Computer Graphics
0. Overview

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Before we start (about language)

▶ This is an **EMI** (English as a Medium of Instruction) course.

▶ The lectures and presentations will mainly be in English.

▶ The slides, homework assignments, and quiz papers (if any) are in English.

▶ Besides English, students are still welcome to ask questions or clarify issues in Mandarin Chinese.

Before we start (about content)

▶ Covering essential concepts of computer graphics, one or two advanced topics, and projects.

    ▶ This course aims at students without computer graphics knowledges. (graduate or undergraduate 3+)

    ▶ Slides for essential parts are compact versions of the under-graduate-level counterpart.

▶ For a student who has taken "Intro. to Computer Graphics", she (or he) can take other courses for specific CG-related topics, e.g.

    ▶ Real-time rendering

    ▶ Computer animation

    ▶ 3D game programming

    ▶ Interactive shape manipulation

    ▶ Extended reality (XR), augmented/virtual Reality (AR/VR)

    ▶ Visual special effects

    ▶ ……

About the course

▶ Course title: Computer Graphics (graduate-level)

▶ Lectures:

  ▶ EC022, 10:10~12:00(Mon.) + asynchronous video (usually uploaded before Thurs noon)

▶ Pre-requisites:

  ▶ Computer programming skills in C/C++.

  ▶ Data structures, such as arrays, trees, and linked lists.

  ▶ Essential concepts about matrix computation.

▶ Teacher:

  ▶ I-Chen Lin (林奕成)

  ▶ Email: ichenlin@cs.nycu.edu.tw

  ▶ Office: EC 704 (工程三館)

  ▶ Tel ext: 56684

About the course (cont.)

- TAs:
  - 王嘉羽(vayne20011125@gmail.com)
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  - 張綺恩(kieann.cs13@nycu.edu.tw)
 - Office: EC229b
  - Phone ext.: 56676

- Course web page: E3, NYCU

- Participating in a Higher Education Certificate Program.
  - Students may be required to voluntarily provide some feedbacks for comparison of course design.

About the course (cont.)

▶ Text book:

  ▶ Edward Angel, Dave Shreiner, *Interactive Computer Graphics: A Top-Down Approach with Shader-Based OpenGL*, 6th Edition., Pearson, 2012 (or later versions).
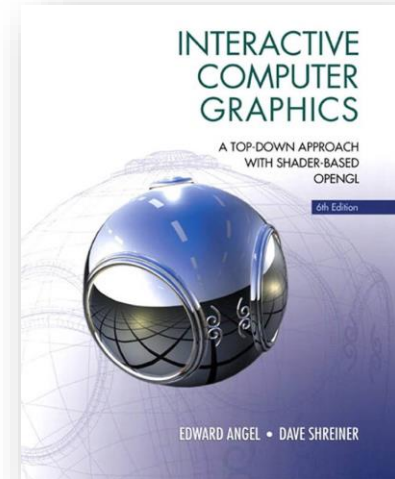
▶ References:

  ▶ Donald D. Hearn, M. Pauline Baker, Warren Carithers, *Computer Graphics with OpenGL* (4th Edition), Pearson, 2010.

  ▶ J. D. Foley, A. van Dam, S. K. Feiner, J. F. Hughes, R. L. Phillips. *Introduction to Computer* Graphics, Addison-Wesley, 1993.

