CS482:
Interactive Computer Graphics

Sung-Eui Yoon
(윤성의)

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

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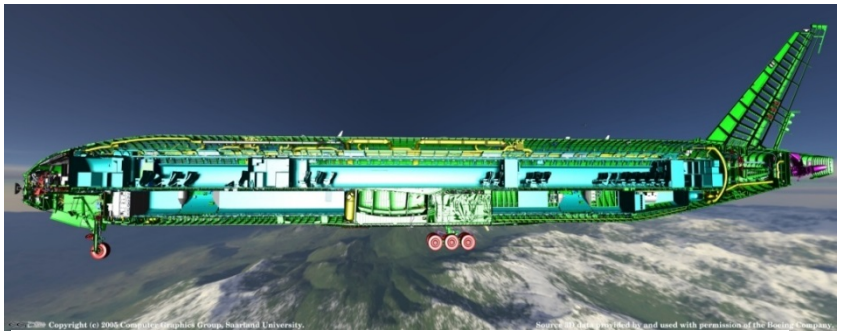
About the Instructor

- **2019: 차세대 과학자상 수상 (IT 부문)**
- **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)**
- **Joined KAIST at 2007**

- **Main research focus**
  - **Rendering, robotics, and vision**

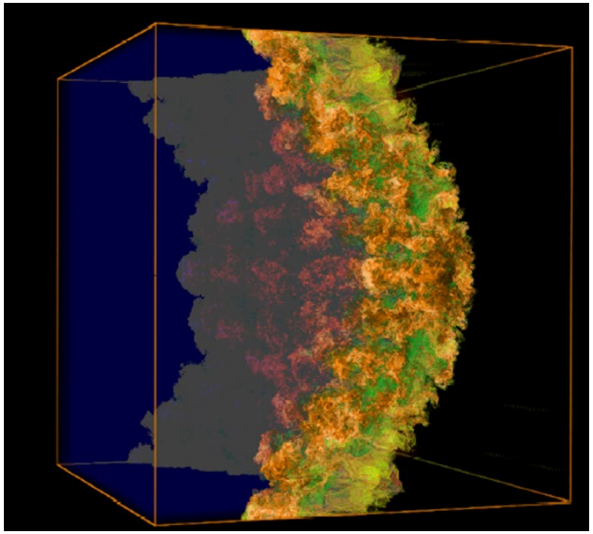
Past: Rendering Massive Geometric Data



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 and intelligent graphics and geometric algorithms* to efficiently handle massive models on commodity hardware**

Photo-realistic rendering

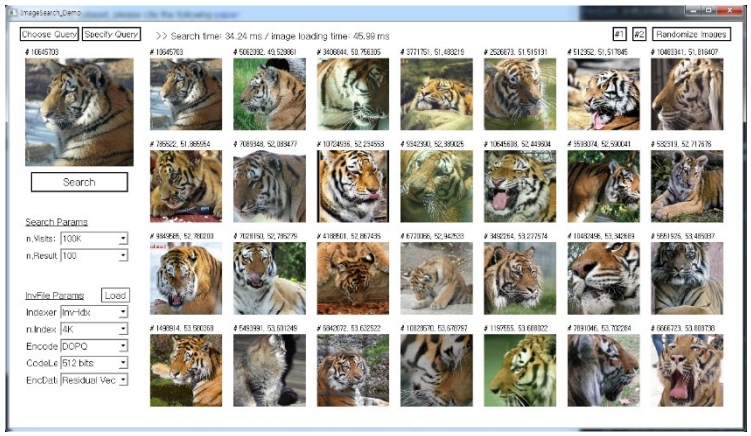


Image search

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**
  - **2:30pm ~ 4:15pm on MW**
  - **Offline class in this semester**

- **Office hours**
  - **Right after class or**
  - **KLMS board**

TA Information

- **Kyubeom Han (한규범)**
  - qbhan@kaist.ac.kr
  - **Office: 3443 at CS building (E3-1)**

- **To be determined: 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

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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

