CP411 Computer Graphics

Instructor: Dr. Hongbing Fan

Lecture time: 4:00-5:20 pm, Monday and Wednesday
Classroom: Bricker Academic Building BA110
Office hours: After class or by appointment

Course introduction

1. Concepts of Computer graphics
   - What is Computer Graphics (CG)
   - Why computer graphics, CG applications

2. Course syllabus
   - Syllabus: objectives, topics, course work, assessment
   - Materials: contents, web system, programming environment
   - Q&A

SIGRAPH 2025 Technical paper trailer
https://www.youtube.com/watch?v=HfHC0wNYry8&list=PL1PdIP1IGMJJzRFjIDajKtb14vvApj1IH&index=3
SIGRAPH 2024 Technical paper trailer
https://www.youtube.com/watch?v=tjYVcOJONdI
SIGRAPH 2023 Technical paper trailer
https://www.youtube.com/watch?v=VBZ2sDxvZQE

What is Computer Graphics?

All Graphical User Interfaces (GUIs) of computers
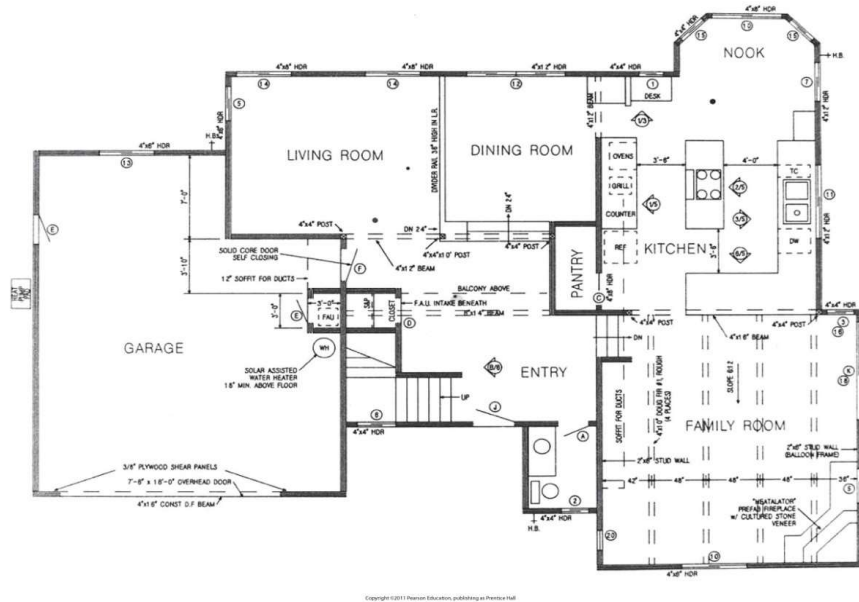
Animations
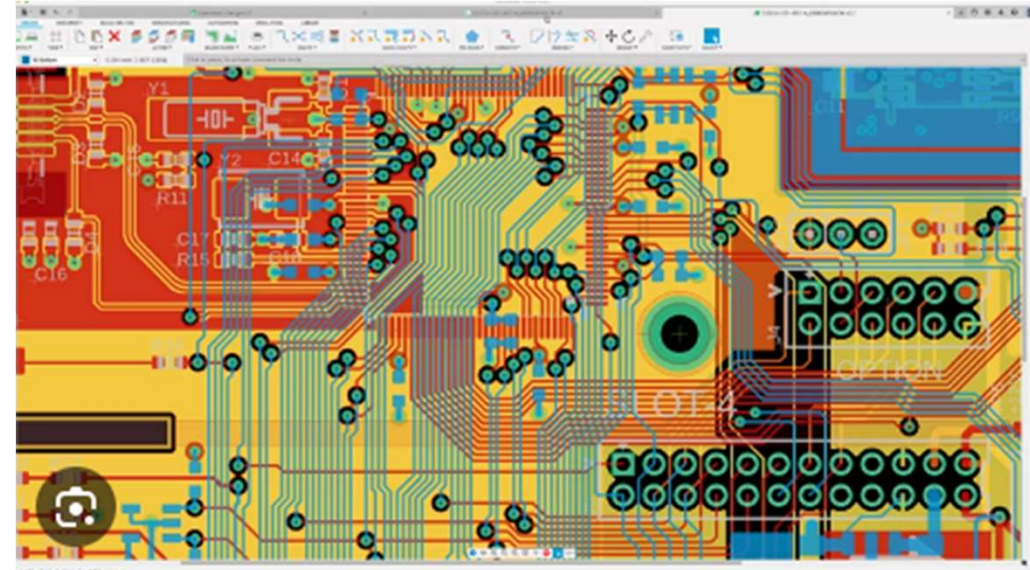

Computer-Generated Imaginary (CGI)