  ▶ Joey de Vries, Learn OpenGL: Learn modern OpenGL graphics programming in a step-by-step fashion, Kendall & Welling, 2020.
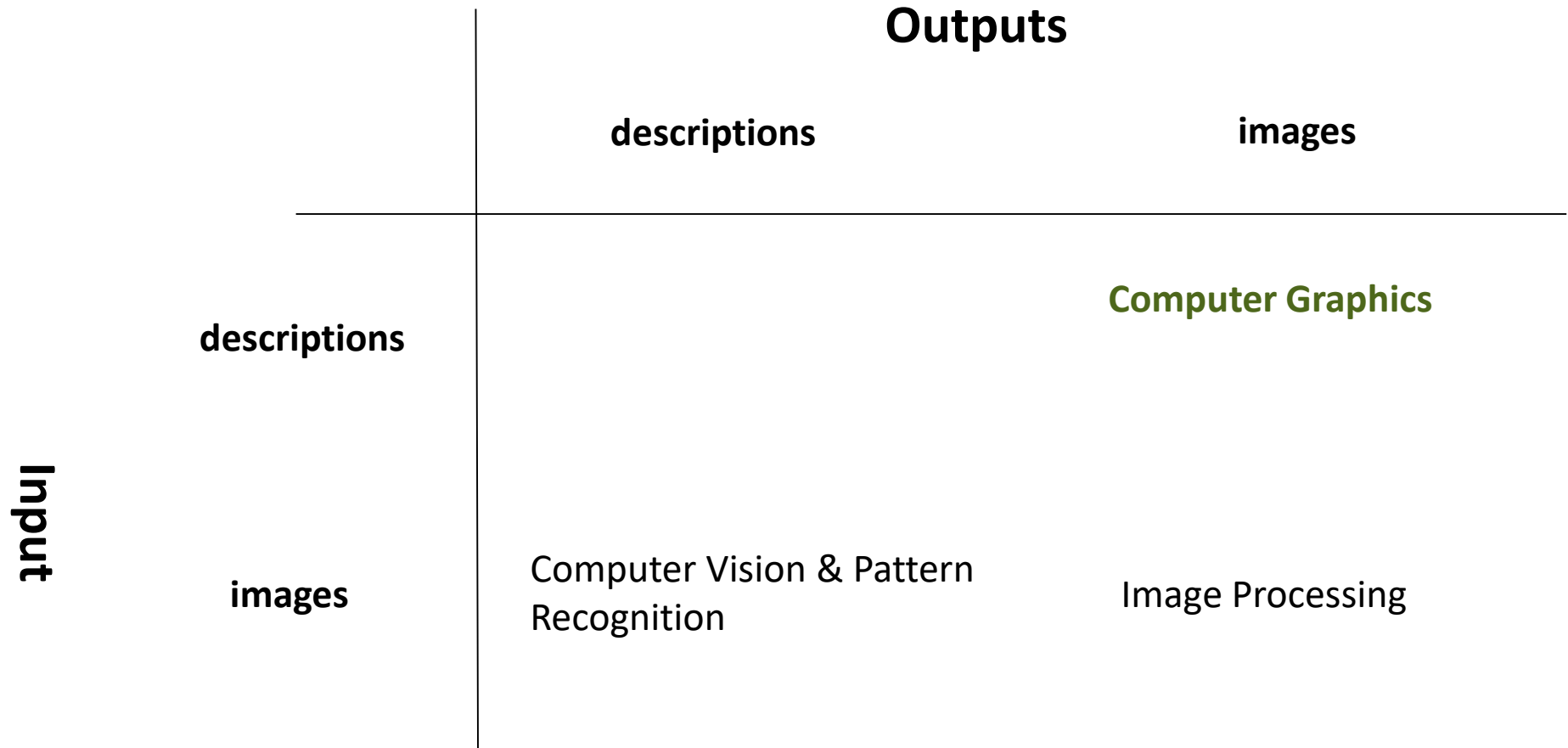
What's CG?

- [C](#)omputer [G](#)raphics.

  - Mainly focuses on 3D graphics.

  - Displays a realistic virtual environment by computers.

  - Or synthesizes virtual objects in the real world.

What's CG? (cont.)

▶ Or demonstrates a virtual world with specific styles. (e.g. non-photorealistic rendering)

▶ CG tech. is the foundation of modern 3D animation, special effects and games.

