CS580:
Graduate-Level Computer Graphics
- Focus on rendering

Sung-Eui Yoon
(윤성의)

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

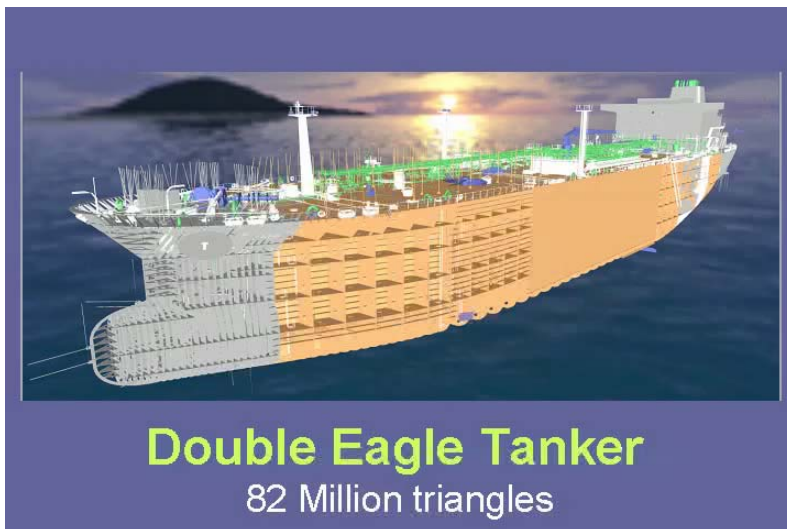**KAIST**

About the Instructor

- **Main research focus**
  - **Rendering, Graphics, Vision, and Robotics**
- **Paper and video**
  - **https://sgvr.kaist.ac.kr/publication/**
  - **YouTube videos**
  - **http://www.youtube.com/user/sglabkaist**

Double Eagle Tanker
82 Million triangles

About the Instructor

- **2018~: ACM Senior member**
- **2015: Gave a SIGGRAPH tutorial on image-space denoising**
- **2012~: IEEE Senior member**
- **2011~2012: conf. and program co-chairs of ACM symp. on Interactive 3D Graphics and Games (I3D)**
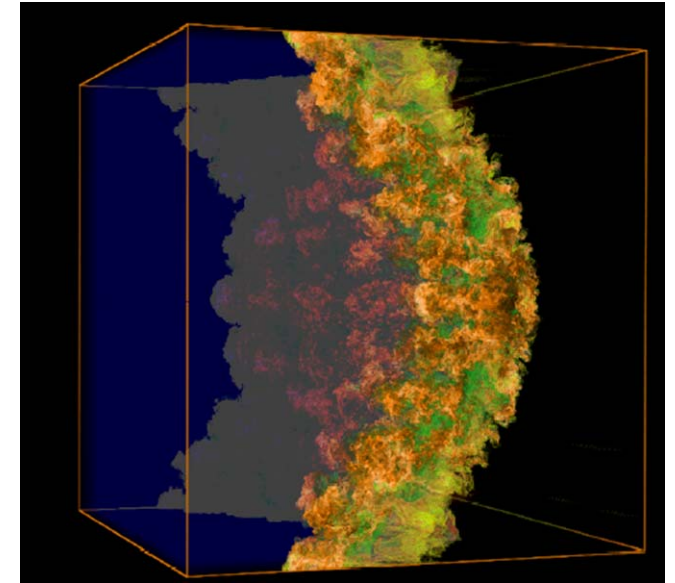- **2007: Joined KAIST**

Past: Rendering Massive Geometric Data

Boeing 777, 470 M tri.

Large-scale virtual world, 83 M tri.

Scanned model, 372 M tri. (10 GB)

Over 3 Terabytes of geometric data

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Present: Scalable Ray Tracing, Image Search, Motion Planning

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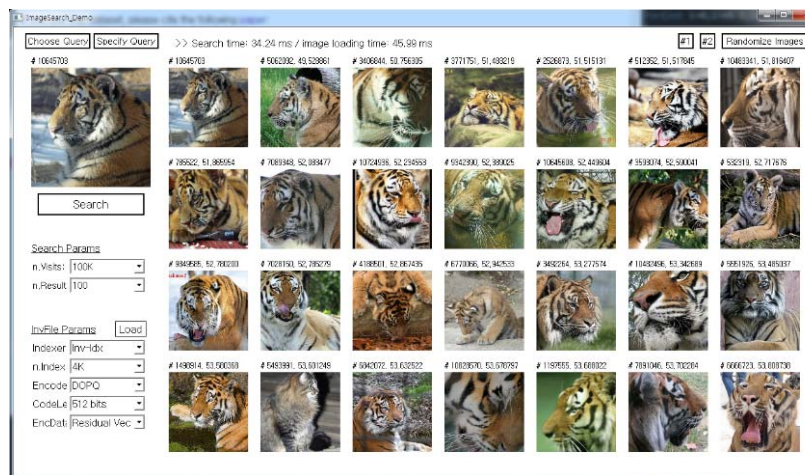

