CS482:
Interactive Computer Graphics
- Focus on Sound Rendering & AR/VR

Sung-Eui Yoon
(윤성의)

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

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About the Instructor

- 2018~: ACM Senior member
- 2012~: IEEE Senior member
- 2011~2012: conf. and program co-chairs of ACM symp. on Interactive 3D Graphics and Games (I3D)
- 2011~2013: 이원부교수
- Joined KAIST at 2007

- Main research focus
  - Scalability of rendering, robotics, and vision

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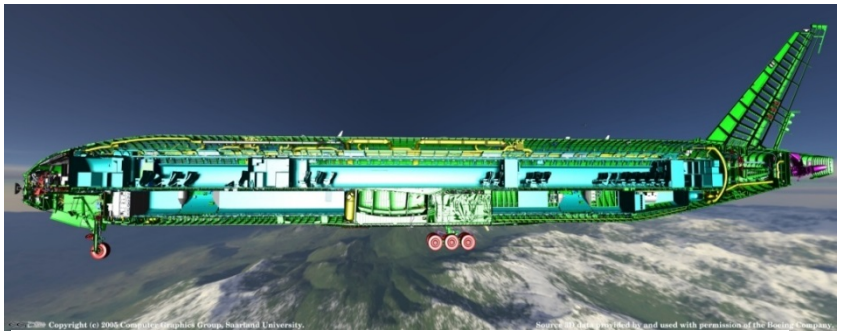
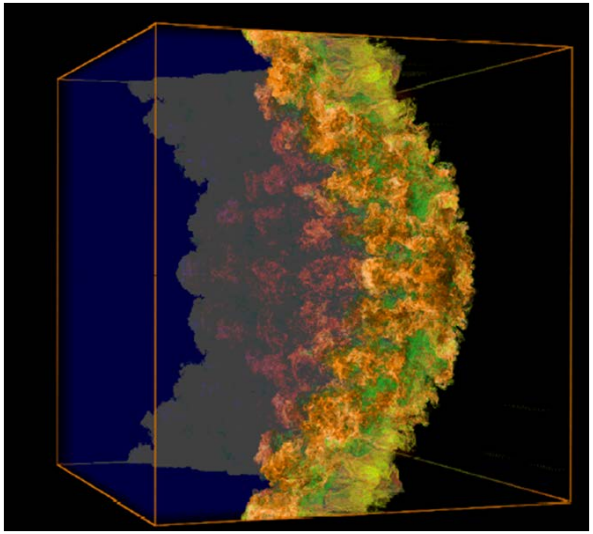
Past: Rendering Massive Geometric Data



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

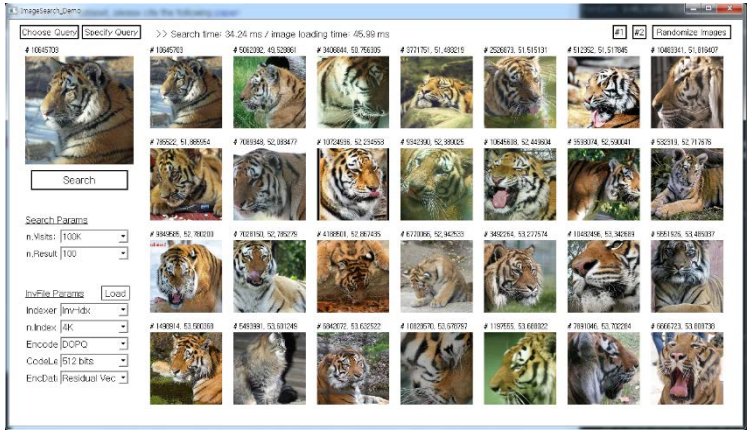

Image search

Motion planning

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About the Instructor

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

Class Information

- **Class time**
  - **10:30am ~ 12:00pm on TTh**
  - **112 at N1**
- **Office hours**
  - **Right after class**

TA Information

- **Inkyu Ahn (안인규)**
  - **dksdlsrb89@gmail.com**
  - **Office hour: right after the class on Tue**
  - **Room: E3-1 #3440**

- **Doheon Lee (이도헌)**
  - **doheonlee95@gmail.com**
  - **Office hour: right after the class on Thur**
  - **Room: E3-1 #3443**

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

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Overview

- **We will discuss various parts of computer graphics, especially on interactive rendering**

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

Computer vision inverts the process

Image processing deals with images

Robotics/AR combine real and virtual worlds

How about sounds?

