CS380: Computer Graphics
Introduction

Sung-Eui Yoon
(윤성의)

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

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About the Instructor

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

High-Performance Graphics 2015
Los Angeles, August 7–9, 2015
Home   Full Program   CFP   Registration   Accommodations   Venue   Submissions   Organization

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

Research: Scalable Ray Tracing, Image Search, Motion Planning

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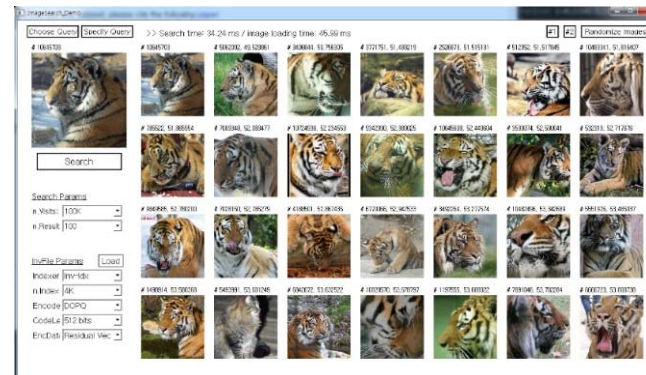

Photo-realistic rendering

Image search

Motion planning

Paper and video: https://sgvr.kaist.ac.kr/category/papers/paper-international/
YouTube videos: http://www.youtube.com/user/sglabkaist

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.)**

KLMS discussion page:

Use this one for sharing Q&A with other students, instead of personal communication (e.g., email) to TAs

KLMS: homework submissions

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

Class Time

- ## Date: every MW
  - ### Time: 10:30am ~ 11:45am

- ## 4 credit course
  - ### OpenGL courses will be given by TAs

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TAs

- **TA email address: cs380ta@gmail.com**
  - **Use KLMS board first**

- **InKyu Ahn (안인규), MinCheol Kang (강민철)**
  - **Office: E3-1, 3439호**
- **HeeChan Shin (신희찬)**
  - **Office: E3-1, 3446호**
- **InYoung Cho (조인영), JaeYoon Kim (김재윤)**
 - **Office: E3-1, 3443호**

Prerequisites

- **Basic knowledge of linear algebra**
  - **E.g., matrix multiplication and inversion**
- **Some level of programming skill**
  - **Require you to know or self-study C-like language (e.g., C and C++)**

- **If you are unsure, consult the instructor at the end of this class**
  - **You can check the programming assignments of the prior homepage**

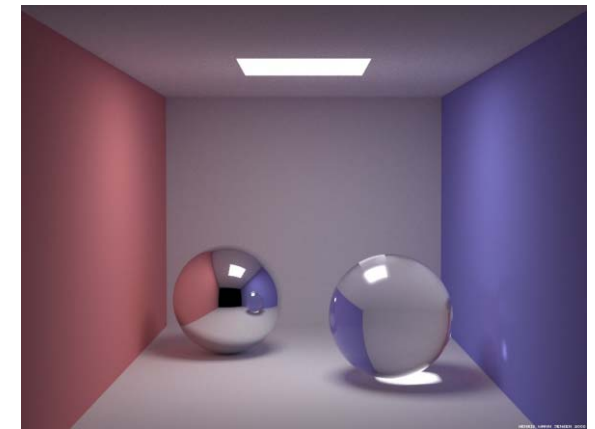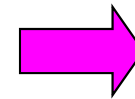**KAIST**

Overview

- **We will discuss various parts of computer graphics**
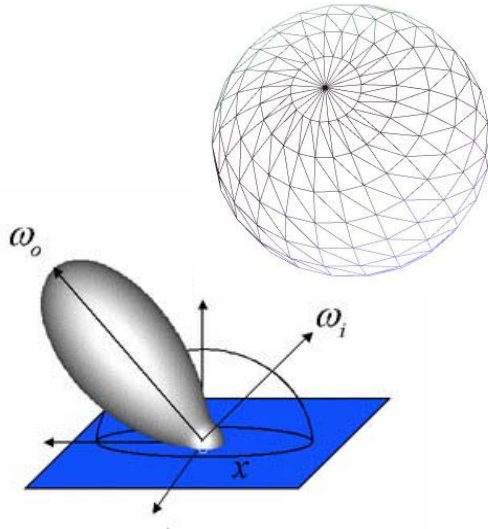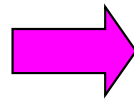
Modelling   **Simulation & Rendering**   **Image**

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**

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Games

2D game

3D shooting game

Large-Scale Open World w/ High Quality Rendering

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

High Quality Mobile Games

- **Big game industry at Korea**

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

Movies and Film Special Effects

Toy story

Matrix

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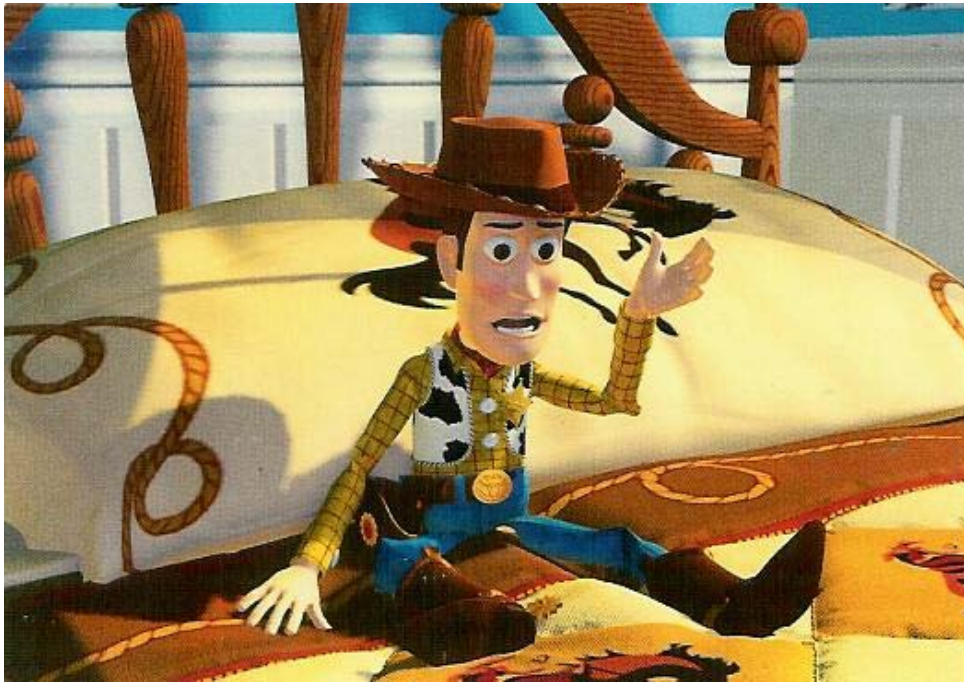
3D Movies

Avatar

3D TV

Samsung 3D TV

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Head-Mounted Display (HMD) for VR

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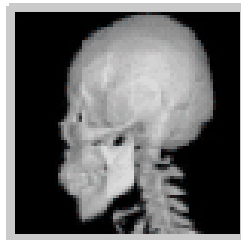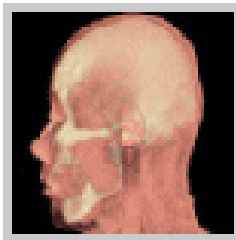
HoloLens for Augmented Reality (AR)

