INTRODUCTION TO COMPUTER GRAPHICS

CSE 409 Computer Graphics

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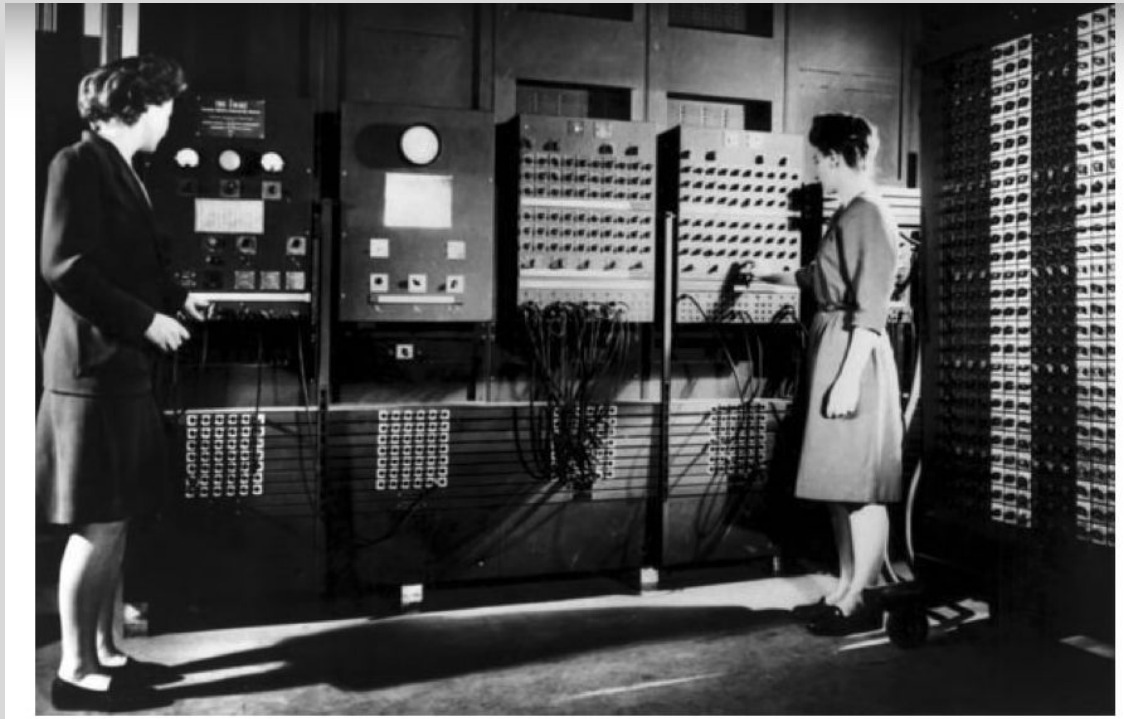
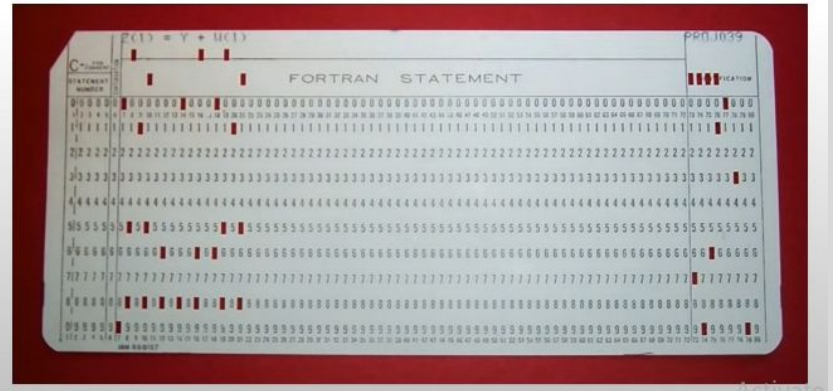
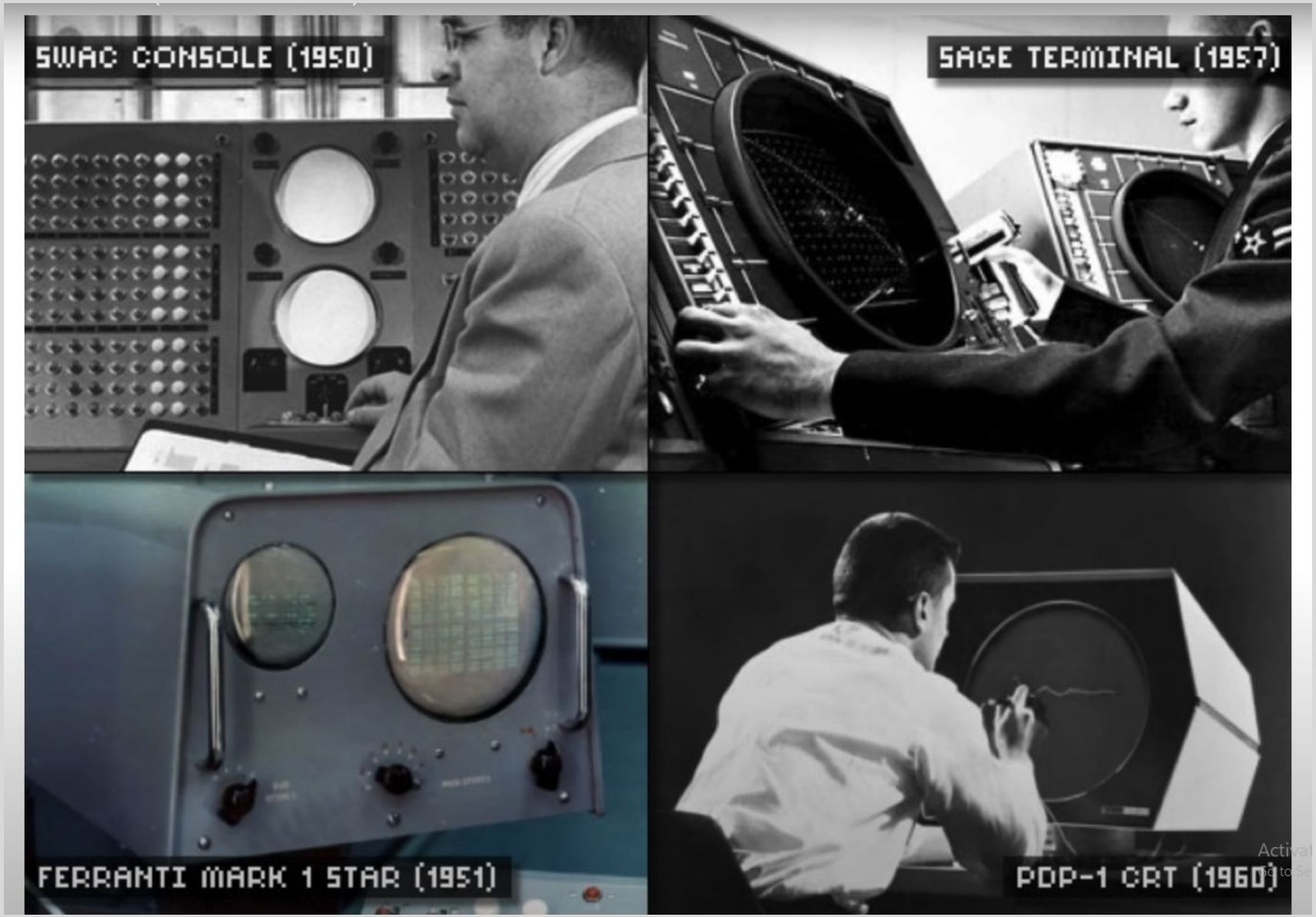
*adapted from Md. Tareq Mahmood



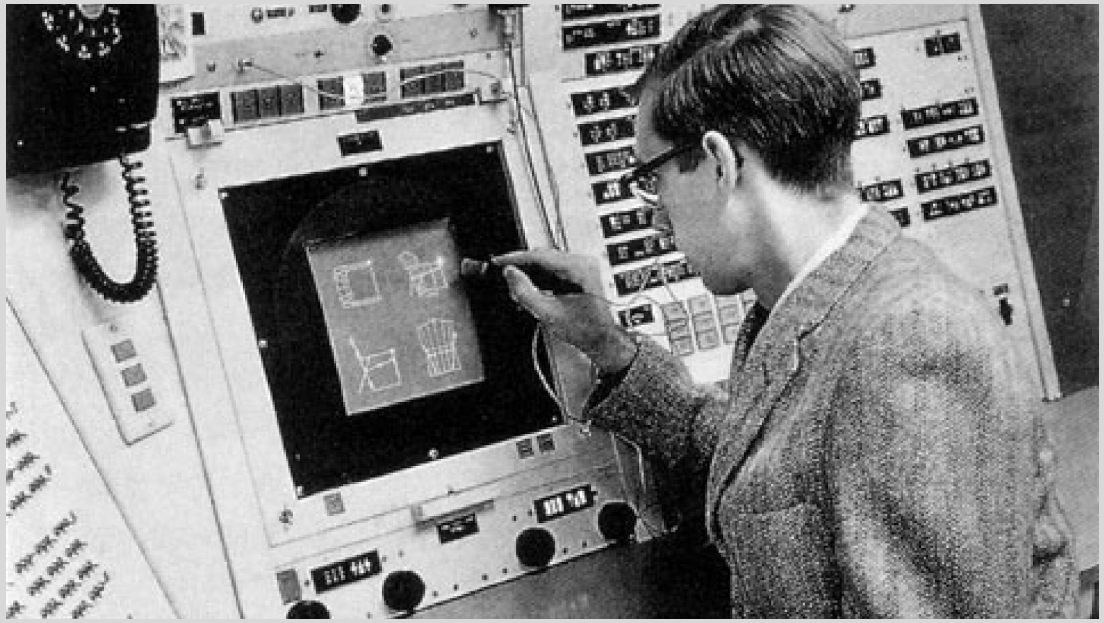
Early computer (ENIAC), 1945



punch card (~120 bytes)