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Applications of Computer Graphics

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

Games

2D game

3D shooting game

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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

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Movies and Film Special Effects

Toy story

Matrix

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3D Movies

Avatar

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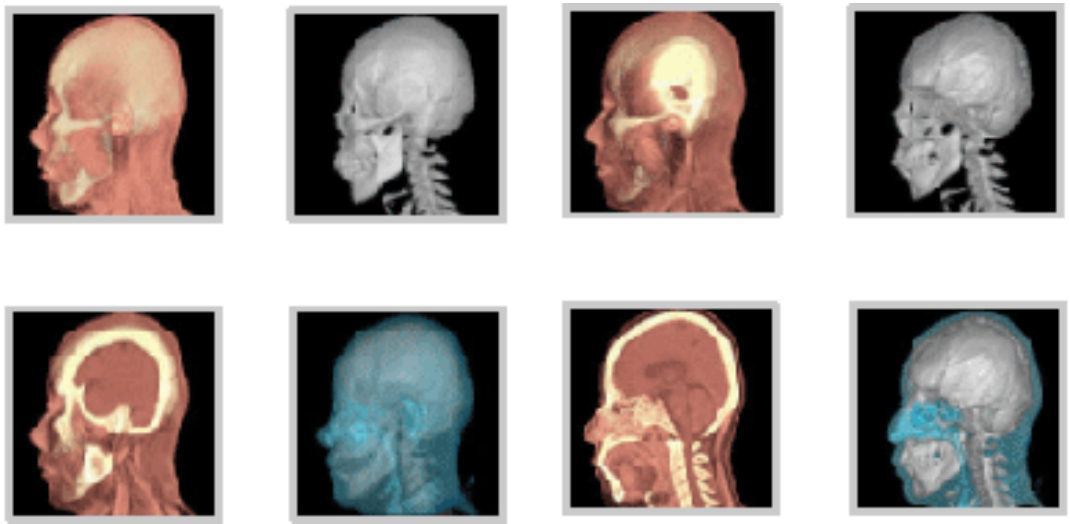
Product Design and Analysis

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

Medical Applications

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



Rapidia homepage

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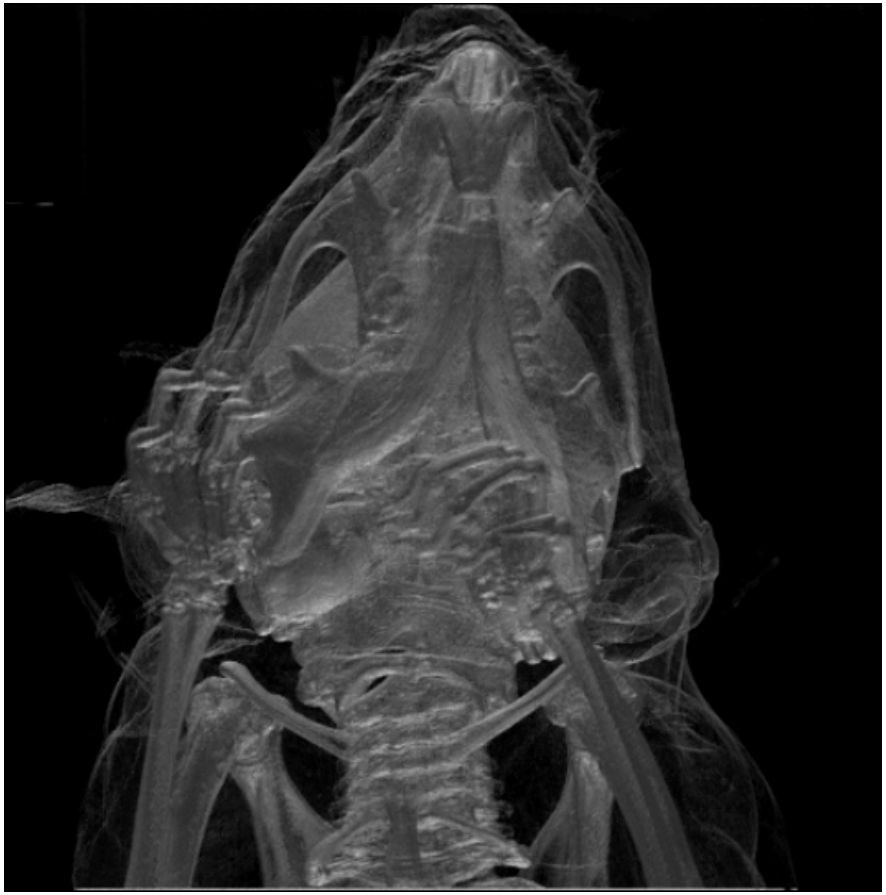
Medical Applications

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



Wikipedia

Mouse skull (CT)