MS

Killer App. For AR

Product Design and Analysis

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

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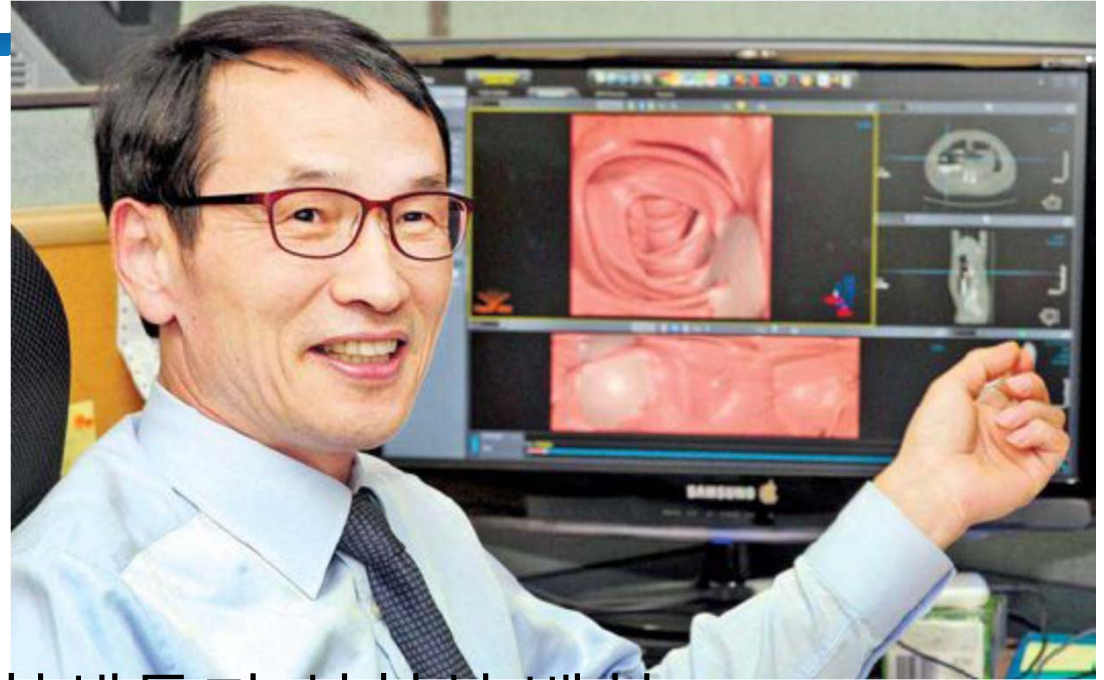
- **Visualizing data of CT, MRI, etc**

Rapidia homepage
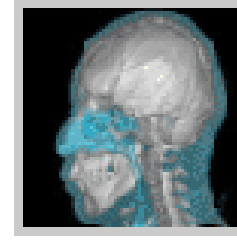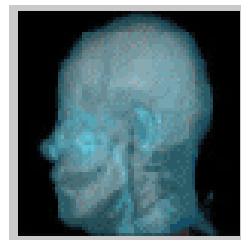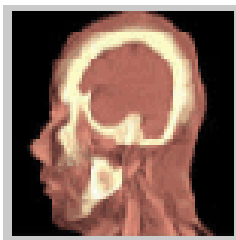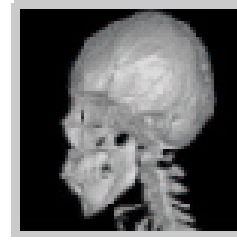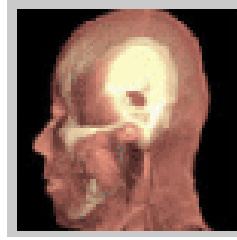
Medical Applications

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

Wikipedia

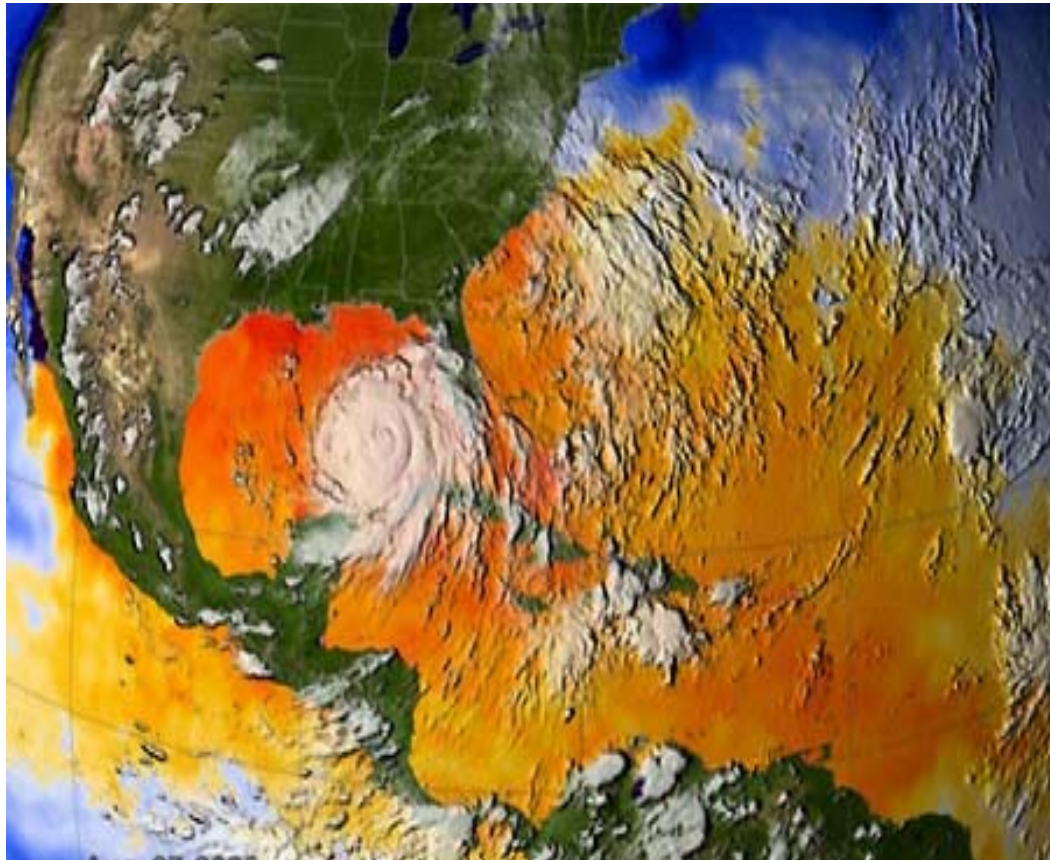**Mouse skull (CT)**

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Medical Applications

벤처 성공으로 유명세 타

... 신 교수는 1990년 대학원 학생들과 실험실 벤처 '3D메드'를 창업했다. 좋은 기술을 갖고 있었기 때문에 더 큰 벤처기업이 인수했고, 몇 년 전에 인수한 벤처기업이 코스닥 주식시장에 상장됐다. 당시 주식을 그대로 갖고 있었던 대학원생들은 꽤 돈을 벌었다고 한다. 기자가 넉넉하게 잡아 "몇 천만 원쯤 벌었나요"라고 물었더니 신 교수는 "집 한 채 샀지요"라고 에둘러 답했다... .

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Scientific Applications

- **Weather visualization**

LLNL

Sound Rendering

Phonon Reverb: OFF

Reverb Preset: Hangar

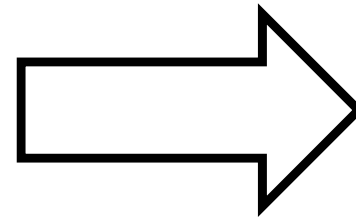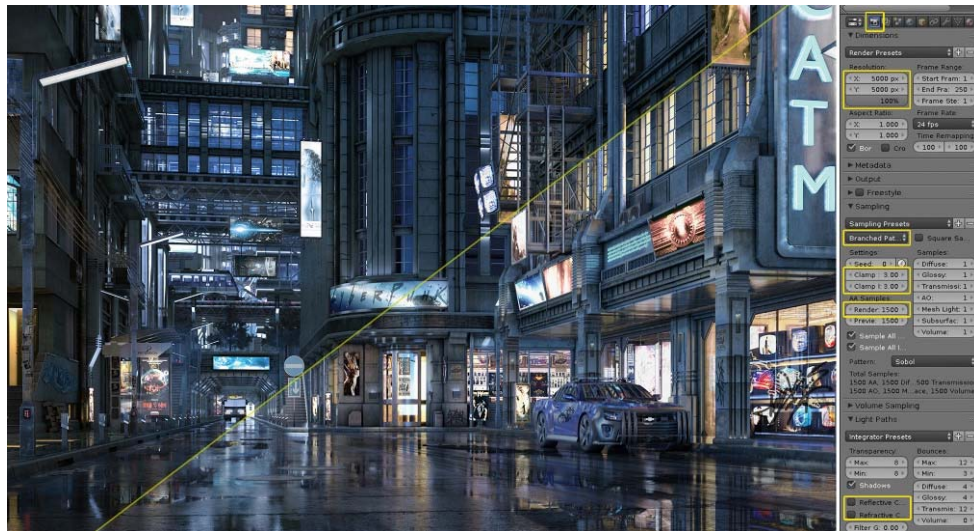[P]: Cycle Phonon Mode | [X]: Say Hello

