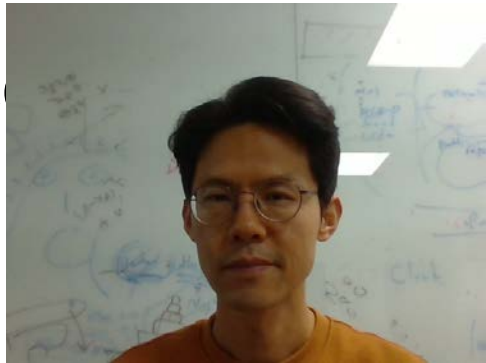
CS580:
Graduate-Level Computer Graphics
- Focus on rendering

Sung-Eui Yoon
(윤성의)

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

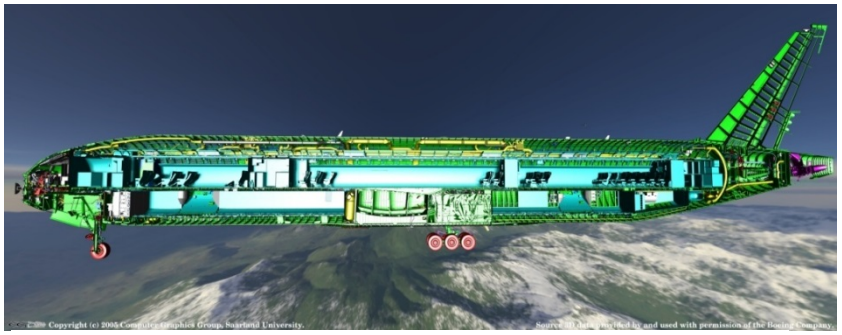


About the Instructor

- Main research focus
  - Rendering, robotics, and vision

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

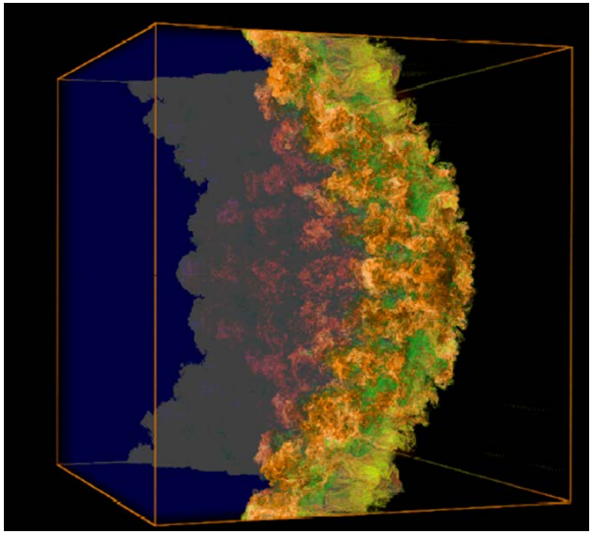
Past: Rendering Massive Geometric Data



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

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

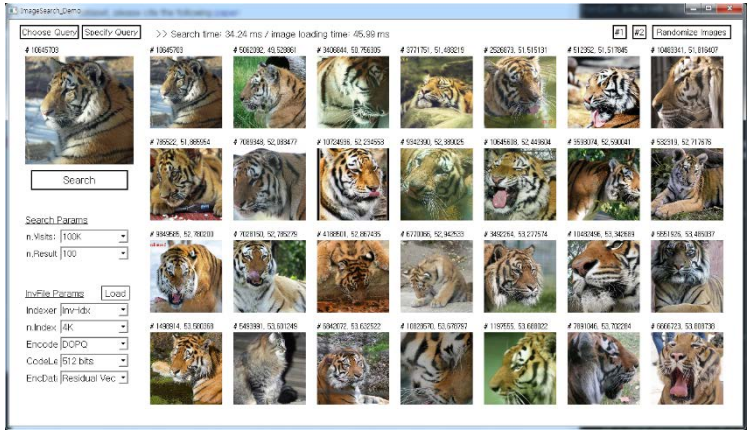


Image search

Motion planning

KAIST

Recognitions and Collaborations

- **2019: 차세대 과학자상 수상 (IT 부문)**
- **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**

KAIST

About the Instructor

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

Class Information

- **Class time**
  - **2:30pm ~ 3:45pm on MW**
  - **Hybrid: offline class in this semester**
- **Office hours**
  - **Right after class or KLMS board**