SWAC CONSOLE (1950)
SAGE TERMINAL (1957)
FERRANTI MARK 1 STAR (1951)
PDP-1 CRT (1960)

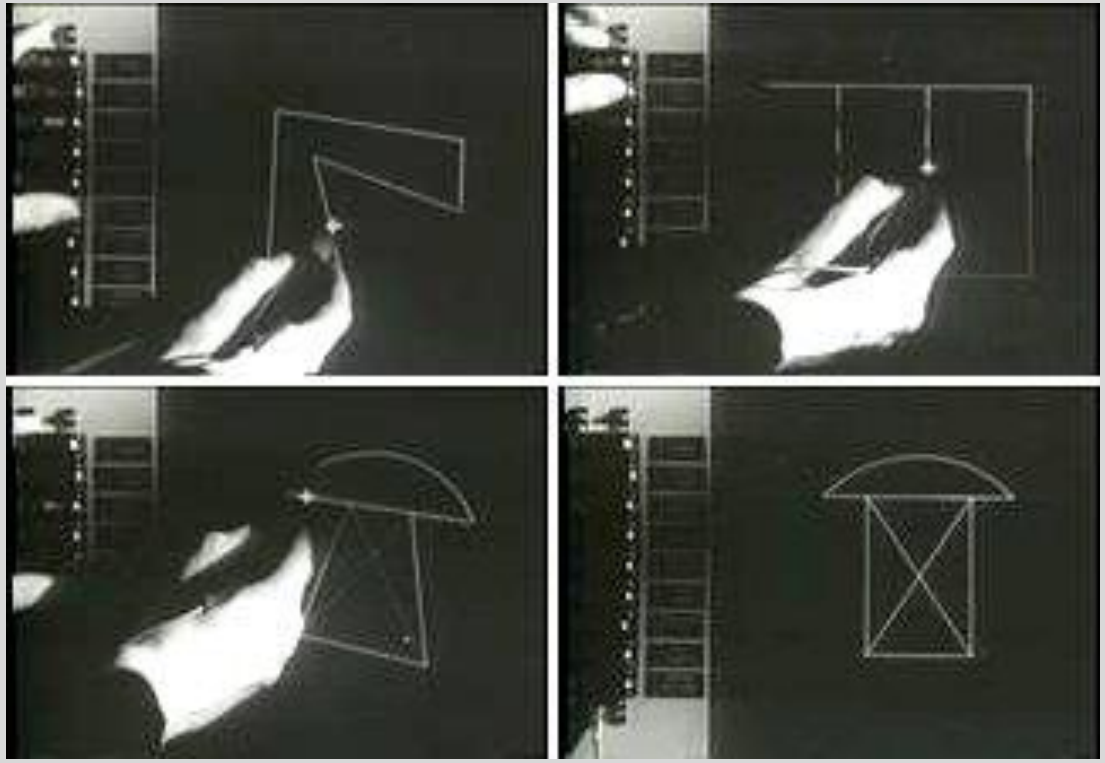
Sketchpad (Ivan Sutherland, 1963)



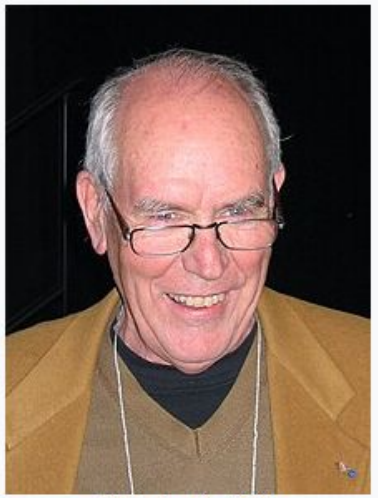
- Pioneered Computer Aided Design (CAD)
- Based on oscilloscope
- Was his PhD Thesis at MIT

https://www.youtube.com/watch?v=6orsmFndx_o

Sketchpad



Ivan Edward Sutherland



Sutherland in 2008

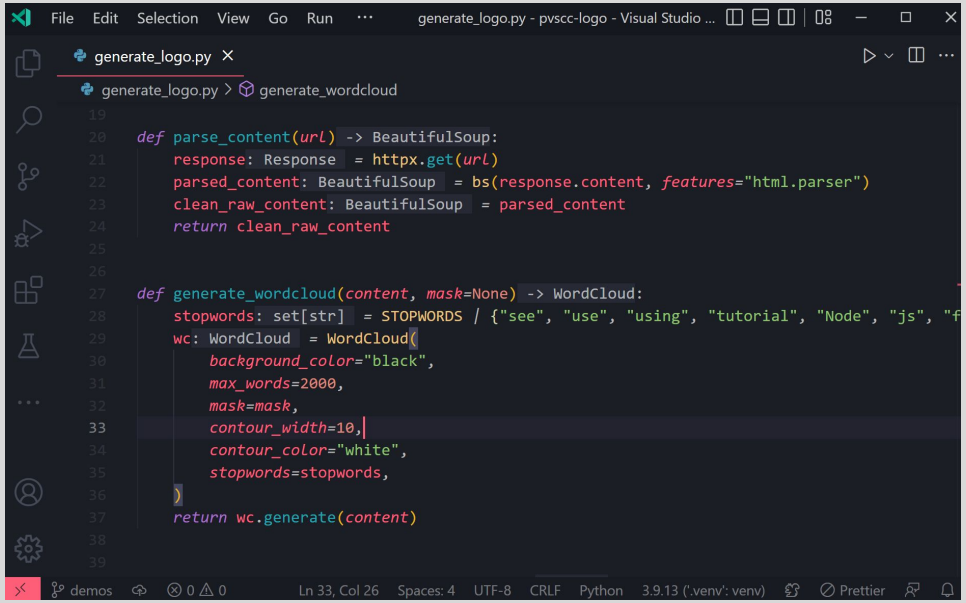
Born	May 16, 1938 (age 85) Hastings, Nebraska, United States
Alma mater	MIT (Ph.D., 1963) Caltech (M.S., 1960) Carnegie Institute of Technology (B.S., 1959)
Known for	Father of computer graphics Direct linear transformation Interactive computing Sketchpad Zooming user interface Cohen–Sutherland algorithm Sutherland–Hodgman algorithm
Awards	Turing Award (1988)