Video games

Computer Aided Design (CAD) software

building design
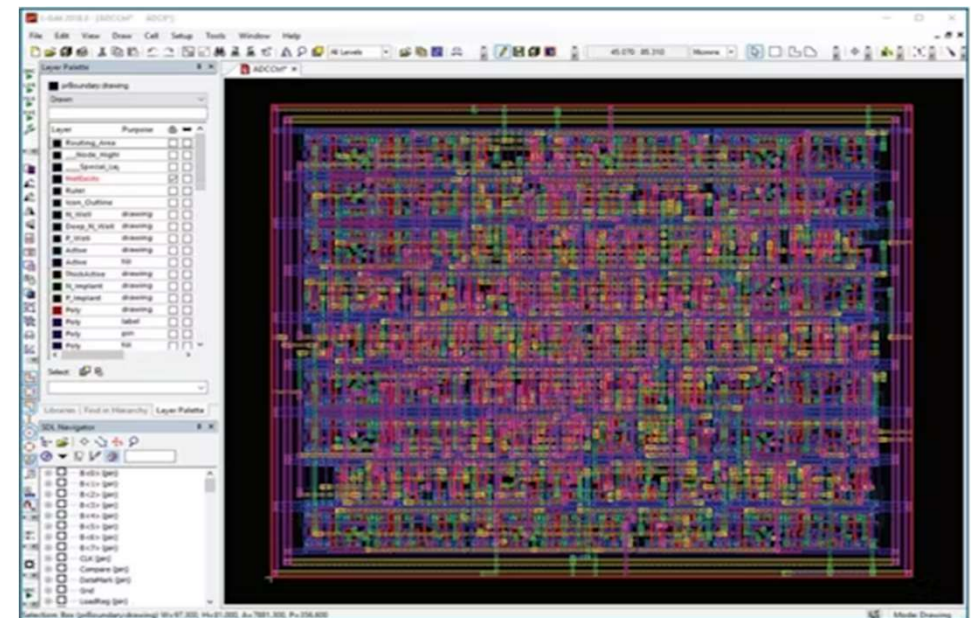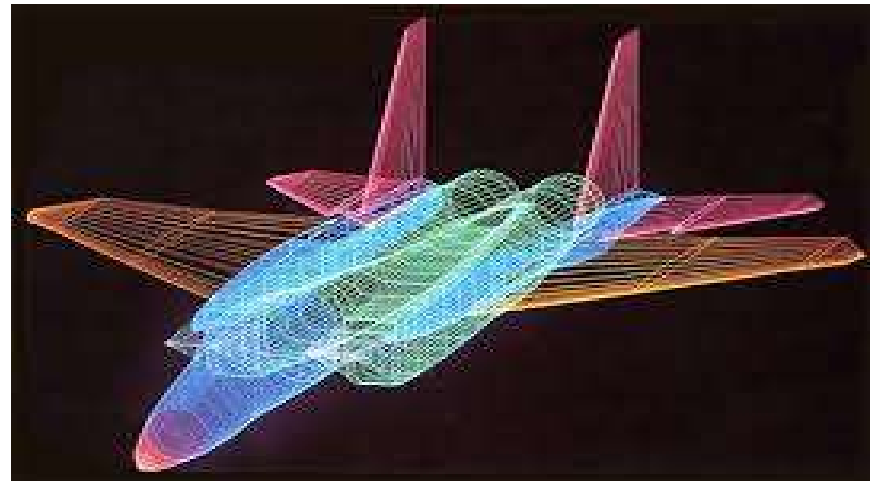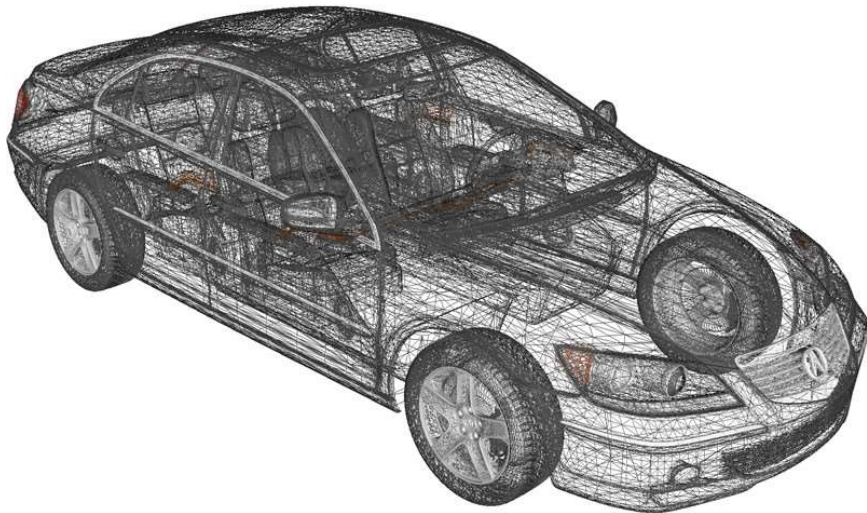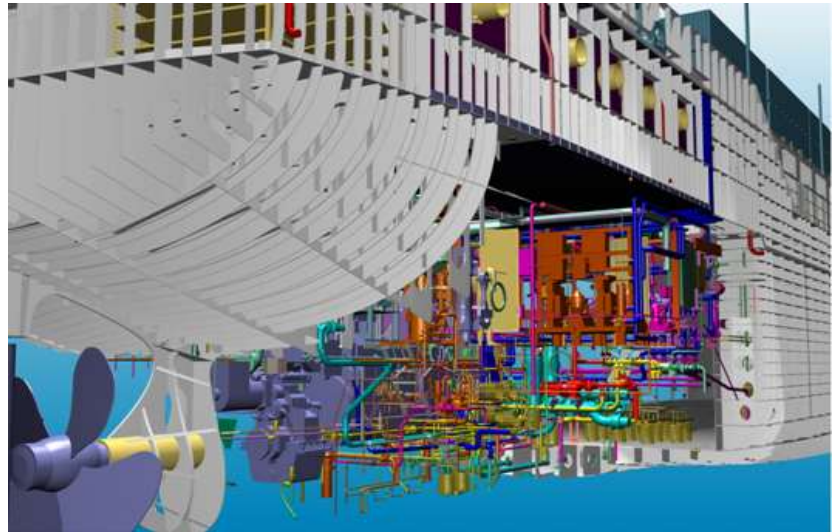
PCB design

IC design

Computer-Aided Engineering (CAE)

