at Pacific Graphics**
  - **Test-of-time award at High Performance Graphics**

  - **Interns/post.doc/collaborations at Disney, Adobe, AMD, Pixar**
  - **Produced two professors on rendering (GIST) and related topics**

Present: Scalable Ray Tracing, Image Search, Motion Planning

- **Designing *scalable graphics and geometric algorithms* to efficiently handle massive models on commodity hardware**

Photo-realistic rendering

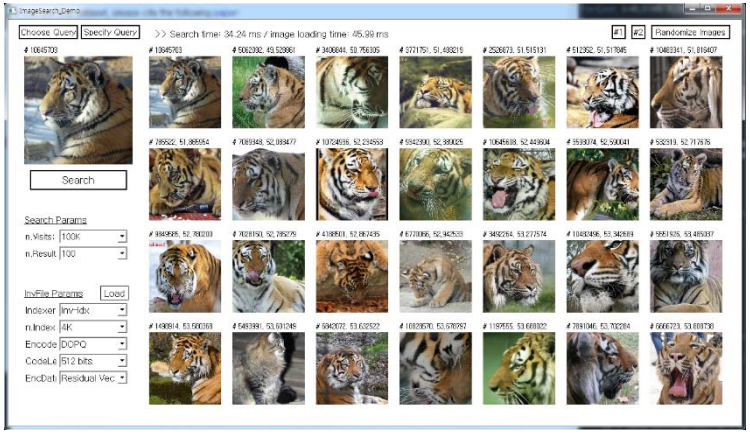

Image search

Motion planning

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Course Information of CS380

Instructor: Sung-eui Yoon

Email: sungeui@gmail.com

Office: 3432 at CS building

Office hours: Right after class time (or by appt.)

Course webpage: http://sglab.kaist.ac.kr/~sungeui/CG/

Noah discussion page:

Use this one for sharing Q&A with other students, instead of personal communication to TAs

KLMS: homework submissions

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Class Time

- **Date: every TTh**
  - **Time: 4:00pm ~ 5:15pm**
- **4 credit course**
  - **A few (2) OpenGL courses given by TAs**

TAs

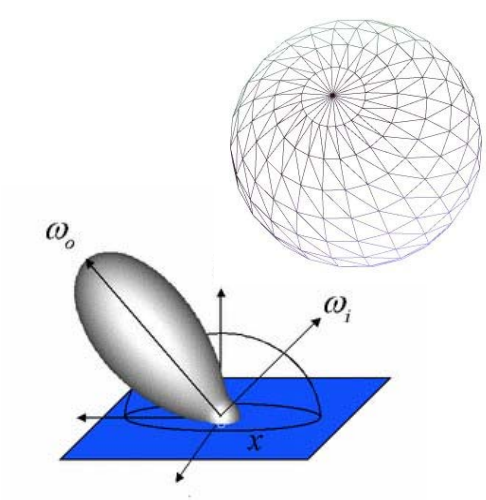
- **TA email address: cs380ta@gmail.com**
  - **Use noah board, if possible**
- **MyungBae Sohn (손명배)**
  - **Office: E3-1, 3443호**
- **YoungKi Kown (권영기)**
  - **Office: E3-1, 3443호**
- **HeeChan Shin (신희찬)**
  - **Office: E3-1, 3443호**
- **HyunHo Ha (하현호)**
  - **Office: E3-1, 3422호**
- **InSoo Kim (김인수)**
  - **Office: E3-1, 3422호**

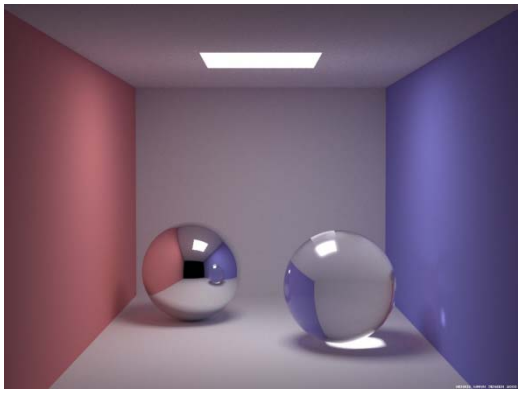
Prerequisites

- 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**





Modelling **Simulation & Rendering** **Image**

Computer vision inverts the process
Image processing deals with images

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Application of Computer Graphics

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

Games

2D game

3D shooting game

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Large-Scale Open World w/ High Quality Rendering

- **Witcher 3**
  - **Used its own engine**

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High Quality Mobile Games

- **Lineage 2 – Revolution**
  - **Based on Unreal engine**

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Game Industry at Korea

- **One of biggest IT sectors in Korea**
  - **A game company can have its own pro. Baseball team (e.g., NC Dinos)**

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

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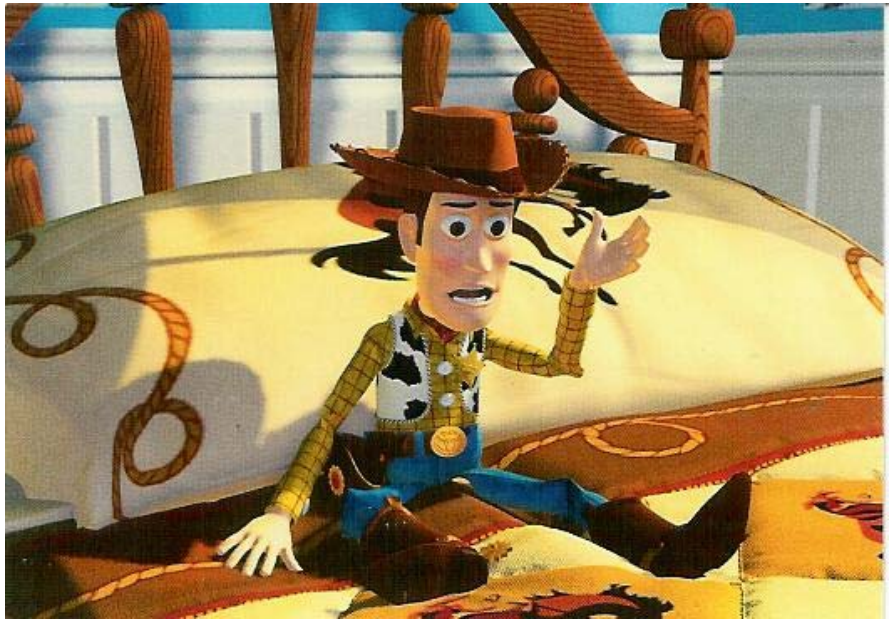
Movies and Film Special Effects



Toy story

Matrix

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3D Movies

Avatar

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3D TV

Samsung 3D TV

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Head-Mounted Display (HMD) for VR

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HoloLens for Augmented Reality (AR)