Faithful Data Generation for Deep Learning

- **Apply CG techniques for generating realistic data for deep learning, which require lots of data**

GPU

Training data for learning

Realistic modeling, rendering & simulation

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**
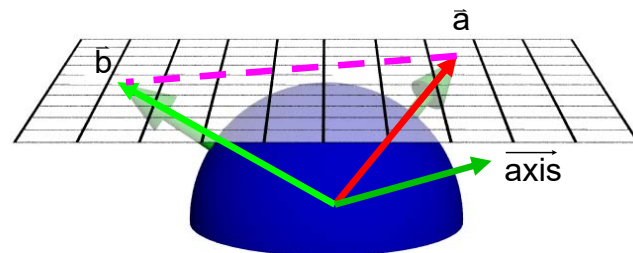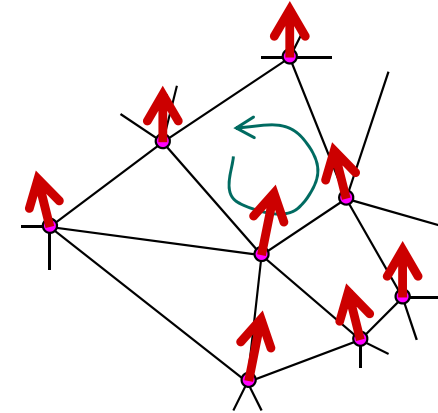- **Graphics hardware, etc**

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Mathematical Tools

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

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$
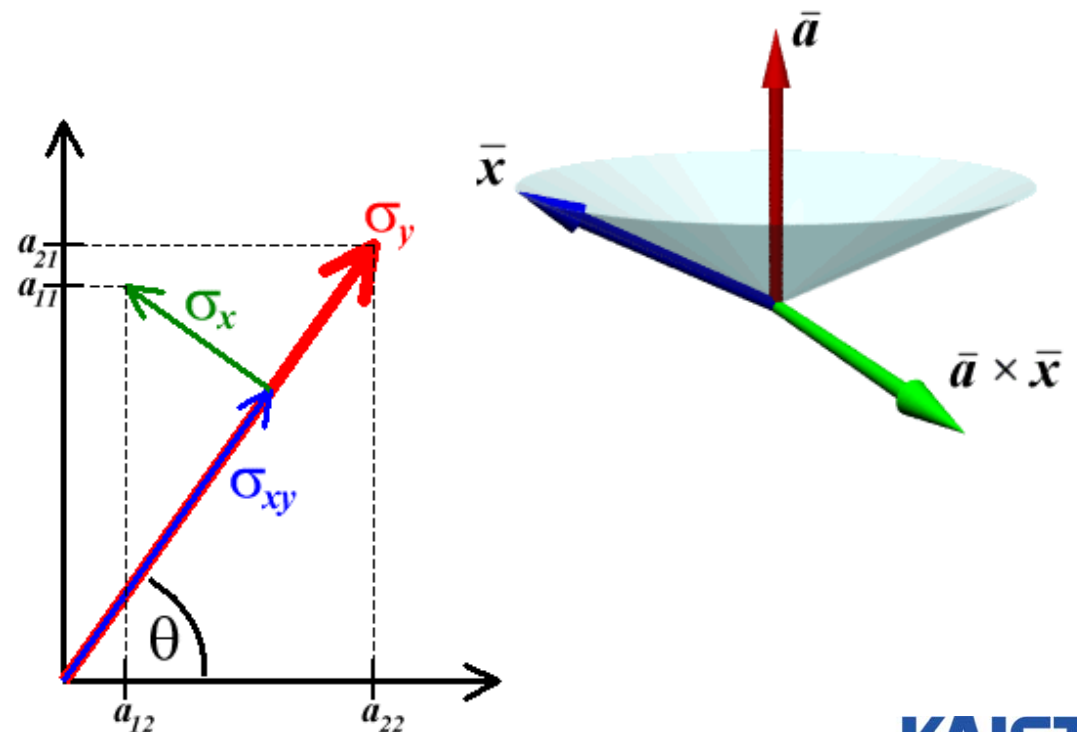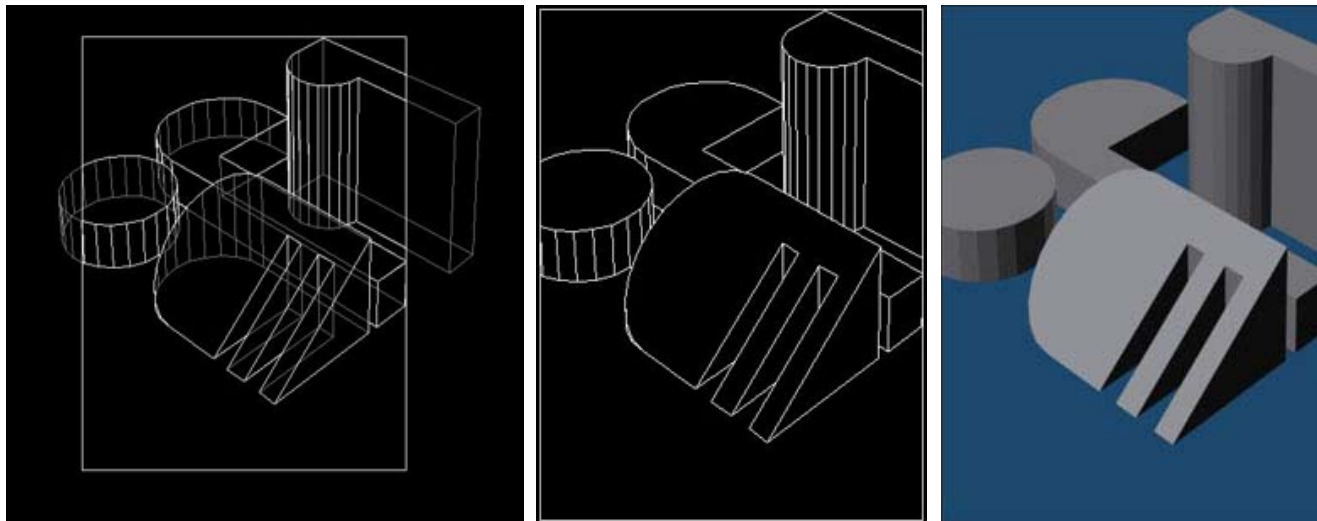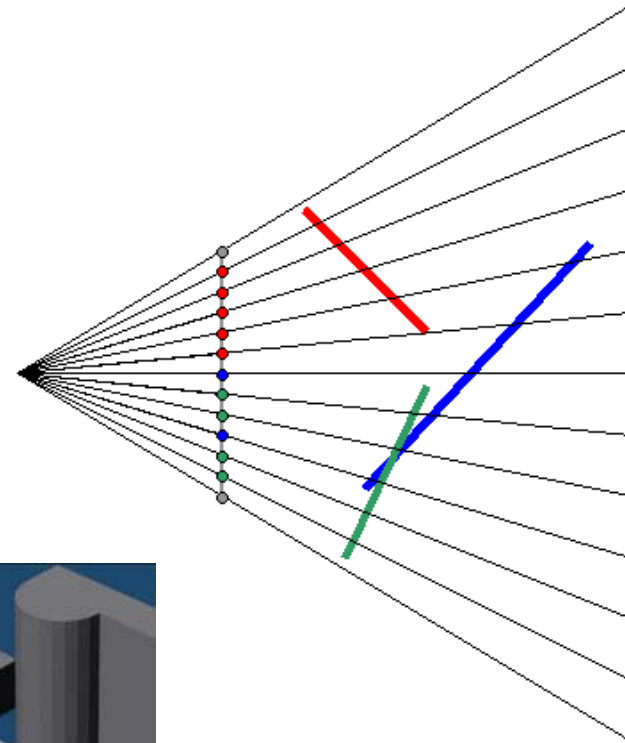
3D Models and Interaction