Photo-realistic rendering

Image search

Motion planning

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Recognitions and Collaborations

- **Test-of-Time Award 2006 at 2015, High Performance Graphics**

- **Produced a few professors at GIST (렌더링), KOREATECH (시뮬레이션, 충돌탐지), SKKU (이미지 검색)**

- **Worked on research collaborations with many domestic and international companies, and funding agencies**

About the Instructor

- **Contact info**
  - **Email: sungeui@kaist.edu**
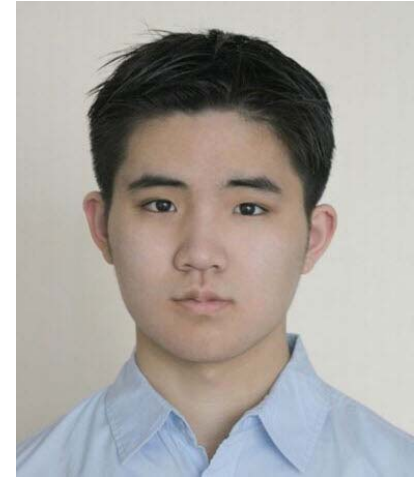 - **Office: 3432 at CS building (E3-1)**
  - **Homepage: http://sgvr.kaist.ac.kr/~sungeui**

Class Information

- **Class time**
  - **10:30am ~ 11:45pm on TTh**

- **Office hours**
  - **Right after class**

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TAs

- **Hunmin Park (박훈민)**
  - **mathematicianscott@gmail.com**
  - **E3-1, Room 3440**
  - **Office hour: right after the class on Thur.**

- **Share questions on KLMS first, before sending emails to TAs**

Overview

- **We will discuss various parts of computer graphics**

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

Computer vision inverts the process
Image processing deals with images
Robotics/AR combine real and virtual worlds
How about sounds?

Application of Computer Graphics

- **Games**
- **Augmented or virtual reality (AR/VR)**
- **Movies and film special effects**
- **Product design and analysis**
- **Medical applications**
- **Scientific visualization**

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Games

2D game

3D shooting game

Game Industry at Korea

- **One of biggest IT sectors in Korea**

  창원에 엔씨소프트 프로야구단 생긴다(종합)

새롭게 창단하는 구단은 모기업의 당기 순이익이 1천억원 이상이거나, ...

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
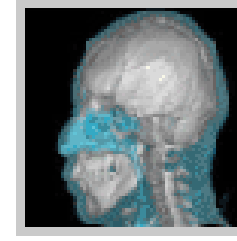

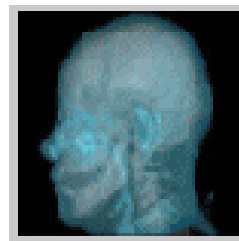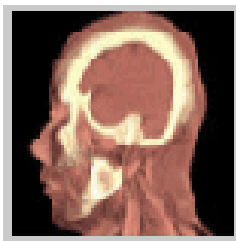**Toy story**
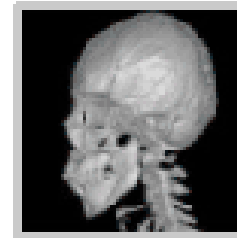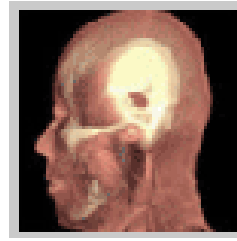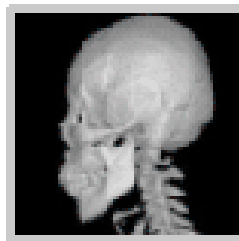

Matrix

3D Movies

Avatar

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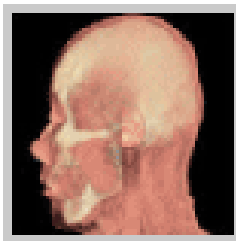# Product Design and Analysis