TA Information

- **Jaeyoon Kim (김재윤)**
  - kimjy2630@gmail.com
  - **Office: 3443 at CS building (E3-1)**

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

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

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

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

Toy story

Matrix

3D Movies

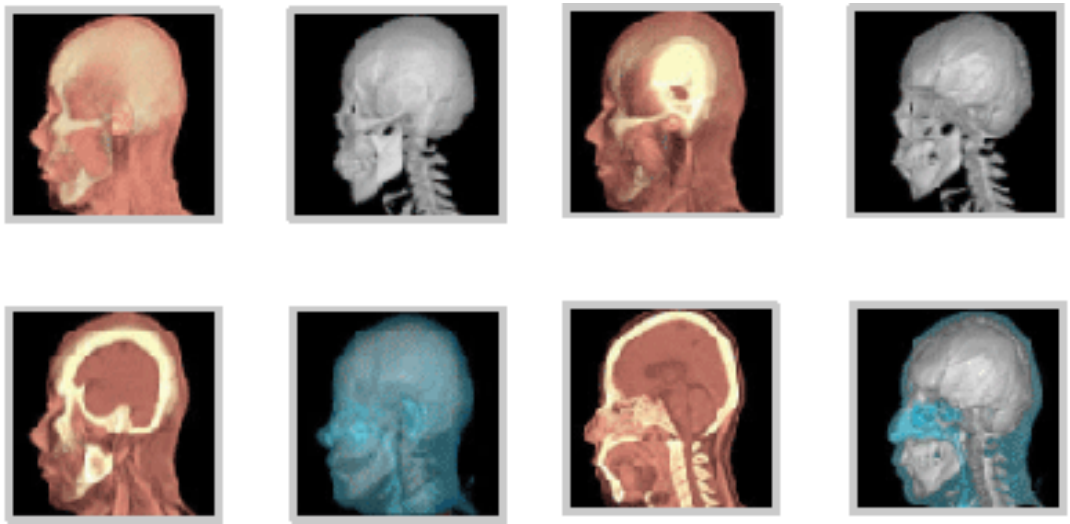
Avatar