MS

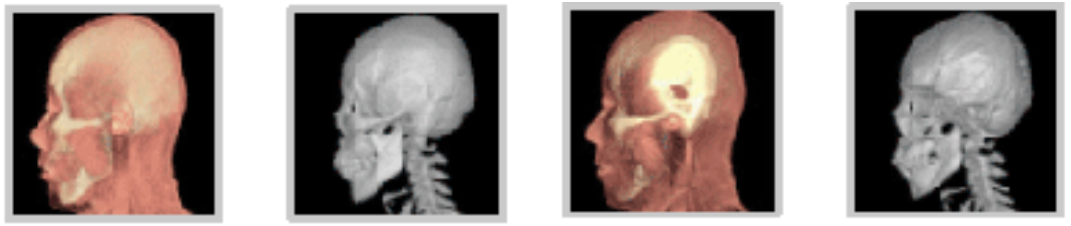
Killer App. For AR

Product Design and Analysis

- **Computer-aided design (CAD)**

Medical Applications

- **Visualizing data of CT, MRI, etc**



Rapidia homepage

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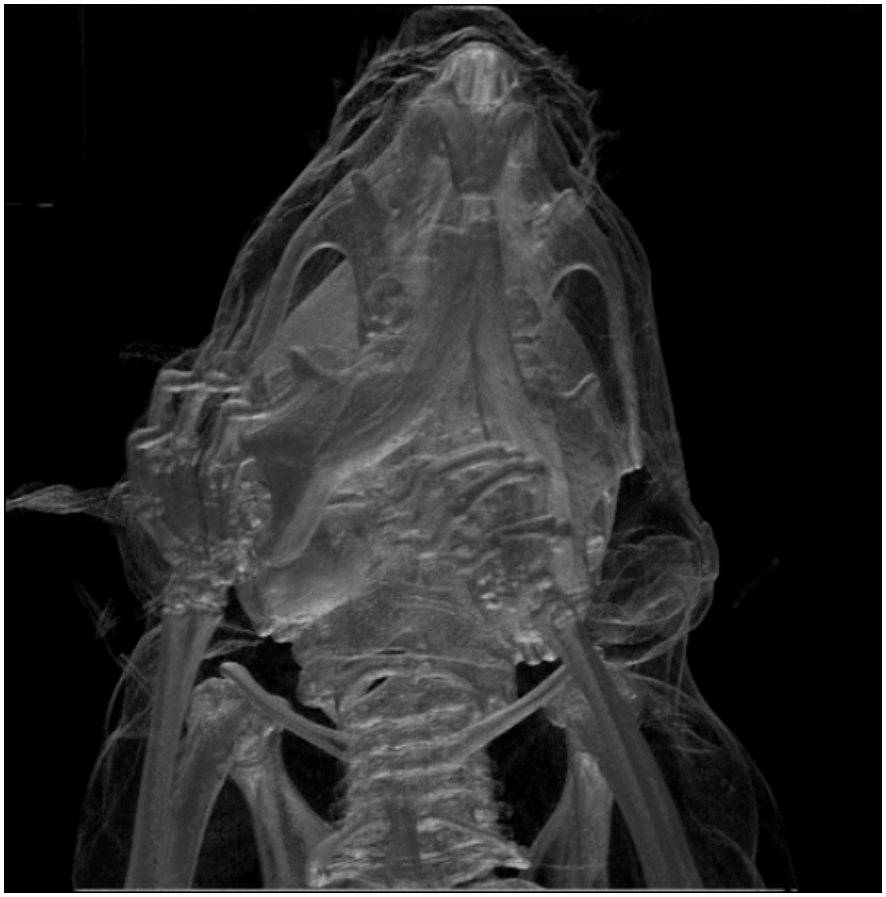
Medical Applications

- **Visualizing data of CT, MRI, etc**



Wikipedia

Mouse skull (CT)

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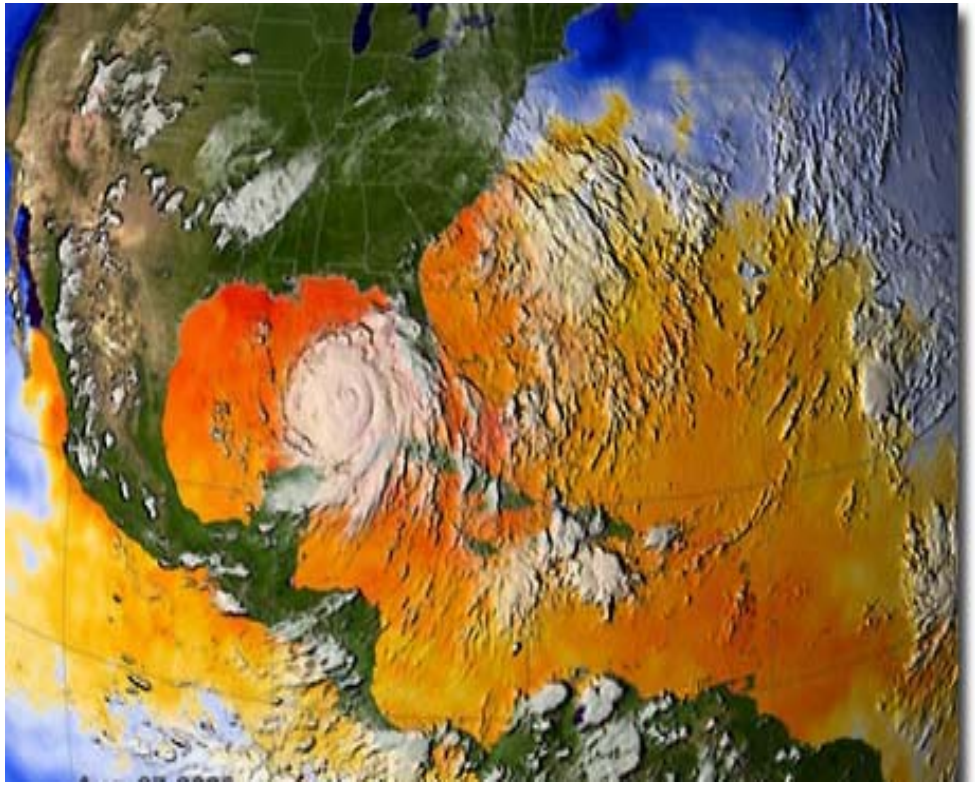
Scientific Applications

- **Weather visualization**



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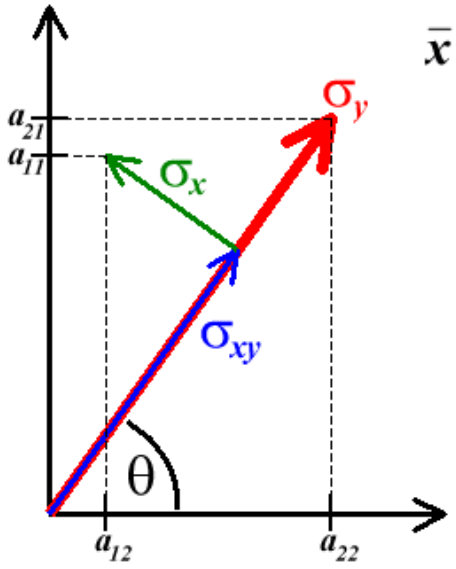
Topics