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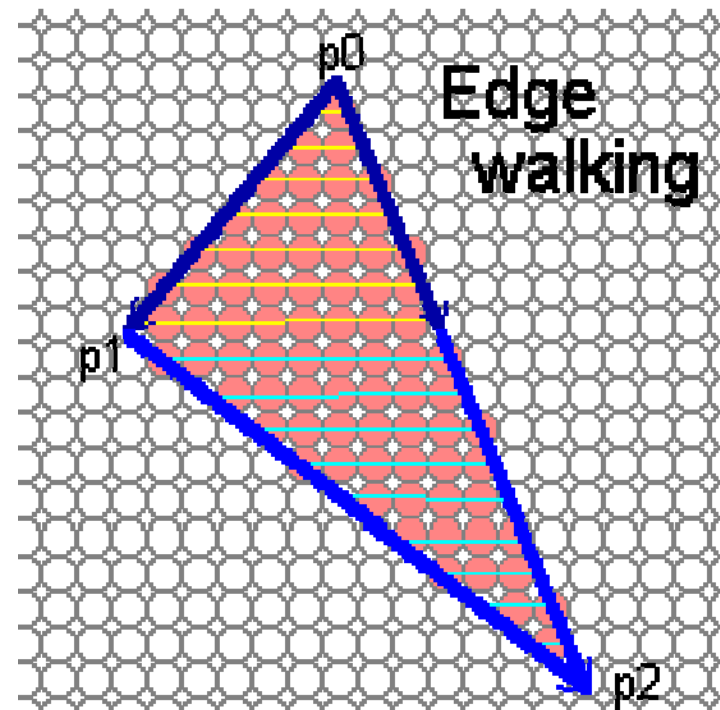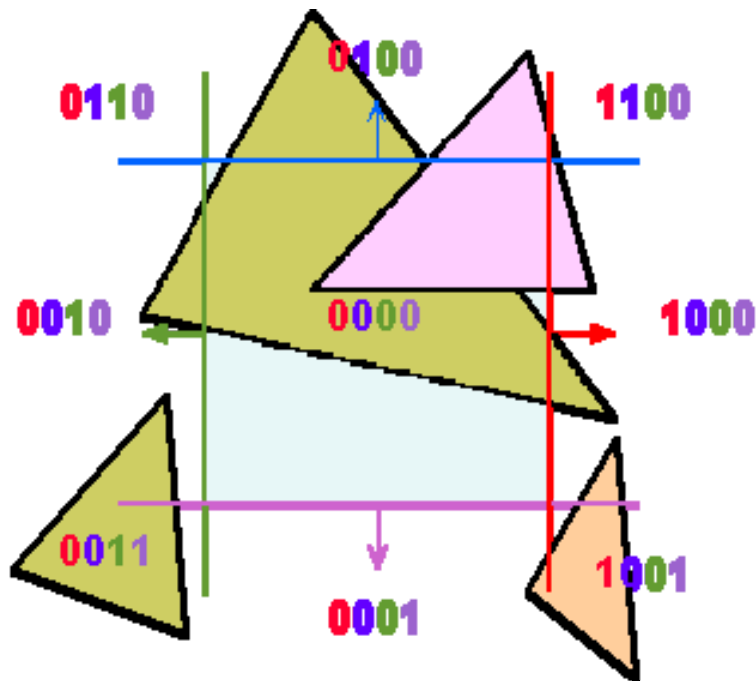- **Virtual reality (VR) is all about interaction**

Hidden Surface Removal

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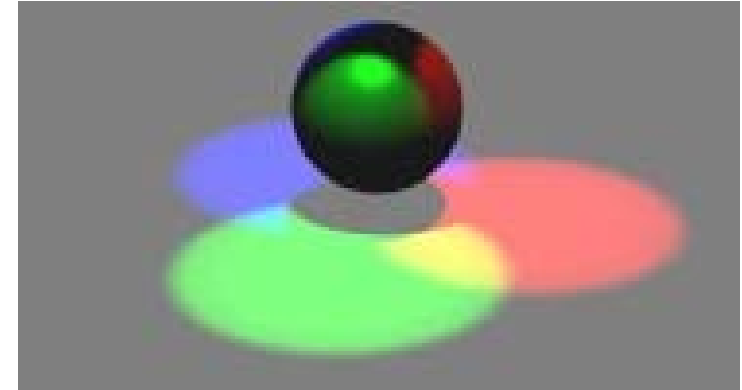- **Ray casting**
- **Depth buffering**

Rasterization
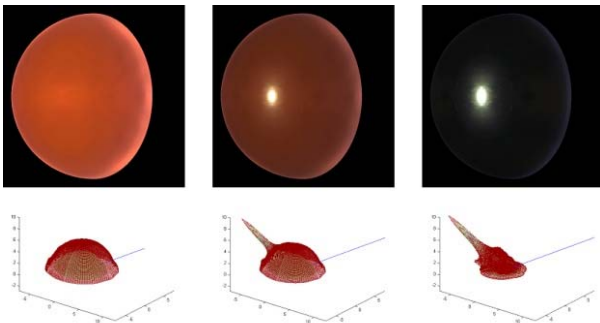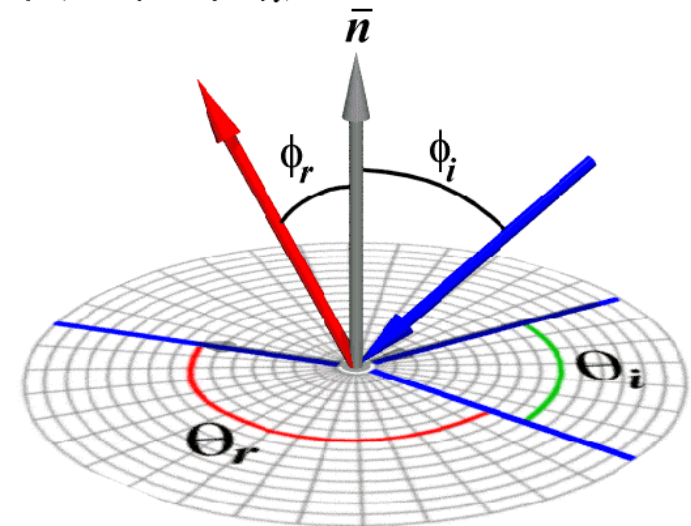
- **Clipping**
- **Scan conversion**

Lighting and Shading

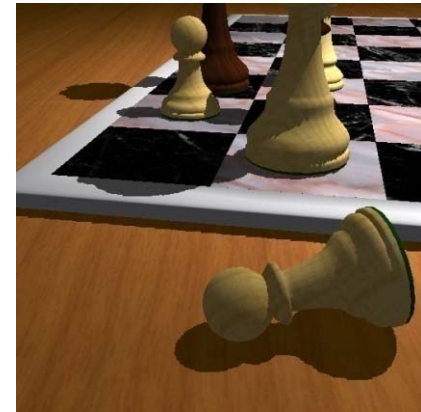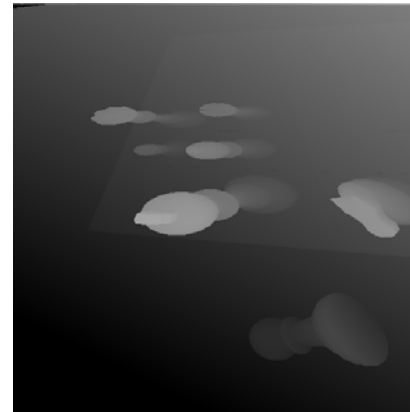- **Flat, gouraud, and phong shading**
- **Empirical and physically-based illumination models**
- **BRDFs**