Simulators

Simulation
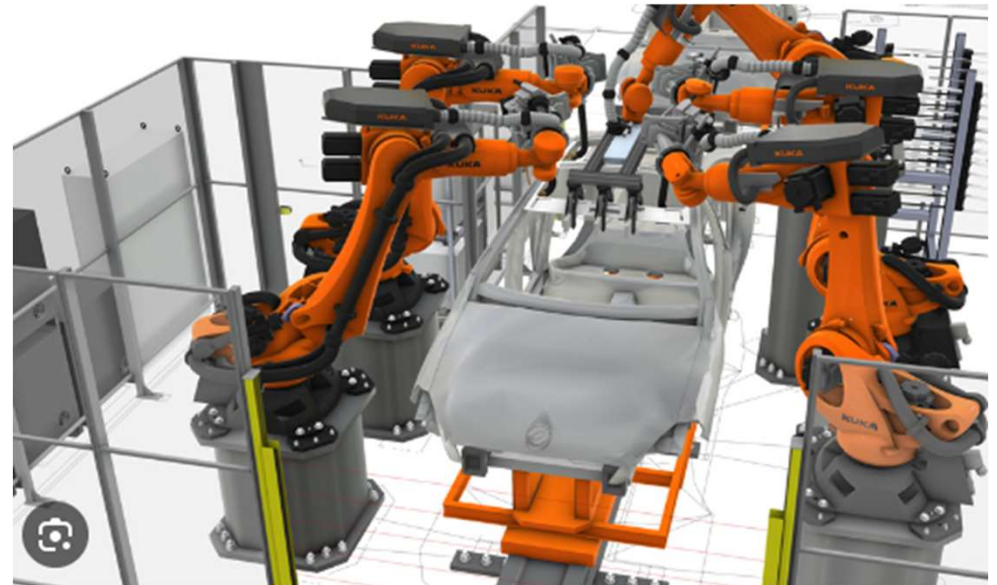
Virtual reality systems in medical fields

What is Computer Graphics?

- Conceptually, it's about the creation, storage, manipulation and display of images using computers.

- Practically, it's about Graphical User Interface (GUI), movies, games, art, training, advertising, design, virtual reality, …, you name it.

- It's a CS&CE field of using computer to generate images for applications.

- Computer-Generated Image is not produced by camera.

- **Definition** of Computer Graphics
  - Creation, storage, manipulation and display of images of models of 2D/3D objects.
  - Pictorial synthesis of real or imaginary objects from their computerized models.

- Two aspects
  1. *Modeling:* creating and representing the geometry of objects in the virtual 2D or 3D world, as well as the changes of objects.
  2. *Rendering:* generating and displaying images of model objects on screens.

Why computer graphics

- **A picture is worth a thousand words**
  - An image can carry lots information. Human are trained to catch information by eyes, response accordingly.
- **CG has many applications**
  - Graphical user interface (GUI)
  - Animation movies, video games
  - CAD, CAE, CAM software
  - Simulation and synthesis of physical world, virtual reality, digital twins.
  - Image processing, pattern recognition, computer vision.
  - Automatic car, humanoid robots.
- **CG is wide, deep, and challenging**