Graphics and related fields

	Outputs	
Input	descriptions	images
descriptions		**Computer Graphics**
images	Computer Vision & Pattern Recognition	Image Processing

Nevertheless, the boundaries between these fields, especially CG and CV, are getting indistinct.

Applications

- Movies
- Games
- Virtual characters

Applications (cont.)

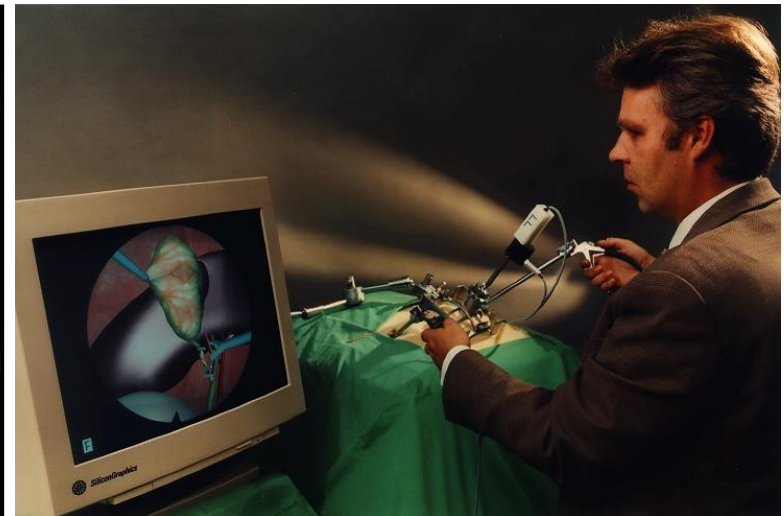▶ Virtual reality (VR)