https://www.youtube.com/watch?v=6orsmFndx_o

Recent…

Computer Graphics

Use of computers to synthesize visual information

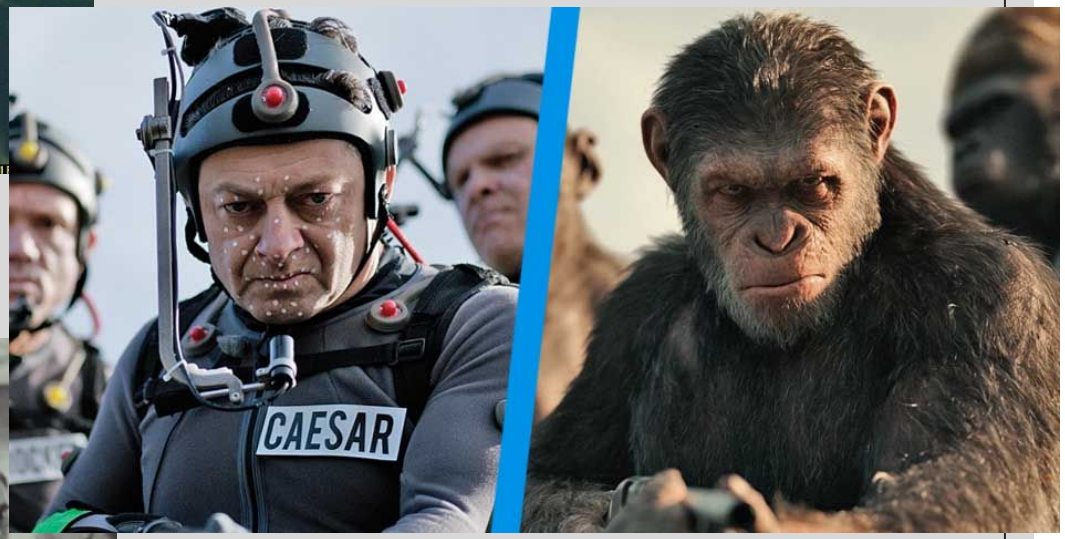


USE OF CG

Animation

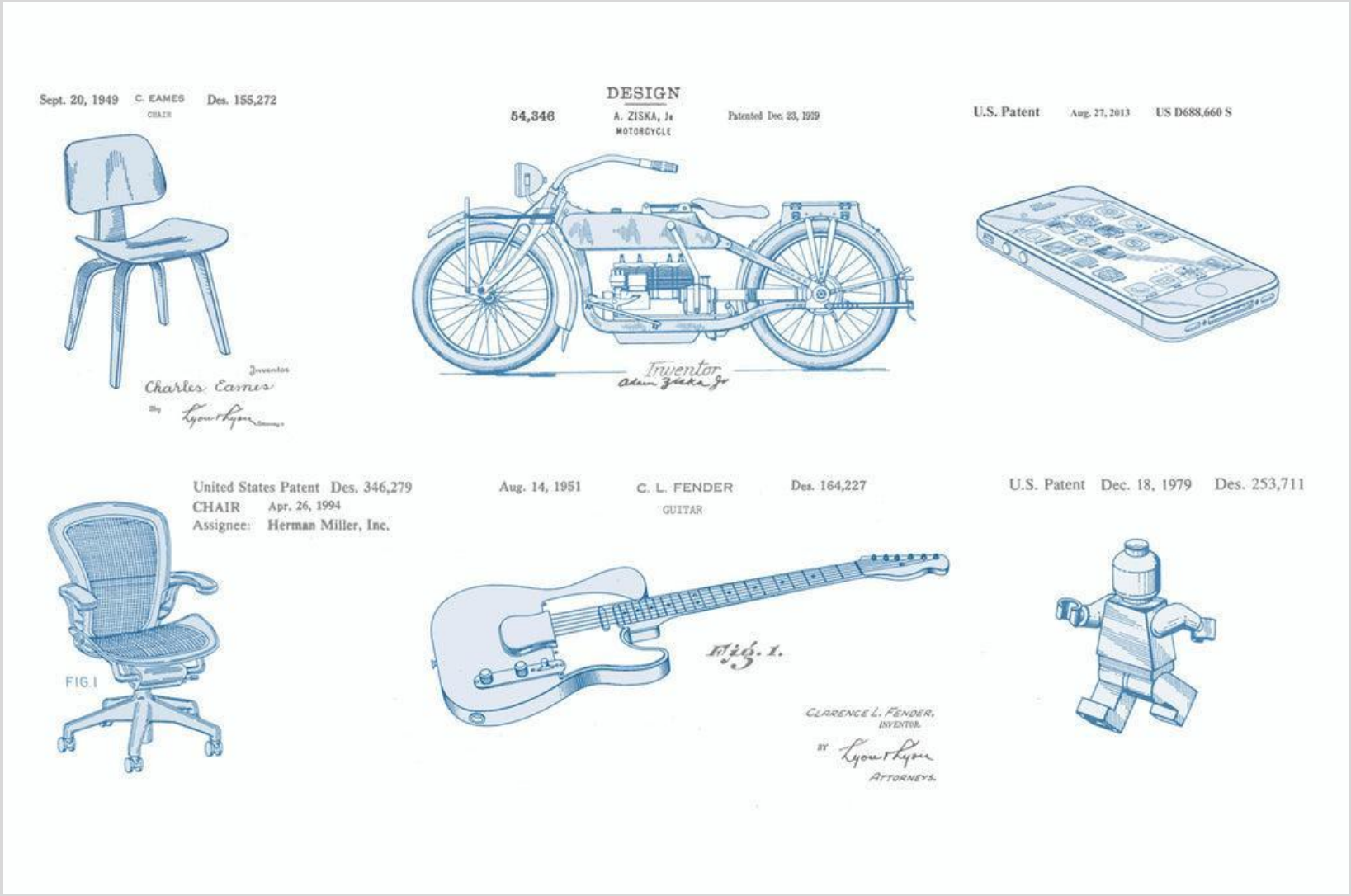
Games

Movies



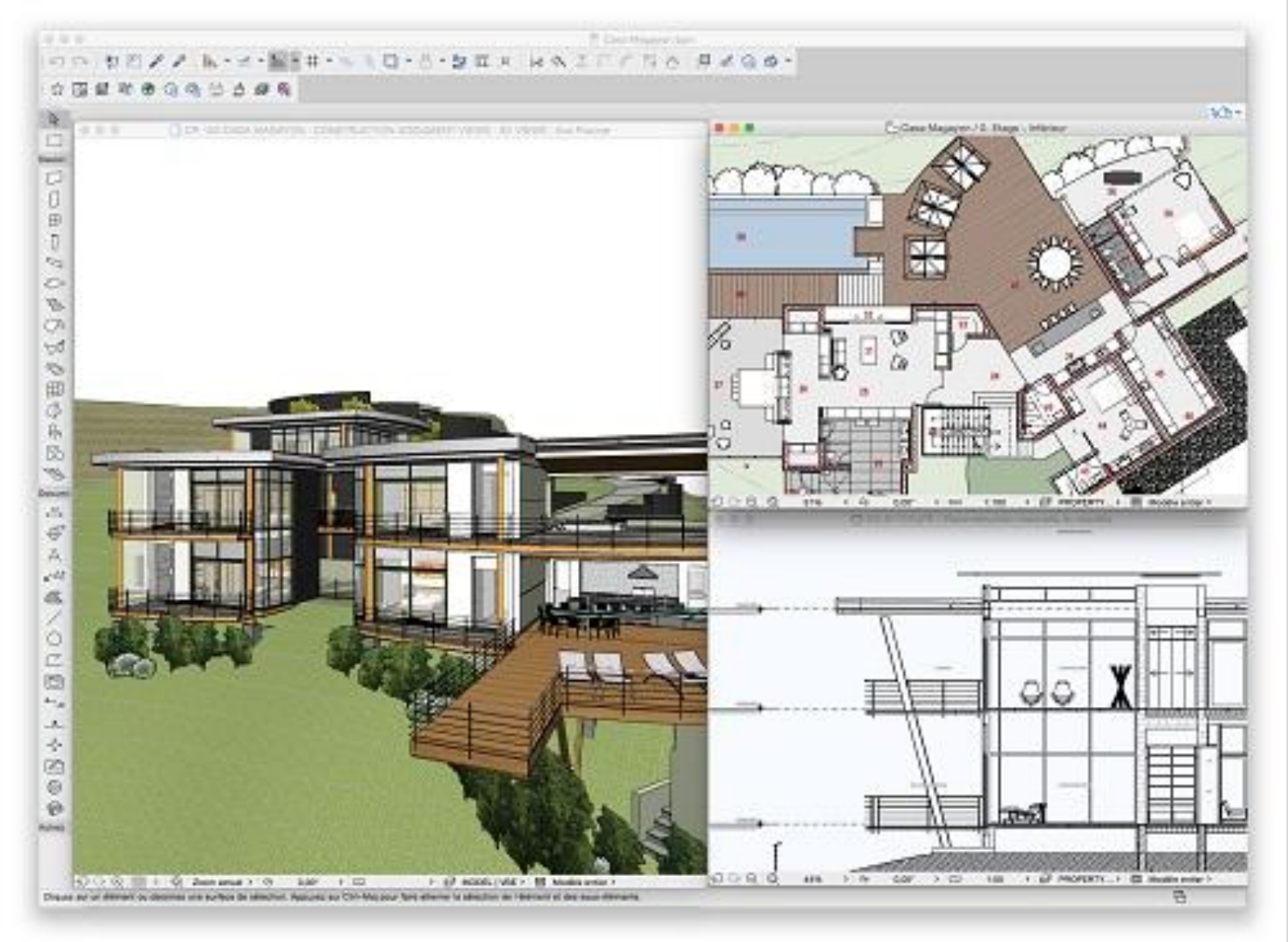
Art & Design

Industrial Design

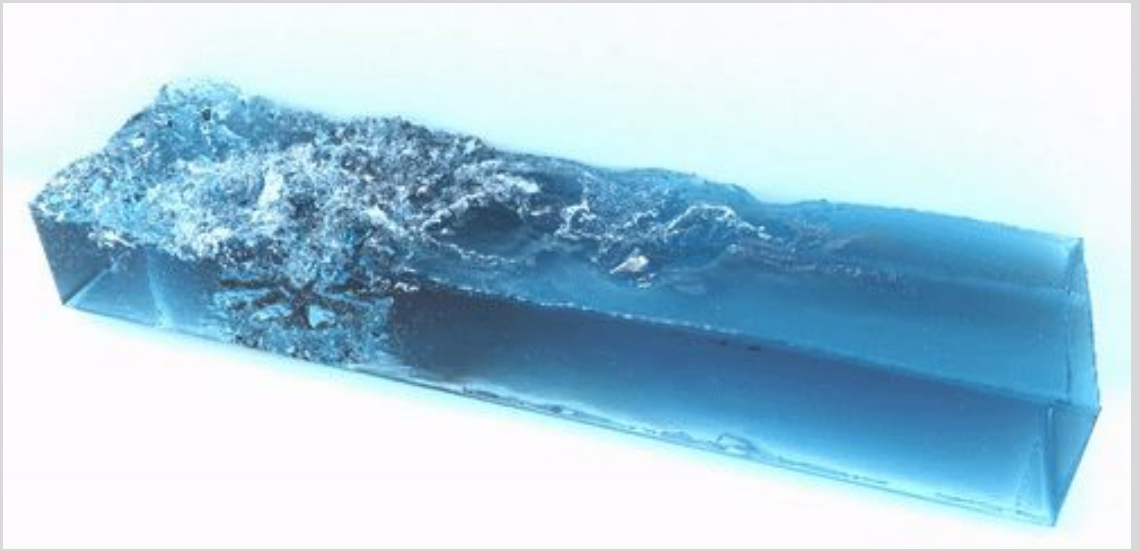


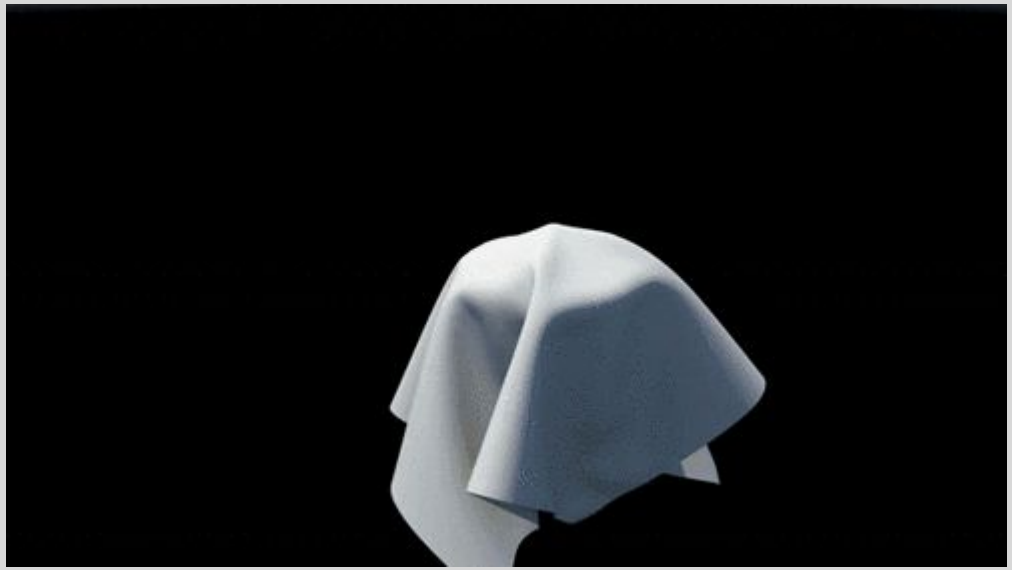
Computer Aided Engineering

Architecture



Simulations





WHAT'S NEW

Research!

- ACM SIGGRAPH
- ACM SIGGRAPH Asia
- EUROGRAPHICS

- SIGGRAPH 2023 Technical Papers Trailer
- https://www.youtube.com/watch?v=VBZ2sDxvZQE

IMPORTANCE IN CS

Two Turing Awards