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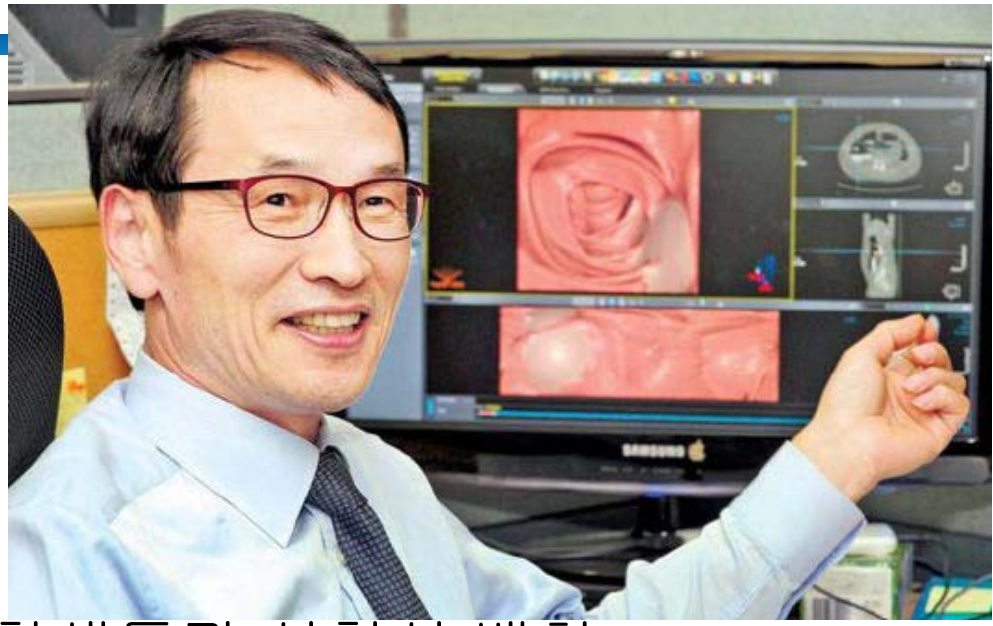
Medical Applications



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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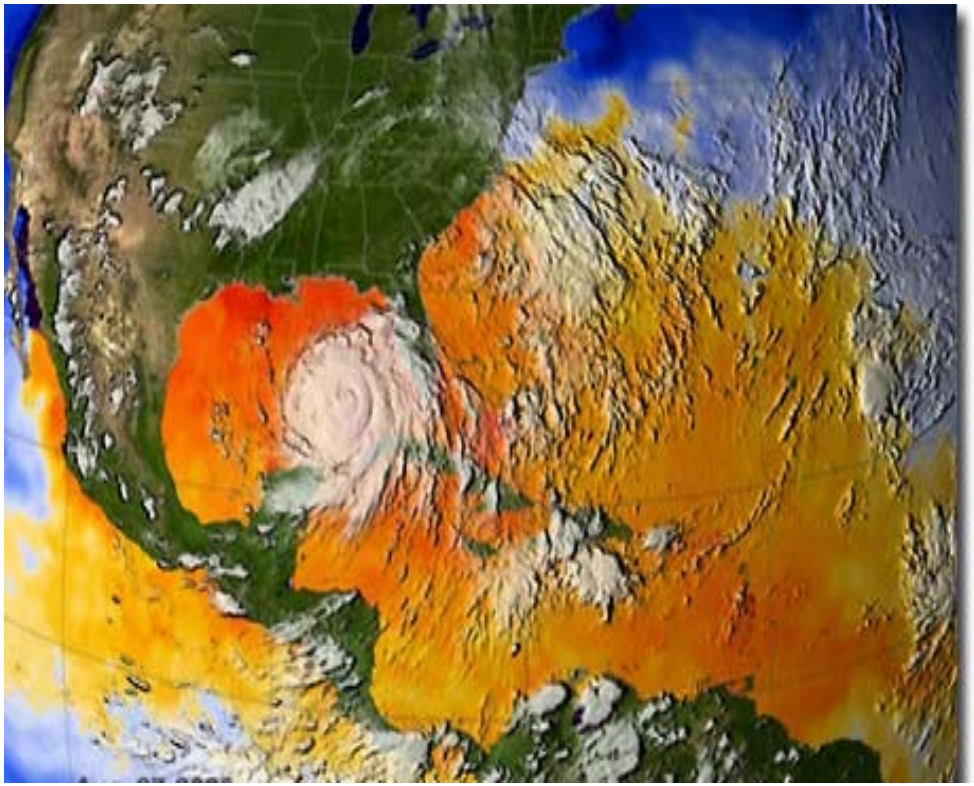
Scientific Applications