VIVE Sync, VIVE Studio

Virtuix Omni

Fig. from:
en.wikipedia.org/wiki/Flight_simulator

Applications (cont.)
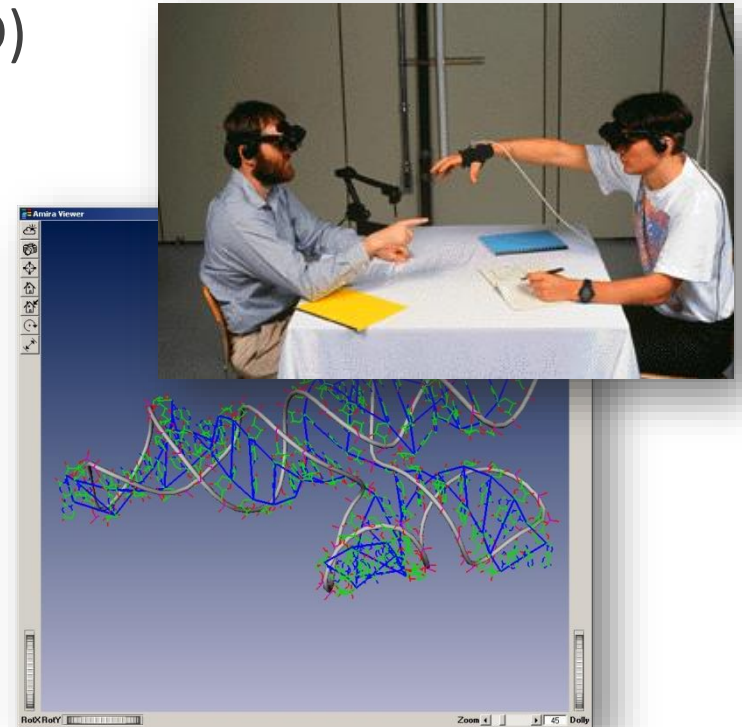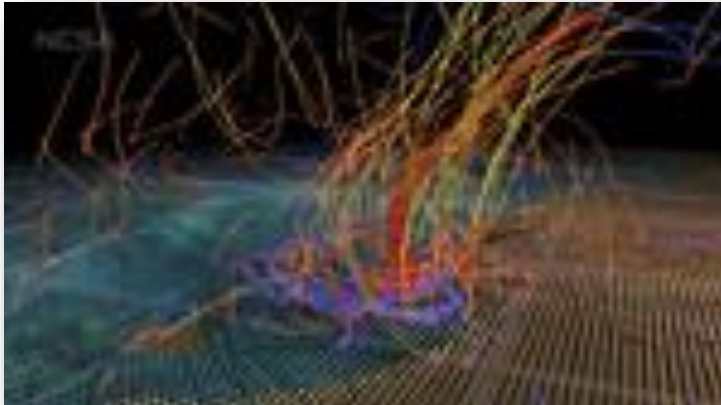
- Medical diagnosis.
- Virtual Surgery.
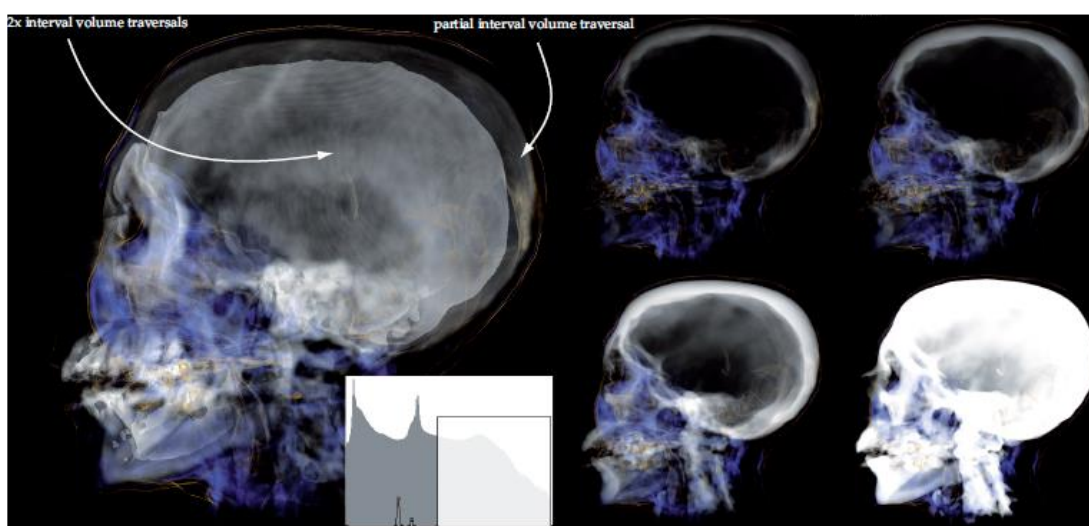
Direct Interval Volume Visualization, IEEE Vis'10

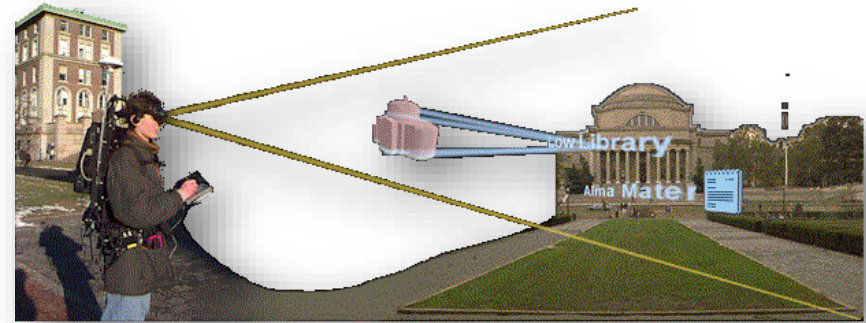The Karlsruhe Endoscopic Surgery Trainer

Applications (cont.)

▶ Computer aided design (CAD)

    ▶ Collaborating on cyberspace.

    ▶ Ex. Cabin design (Boem Inc.)