1988	Ivan Sutherland		For his pioneering and visionary contributions to computer graphics, starting with Sketchpad, and continuing after.	Stanford University, Harvard University, University of Utah, California Institute of Technology

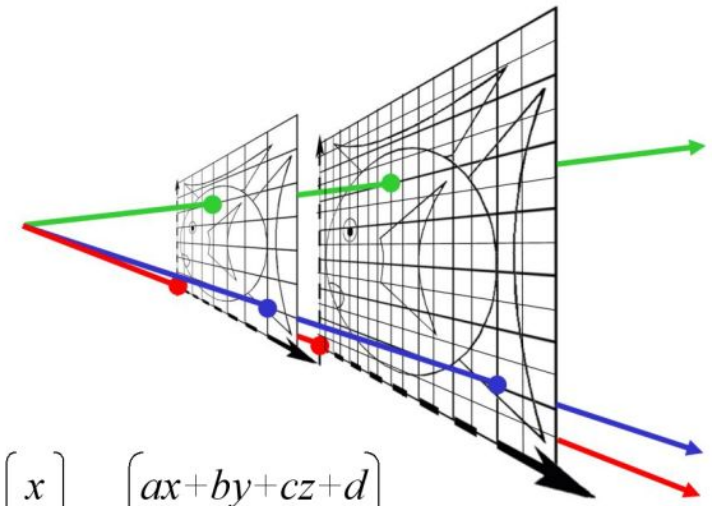
Two Turing Awards

2019	Edwin Catmull		For fundamental contributions to 3-D computer graphics, and the revolutionary impact of these techniques on computer-generated imagery (CGI) in filmmaking and other applications.[50]	University of Utah, Pixar, Walt Disney Animation Studios
	Pat Hanrahan			Pixar, Princeton University, Stanford University

CONCEPTS

Transformations

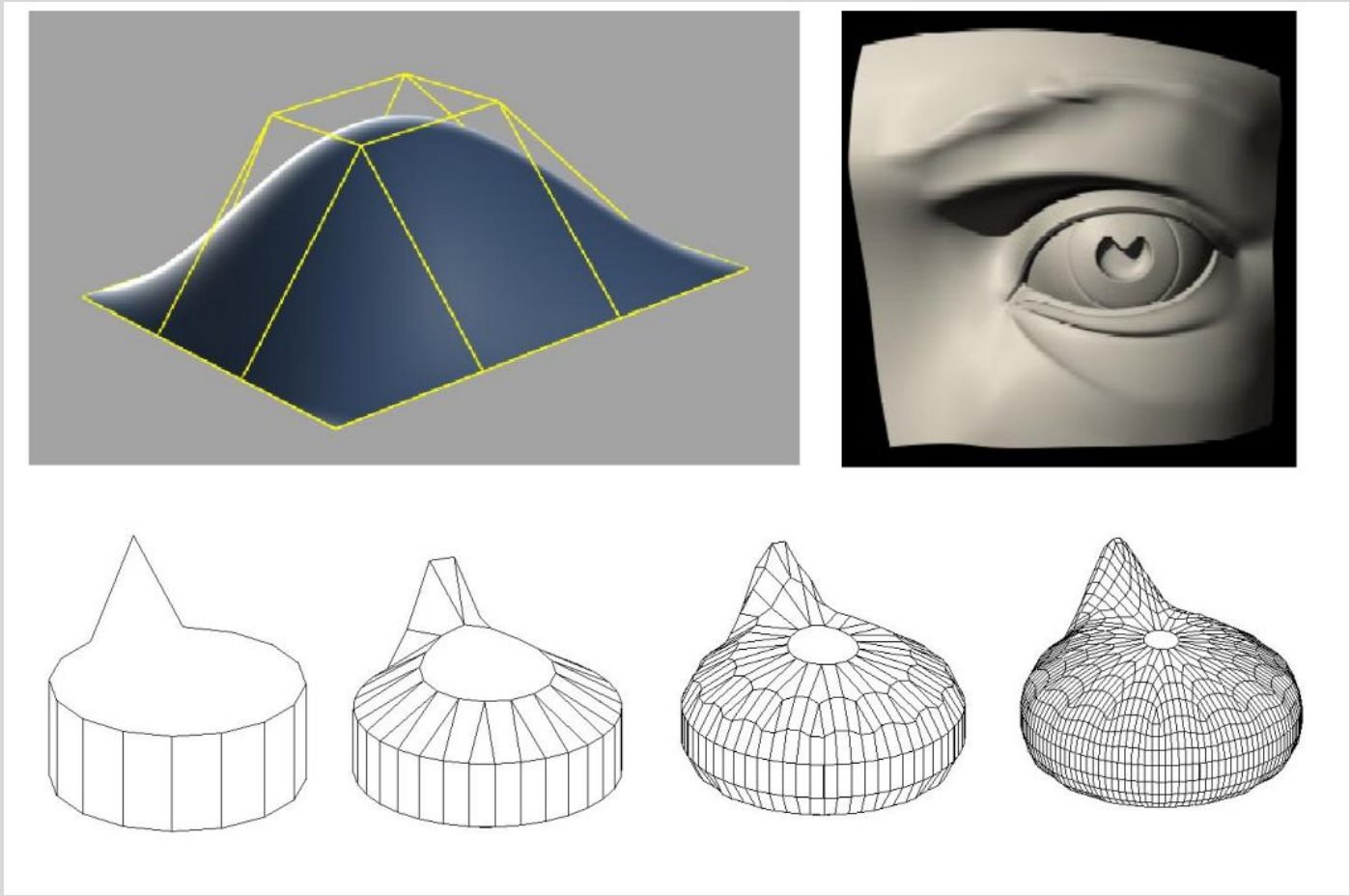
- Linear Algebra.
- Homogeneous coordinates