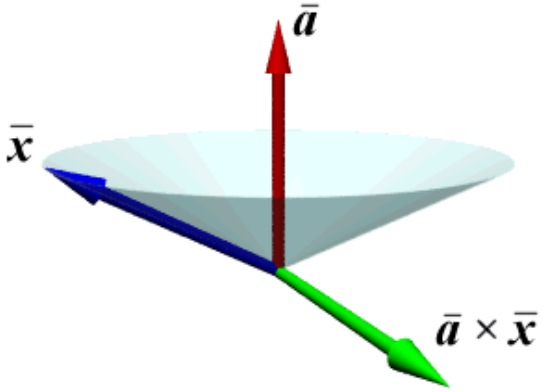
- Mathematical tools
- 3D models and interaction
- Hidden surface removal
- Rasterization
- Lighting and shading
- Shadows
- Texture mapping
- Ray tracing
- Global illumination
- Curves and surfaces
- Simplification and levels of detail
- Collision detection
- Graphics hardware, etc

Mathematical Tools

- **Homogeneous coordinates**
- **Vectors**
- **Planes**
- **Frames**
- **Transformations**

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





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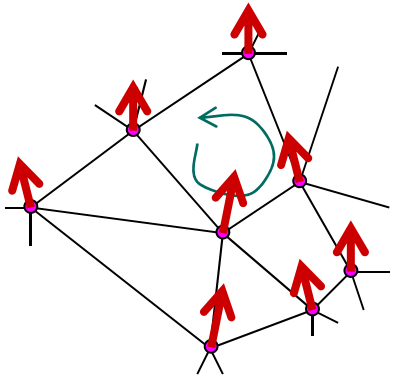
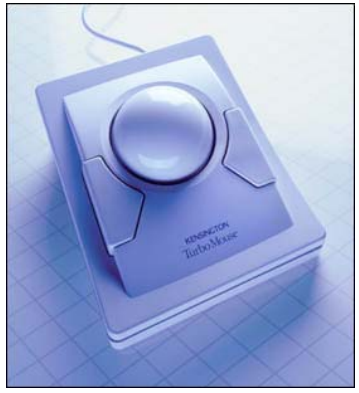
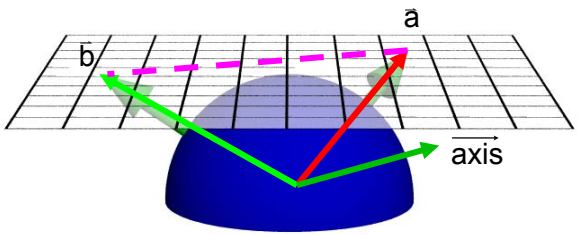
3D Models and Interaction

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







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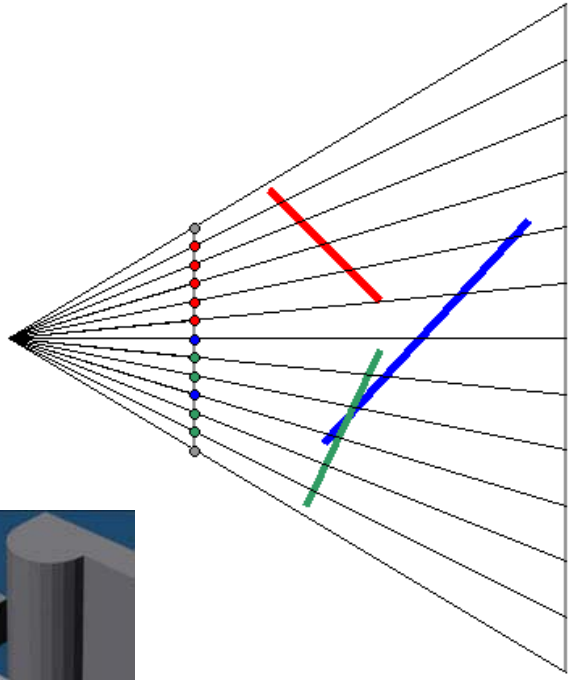
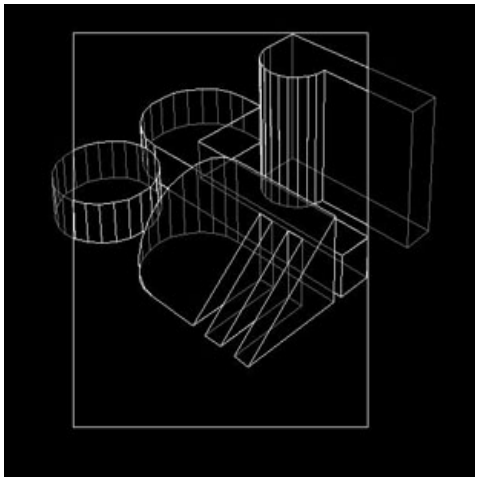
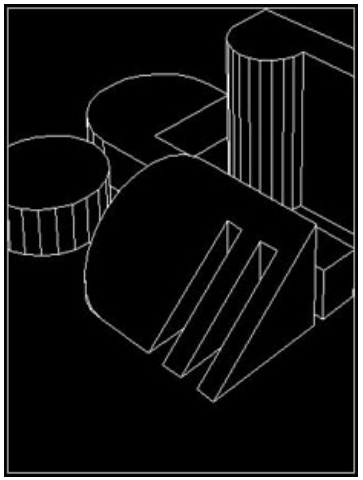
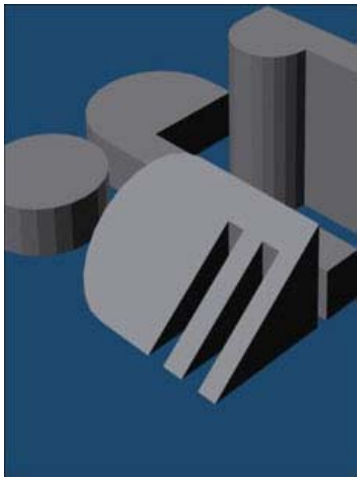
Hidden Surface Removal