Product Design and Analysis

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

Medical Applications

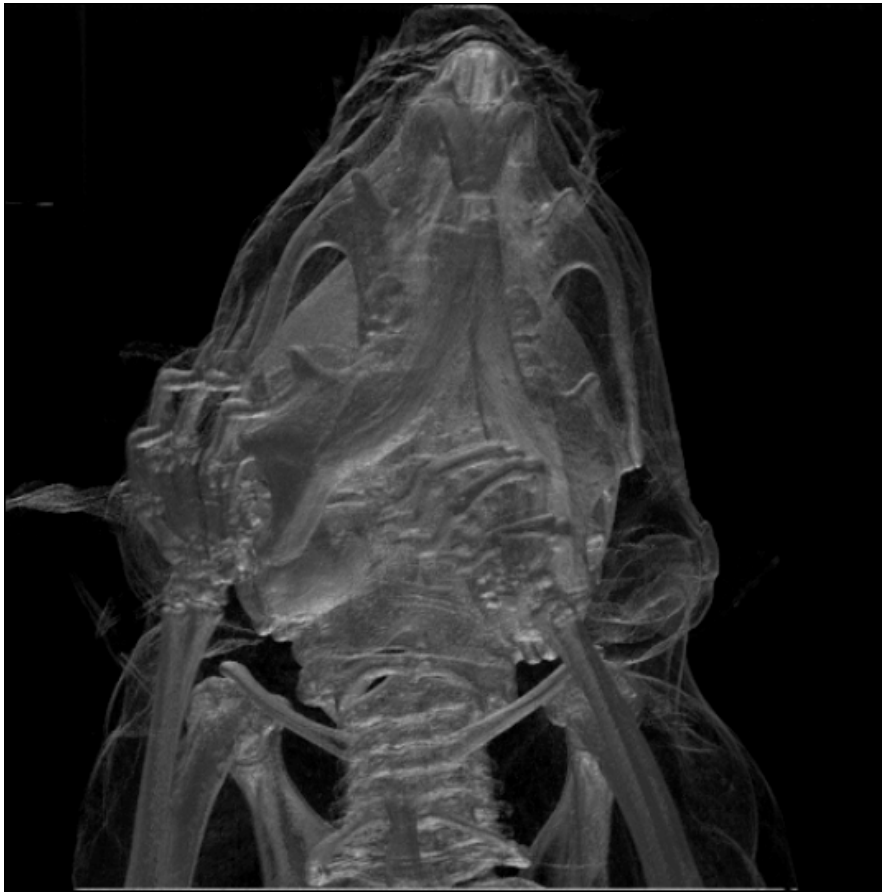
- **Visualizing data of CT, MRI, etc**



Rapidia homepage

Medical Applications

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



Wikipedia

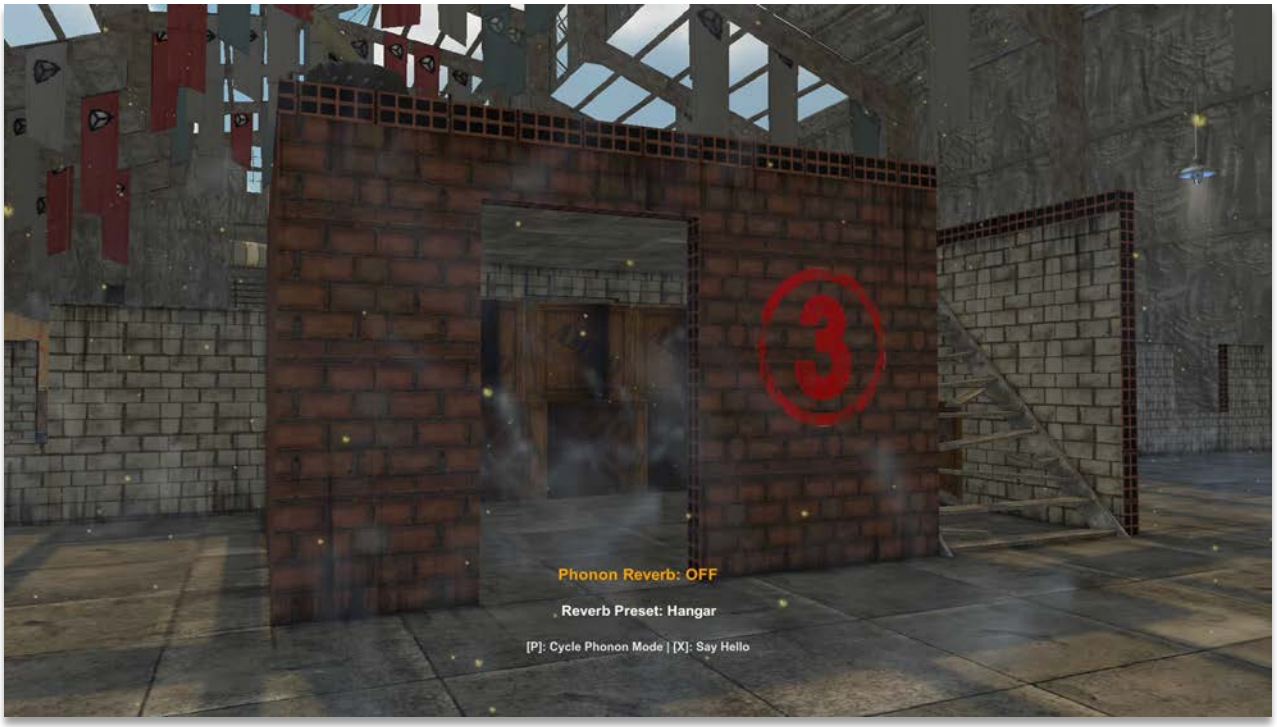
Mouse skull (CT)

Head-Mounted Display (HMD) for VR

HoloLens for Augmented Reality (AR)