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

Shadows

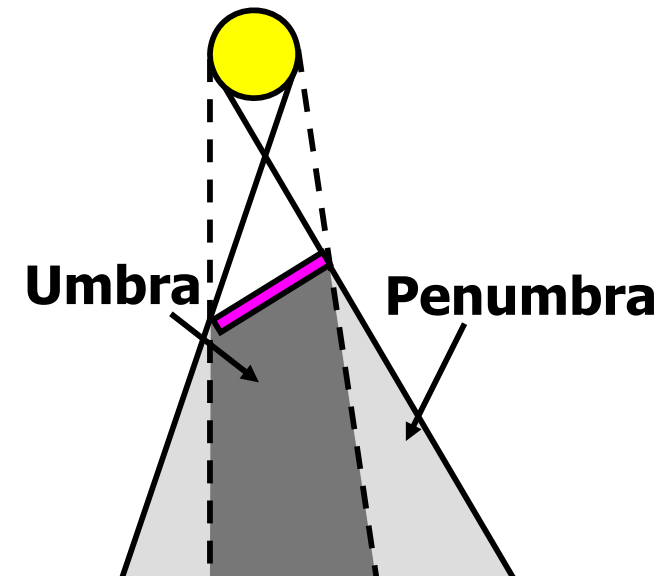- **Shadow volumes**
- **Shadow maps**

Images courtesy of Stamminger and Drettakis 02

Umbra   **Penumbra**

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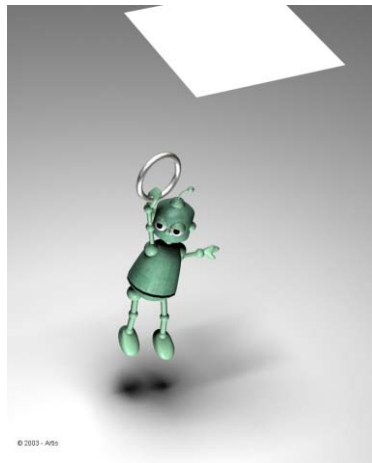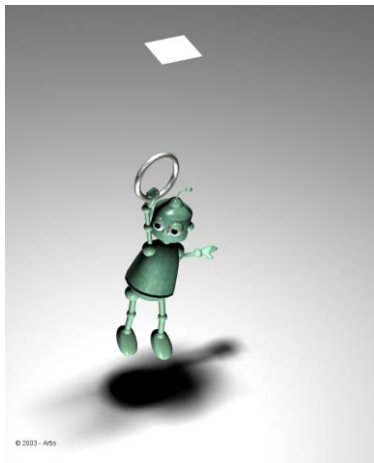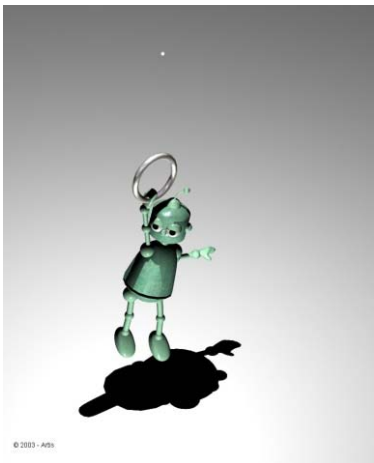
Texture Mapping

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

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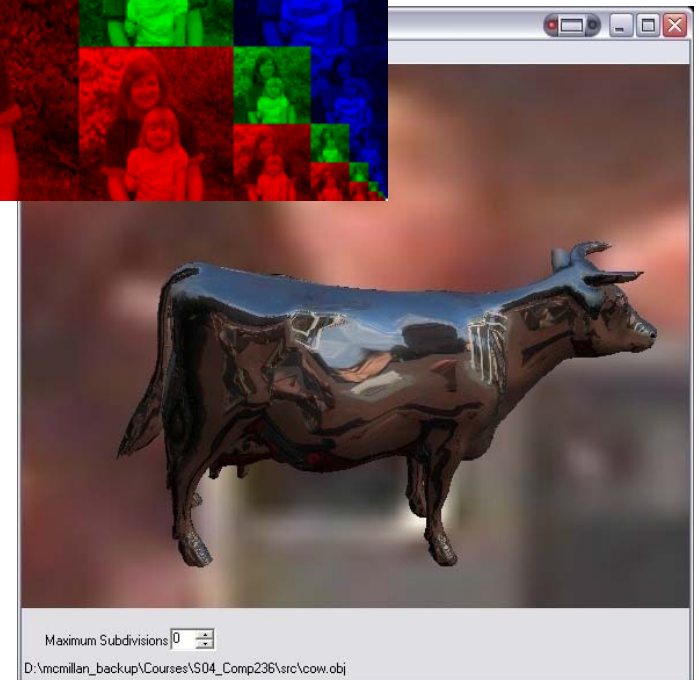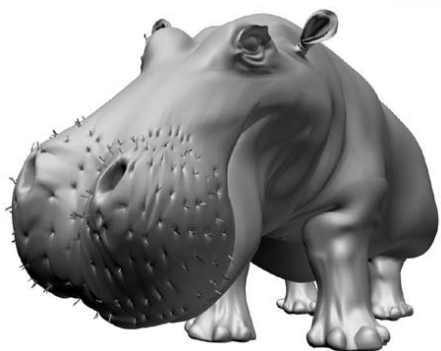
Ray Tracing

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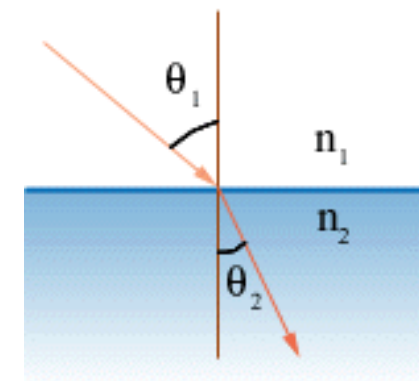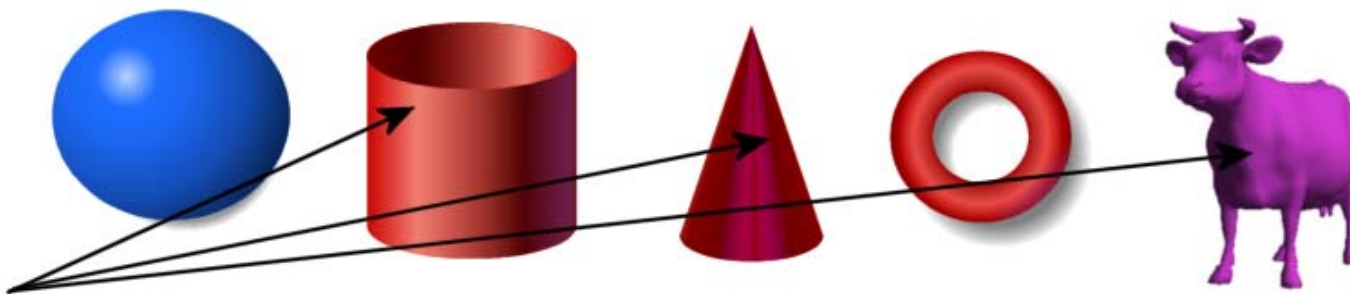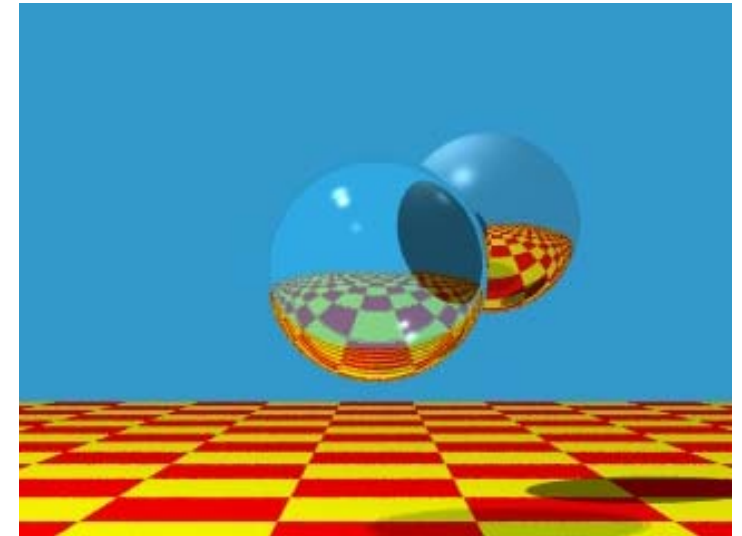
Global Illumination

- **Rendering equation**
- **Path tracing, photon mapping, radiosity**
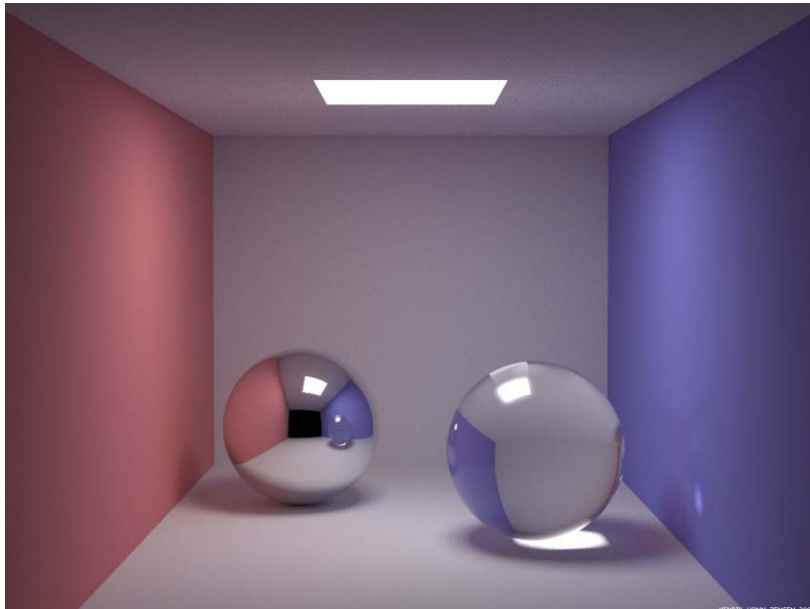
Images courtesy of Caligari (www.caligari.com)