- **Weather visualization**



LLNL

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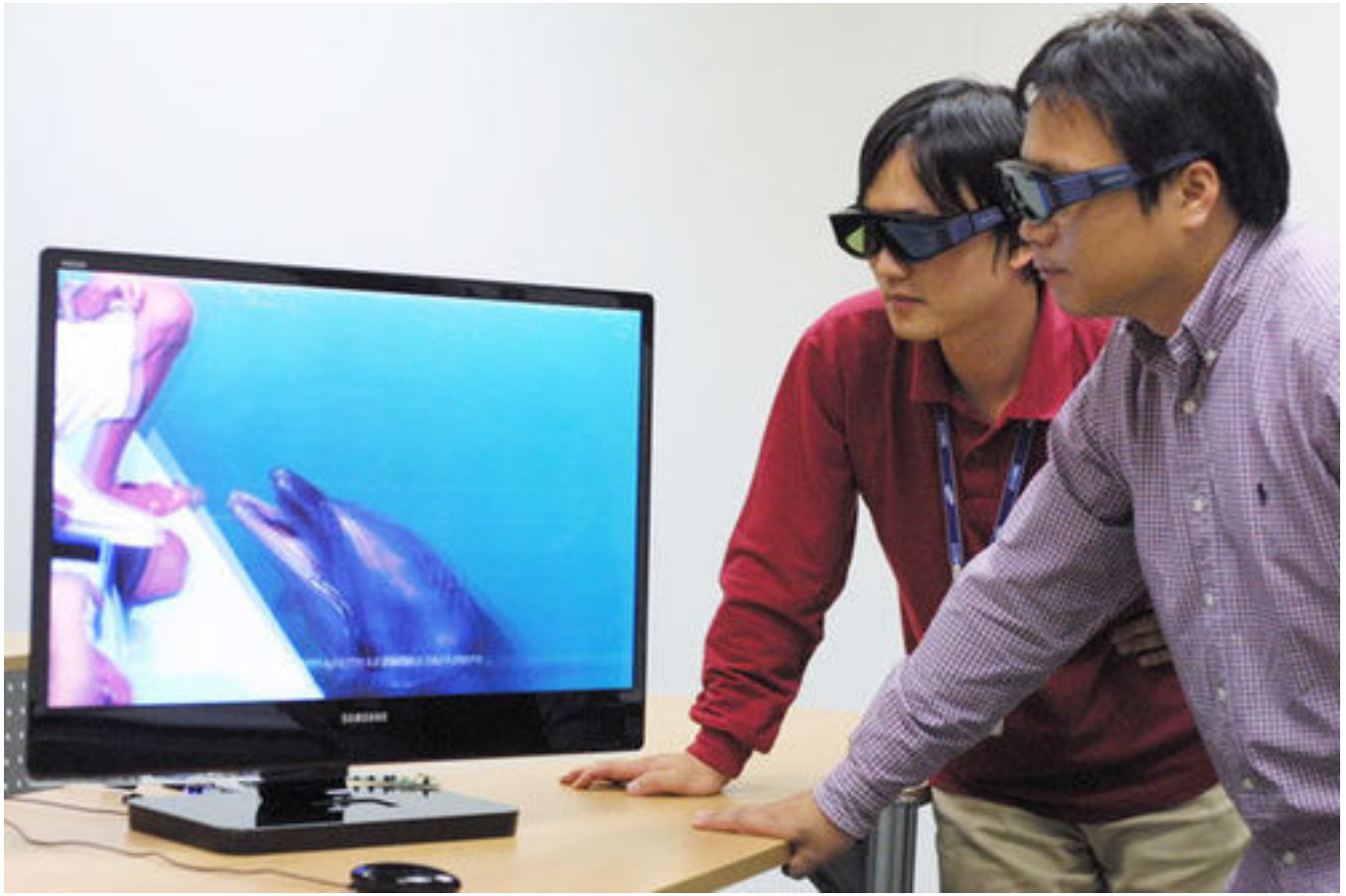
3D TV



Samsung 3D TV

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Head-Mounted Display (HMD) for VR