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









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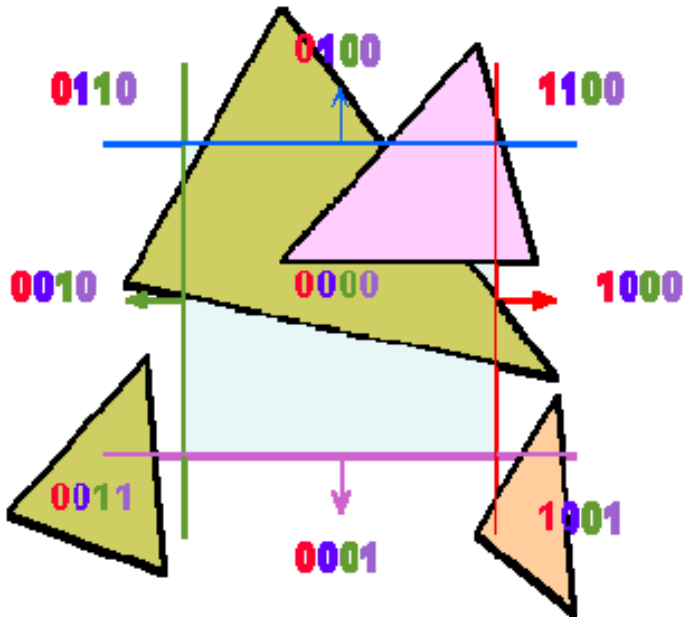
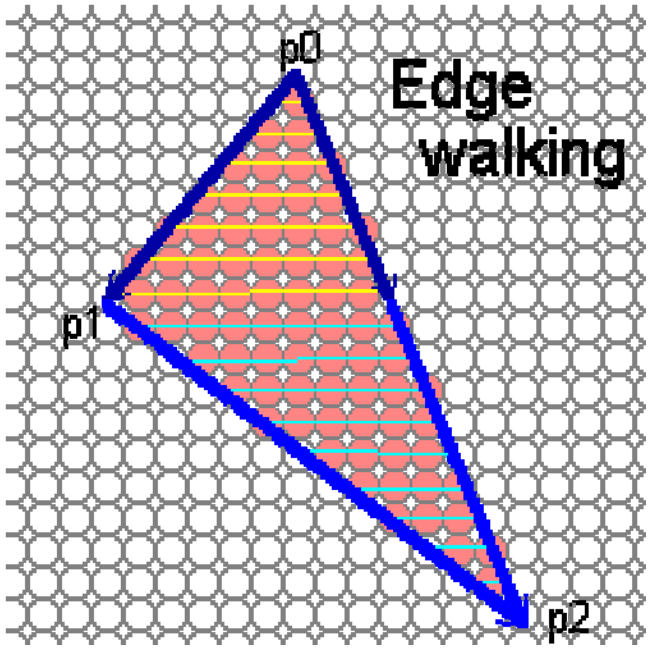
Rasterization

- Clipping
- Scan conversion





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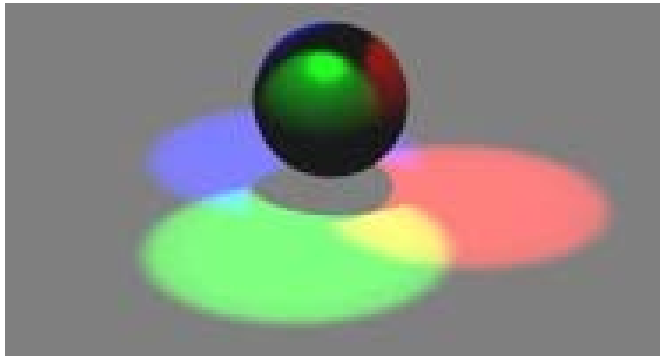
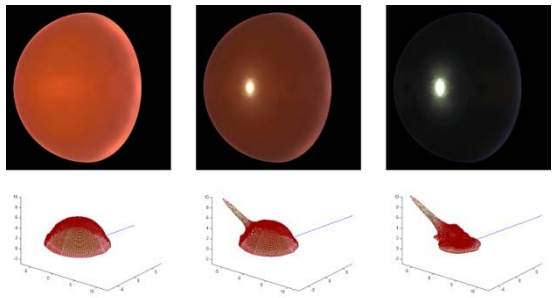
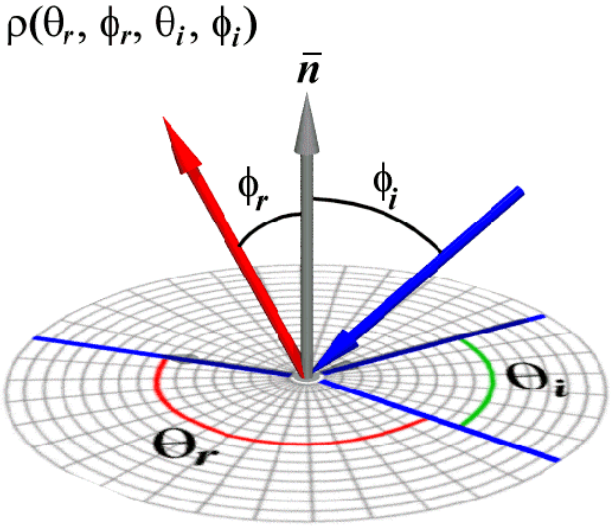
Lighting and Shading

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







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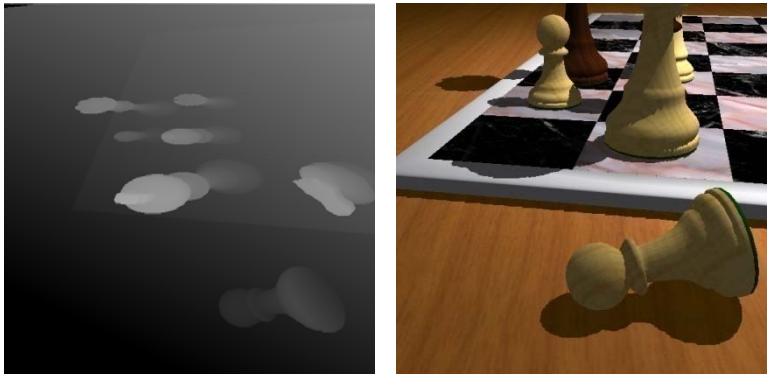
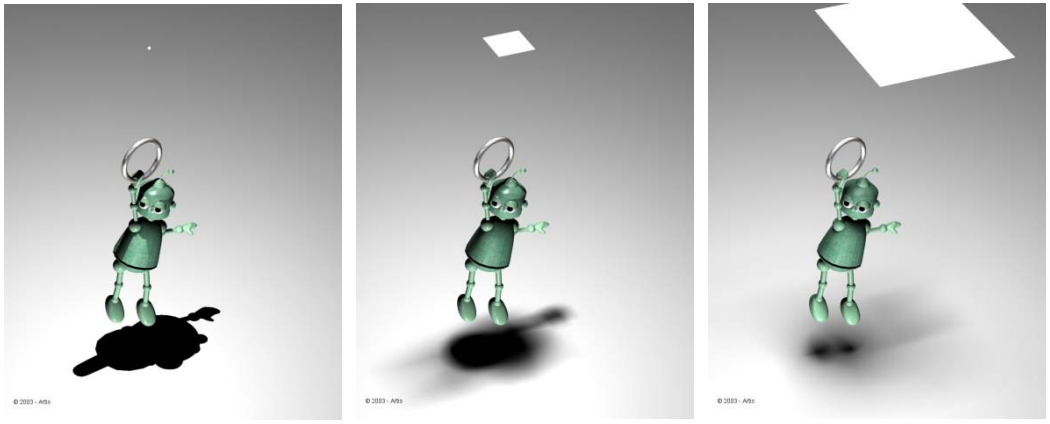
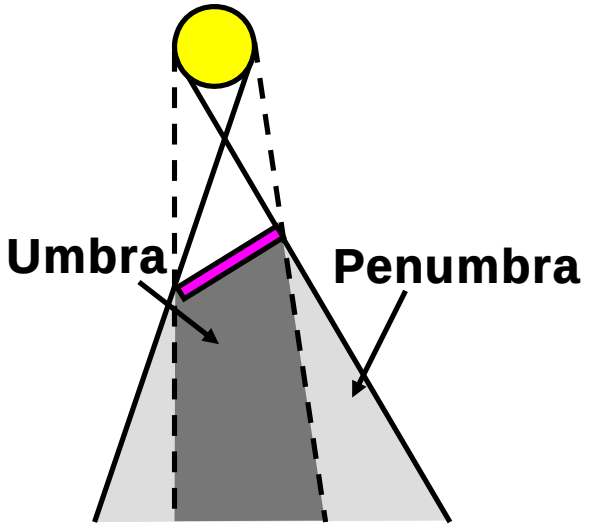
Shadows