Movies and Film Special Effects

Toy story

Matrix

3D Movies

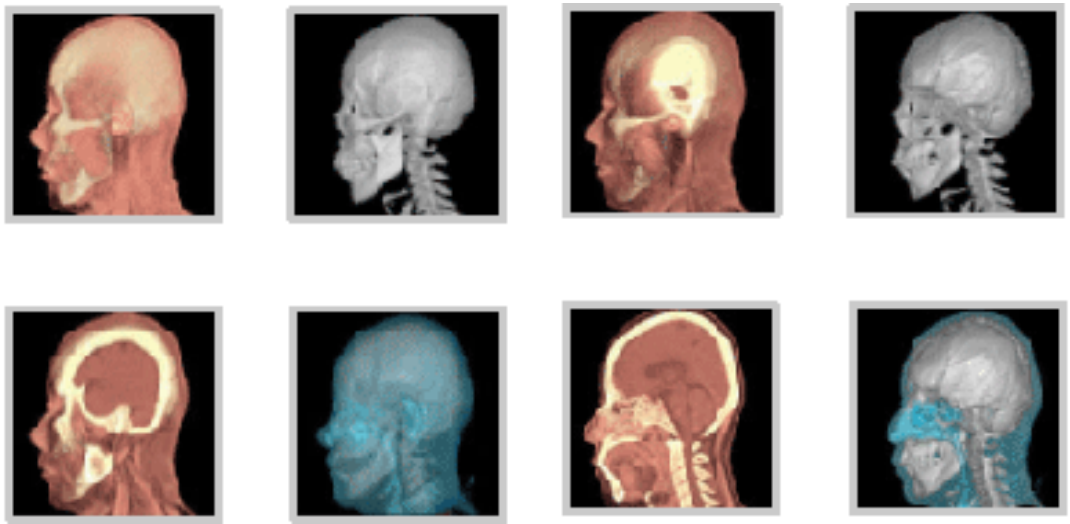
Avatar 1 and 2

Product Design and Analysis

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

Medical Applications

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



Rapidia homepage

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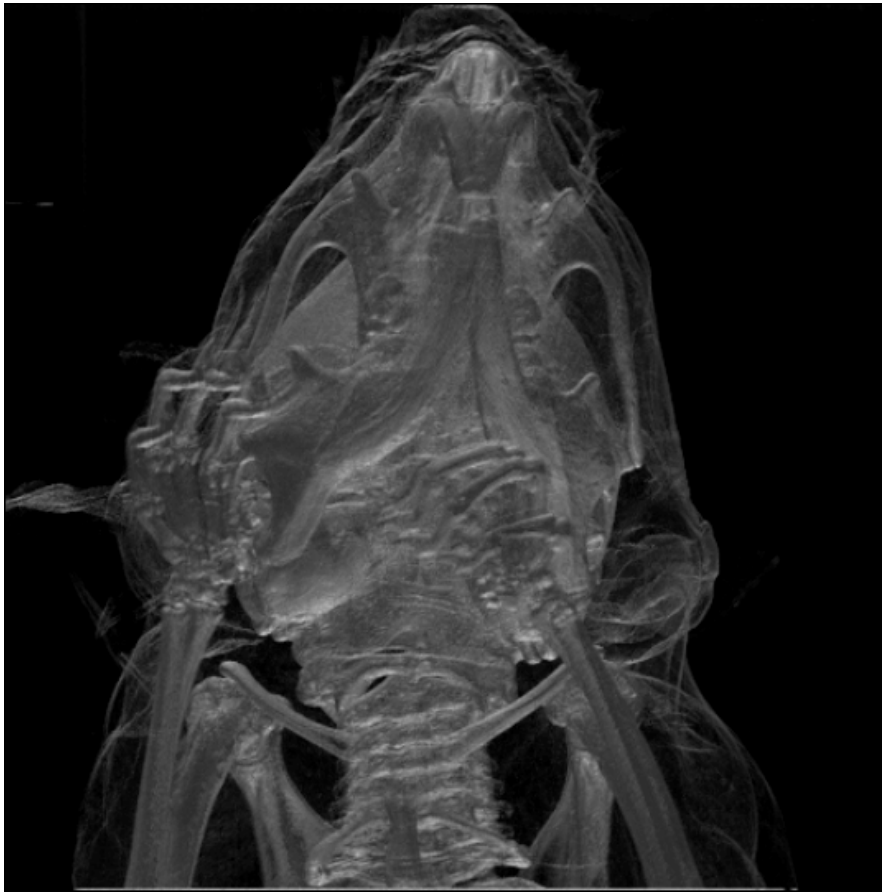
Medical Applications