$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} a & b & c & d \\ e & f & g & h \\ i & j & k & l \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = \begin{bmatrix} ax+by+cz+d \\ ex+fy+gz+h \\ ix+jy+kz+l \\ 1 \end{bmatrix}$$

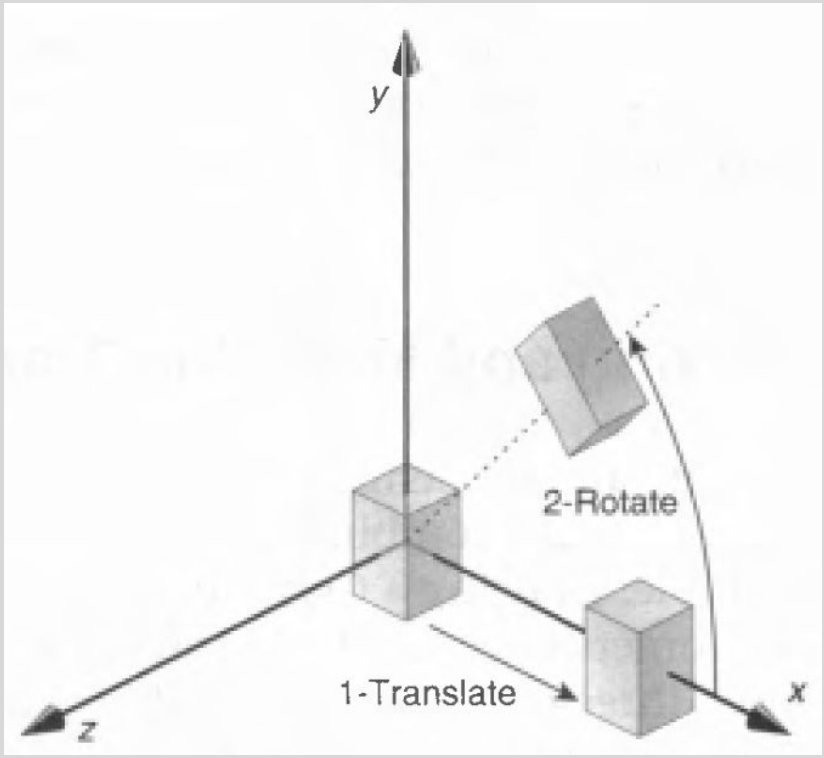
Modeling

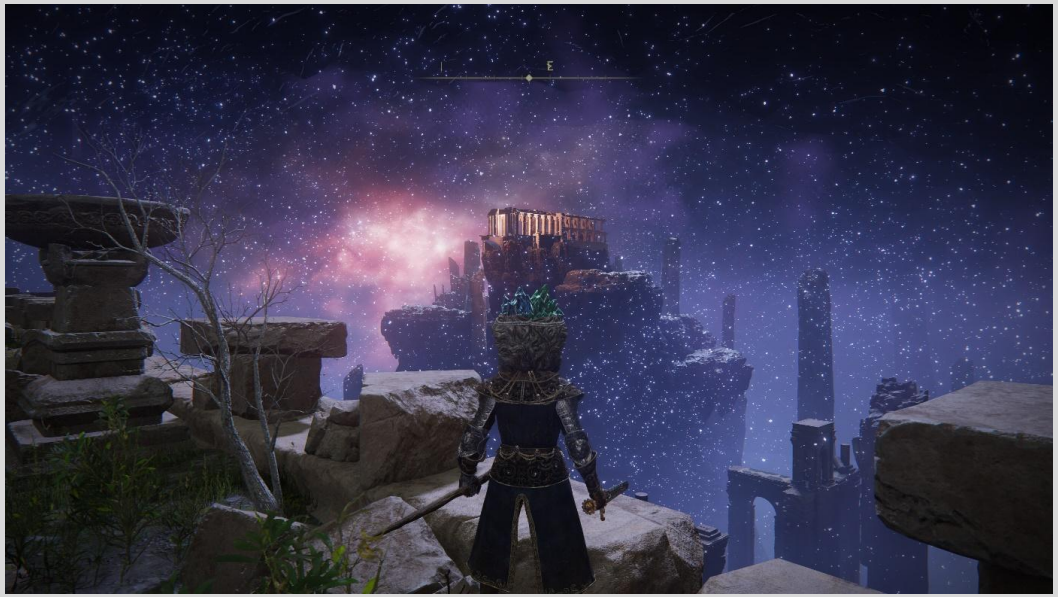
- Curved Surface
- Subdivision surface

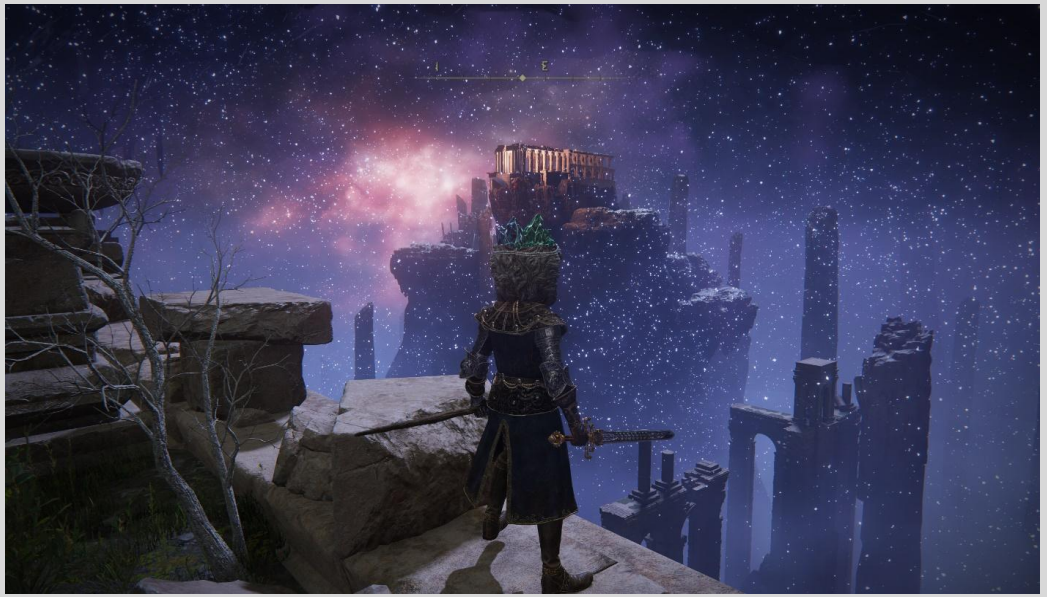


Modeling Transformation

- Use transformation to position objects
- Reuse objects

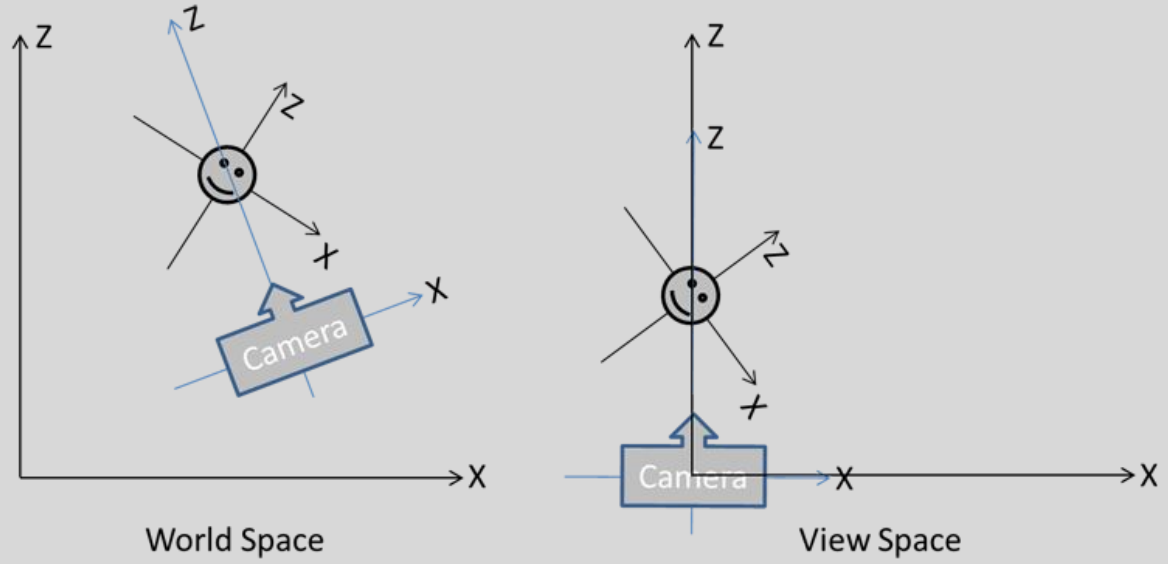