- Shadow volumes
- Shadow maps



Images courtesy of Stamminger and Drettakis 02





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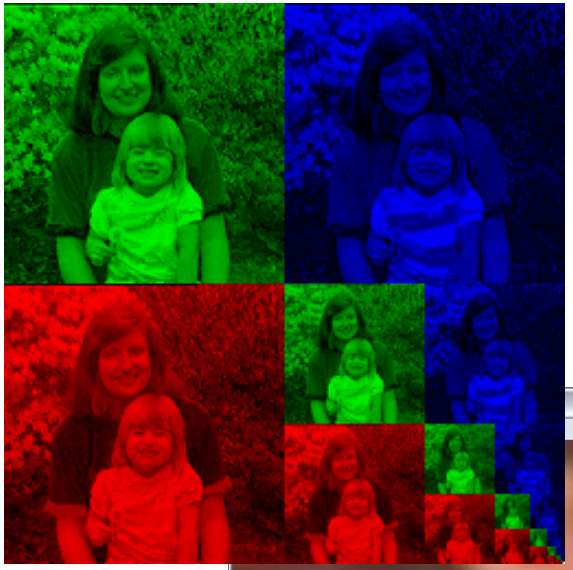
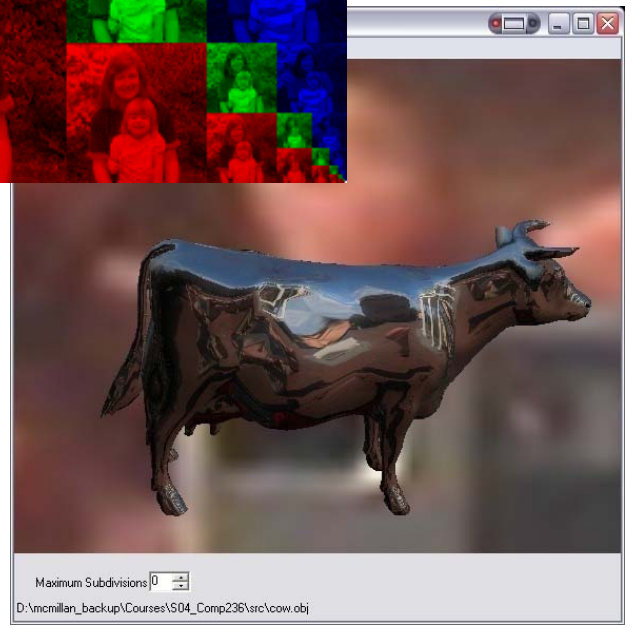
Texture Mapping

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





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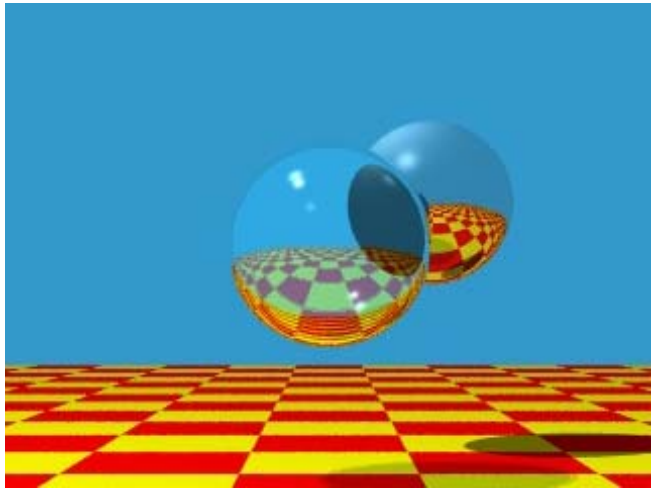
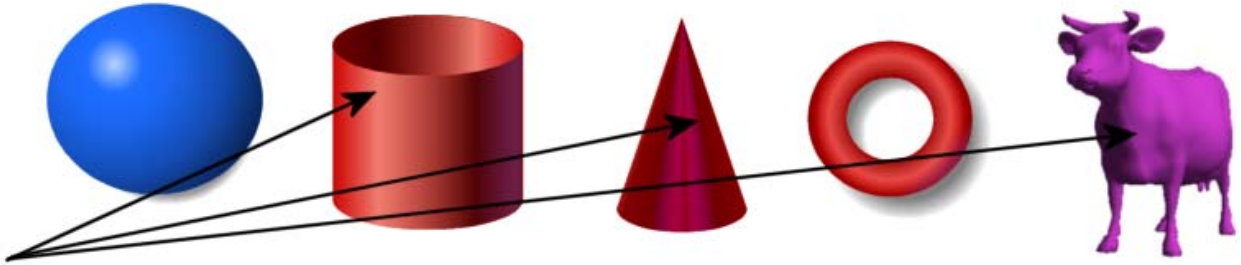
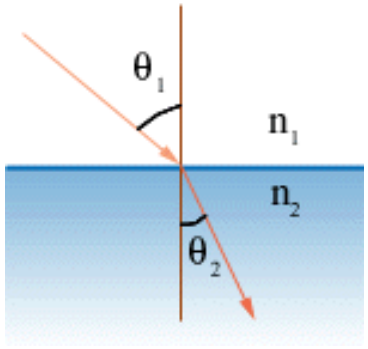
Ray Tracing