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

Medical Applications

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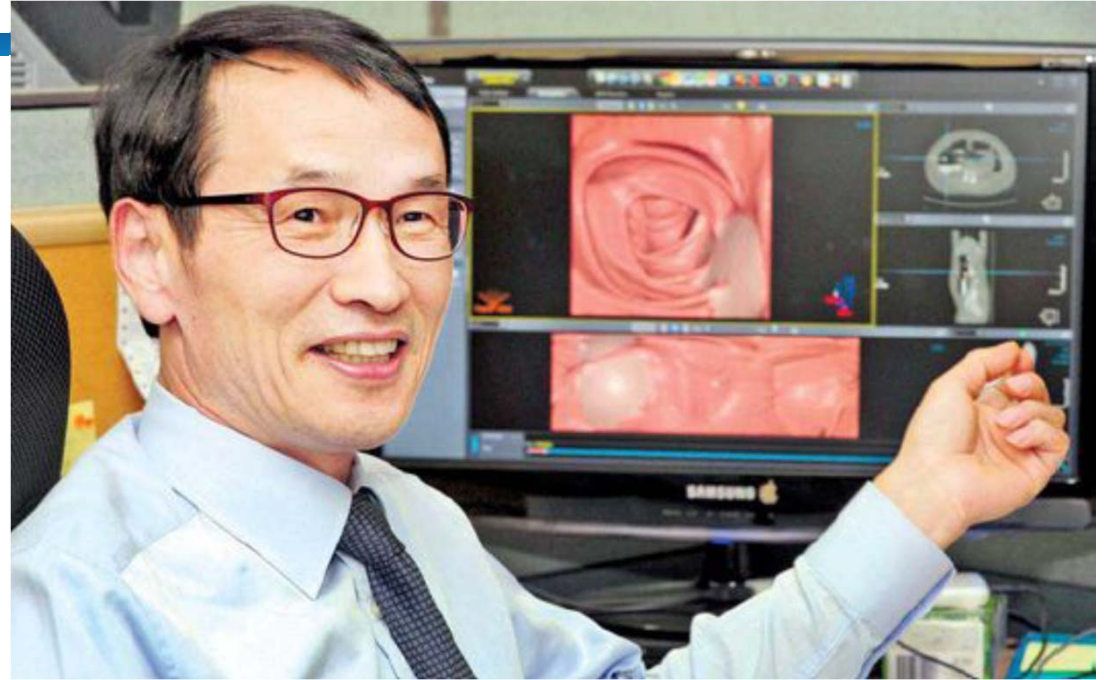

Rapidia homepage

Medical Applications

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

Wikipedia

Mouse skull (CT)

Medical Applications

벤처 성공으로 유명세 타

... 신 교수는 **1990**년 대학원 학생들과 실험실 벤처 '**3D**메드'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... .