  - Wide range knowledge base involving mathematics, data structures, algorithms, physics, etc.
  - Deep technology in hardware and software, continuously innovated, developed, and evolved.
  - Deal with complex problems, complicated solutions and systems.

- CG has over past 60 year's history. It is one of well-established and most fast developing CS&CE fields, deeply rooted in academia, industry, and consumers.

- CG continuously evolves in areas:
  - CG hardware, e.g., GPU technology
  - CG software, tools to create models and render images.
  - CG devices, computers, phones, game consoles, I/O devices, VR
  - Modeling and rendering algorithms and techniques
  - Applications in almost all fields of science and engineering
  - Artificial intelligence:

    - CG computing technology enhances AI computing
    - AI accelerates CG computing

Relations to other fields as CG applications

1. Image processing and computer vision
    –   Image enhancement
    –   Feature retrieval
    –   Pattern recognition and analysis of scenes
    –   Reconstruction of models of 3D objects, machine learning, use decision making and control
2. User interface design
    –   Understanding human
    –   It pertains to user
    –   Ergonomics
3. CAD/CAM
    –   Manufacture industry
    –   Construction industry
    –   Digital twins
4. AI and applications
    –   Automatic driving
    –   Robotic

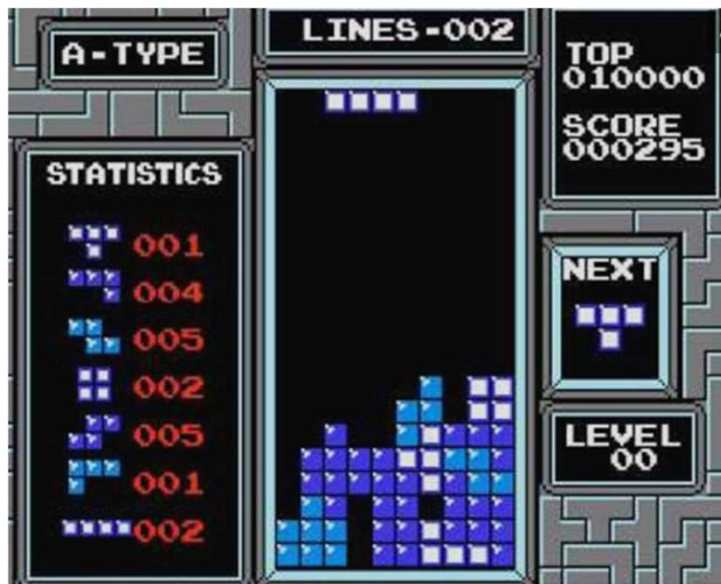# Graphics Applications
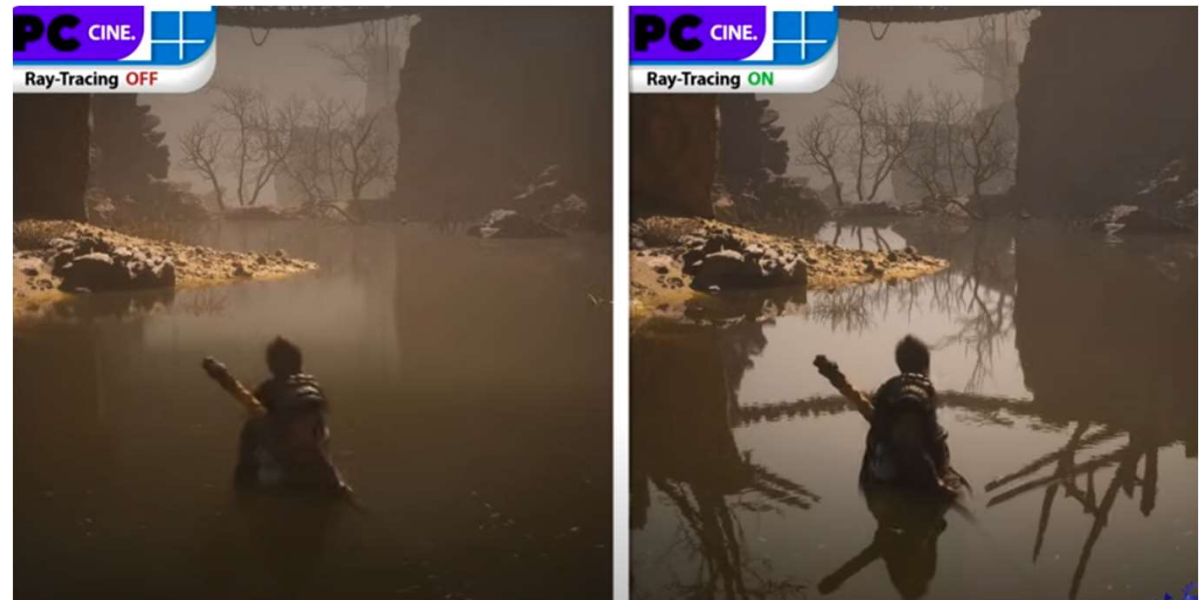
- Entertainment