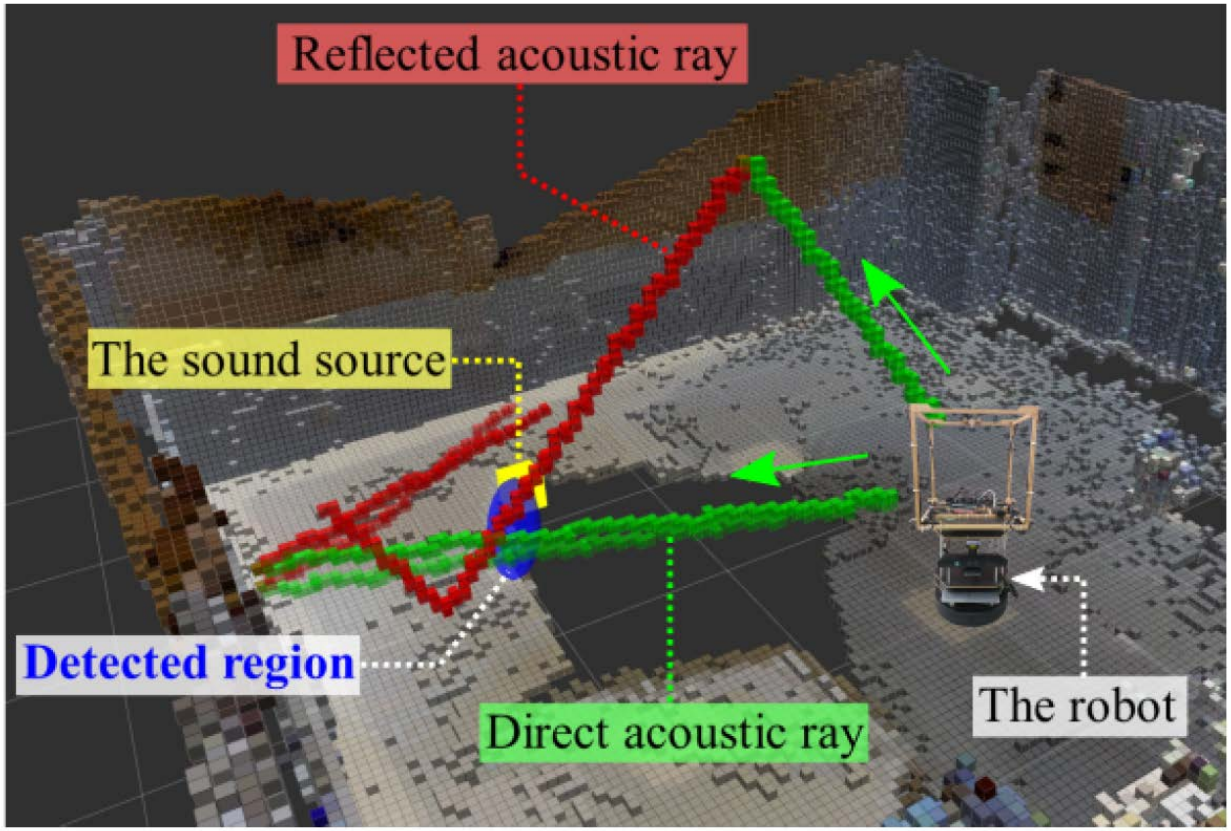
MS

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**
  - **Study recent techniques, and discuss their pros and cons**
  - **Implement a recent technique, and discuss its pros and cons**

Photo-Realistic Rendering

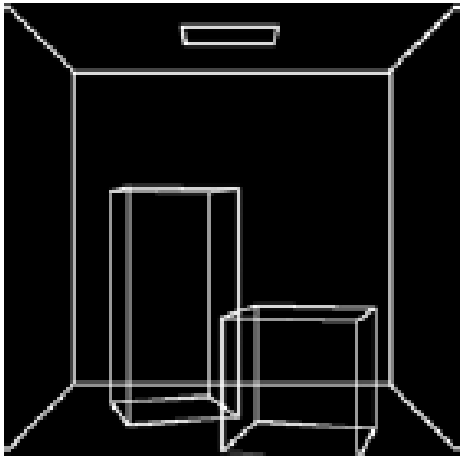
- **Achieved by simulating light and material interactions**

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

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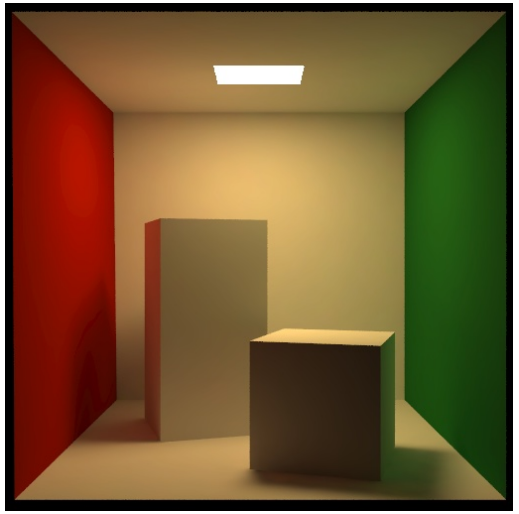
Emission (light sources)
Geometry (objects)
BRDF (materials)