Scientific Applications

- **Weather visualization**
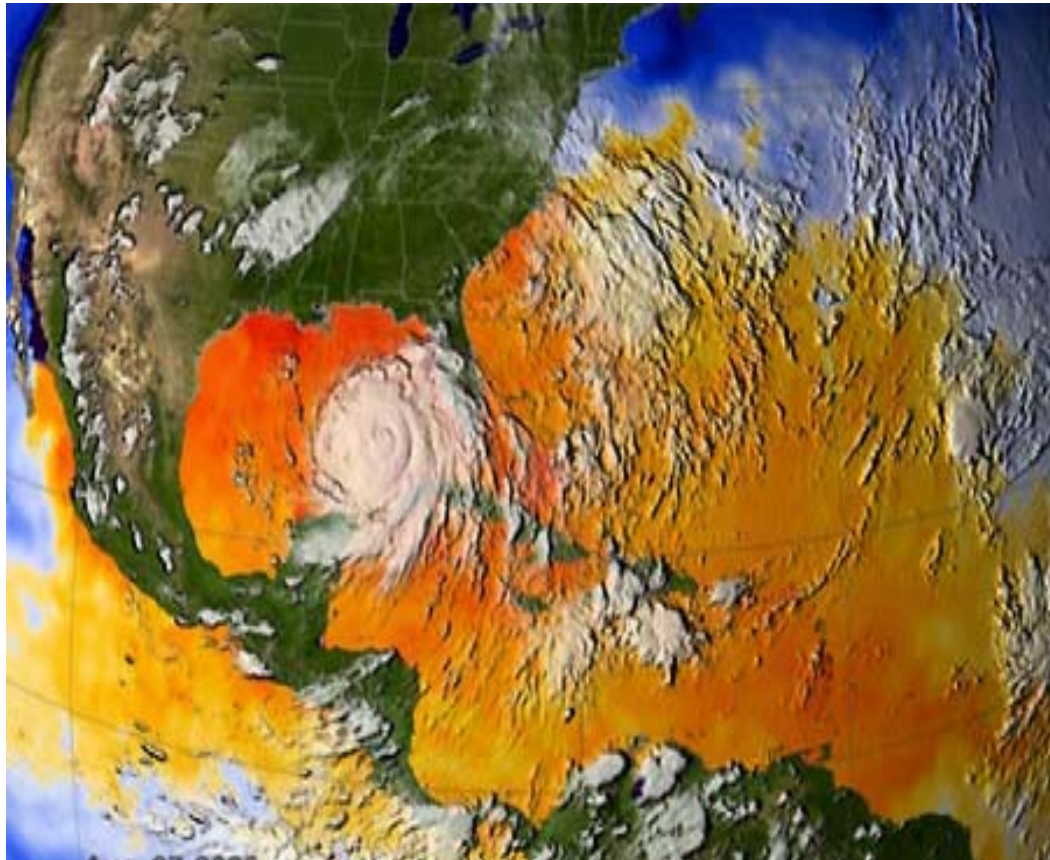
LLNL

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
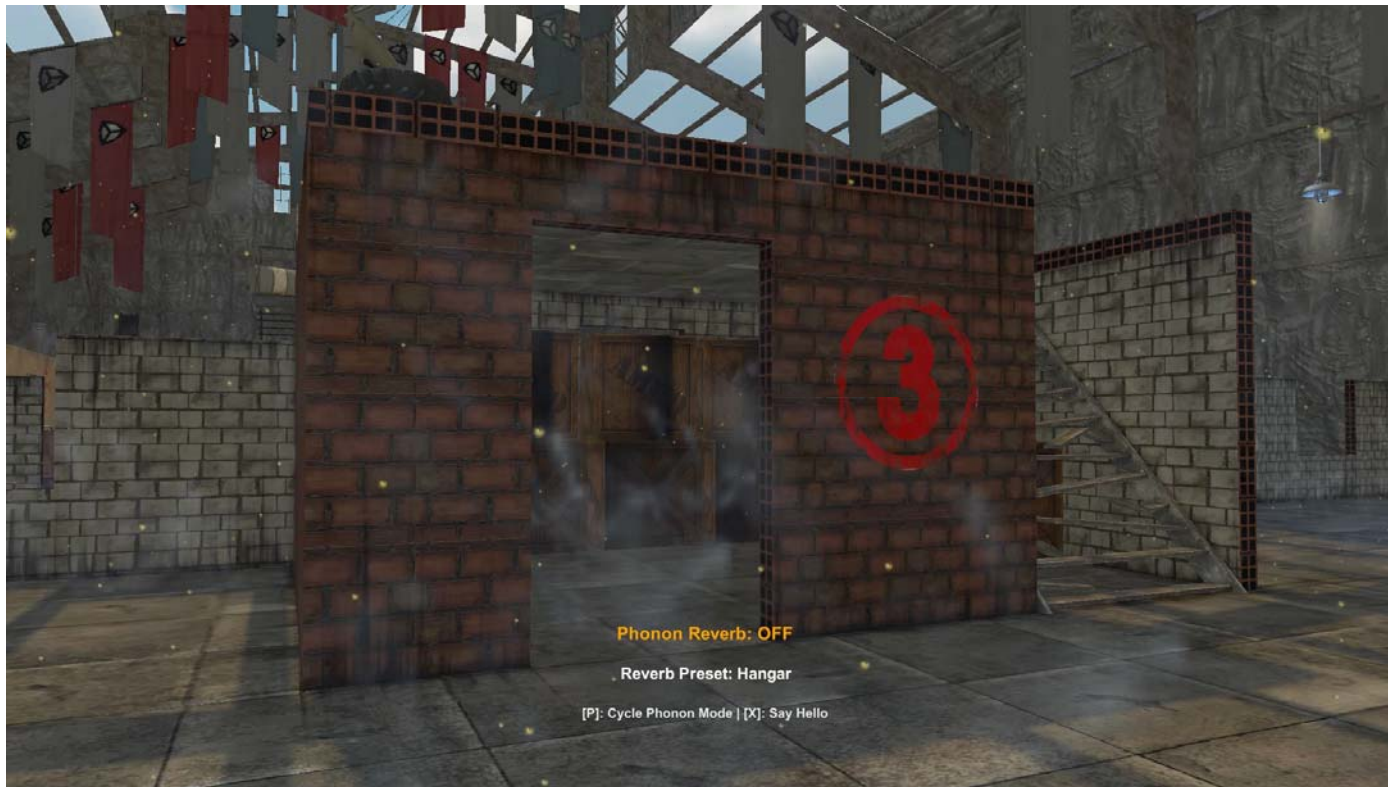
Sound Rendering