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







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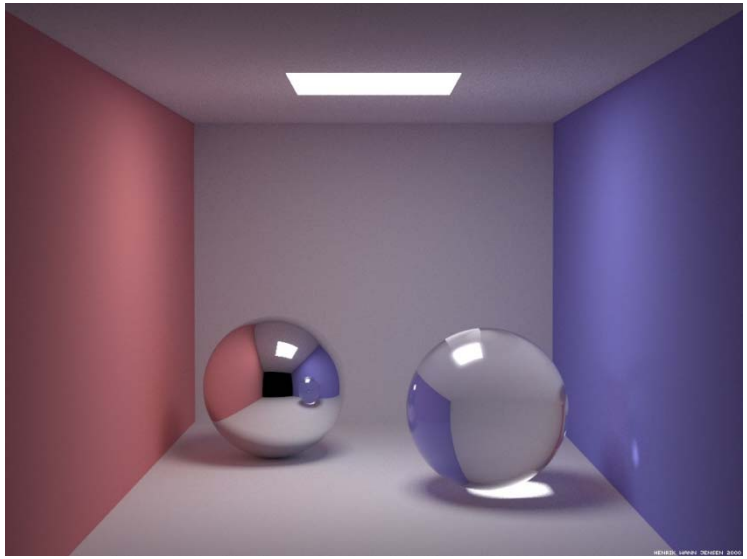
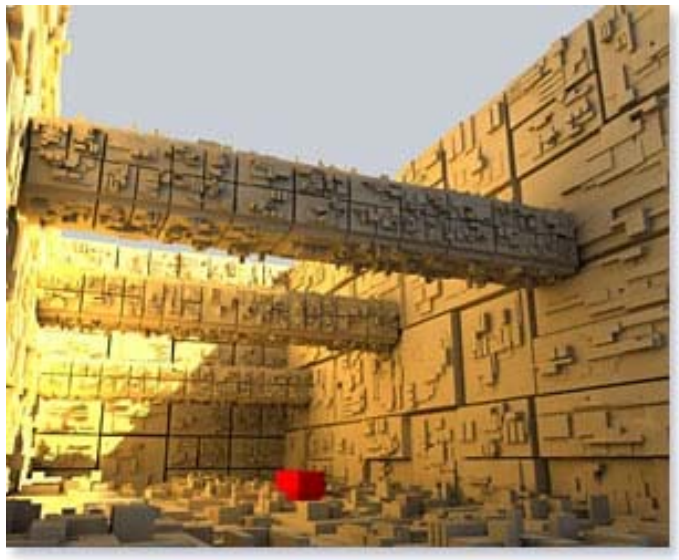
Global Illumination

- **Rendering equation**
- **Path tracing, photon mapping, radiosity**





Images courtesy of Caligari (www.caligari.com)

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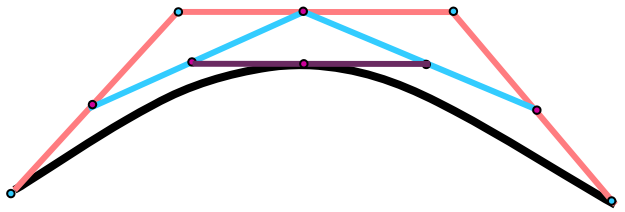
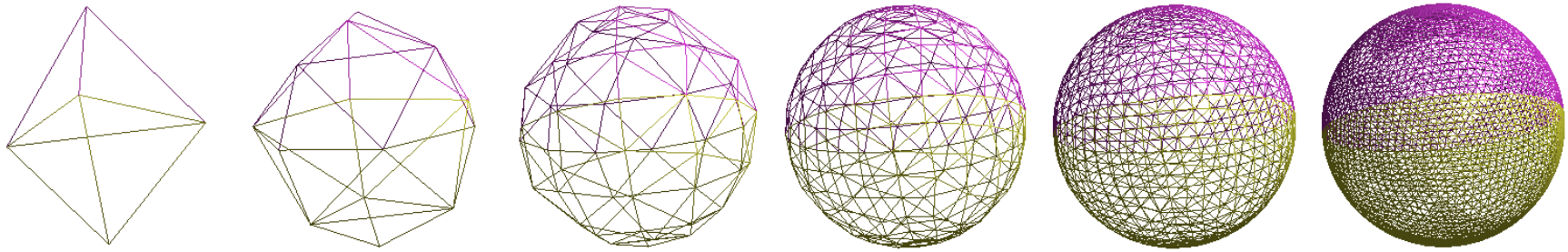
Curves and Surfaces

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





0−levels *1−level* *2−levels* *3−levels* *4−levels* *5−levels*

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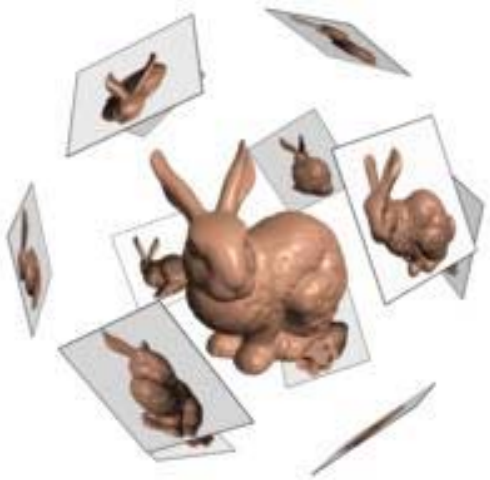
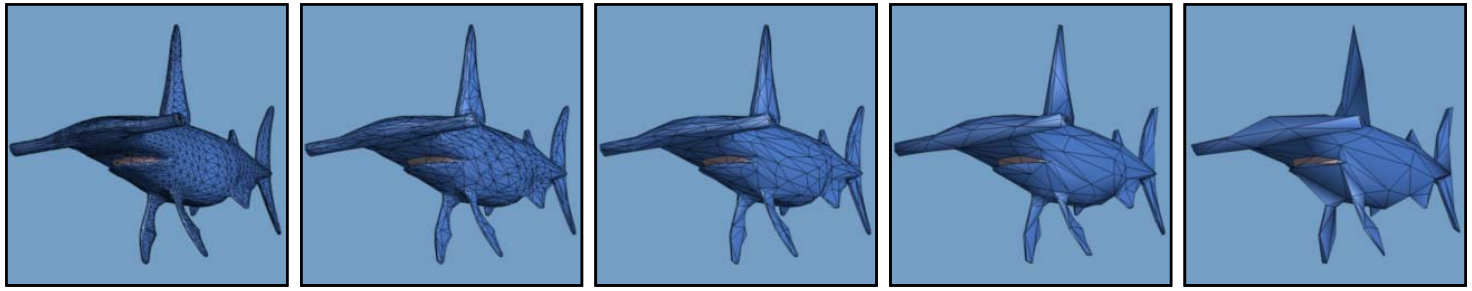
Simplification and LOD