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



Wikipedia

Mouse skull (CT)

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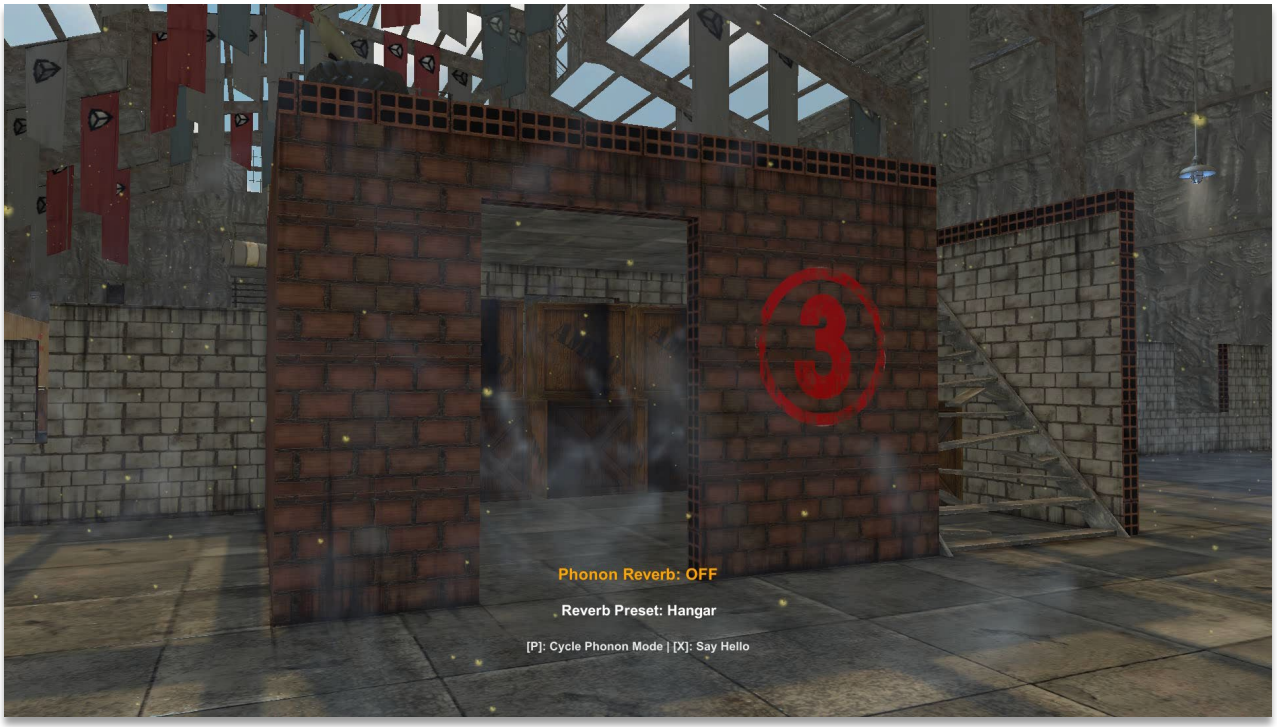
Head-Mounted Display (HMD) for VR

HoloLens for Augmented Reality (AR)