View Transformation

- Translate camera to origin
- Set view direction along a principal axis

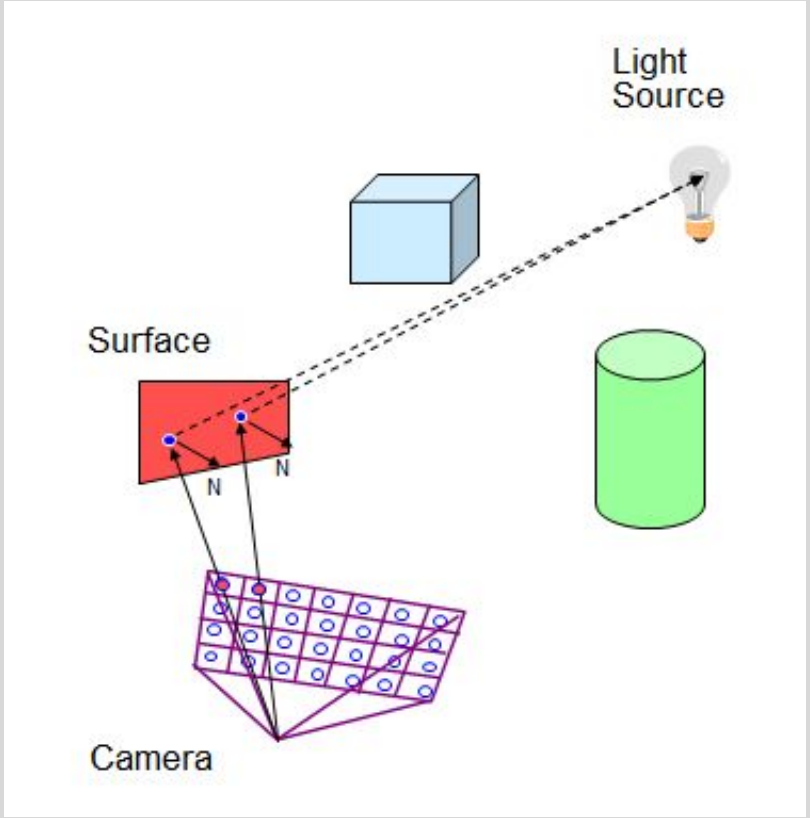



UNKNOWN CALLER
Enter the Communications Dept. to find the Hotline
EXECUTIVE / DEAD LETTERS


UNKNOWN CALLER
Enter the Communications Dept. to find the Hotline
EXECUTIVE / DEAD LETTERS

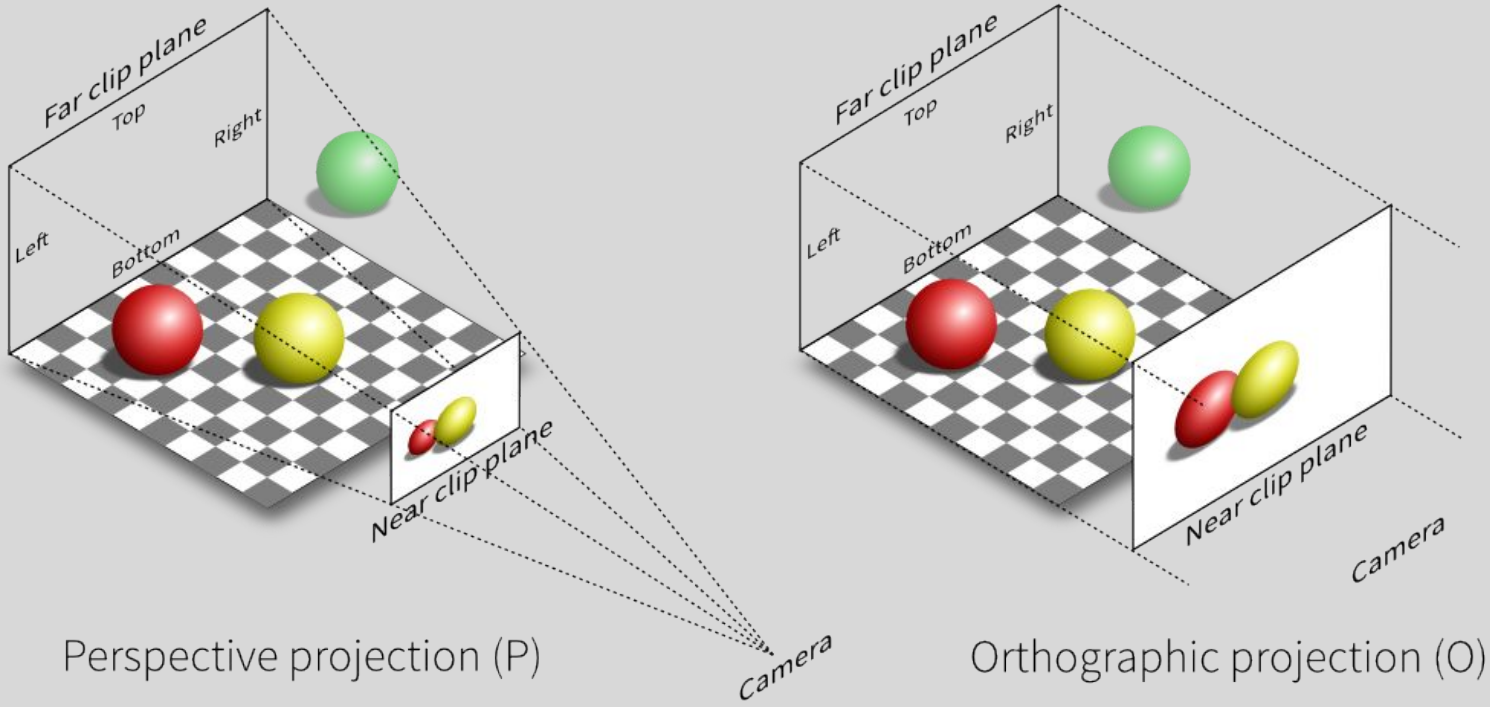
Illumination

- Light the scene according to material properties of objects and light sources
- Highly important to generate realistic image