⇨ **GI Algorithm** ⇨

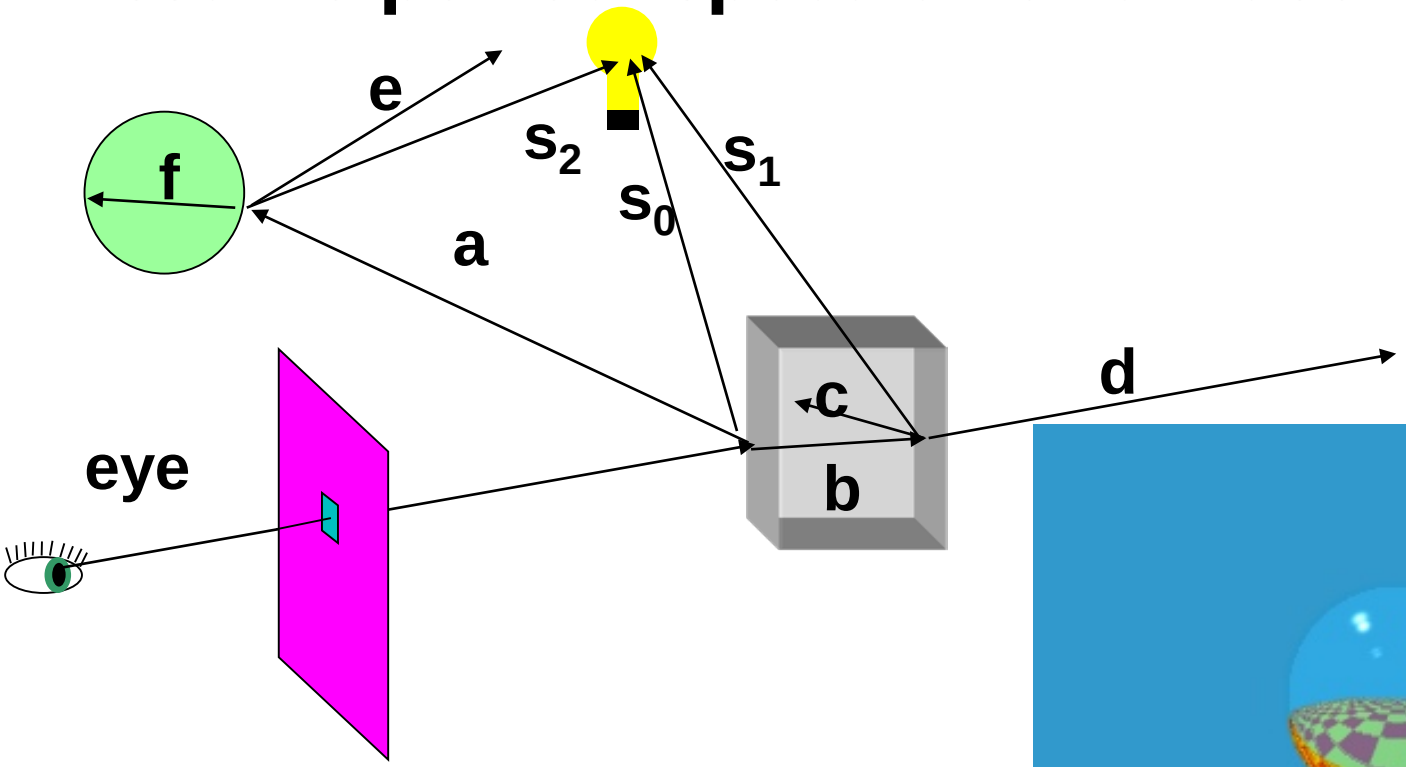


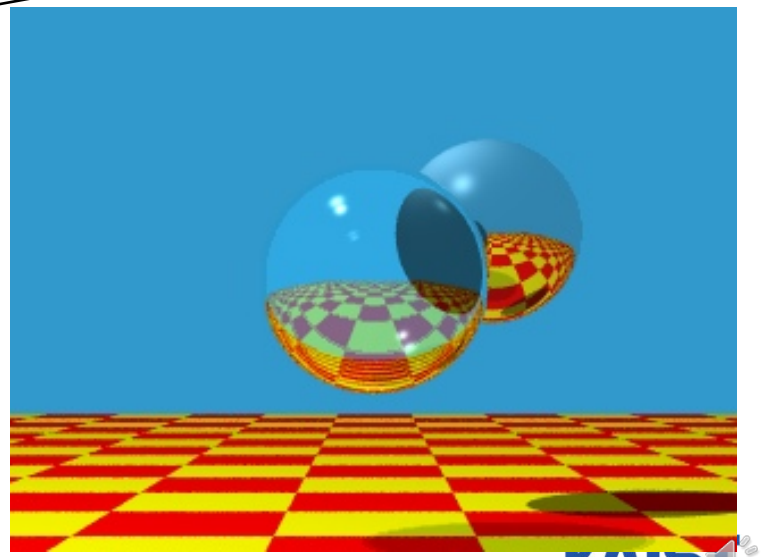
Classic Methods of GI

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

Classic Ray Tracing

- Assume perfect specular or diffuse material





Classic 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**

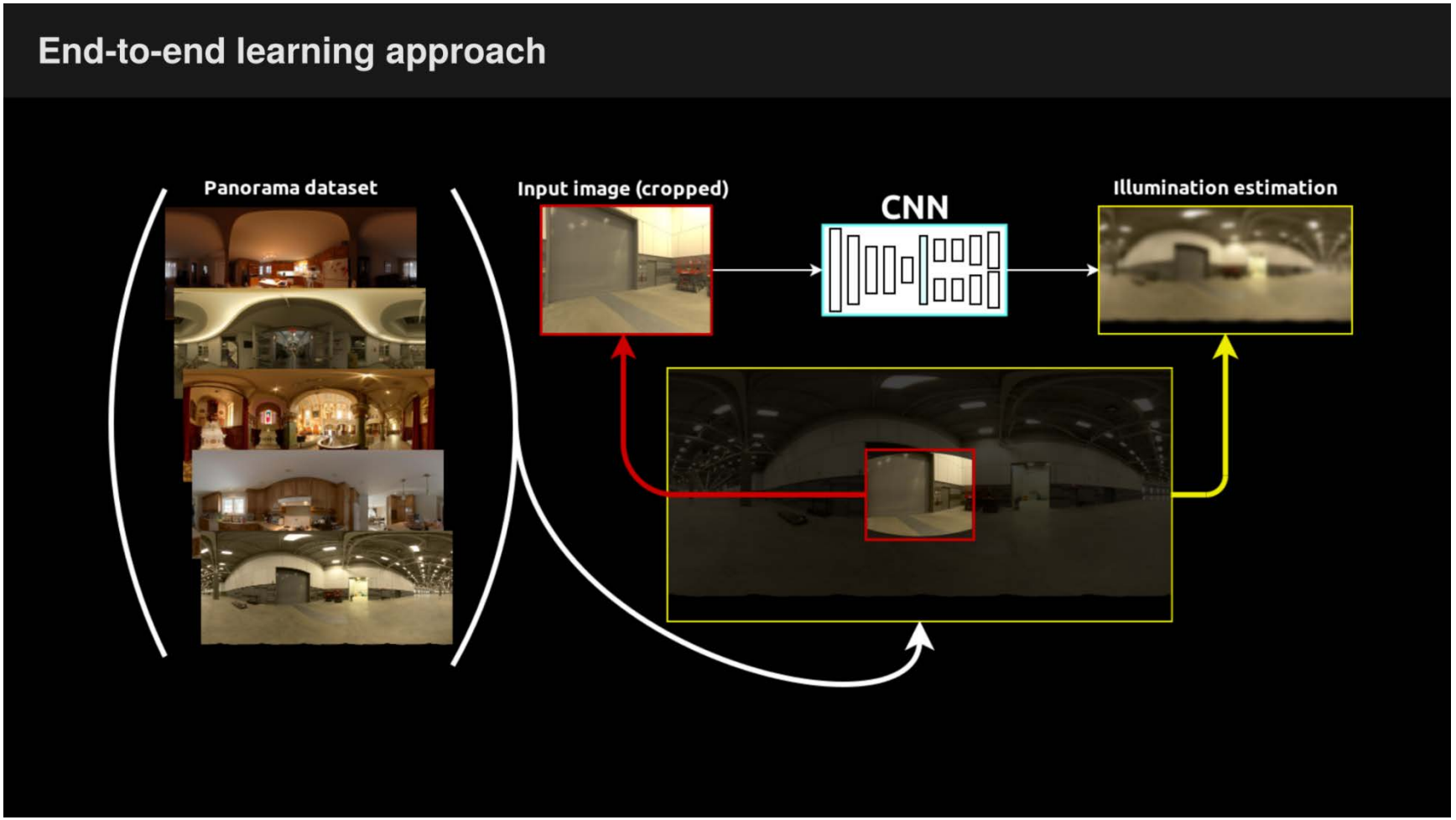
from photon map paper

from Pixar movie

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

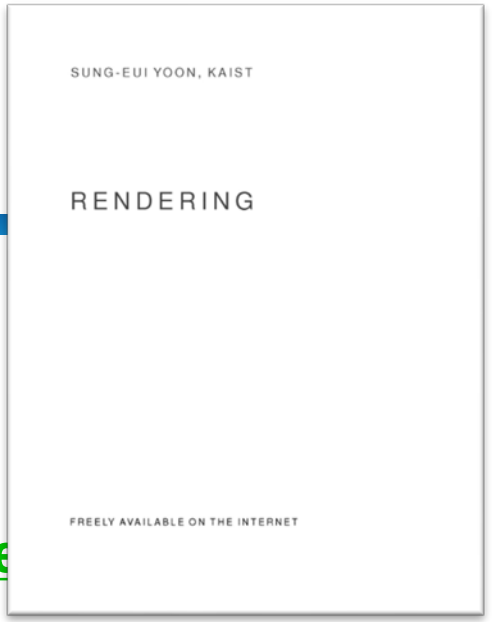
- Ray tracing
- Path tracing
- BRDF
- Rendering equations
- Monte Carlo method
- Textures
- Lighting and shading
- Radiosity
- Instant radiosity
- GPU acceleration
- Sampling and reconstruction
- Sound rendering and localization
- Rendering for AR/VR
- Deep learning for light/material estimation

Prerequisites

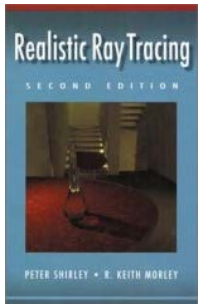