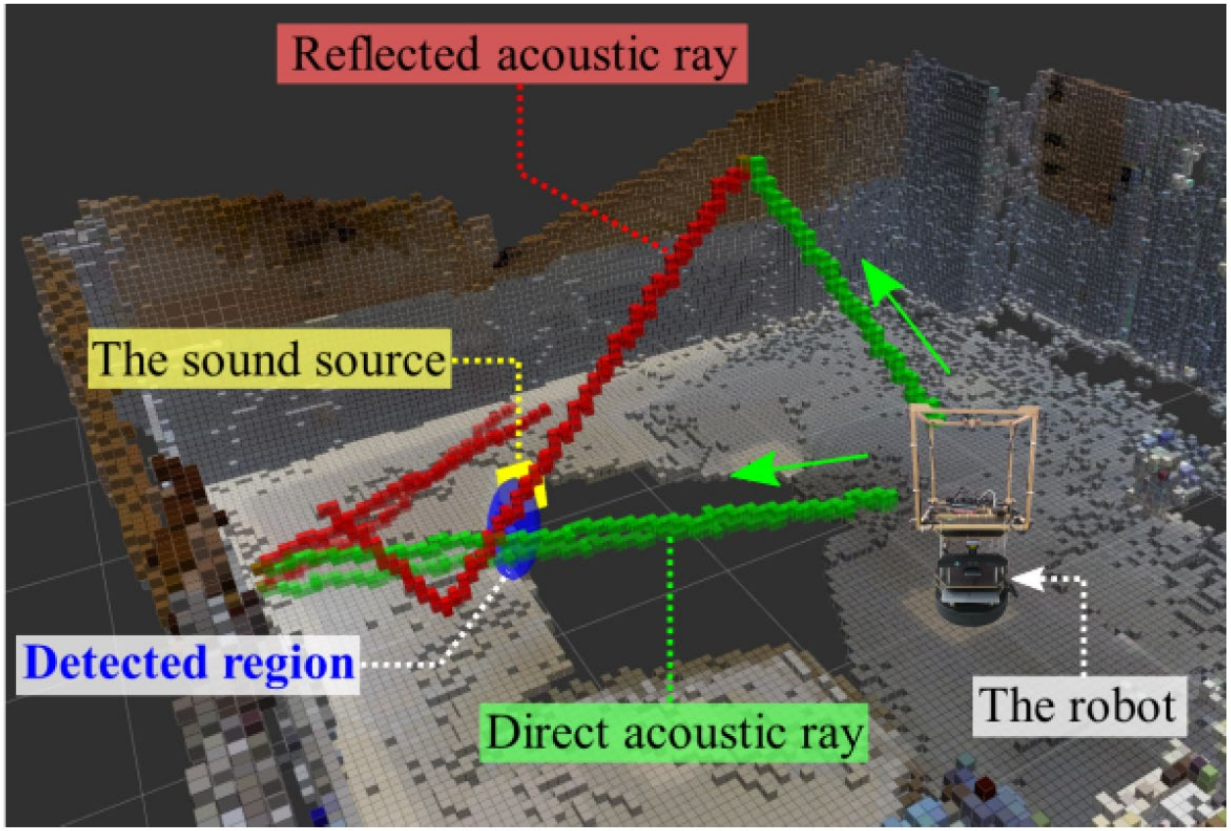
MS

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**

Photo-Realistic Rendering

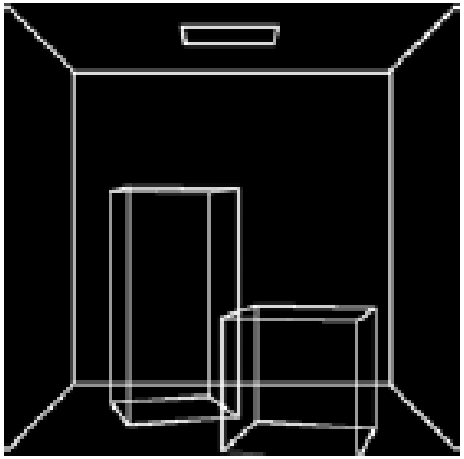
- **Achieved by simulating light and material interactions**