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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*
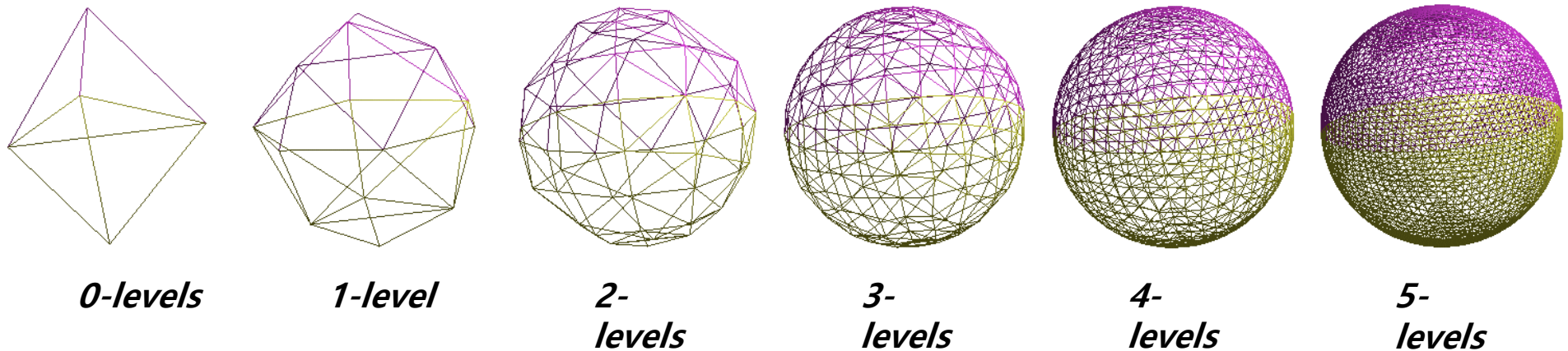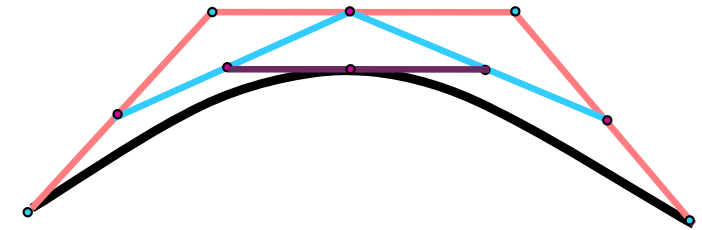
Simplification and LOD

- **Levels of detail**
- **Progressive meshes**

82 million triangles
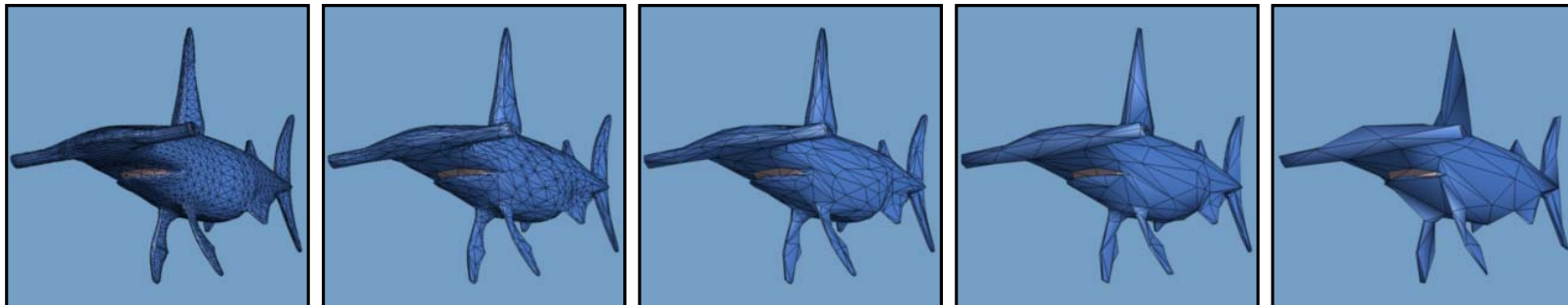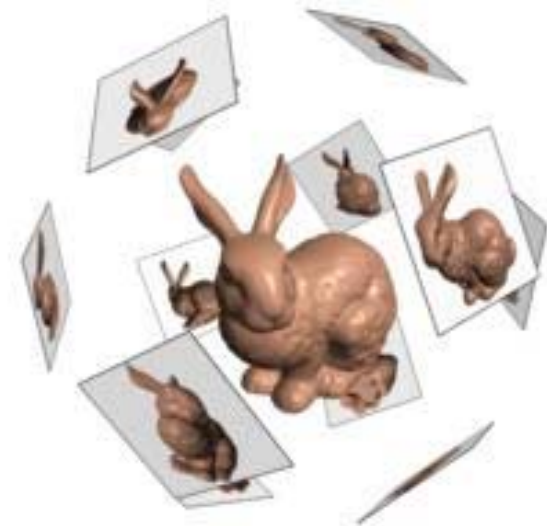
Graphics Hardware

- **History**
- **Architecture**
- **Shading languages**
- **Future**

Excerpted from GPU Gems 2
Copyright NVIDIA Corp. 2005

Host

Vertex Processing — 2-6 MIMD Units

Cull / Clip / Setup

Z-Cull — Rasterization

16 - SIMD Units
4 units each
processing a
2 x 2 block

Texture and
Fragment Processing — Texture Cache

Fragment Crossbar

Z-Compare
and Blend

Memory Partition | Memory Partition | Memory Partition | Memory Partition

DRAM(s) | DRAM(s) | DRAM(s) | DRAM(s)
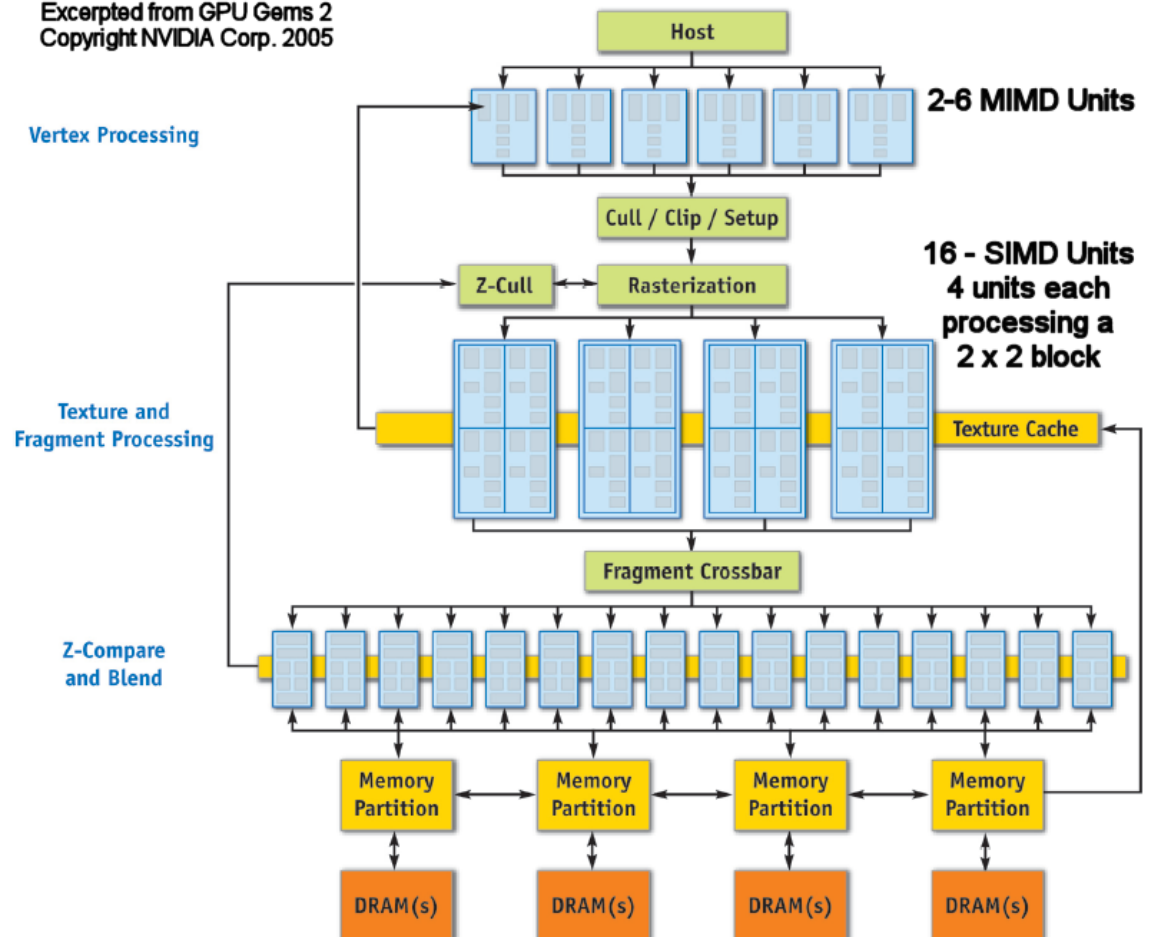
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Animation