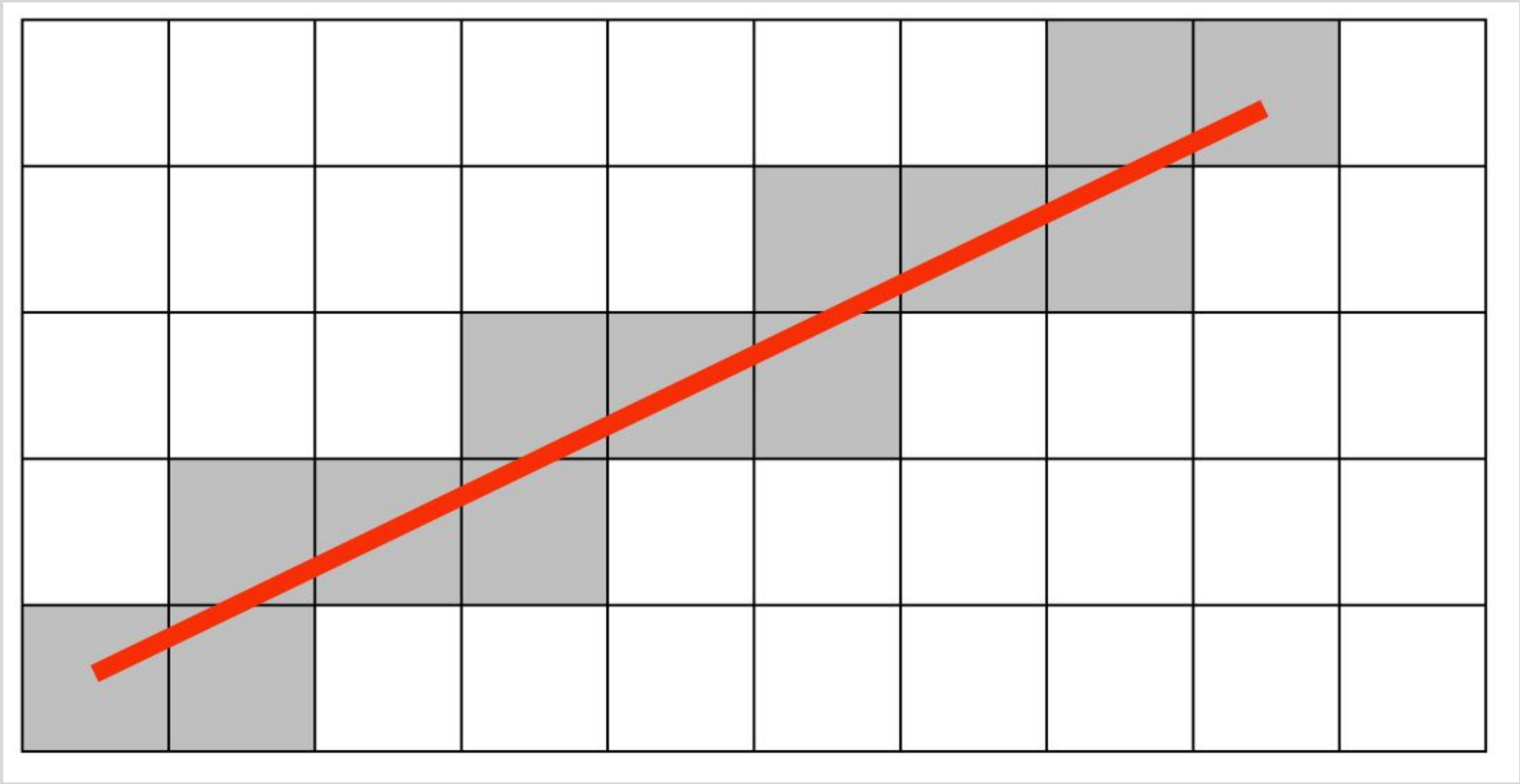
Projection and Clipping

- Project the 3d model on a 2d screen
- Clip objects outside viewing frustum



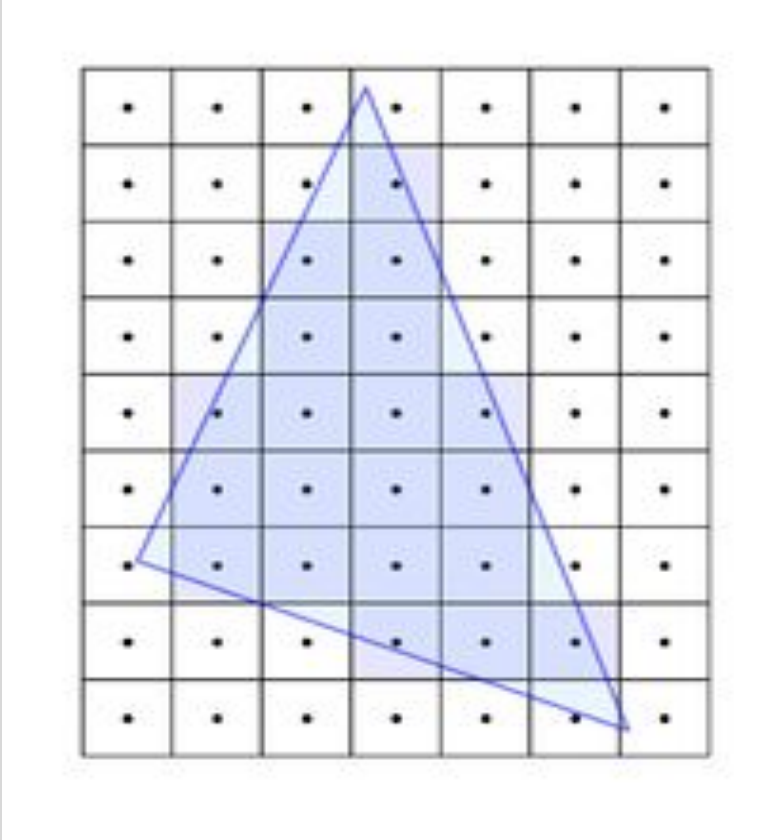
A Modern Display

Rasterization

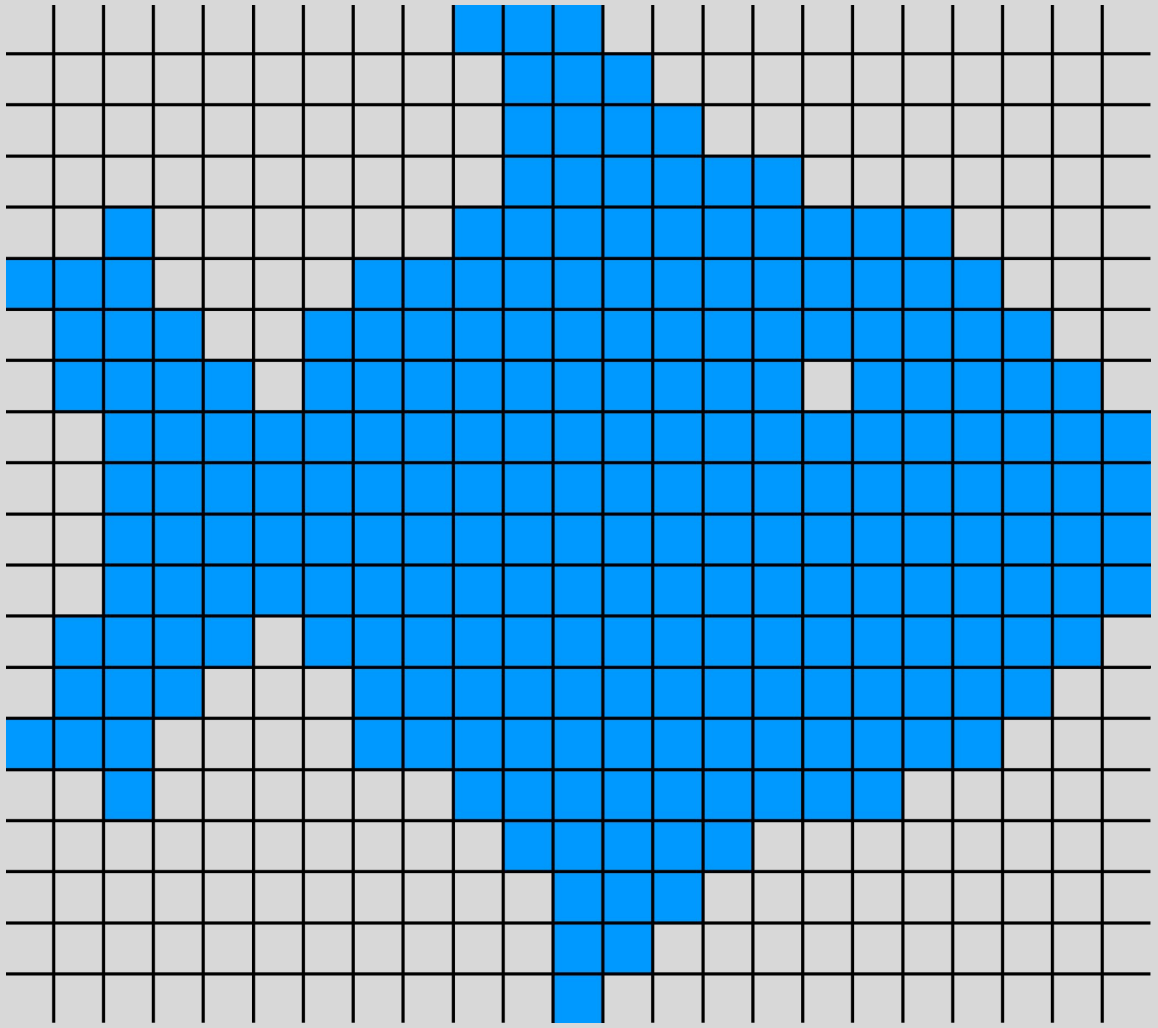


Rasterization

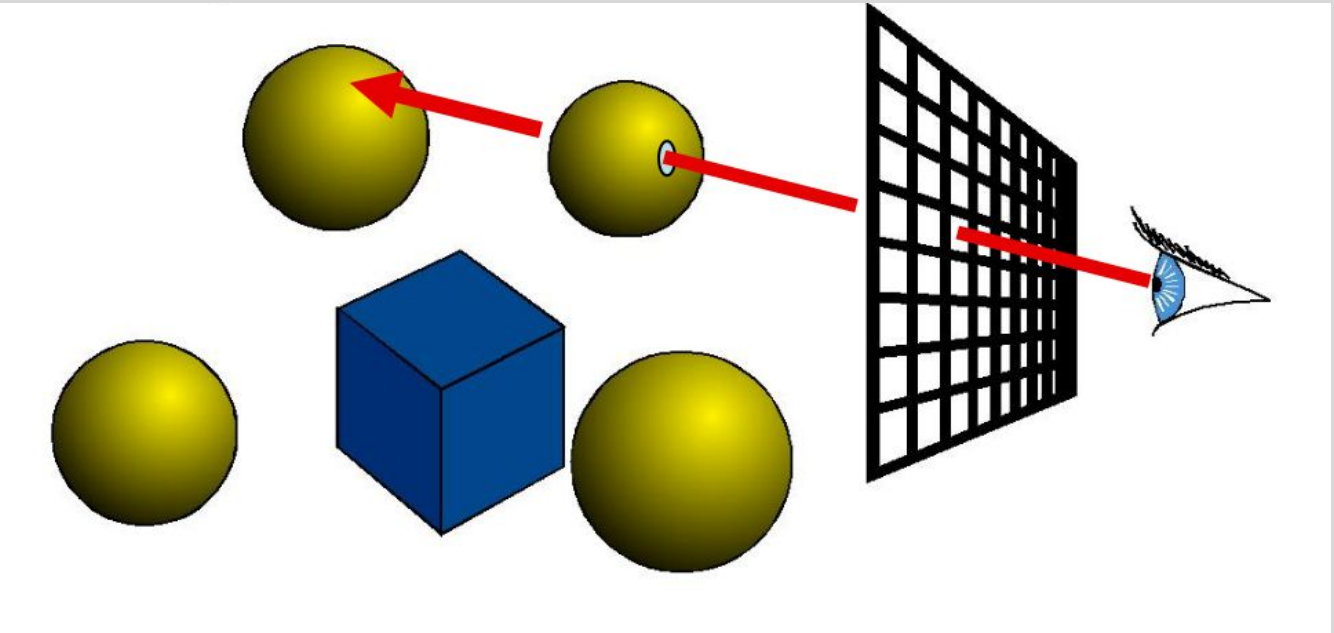
- Determine which pixels to light on the screen