- Levels of detail
- Progressive meshes

82 million triangles





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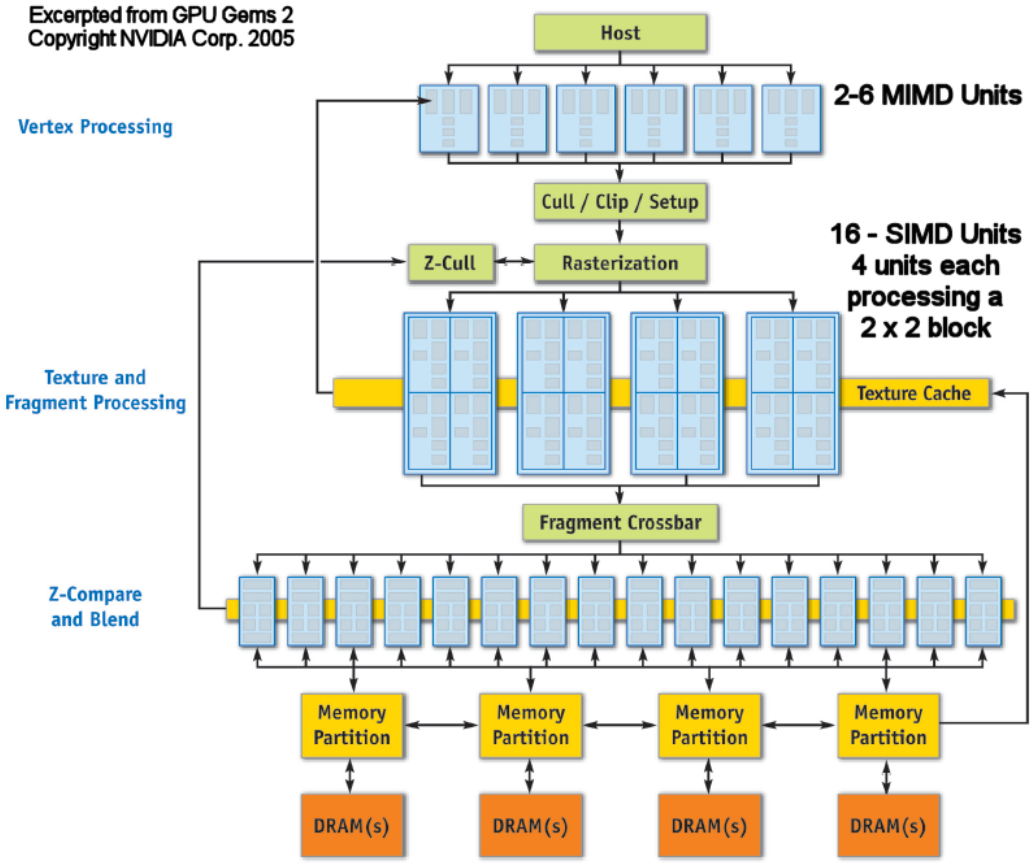
Graphics Hardware

- History
- Architecture
- Shading languages
- Future



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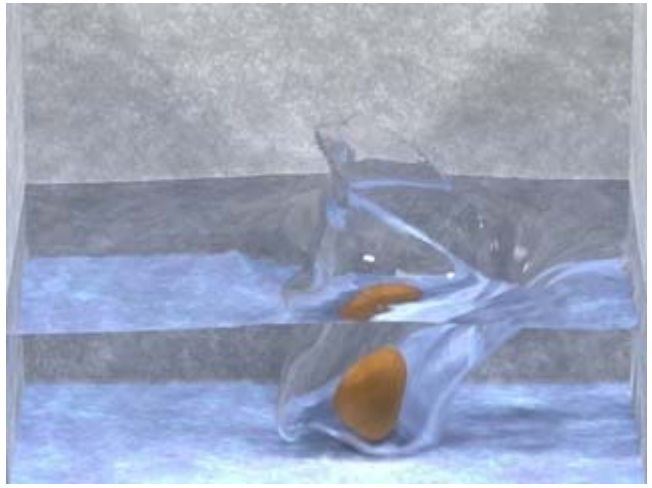
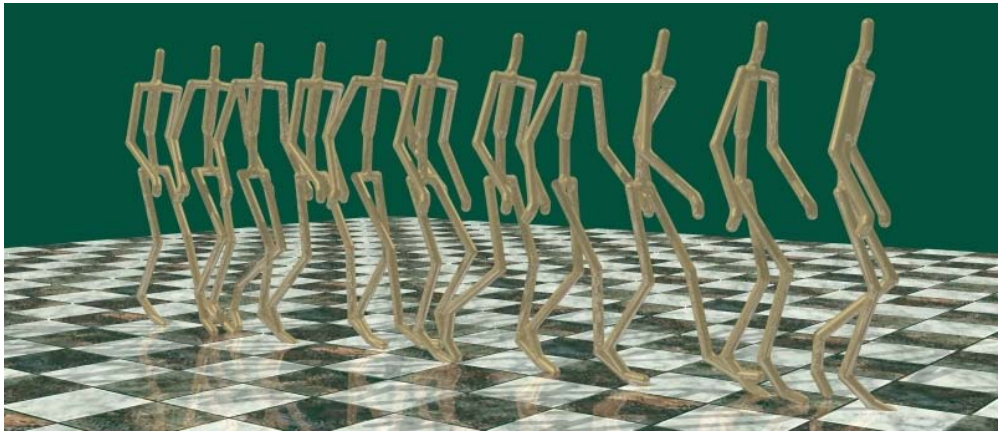
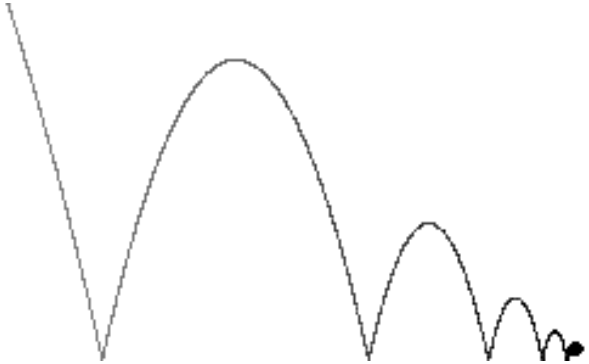
Animation

- Keyframing
- Parameteric splines
- Motion capture
- Simulation







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Textbook

- **A book of Rendering**
  - **Draft, Sung-eui Yoon**
  - **1st Edition near the end of 2017**
  - **Available freely as a pdf file through the course web page**

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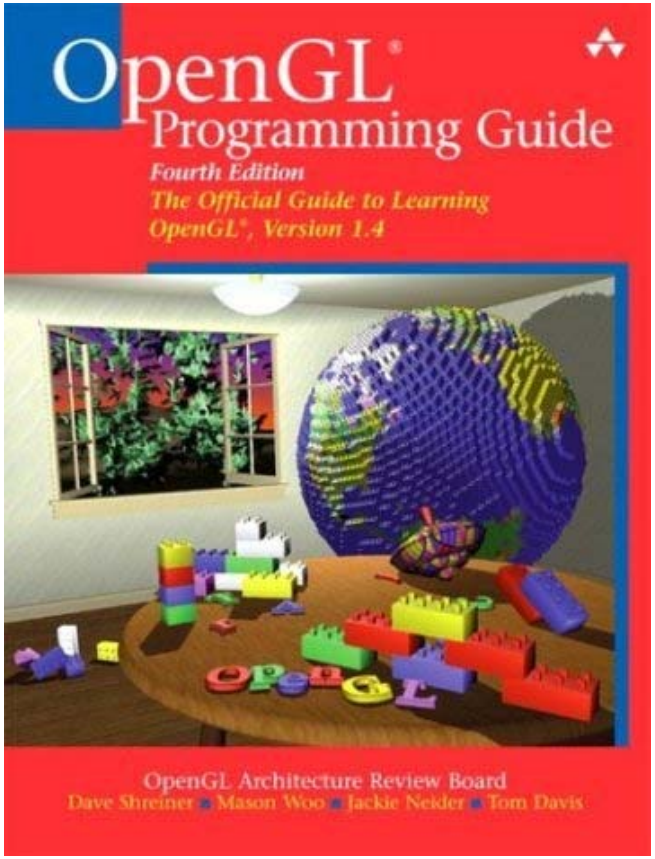
Reference – OpenGL