Sound Localization

- **React to sound in AR applications**
  - **Tightly couple real and simulated environments**
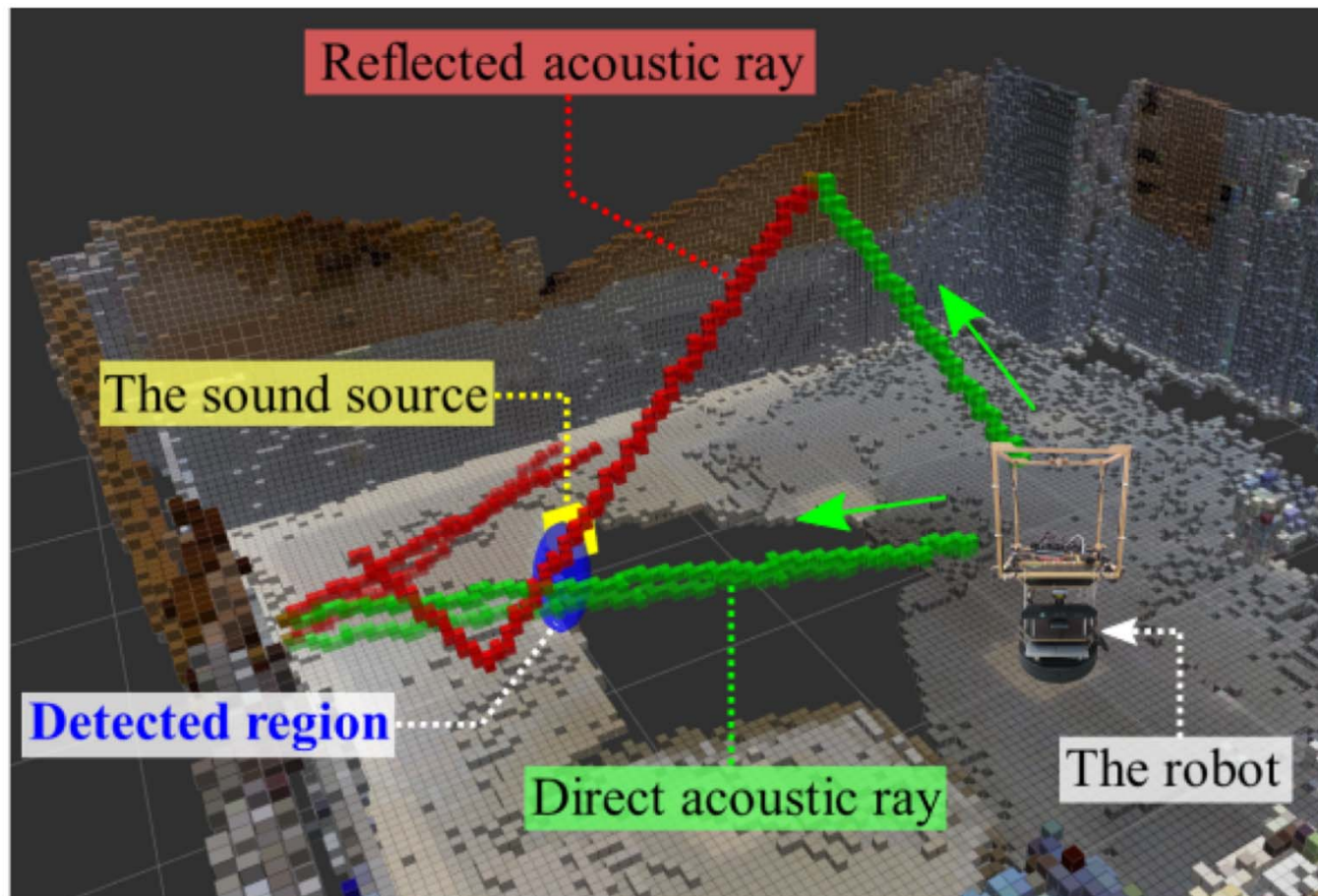
About the Course

- **We will focus on the following things:**
  - **Study basic concepts of physically-based rendering**
  - **Discuss various basic concepts of computer graphics**
  - **Implement a recent technique, and discuss its pros and cons**

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Photo-Realistic Rendering

- **Achieved by simulating light and material interactions**

from Prof. Bala's slide

- **Rendering equation**
  - **Mathematical formulation of light and material interactions**

Global Illumination (GI)

- **GI algorithms solve the rendering equation**
  - **Generate 2D image from 3D scene**
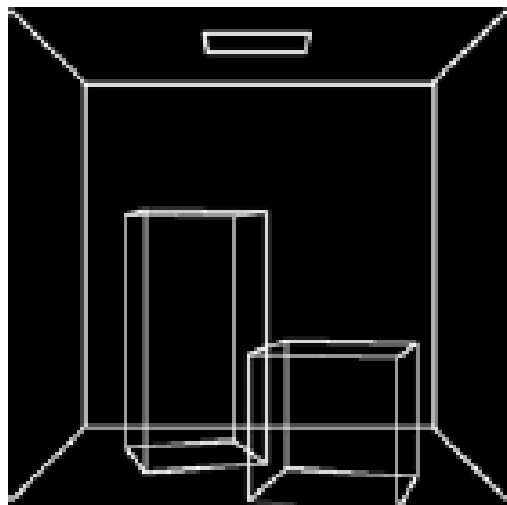
from Prof. Bala's slide