Pixar: Monster's Inc.
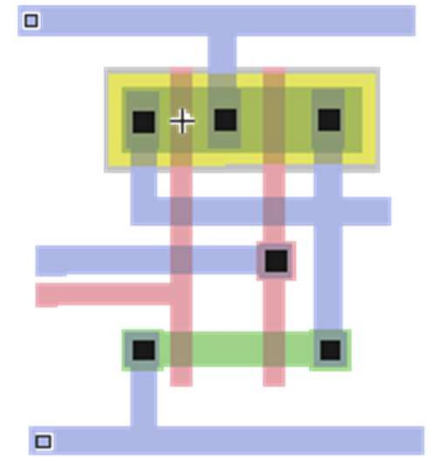

Computer-generated imagery (CGI)

- Video games

https://www.youtube.com/watch?v=T4DFKOIrXCQ

https://www.youtube.com/watch?v=A5boaueGopg

Virtual Reality (VR)

- CAD and CAE for parts and systems
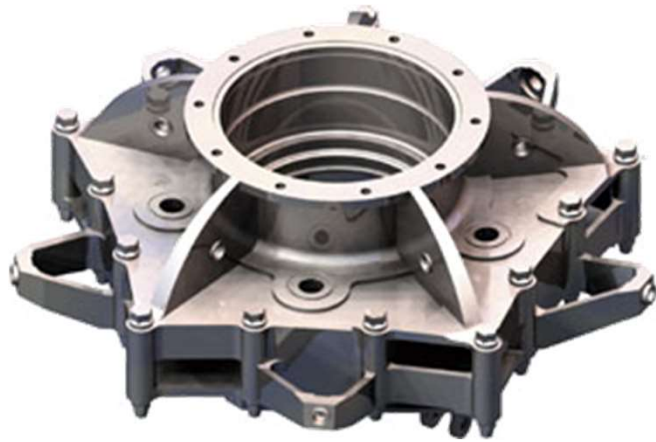
- Electronic Design Automation (EDA, or ECAD) design software for printed circuit board (PCB) and Integrated circuits (IC), VLSI
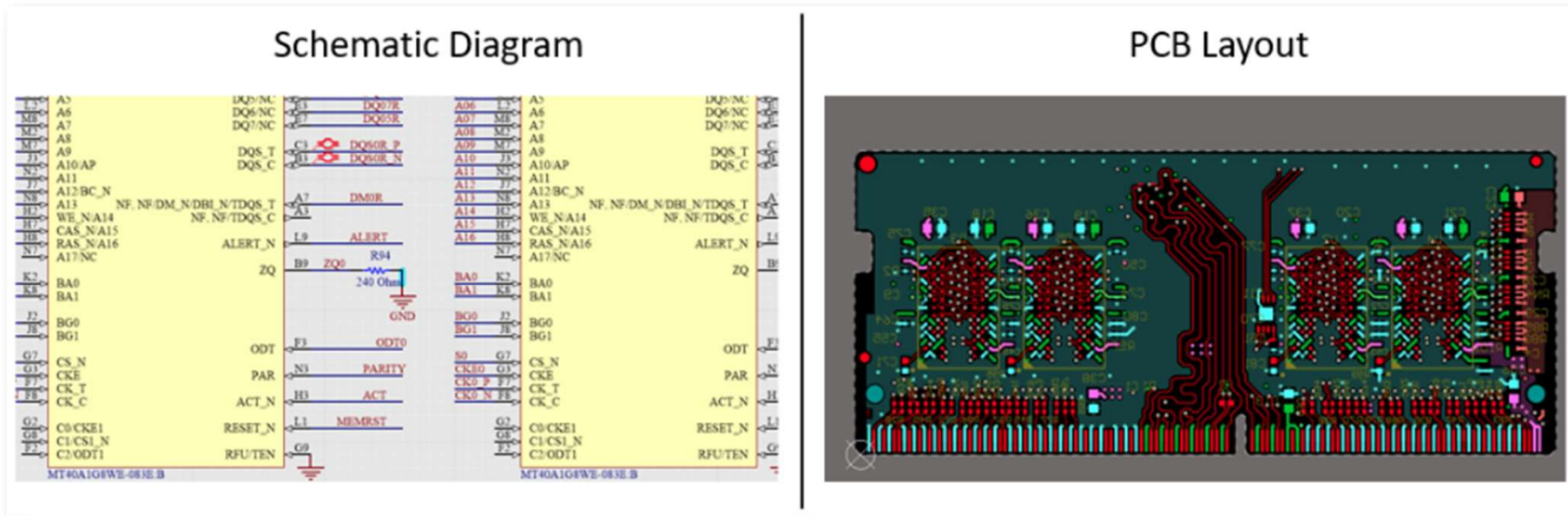