▶ Visualization tools

    ▶ Meteorology

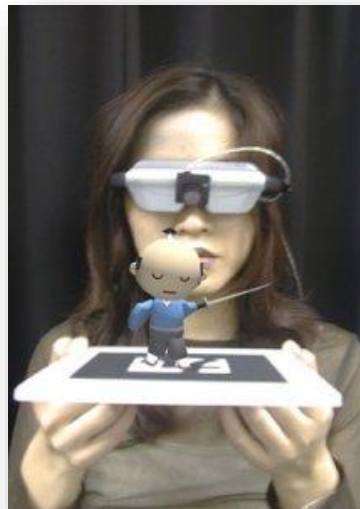http://ilab.cs.ucsb.edu/projects/helly.html

Applications (cont.)

▶ Augmented reality (AR)

▶ Advanced human computer interfaces

AR, U. Columbia

AR on iPhone,
Fig. from en.wikipedia.org/wiki/Augmented_reality

AR Toolkit

Microsoft Hololens

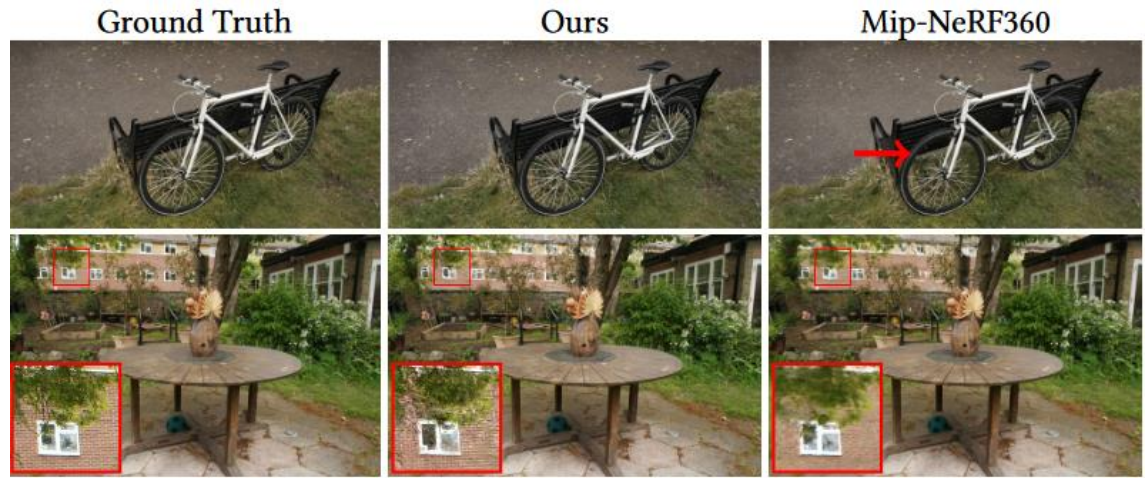# Nowadays: Graphics + Learning (and/or Optimization)

a lion reading the newspaper*

Poole et al., DreamFusion: Text-to-3D using 2D Diffusion, Google Research

Siddiqui et al., MeshGPT, CVPR'24

Note: This course may only cover one topic about *Graphics + learning and/or optimization*.

Kerbl et al., 3D Gaussian Splatting, SIGGRAPH'23

Intended learning outcomes of this course

▶ On completion of this ICG course, a student will be able to:

  ▶ Describes the fundamental concept of a computer graphics system.

  ▶ Explain how an image is synthesized by a graphics system.

  ▶ Apply graphics algorithms for image and animation synthesis through graphics programming language GLSL.

  ▶ Compare classic graphics algorithms and their advantages and limitations.