- **Keyframing**
- **Parameteric splines**
- **Motion capture**
- **Simulation**
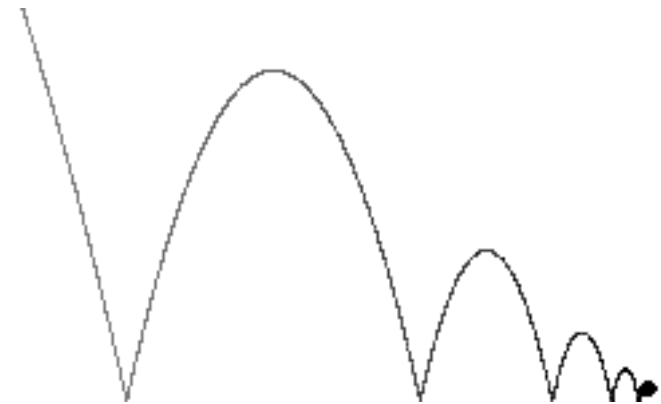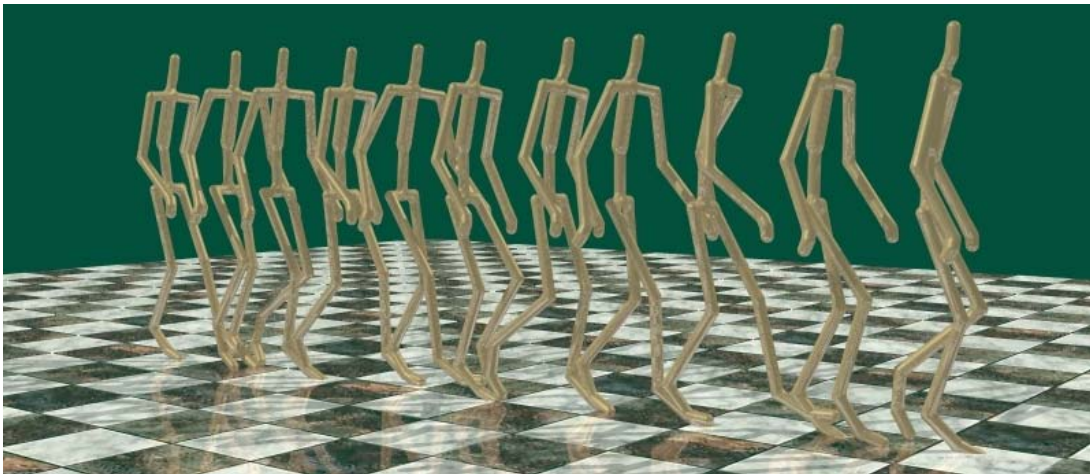
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Textbook

- **Rendering**
  - **Sung-eui Yoon**
  - **1st Edition, 2018**
  - **Freely available**

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RENDERING

FREELY AVAILABLE ON THE INTERNET

https://sgvr.kaist.ac.kr/~sungeui/render/
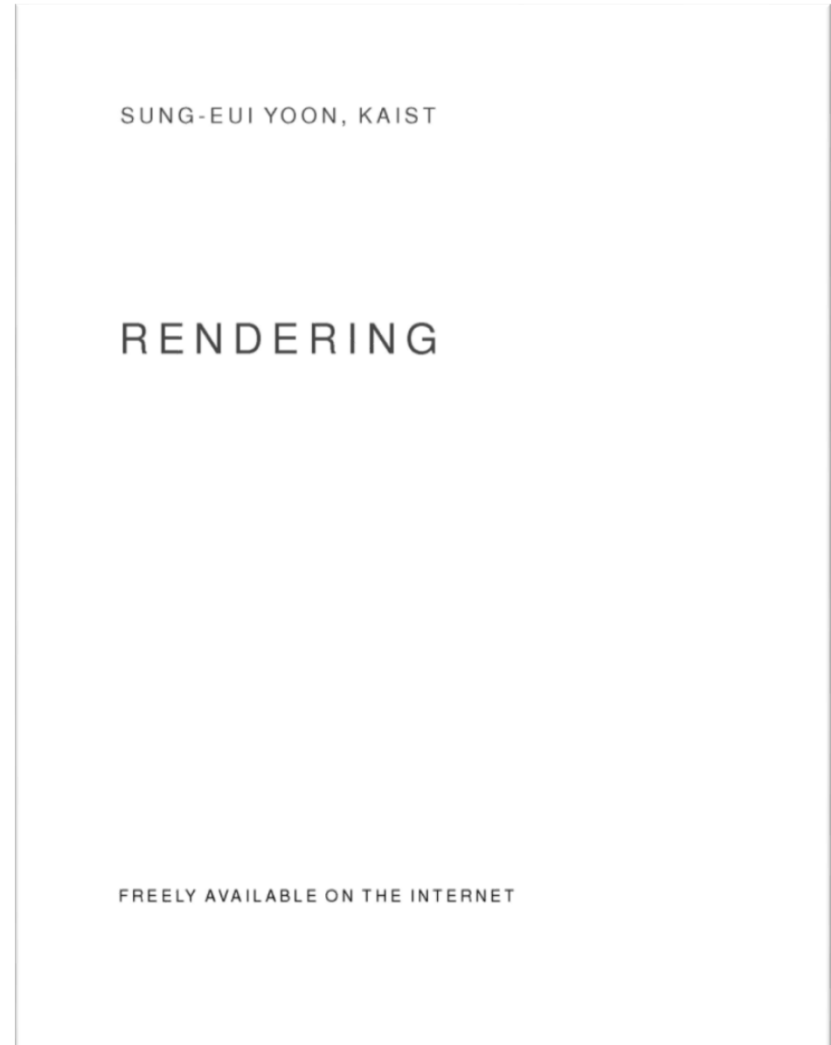
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Reference – OpenGL

- **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
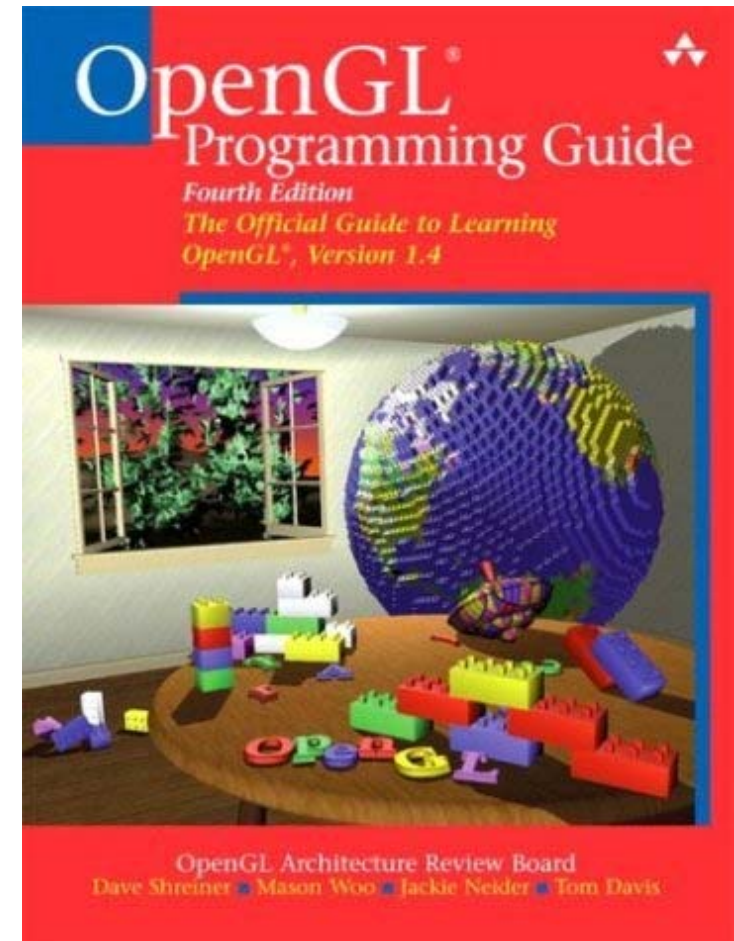
Reference