- **Basic programming skill**
- **Understanding on data structures (e.g., stack) and linear algebra (e.g., matrix multiplication)**
- **Basic deep learning (DL) knowledge & programming**
  - **We cannot teach basic DL concepts here**

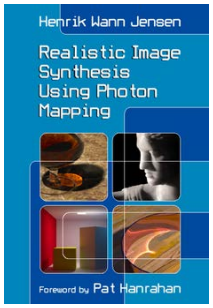
- **If you are not sure, ~~please consult the instructor at the end of the course~~ discuss it at KLMS w/ TAs**

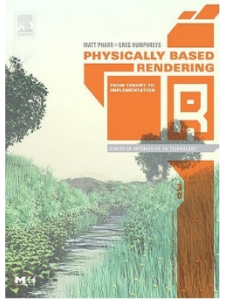
Resource



- **Rendering**
  - **1st edition, July 2018, 148 pages**
  - **Sung-eui Yoon, Copyright 2018**
  - **https://sgvr.kaist.ac.kr/~sungeui/rende**
- **Reference**
  - **Physically based rendering, Matt Pharr et al.**
  - **Advanced Global Illumination, Philip Dutre et al. 2nd edition**
  - **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

- 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 (Major activity)

Important: 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: 30%
- Class presentations: 30%
- Final project: 40%

- Late policy
  - No score for late submissions
  - Submit your work before the deadline!
- Instructor/TA and students will evaluate presentations and projects
  - Instructor/TA: 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

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/**

Homework

- **Watch 2 SIGGRAPH or CVPR Videos**
  - **EGSR, HPG and I3D are also possible**
  - **ISMAR, ICRA, ECCV/ICCV are also possible**
  - **Write their summary and submit it online before Mon. class**

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

Title: XXX XXXX XXXX, Year: 2022
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

- **Ray tracing and radiosity**