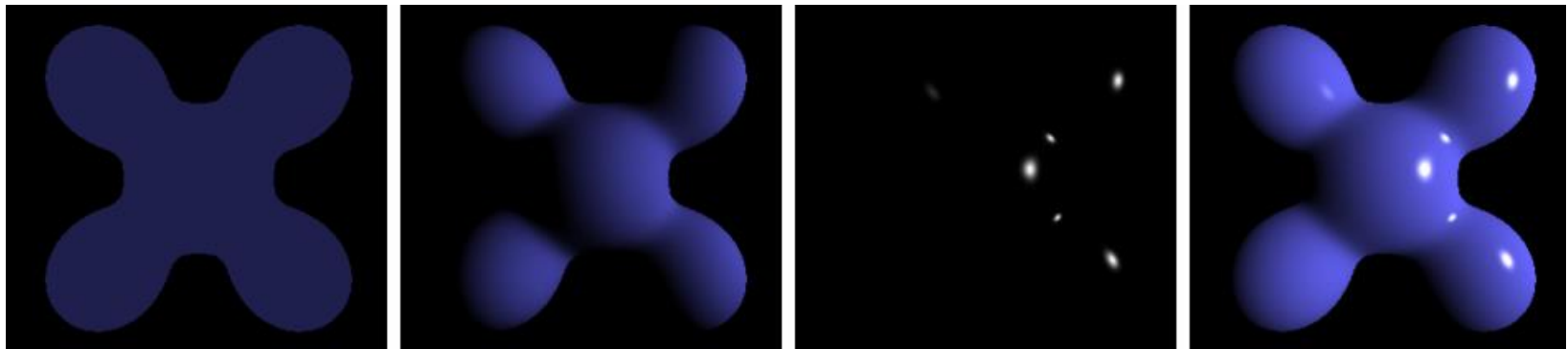 ▶ Identify an advance graphics method for a specific topic.

Syllabus

▶ Introduction

▶ Graphics primitives

▶ Geometric transformations

▶ Viewing in 3D

$${}^c_w\mathbf{T}$$

y

x

z

Camera
Coordinates

z

World
Coordinates

y

x
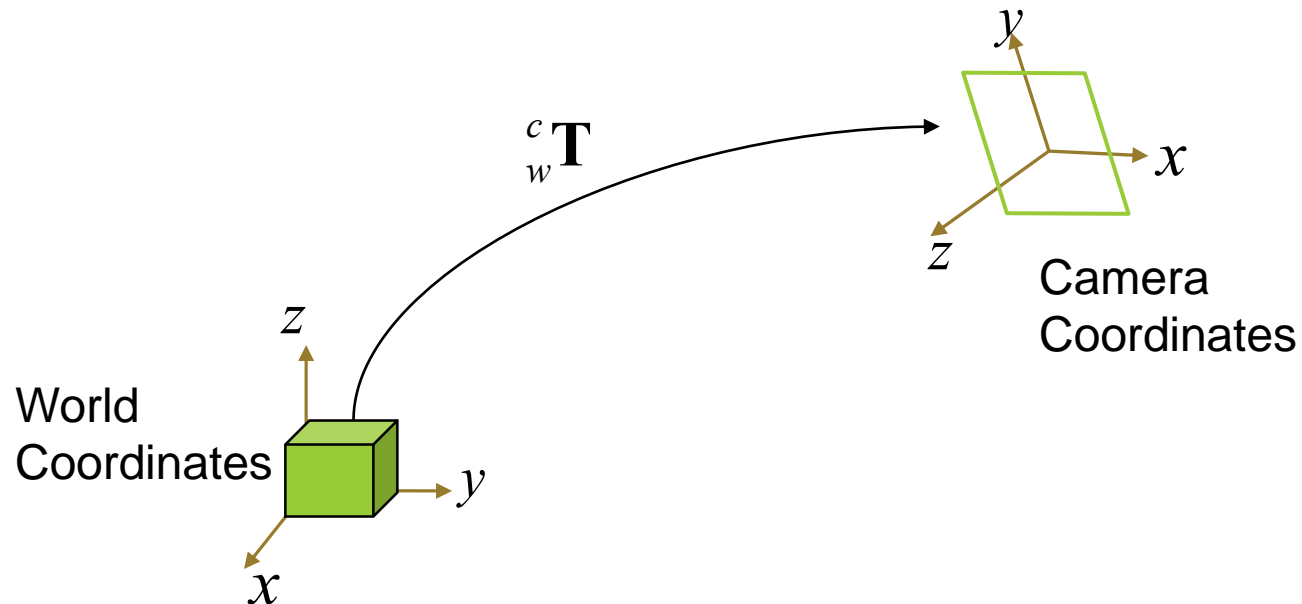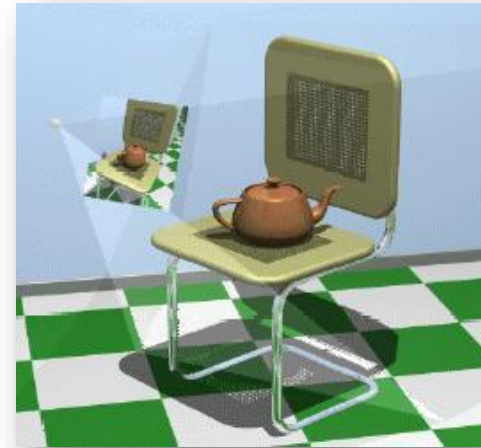
Syllabus (cont.)