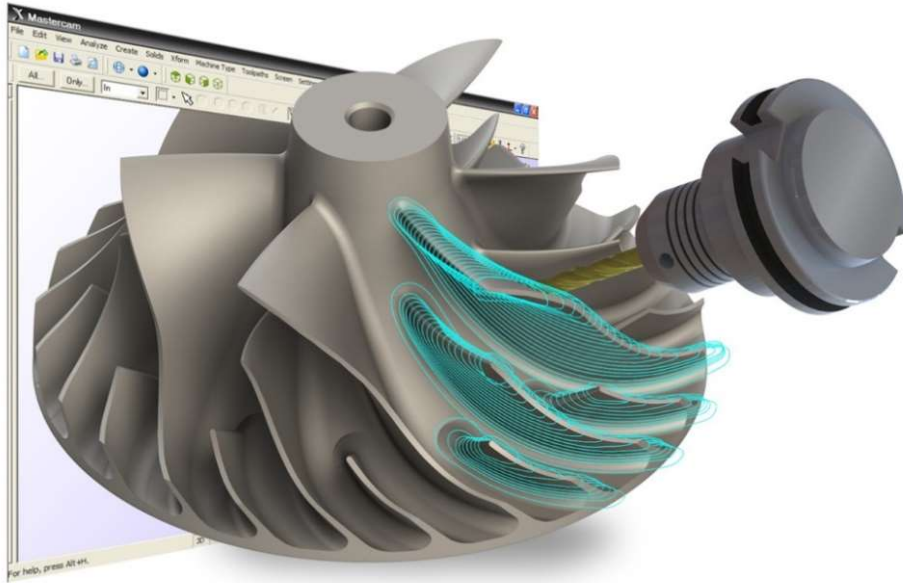Fig. 1. PCB schematic vs. layout for an example DDR3 memory stick project from Altium Designer.

Computer Aided Manufacturing (CAM)

3D printing

Data Visualization

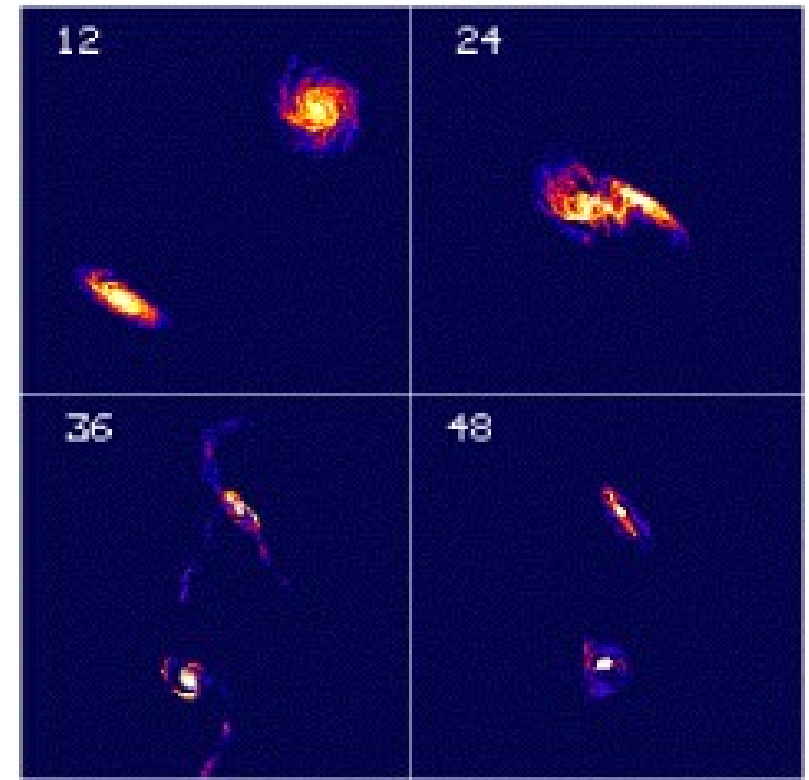*CP411 Computer Graphics, Wilfrid Laurier University*
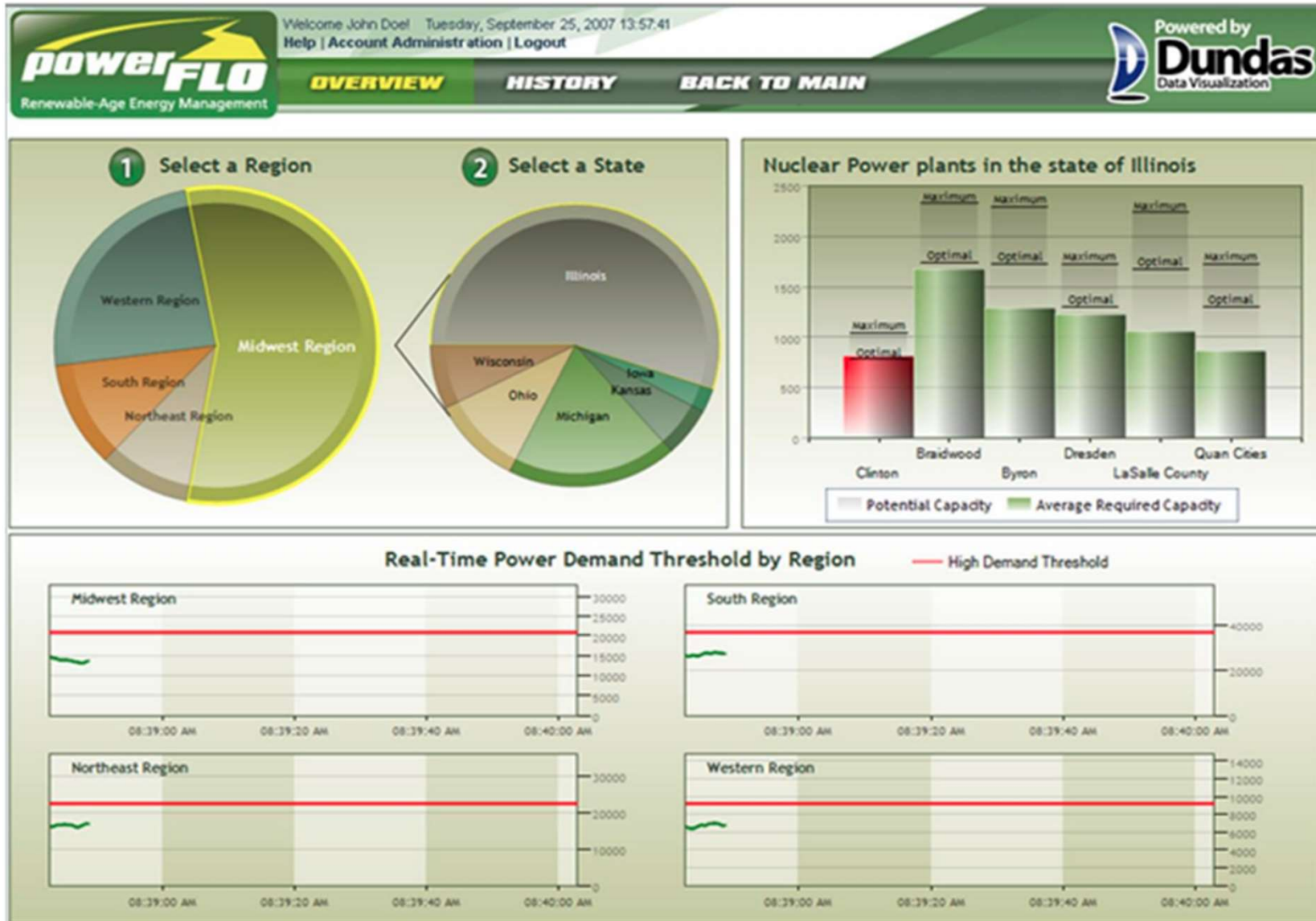
Scientific Data Visualization