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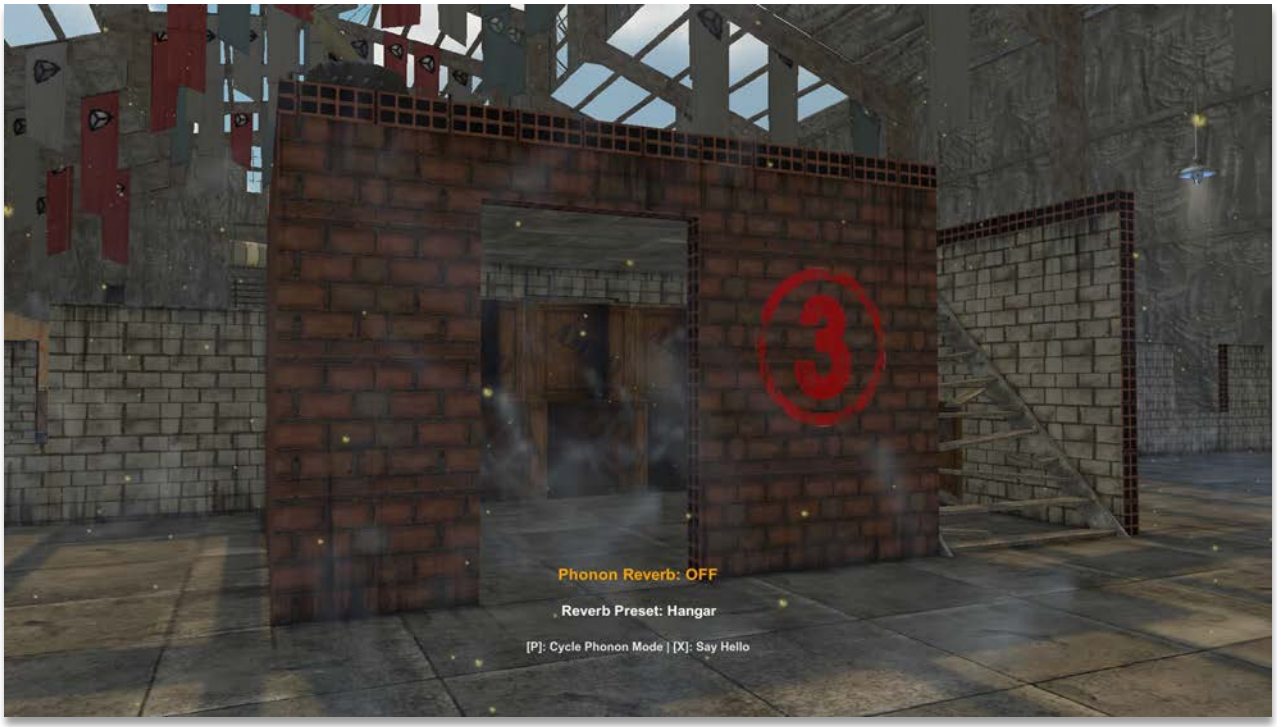
HoloLens for Augmented Reality (AR)

MS

Sound Rendering



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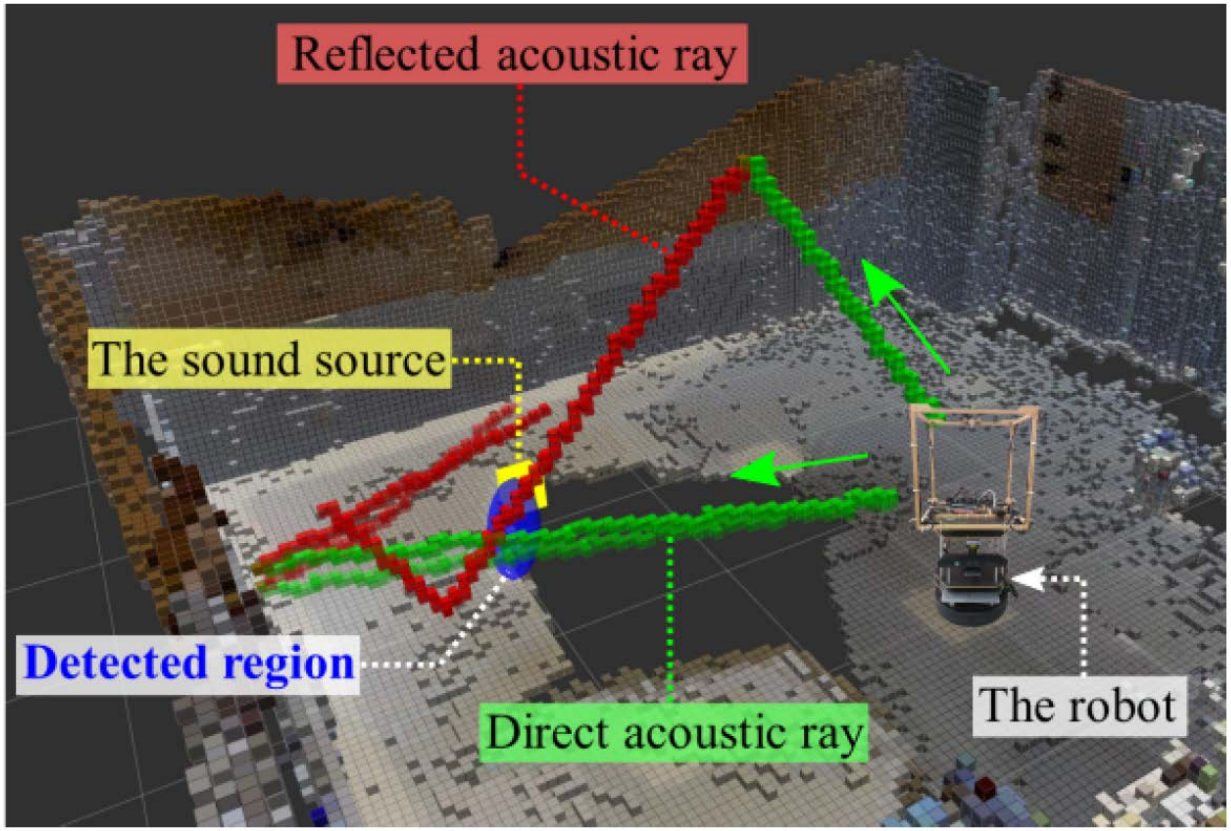
Sound Localization