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**

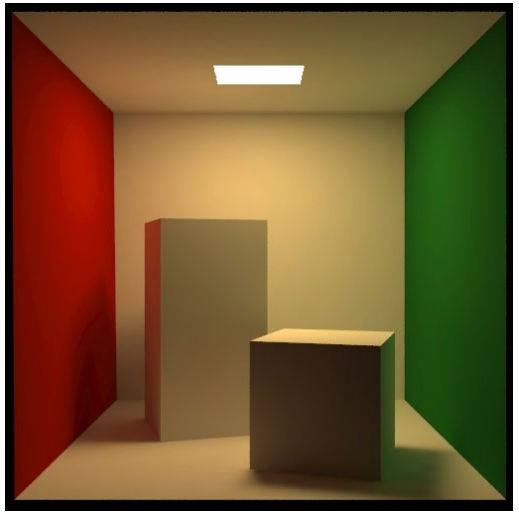


from Prof. Bala's slide

+

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

⇨ **GI Algorithm** ⇨

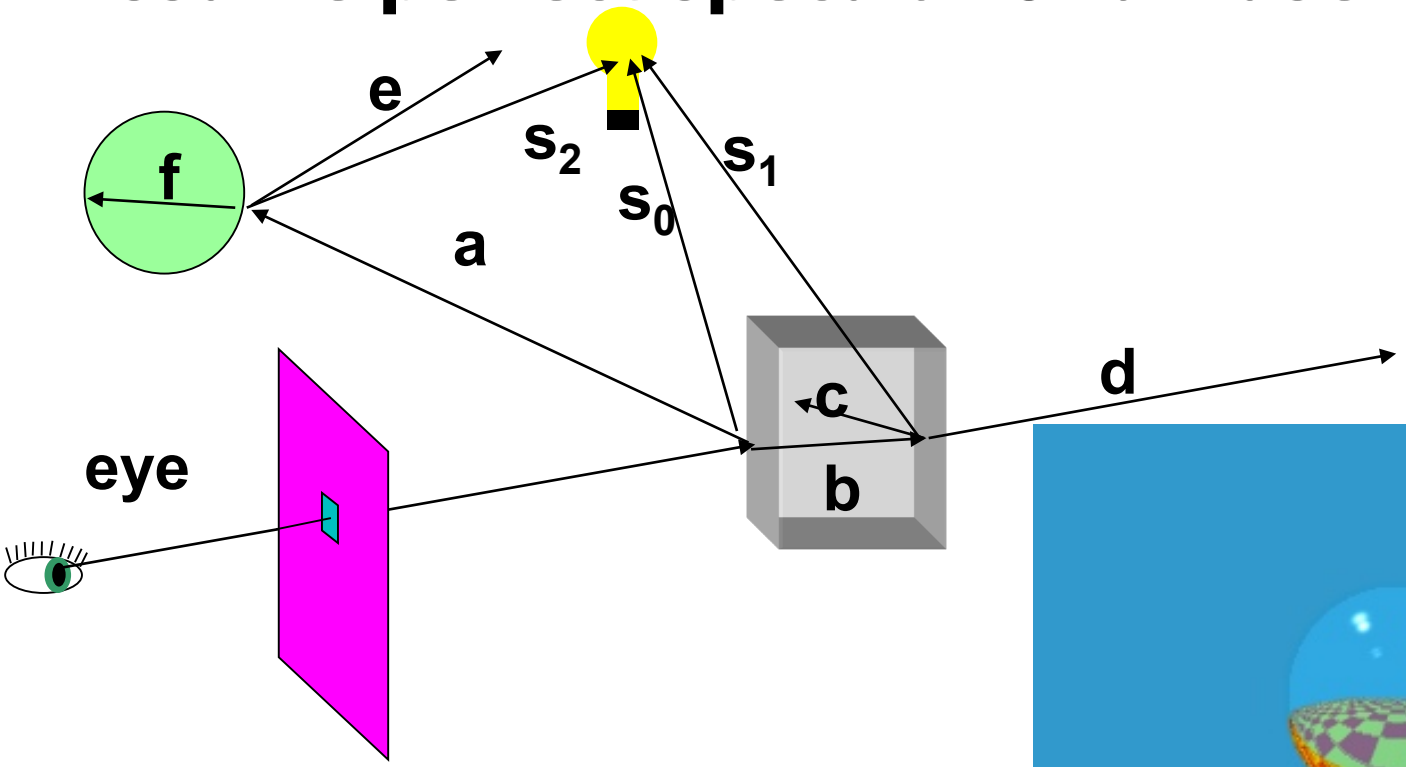


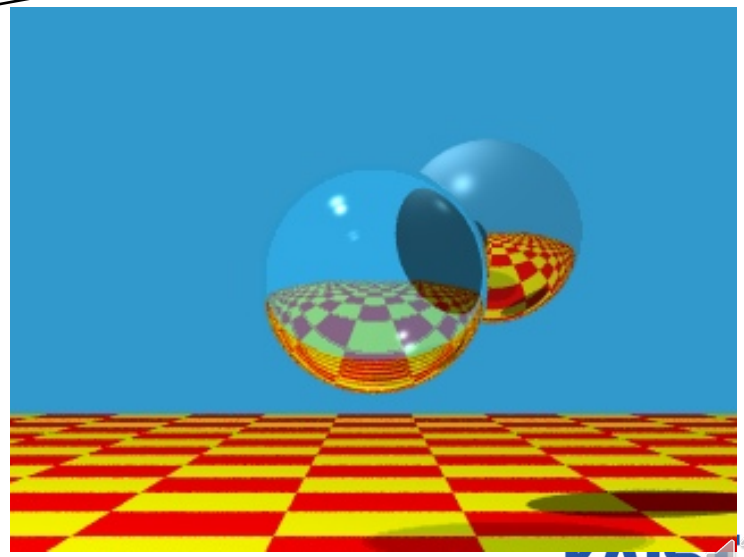
Classic Methods of GI

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

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**

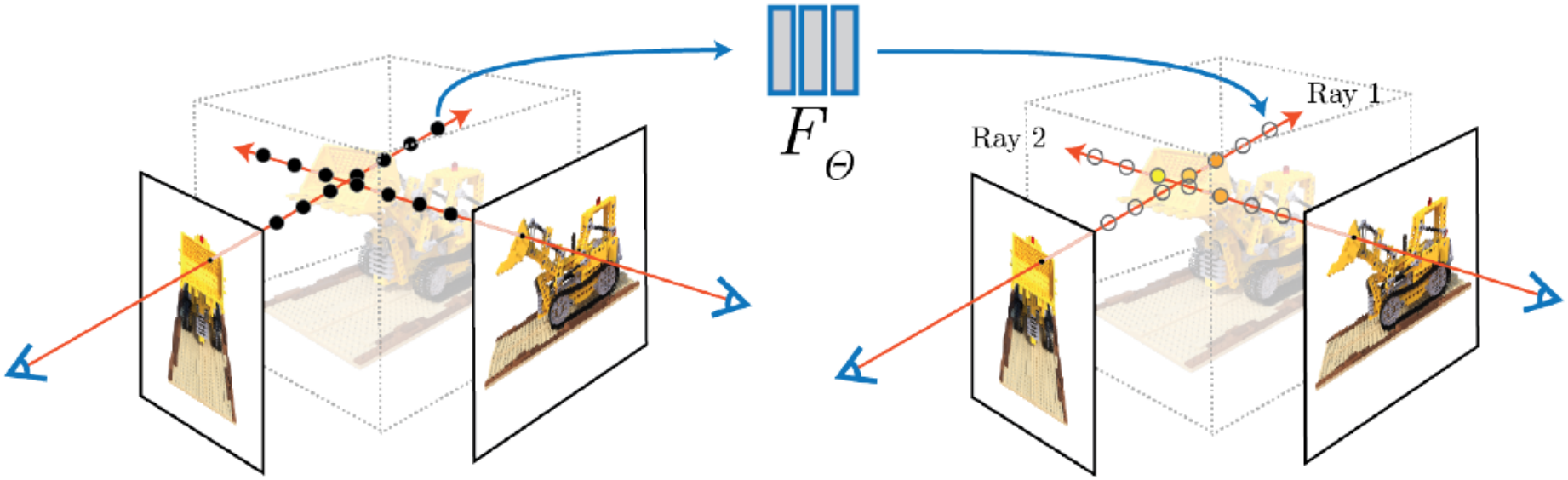
from photon map paper

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?

NeRF: Representing Scenes as Neural Radiance Fields for View Synthesis



NeRF

Representing Scenes as Neural Radiance Fields for View Synthesis

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Physics-based Inverse Rendering

- **Differential rendering is desirable for deep learning**

Scene parameters

Geometry, materials, lighting, ...