- # Medical Visualization

MIT: Image-Guided Surgery Project
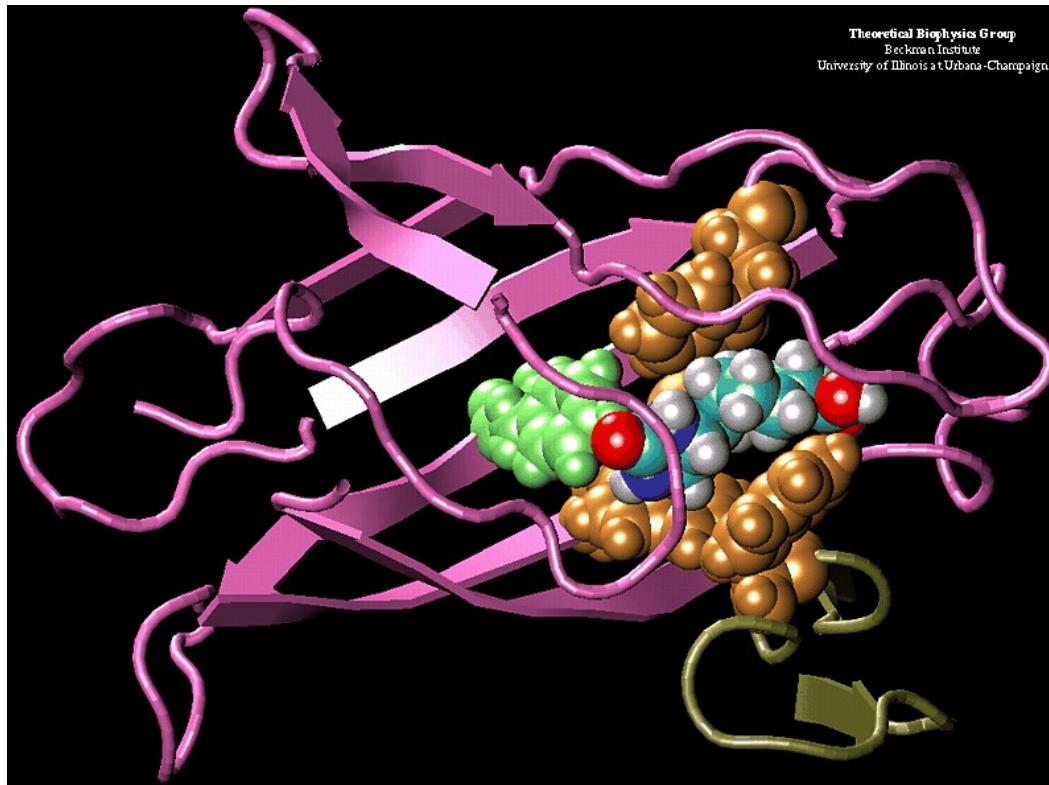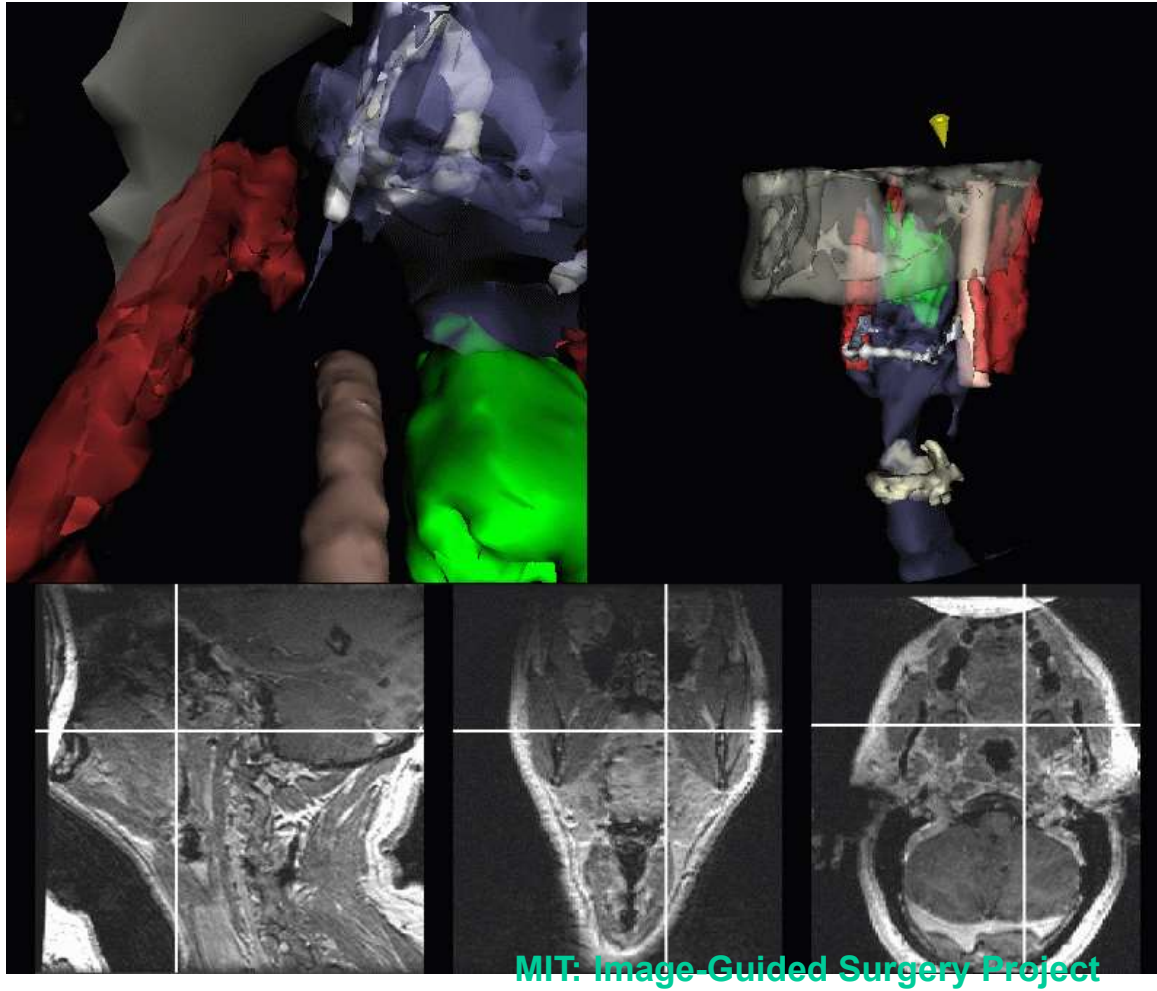
The Visible Human Project