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



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About the Course

- **We will focus on the following things:**
  - **Study basic concepts of physically-based rendering**
  - **Study its two applications, sound generation and augmented reality**
  - **Implement a recent technique, and discuss its pros and cons**

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Photo-Realistic Rendering

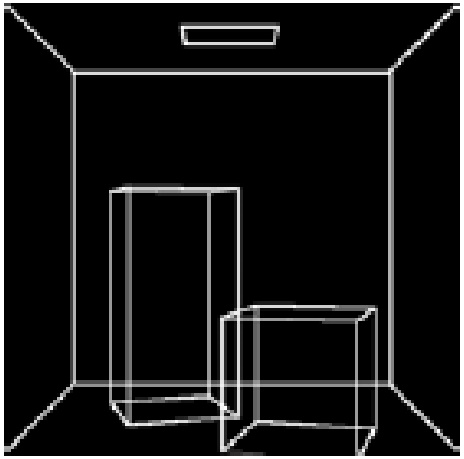
- **Achieved by simulating light and material interactions**

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**

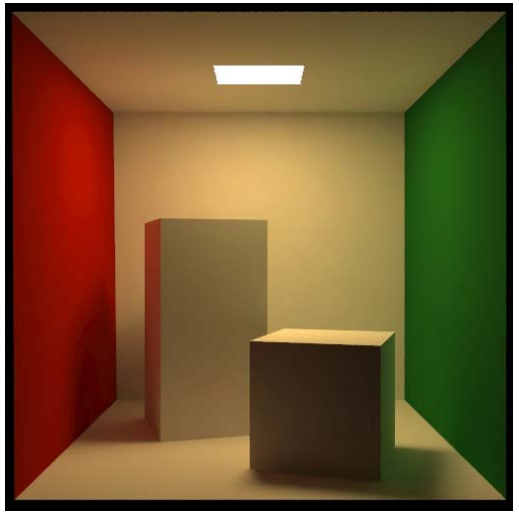


from Prof. Bala's slide

+

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

⇨ **GI Algorithm** ⇨

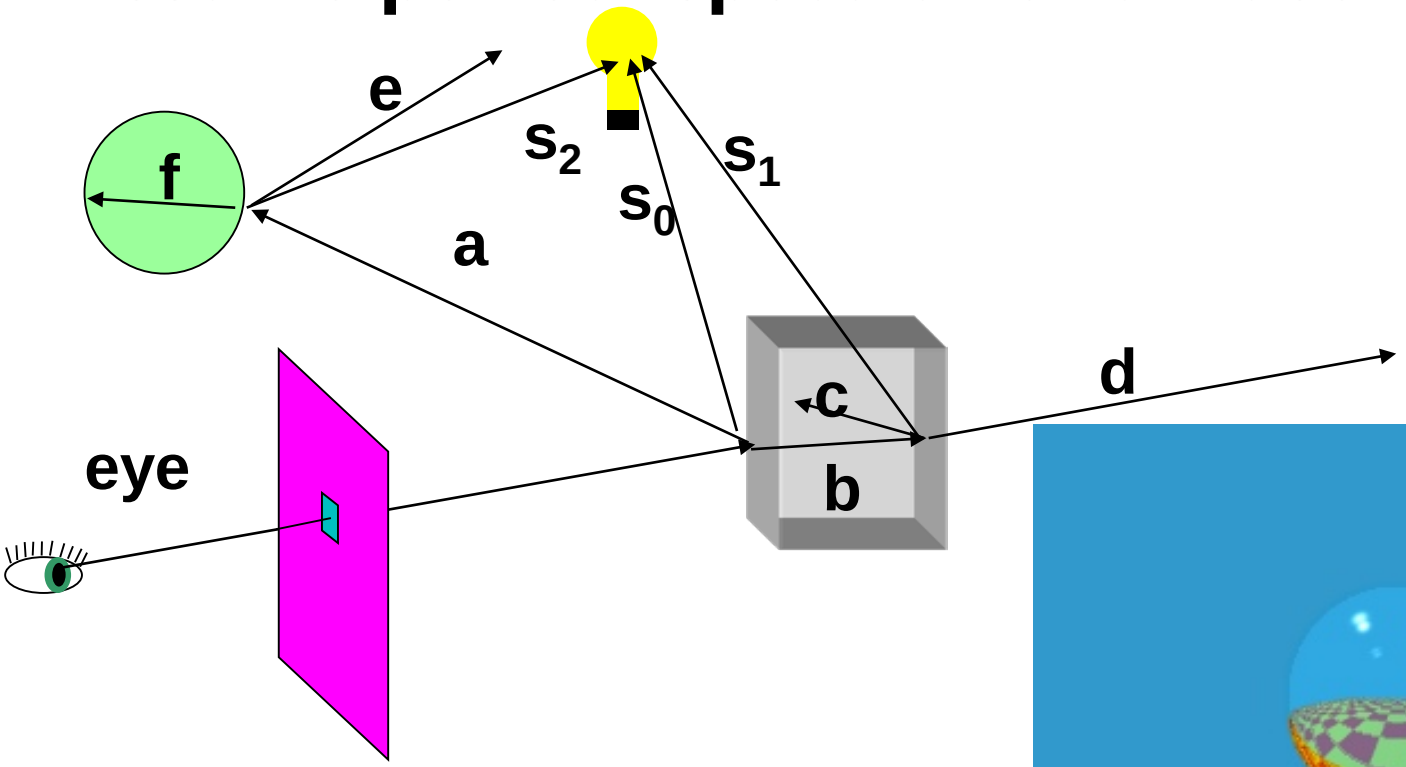


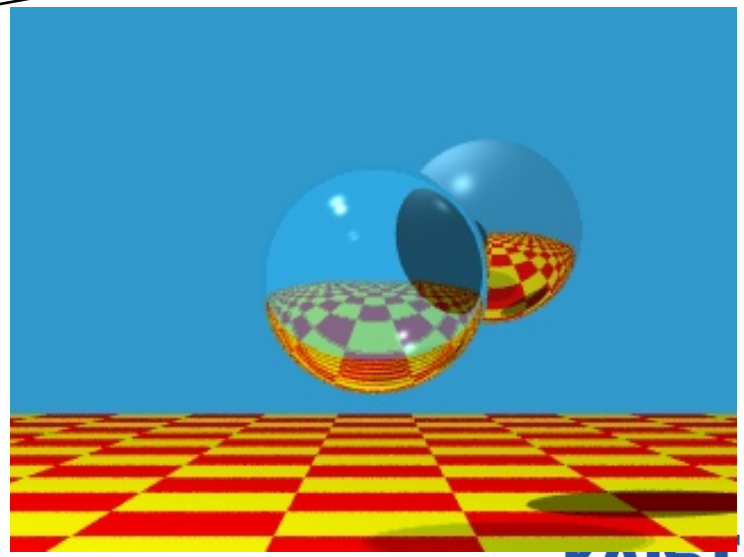
Classic Methods of GI

- 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**

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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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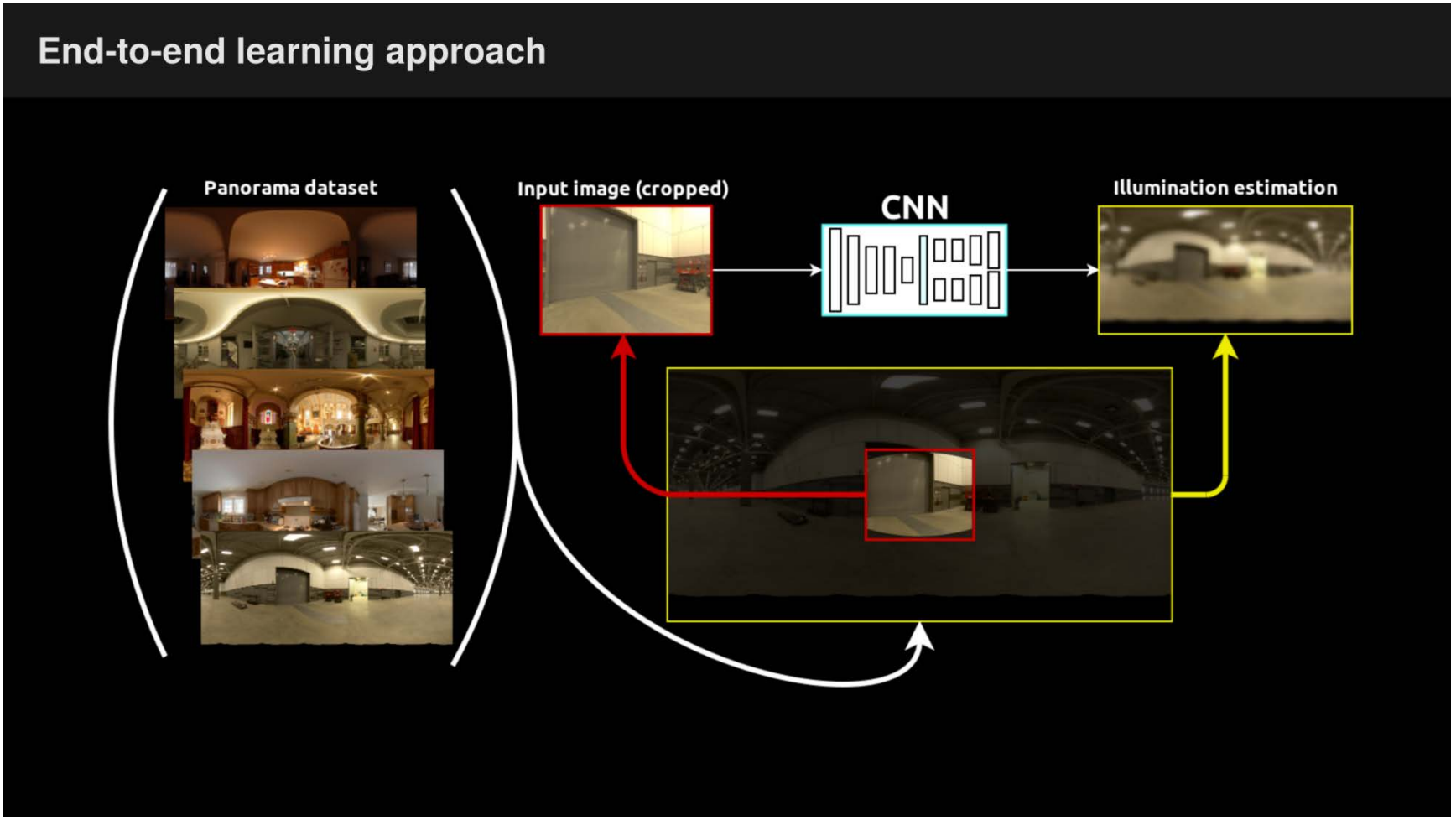
Sound and AR/VR Applications