▶ Illumination and surface rendering

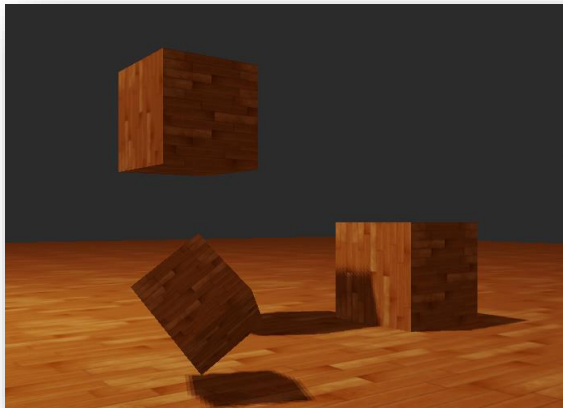Ambient   +   Diffuse   +   Specular   =   Phong reflection

▶ Visible-surface detection

Syllabus (cont.)

▶ Texture mapping

▶ Programming with Graphics processing unit (GPU)

▶ Global illumination

Samples from http://leanopengl.com

http://www.ozone3d.net/ tutorials/bump_mapping.php

the Chartres Cathedral www.graphics.cornell.edu

Syllabus (cont.)

▶ Advanced topics or research in CG, for instance
  ▶ Volume rendering and 3D gaussian splatting
  ▶ Or modeling with 3D point clouds
▶ Curves and surfaces (optional)

▶ (Note: advanced graphics-related courses in NYCU)
  ▶ Computer animation and visual effects
  ▶ Image manipulation techniques and visual effects
  ▶ Interactive shape manipulation
  ▶ Real-time rendering
  ▶ 3D game programming
  ▶ ……

About the course (cont.)

▶ Grading: (provisional)

　▶ Assignments (2 programs)

　　▶ OpenGL/GLSL viewer: transformation + viewing + texture.

　　▶ Shading and shadow with GLSL.

　▶ Project (proposal + demo)

　　▶ Research task or animation with GLSL effects

　　▶ 1 ~ 3 members per group

　▶ Quiz (0~15%)

　▶ Class participation (1 ~ 10% or bonus)