$\Rightarrow$ **GI Algorithm** $\Rightarrow$

+
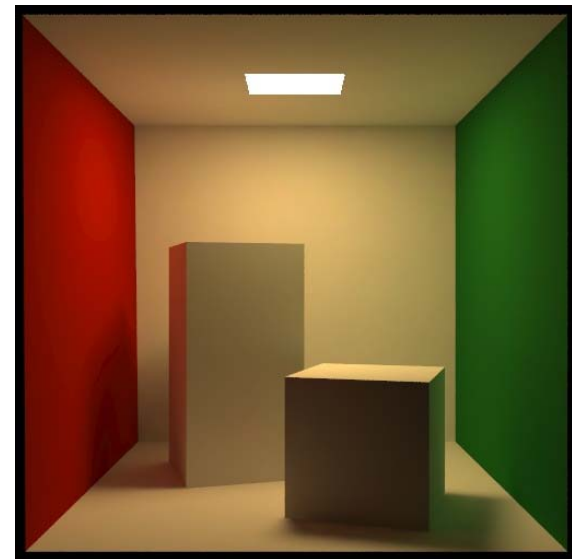
Emission (light sources)
Geometry (objects)
BRDF (materials)

Classic Methods of GI

- **Ray tracing**
  - **Introdued by Whitted in 1980**
- **Radiosity**
  - **Introduced in 1984**
- **Monte Carlo rendering**

Ray Tracing

- **Assume perfect specular or diffuse material**
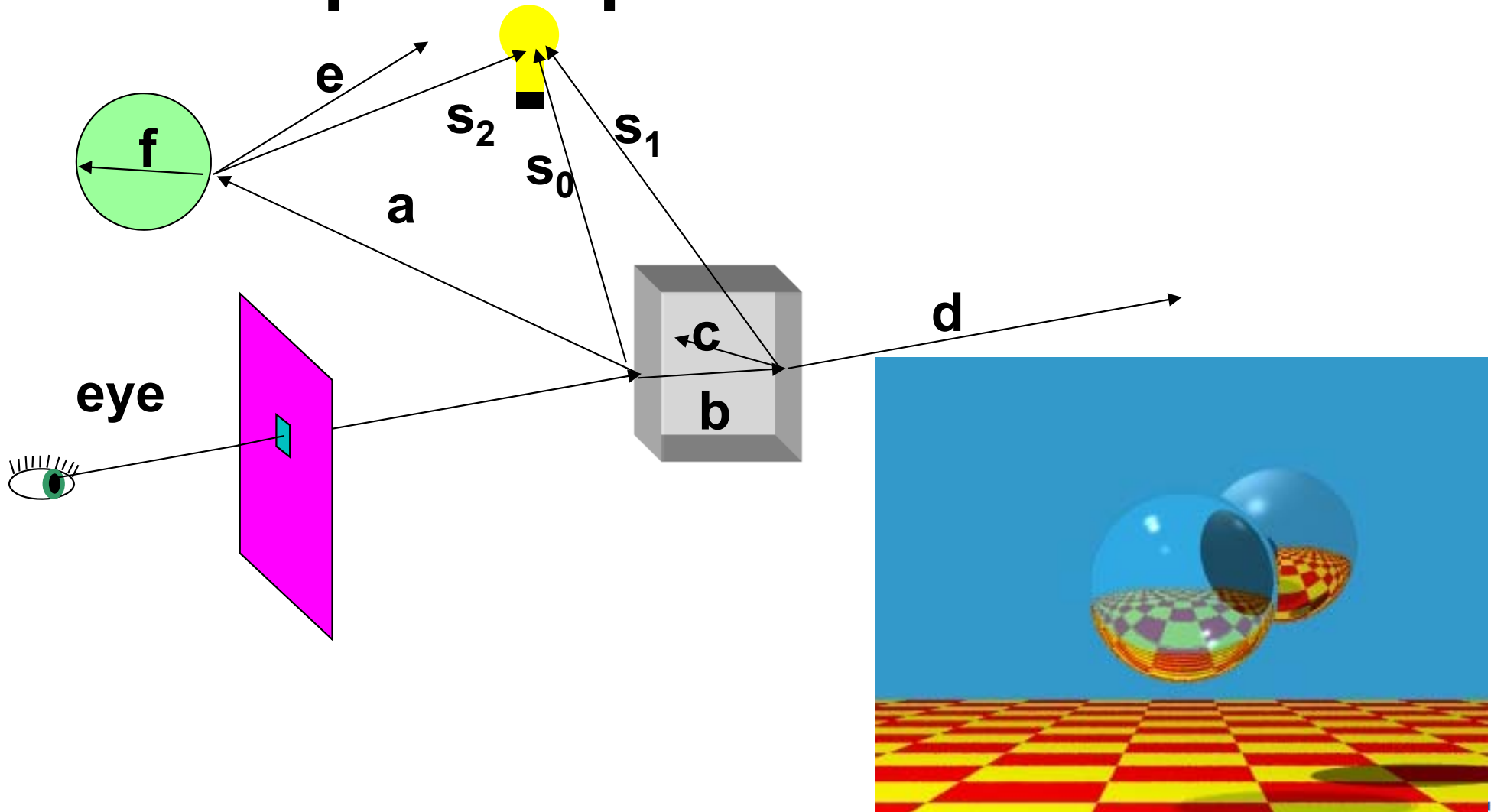
Radiosity