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

Indoor Light Estimation



Gardner et al.

Some of Topic Lists

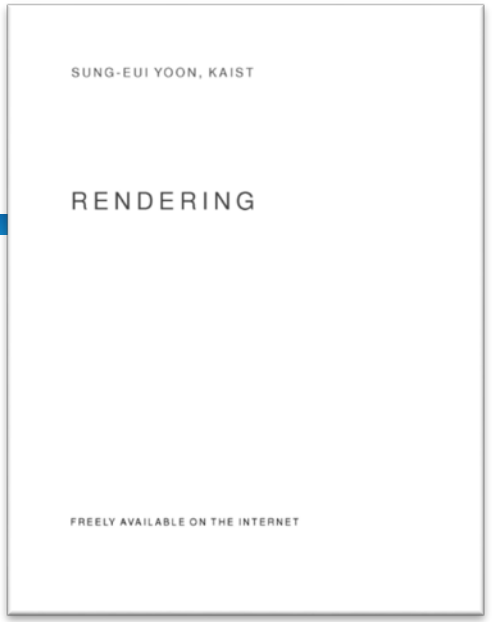
- Ray tracing
- Path tracing
- BRDF
- Rendering equations
- Monte Carlo method
- Textures
- Lighting and shading
- Radiosity
- Instant radiosity
- GPU acceleration
- Sampling and reconstruction
- Sound rendering and localization
- Rendering for AR/VR
- Deep learning for light/material estimation

Prerequisites

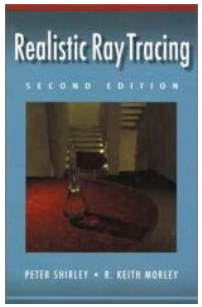
- More or less CS380
- Basic programming skill
- Basic understanding on data structures (e.g., stack) and linear algebra (e.g., matrix multiplication)

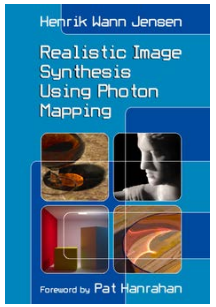
- If you are not sure, please consult the instructor at the end of the course

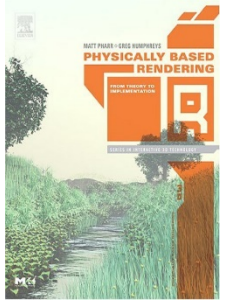
Resource



- **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.**







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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

- 1/2 of lectures and 1/2 of student presentations
  - Mid-term & final-term exams with a few quiz
  - A few programming assignments
  - A few paper presentations
  - Team project

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 and improve them**
    - **Role of each team member should be clear**
  - **Present what the team did for the team project**

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**

Grading

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

- 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**

- **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**

Schedule

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

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 typical questions**
  - **2 for questions with thoughts or that surprised me**
- **Write a question more than 4 times on Sep./Oct.**
  - **Online submission is available at the course webpage**

My Responses to Those Questions

- Identify common questions and address them at the Q&A file
- 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 are already well trained for answering questions

Homework

- **Watch 2 SIGGRAPH or CVPR Videos**
  - **EGSR, HPG and I3D are also possible**
  - **ISMAR, ICRA, ECCV/ICCV are also possible**
  - **Write their abstracts and submit at the beginning of every Tue. class, or**
  - **Submit it online before the Tue. class**
- **Example of an abstract**
  - **Just one paragraph for each abstract**

Title: XXX XXXX XXXX, Year: 2017
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.

About You

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

- What is your major?
- Previous graphics experience

- Any questions

Next Time

- **Ray tracing and radiosity**