- **Fundamentals of Computer Graphics**
  - **Peter Shirley et al.**
  - **AK Peters**

  - **Available at the KAIST library**
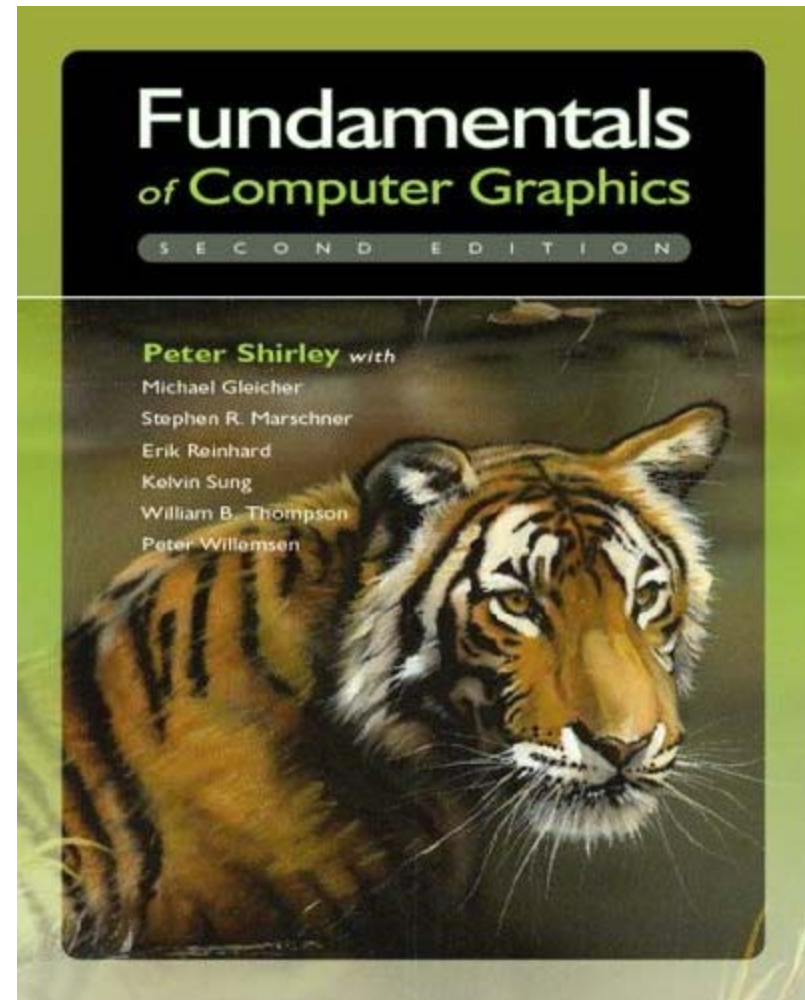
Resource on Physically-based Rendering

- **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.**
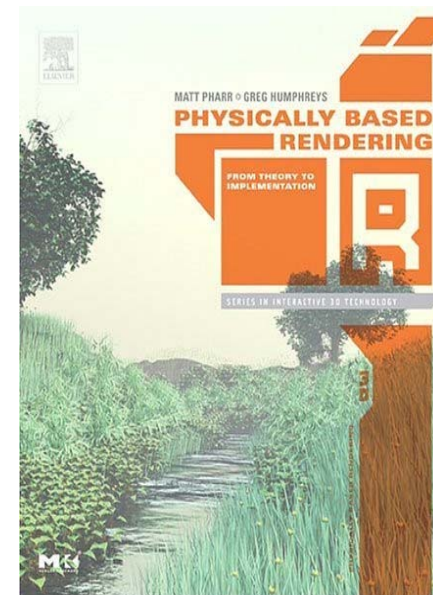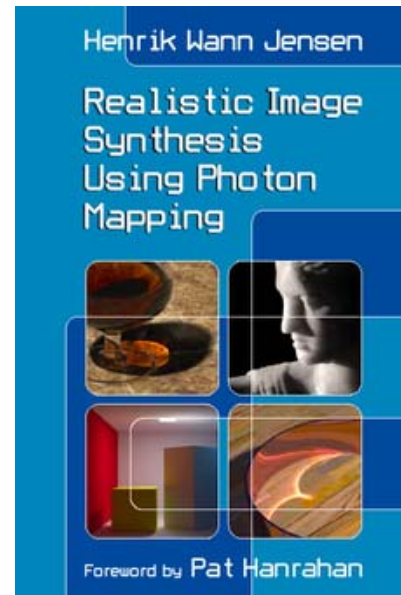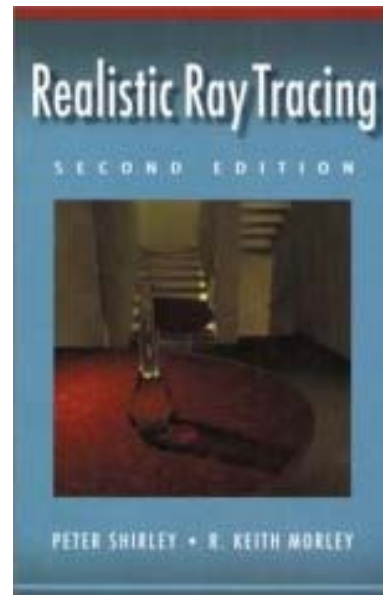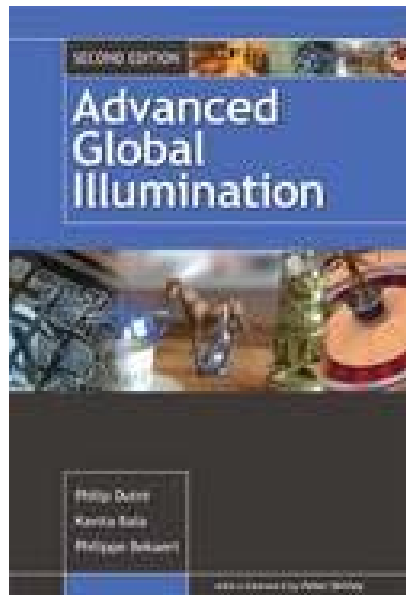
Other Reference

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

- **Course homepages**
- **Google or Google scholar**

Program Assignments (PAs) and Quiz

- **6 or 7 PAs**
  - **Viewing and manipulating 3D models with OpenGL**
  - **Rasterization and clipping**
  - **Texture mapping and lighting**
  - **Raytracing**
  - **Their difficulty is growing!**
  - **Require you to know or self-study C/C++**

- **Quiz**
  - **We will frequently have quiz sessions, which also serve as attendance check**

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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 summary submission every week**
  - **Preparation for poster presentation**

- **Question submissions two times during the whole semester**

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Poster Presentation

- **Related to research activity, which is useful for your long-term career**

- **Make a team of 2 persons**
- **Identify a paper and present poster presentation near the end of the semester**
  - **Discuss the paper among the team for better understanding**

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Grading

- **Mid-term:** **20%**
  Final-term: **30%**
  Quiz and assignments: **40%**
  Poster presentation: **10%**

- **Late policy**
  - **No score for late submissions**
  - **Submit your work before the deadline!**

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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 w/ proper certificate or official documents**

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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**

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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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Next Time...

- **Screen & world space**
- **Basic OpenGL usage**

About You

- **Name**

- **What is your major?**
- **Previous graphics experience**

- **Any questions?**

- **Online submission within today**
  - **https://forms.gle/aHT8abgjaYAsV2wDA**
  - **You can also find the link at the course homepage**

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