- **Assume diffuse inter-reflections**

Advanced Global Illumination

- **Extend to handle more realistic materials than just perfect specular/diffuse**
  - **Classic ray tracing and classic radiosity are basic building blocks**

from photon map paper

from Pixar movie

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Sound and AR/VR Applications

- **How can we interactively generate sounds?**
- **How can we effectively locate sound sources?**
- **How can we integrate them with AR/VR applications?**

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Indoor Light Estimation
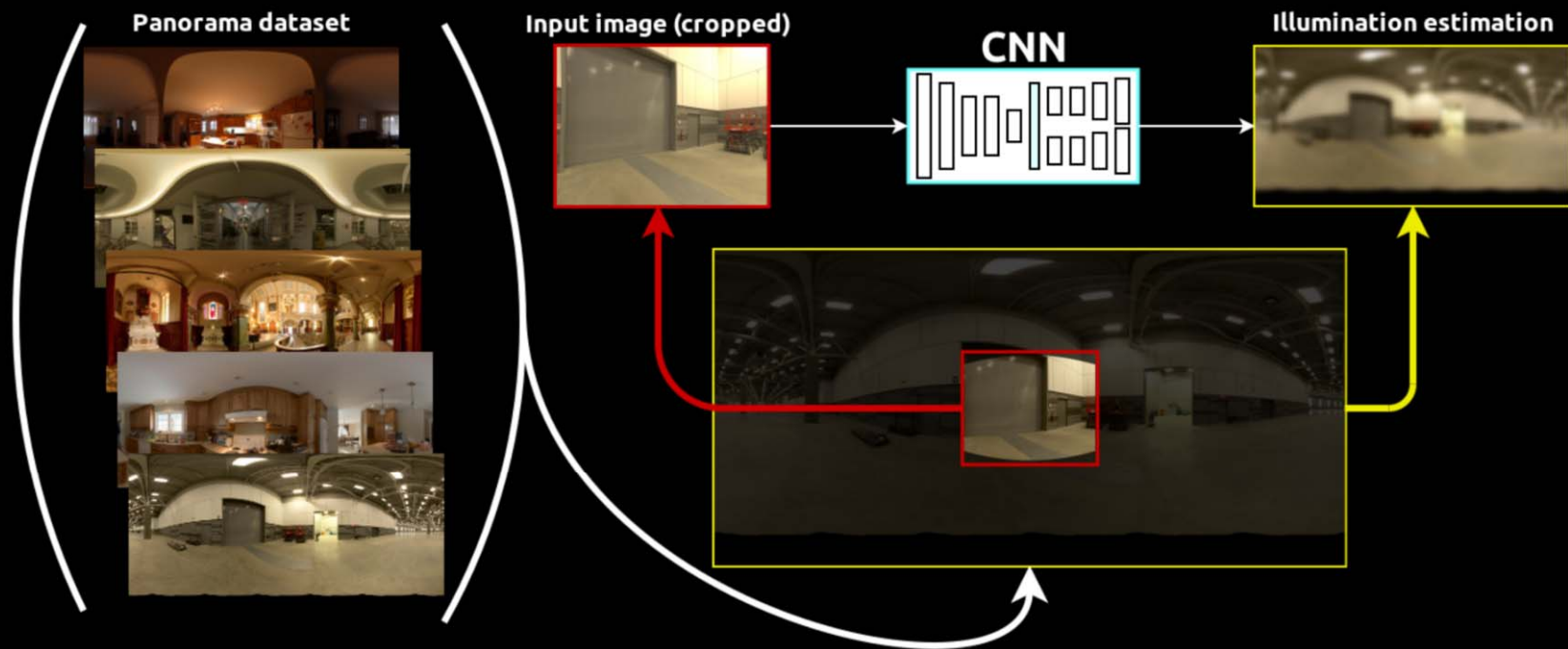
Gardner et al.

Some of Topic Lists

- Ray tracing
- **Path tracing**
- BRDF
- **Rendering equations**
- **Monte Carlo method**
- Textures
- Lighting and shading
- Radiosity
- Instant radiosity

- GPU acceleration
- Sampling and reconstruction
- Sound rendering and localization
- **Rendering for AR/VR**
- **Deep learning for light/material estimation**

Prerequisites

- **Programming skill (C/C++)**

- **Understanding on data structures (e.g., stack) and linear algebra (e.g., matrix multiplication)**

- **We do not teach deep learning (DL)**
  - **Discuss only high-level concepts**
  - **If you want to do deep learning related projects, you need to prepare such basic knowledge**

- **If you are not sure, please consult the instructor at the end of the course**
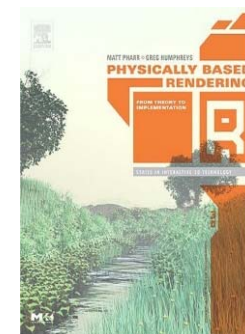
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Resource