Computer Art
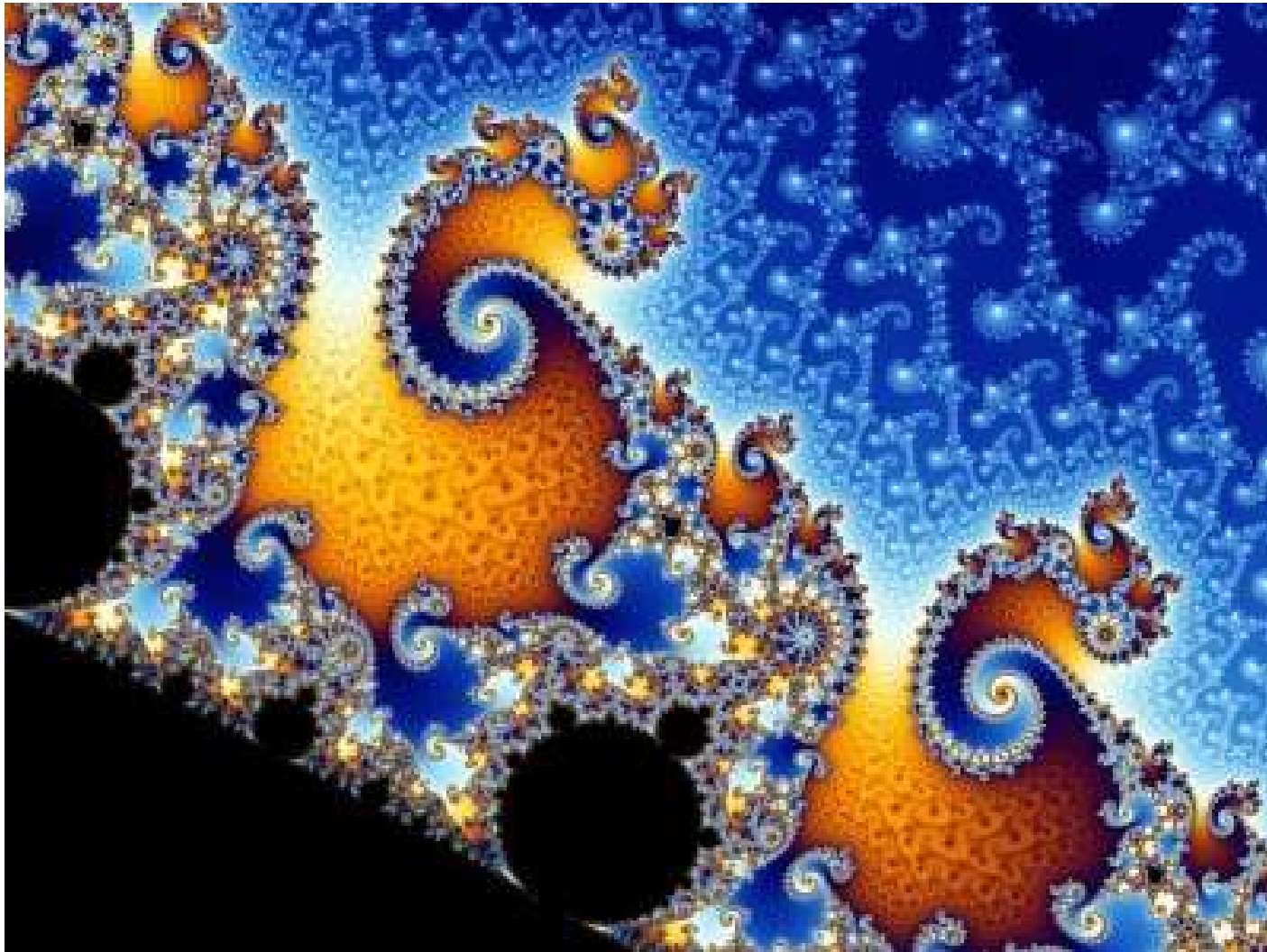
More

Graphical User Interfaces (GUIs)

Touch GUI

The next big CG applications

the next big evolution of the internet, the metaverse.

- **The Physical Turing Test: Jim Fan on Nvidia's Roadmap for Embodied AI, 2005**
  https://www.youtube.com/watch?v=_2NijXqBESI
- **NVIDIA Keynote at SIGGRAPH 2023**
  https://www.youtube.com/live/3qSQjRaseos?feature=share&t=1695
- NVIDIA Special Address at SIGGRAPH 2022
  https://www.youtube.com/watch?v=Pev84SGO2r0

Course syllabus

- Objectives

1. Understand fundamental concepts, principles, algorithms of computer graphics.

2. Gain the fundamental knowledge, skill, and experience on computer graphics software development.

3. CG programming with C/C++, OpenGL, GLSL

4. GPU programming with GLSL, CUDA for high performance computing

Topics

1. Graphics hardware and software
2. Graphics pipeline, transformations, culling, clipping, lighting, and shading
3. Graphics primitives and rendering algorithms
4. Graphics object modeling and representations
5. Modeling of curve, surface, and fractal objects
6. Scene description and representations
7. Graphics programming with C/C++ and OpenGL
8. GPU programming with GLSL and CUDA

- Course work
  1. Attending lectures and reading lecture notes. 24 lectures, covering the graphics concepts, principles, algorithms, and assignment tutorials.
  2. 6 assignments, lab practices are embedded.
  3. Final exam

- Assessment
  – 6 assignments   55%
  – Final exam   45%

- Requirements
  – Attend classes (mandatory)
  – Read lecture notes (necessary)
  – Read textbook chapters (optional)
  – Do assignments (graded)
  – Pass 50% of the overall grade to pass the course

Textbooks and References

1. Primary textbook (optional)
   Computer Graphics with OpenGL, 4/E
   Donald Hearn, M. Pauline Baker and Warren R. Carithers

2. Secondary textbook (optional)

   Interactive Computer Graphics: A Top-Down Approach with Shader-Based OpenGL, 6/E by Edward Angel

3. Reference books (optional)
   - OpenGL Programming Guide
   - OpenGL Reference Manual
   - OpenGL Shading Language, 2nd ed

4. More reference links are listed in course web site.

Prerequisites

- ## CP264 Data Structures II
  - Data structures
  - C programming language
  - C software development environment

- ## MA122 Introductory Linear Algebra
  - coordinate systems
  - vector
  - matrix
  - linear transformations

Programming Environment

- Programming tools for assignments
  - C/C++ compiler MinGW, OpenGL, GLSL
  - VS code as default IDE
  - Windows OS (supported).
  - Colab will be used in A6 for CUDA programming.

- OpenGL will be used (required)
  - Provides APIs for drawing 2D/3D graphics objects
  - Included as part of Windows, available for Linux either as software or hardware drivers for using GPU

- Questions

Web system and support

- Course web site (access from MyLS)
  - Updated on regular basis
  - Additional resources and links are provided
  - Announcement, assignments, examples, references
  - Most lecture notes will be posted on MLS.
  - Taking notes is recommended for some classes

- Individual help and support: by appointment

History and state of art of CG

1. A Brief History of Graphics

https://www.youtube.com/live/3qSQjRaseos?feature=share&start=6459
see more
https://www.youtube.com/watch?v=LzZwiLUVaKg
https://www.youtube.com/watch?v=S3hqS6JIKEc

2. Current state of art on CG

- **NVIDIA Keynote at SIGGRAPH 2023, August 9**

https://www.youtube.com/live/3qSQjRaseos?feature=share&t=1695

- **NVIDIA Keynote at COMPUTEX 2023, May 30**

https://www.youtube.com/watch?v=i-wpzS9ZsCs

- **GTC 2023 Keynote, NVIDIA CEO Jensen Huang, Mar 21**

https://www.youtube.com/watch?v=DiGB5uAYKAg

- Jensen Huang interview at SIGGRAPH 2024
  https://www.youtube.com/watch?v=H0WxJ7caZQU&t=120s

- Jensen Huang and Mark Zuckerberg at SIGGRAPH 2024
  https://www.youtube.com/watch?v=w-cmMcMZoZ4