Inverse rendering

$$\boldsymbol{\theta} = \mathscr{R}^{-1}(\boldsymbol{I})?$$

- Inverting **physics-based** forward rendering
- Crucial to many applications

Rendered image

Scene: "bed classic" from Jiraniano

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Some of Topic Lists

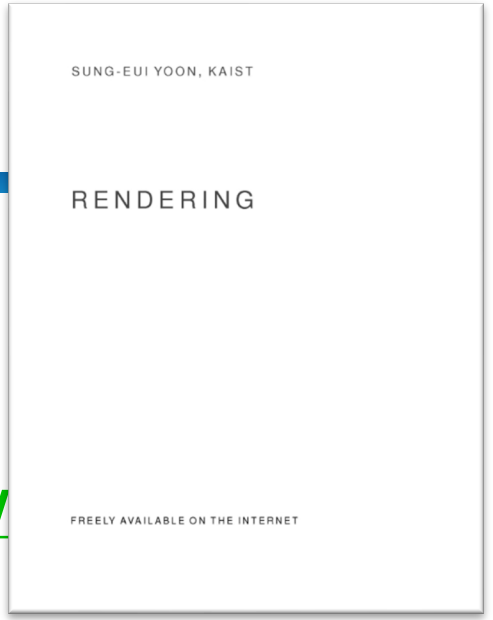
- Ray tracing
- Path tracing
- BRDF
- Rendering equations
- Monte Carlo method
- Textures
- Lighting and shading
- Radiosity
- Instant radiosity
- GPU acceleration
- Sampling and reconstruction
- Sound rendering and localization
- Rendering for AR/VR
- Deep learning techniques

Prerequisites

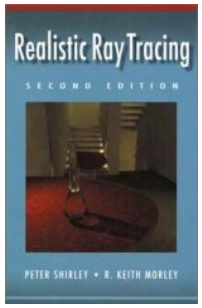
- More or less CS380
- Basic programming skill
  - Basic understanding on data structures (e.g., stack) and linear algebra (e.g., matrix multiplication)
- Basic deep learning knowledge & programming

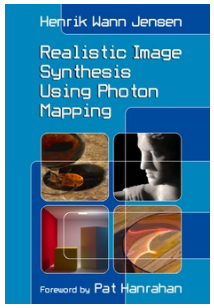
- If you are not sure, please consult the instructor at the end of the course discuss it at KLMS w/ TAs

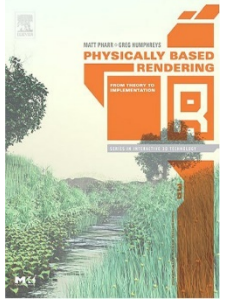
Resource



- **Rendering**
  - **1st edition, July 2018, 148 pages**
  - **Sung-eui Yoon, Copyright 2018**
  - **https://sgvr.kaist.ac.kr/~sungeui/render/**
- **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

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/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**

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 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 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 summary and submit it online before Mon. class**

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

Title: XXX XXXX XXXX, Year: 2023
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**