- **Rendering**
  - **1st edition, July 2018, 148 pages**
  - **Sung-eui Yoon, Copyright 2018**

- **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.**
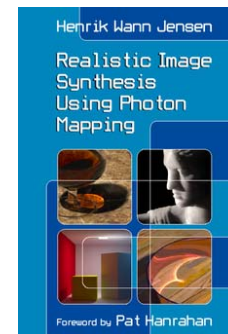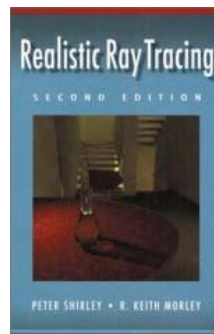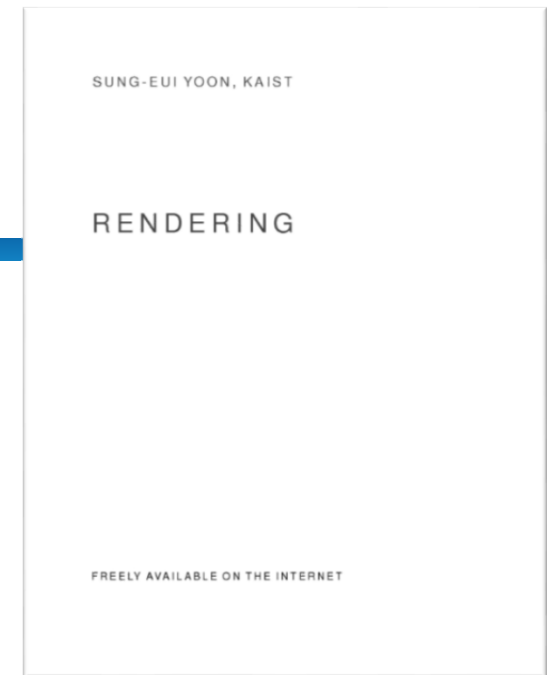
Other Reference

- **Technical papers**
  - **Graphics-related conference (SIGGRAPH, etc)**
  - **http://kesen.huang.googlepages.com/**
- **SIGGRAPH (Asia), ISMAR, CVPR/ICCV, ICRA/IROS papers and tutorials**
- **Course homepages**
- **Google or Google scholar**

Course Overview

- **Half lectures and another half for student presentations**
  - **Mid-term & final-term exams with a few quiz**
  - **Two programming assignments**
  - **A few paper presentations**
  - **Team project (Major activity)**

- **Edu 4.0 Course**

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What you will do

- **Paper presentation and final team project**
  - **Make a team of two or three members**
  - **Choose a topic for the team, and each team member presents a paper related to it**
  - **All the team members implement techniques of a paper**
    - **Role of each team member should be clear**
  - **Present what the team did for the team project**

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Course Awards

- **Best speaker and best project**
  - **Lunch or dinner for awardees with me and TAs**

- **A high grade will be given to members of the best project**

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Grading

- **Quiz, assignments, and exams: 30%**
- **Class presentations: 30%**
- **Final project: 40%**

- **Late policy**
  - **No score for late submissions**
  - **Submit your work before the deadline!**
- **Instructor and students will evaluate presentations and projects**
  - **Instructor: 50% weights**
  - **Students: 50% weights**

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**

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Honor Code

- **Collaboration encouraged, but *assignments must be your own work***
- **Cite any other's work if you use their code**

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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**

Schedule

- **Please refer the course homepage:**
  - **http://sgvr.kaist.ac.kr/~sungeui/GCG/**

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Homework for Every Class

- **Go over the next lecture slides**
- **Come up with one question on what we have discussed today and submit at the end of the class**
  - **1 for already answered questions**
  - **2 for questions with thoughts or that surprised me**

- **Write a question at least 3 times before the mid-term exam**
  - **Online submission is available at the course webpage**

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My Responses to Those Questions

- **Identify common questions and address them at my book**
- **Some of questions will be discussed in the class**

- **If you want to know the answer of your question, ask me or TA on person**
  - **Feel free to ask questions in the class**
- **We are focusing on having good questions!**
  - **All of us have been already well trained for answering questions**

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Homework

- **Watch 2 SIGGRAPH (Asia) Videos**
  - **EGSR, HPG and I3D are also possible**
  - **ISMAR, ICRA, ECCV/ICCV are also possible**
  - **Write their summary and submit before the beginning of every Tue. class through online**

- **Example of a summary**
  - **Just one paragraph for each abstract**

  Title: XXX XXXX XXXX, Conf: XXX, Year: 2017
  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.

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About You

- **Name**
- **Your (non hanmail.net) email address**

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

- **Any questions**

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Next Time

- **Ray tracing and radiosity**

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