- OpenGL Programming Guide
  - Addison-Wesley Professional
  - Ver 4.3 is ordered to KAIST library
- Version 1.1 is available at internet and the course webpage
- Reference book is also available



http://www.glprogramming.com/blue

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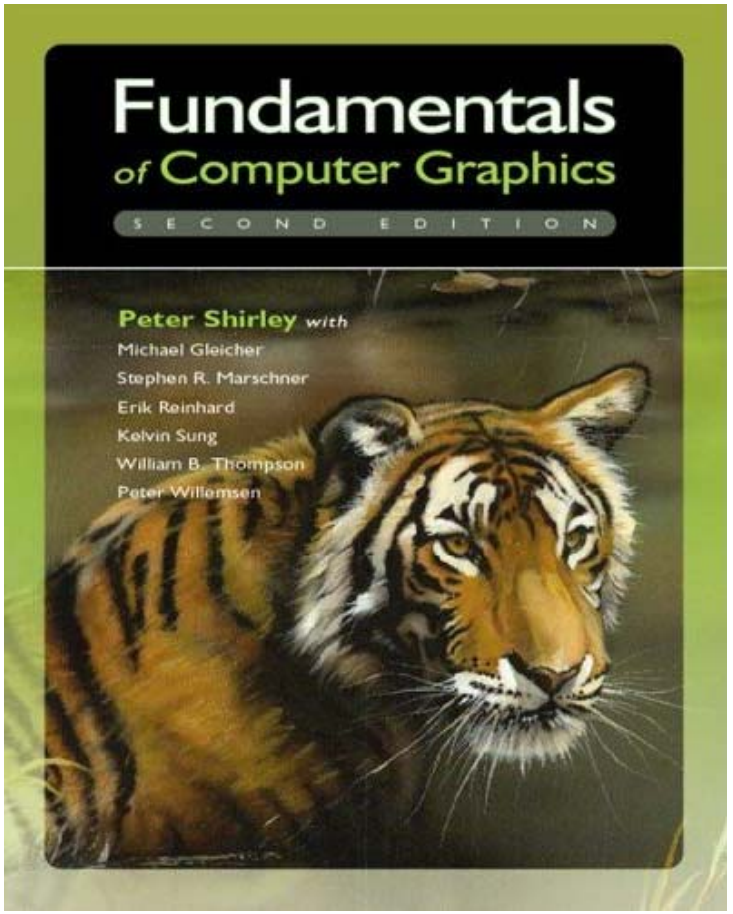
Reference

- **Fundamentals of Computer Graphics**
  - **Peter Shirley et al.**
  - **AK Peters**
  - **Available at the KAIST library**



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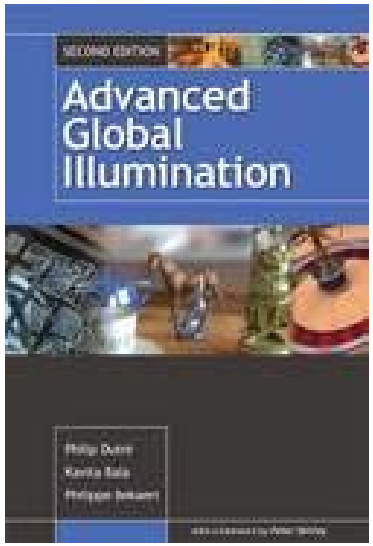
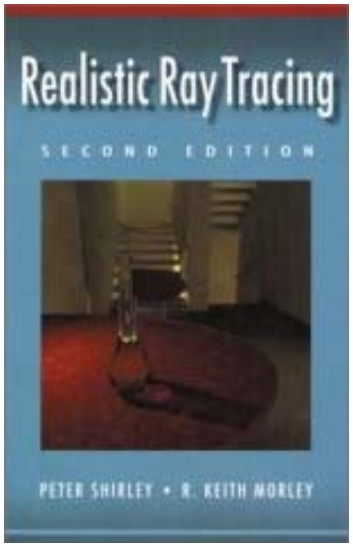
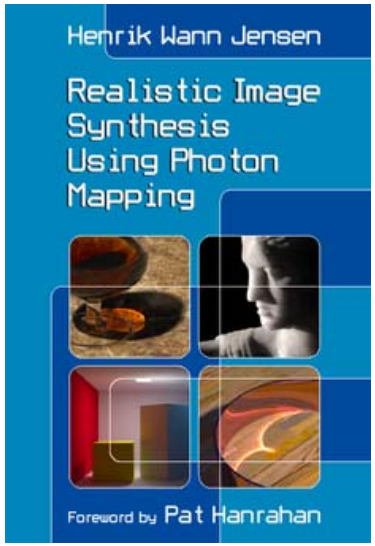
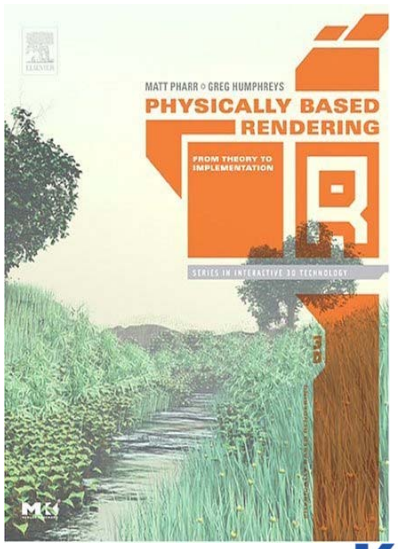
Resource on Physically-based Rendering

- **Reference**
  - **Physically based renderig, Matt Pharr et al.**
  - **Advanced Global Illumination, Philip Dutre et al. 2nd edition**
  - **Realistic Image Synthesis Using Photon Mapping, Henrik Jensen**
  - **Realistic Ray Tracing, 2nd edition, Peter Shirley et al.**









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Other Reference

- Technical papers
  - Graphics-related conference (SIGGRAPH, etc)
  - http://kesen.huang.googlepages.com/
- Course homepages
- Google or Google scholar

Program Assignments (PAs)

- 6 or 7 PAs
  - Viewing and manipulating 3D models with OpenGL
  - Rasterization and clipping
  - Texture mapping and lighting
  - Raytracing
  - Their difficulty is growing!

Grading

- **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

- **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 and Etiquette

- 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
- Classroom etiquette
  - Help you and your peer to focus on the class
  - Turn off cell phones
  - Arrive to the class on time
  - Avoid private conversations
  - Be attentive in class

Official Language in Class

- **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**

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Other Related Courses

- CS580 (Graduate-level introductory CG, Spring semester)
  - Focus on high quality rendering, which will be briefly touched at the end of CS380
  - Undergraduate students can take the course
- CS380 (Spring semester)
- CS482 (Fall semester)
  - Focus on advanced, real-time rendering techniques

- All the courses will be given among me, Prof. Park, and Prof. Kim.

Homework for Each Class

- Go over the next lecture slides before the class
  - Just 10 min ~ 20 min for this should be okay
- Two video abstract submission every week
- Question submissions at least four times before the mid-term exam

Next Time...

- Screen & world space
- Basic OpenGL usage

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About You

- Name

- What is your major?
- Previous graphics experience

- Any questions?