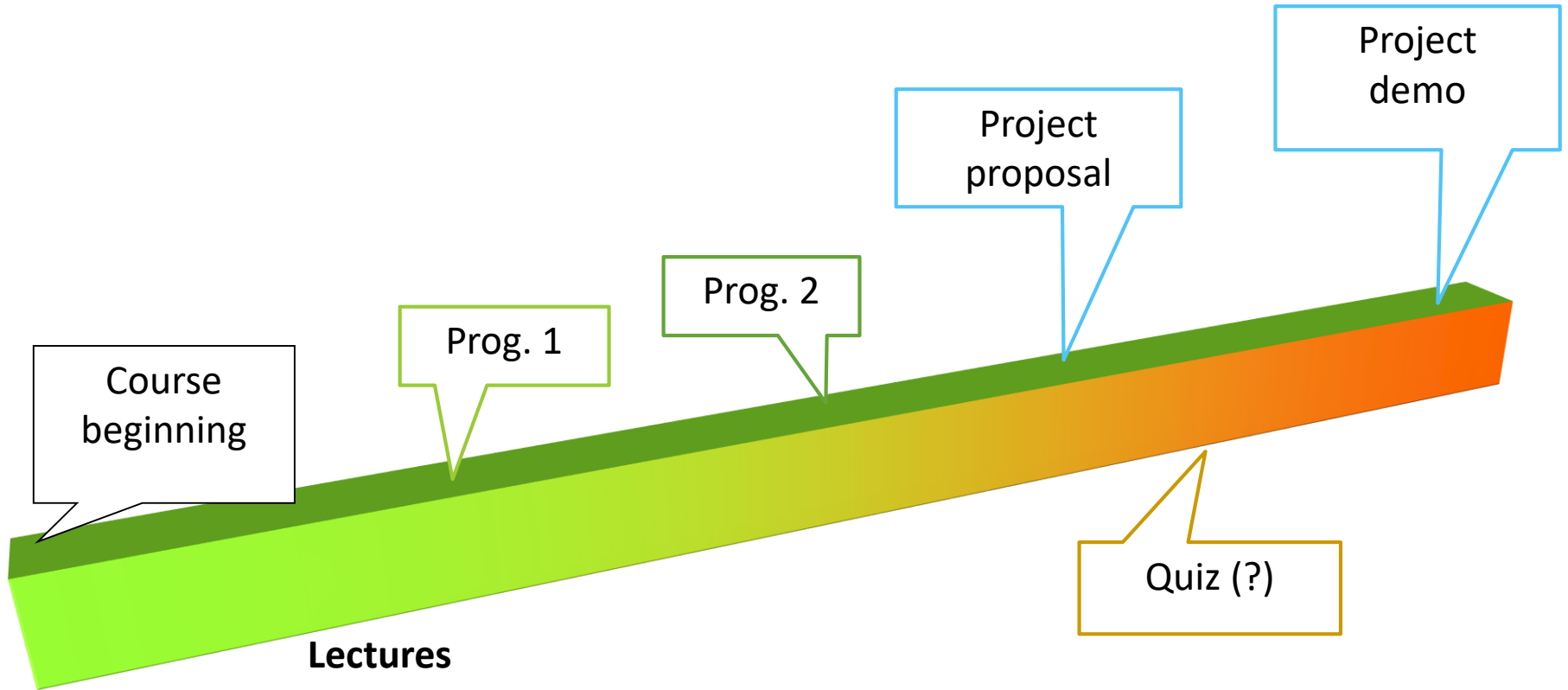　　▶ Live interaction with Slido (Accessing through QR codes)

Note:
HW sample codes on Windows will be provided.
SDK settings for MacOS will be introduced.
(Note: Apple may cease supporting OpenGL)

　▶ Note: The numbers of quizzes and assignments and their percentages may vary.

Schedule

What can I obtain in this course?

▶ Fundamentals of computer graphics techniques.

▶ Programming ability for 3D graphics.

▶ Preliminary concepts about graphics-related topics, e.g. 3D games, animation, VFX movies.

▶ Recent trends about specific graphics topics.

Conclusion

▶ The role of graphics people in CS

    ▶ Improving faithfulness or visual effects.

    ▶ Speed-up of CG generation.

    ▶ Exploring the use of graphics.

    ▶ (through computer techniques)

CG gives "wizards" the "wands" and "spells" !