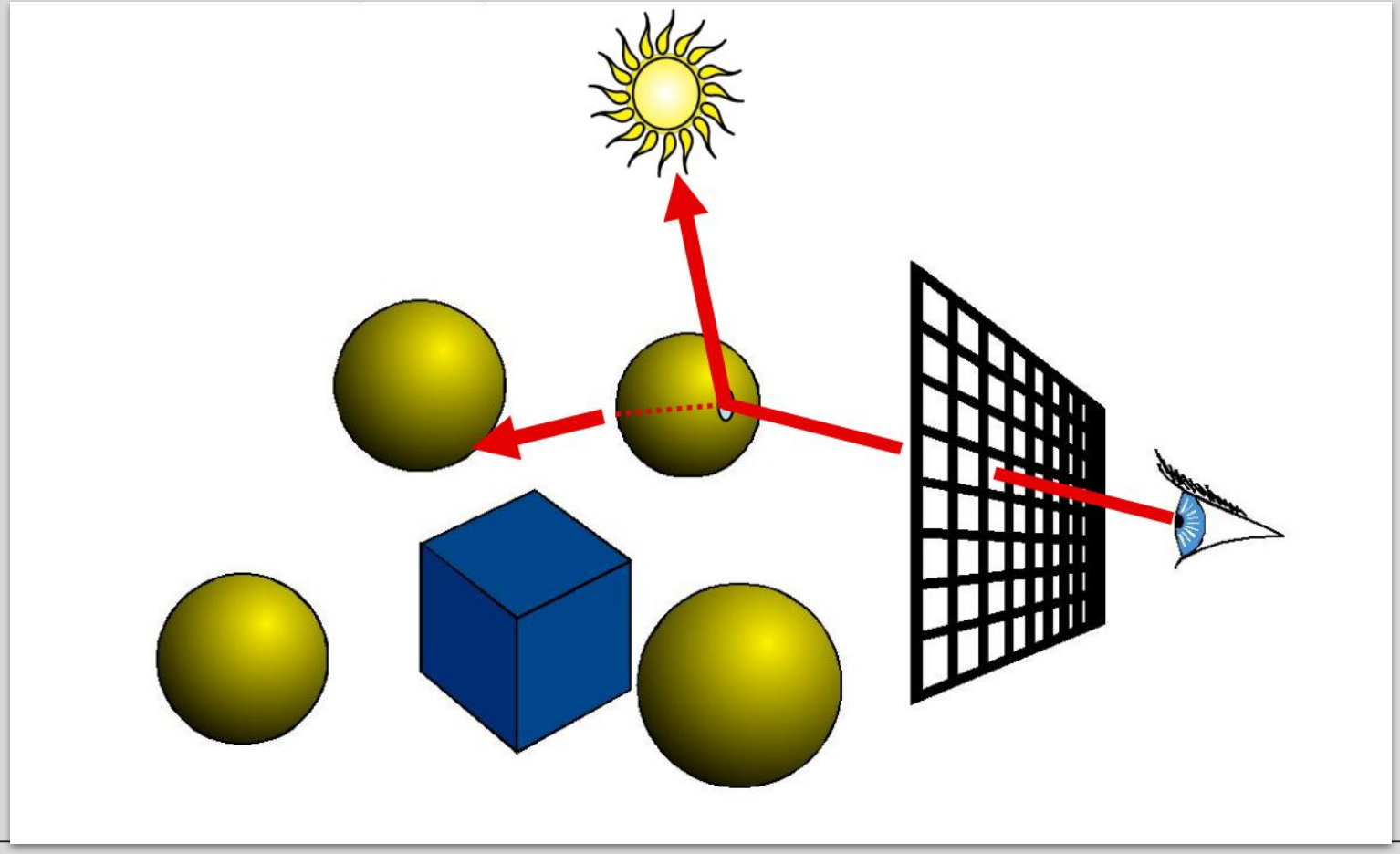
Rasterization



Ray Casting

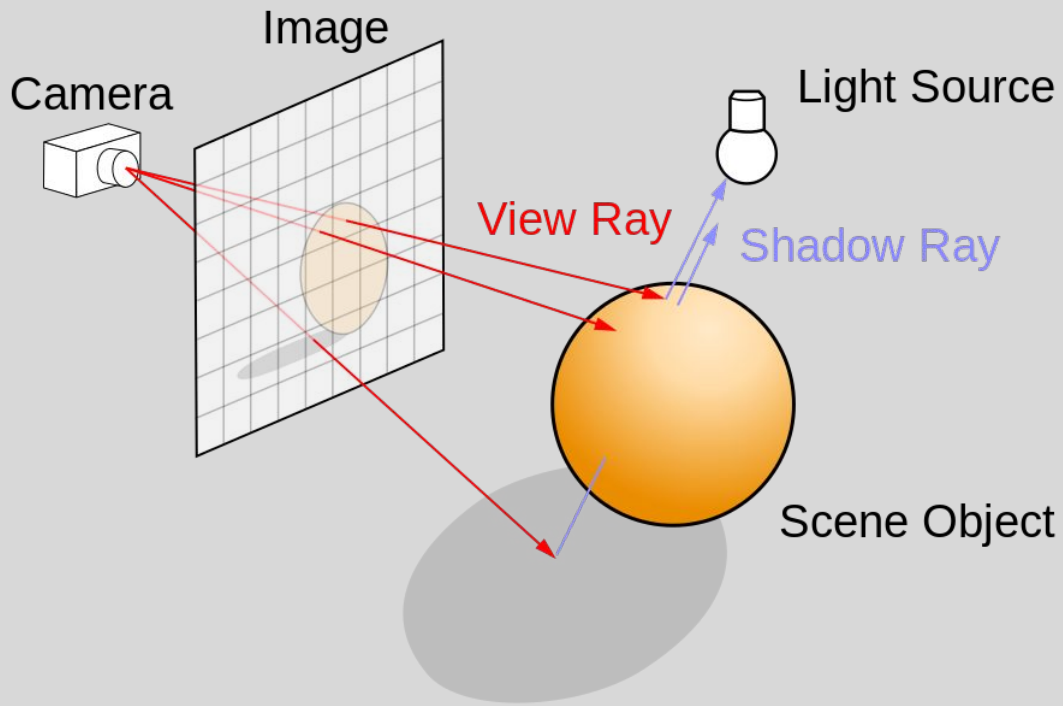


Ray Tracing



Ray Tracing

- Cast rays from eye to each pixel to determine the color of pixel

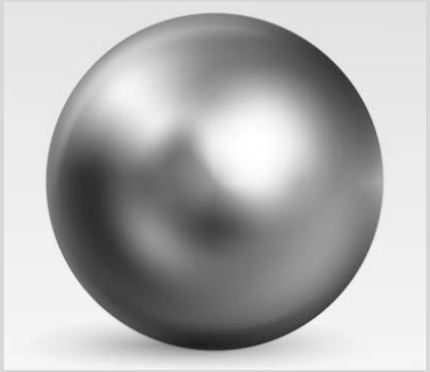


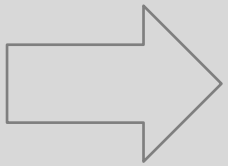
Ray Tracing

- Produces highly realistic image

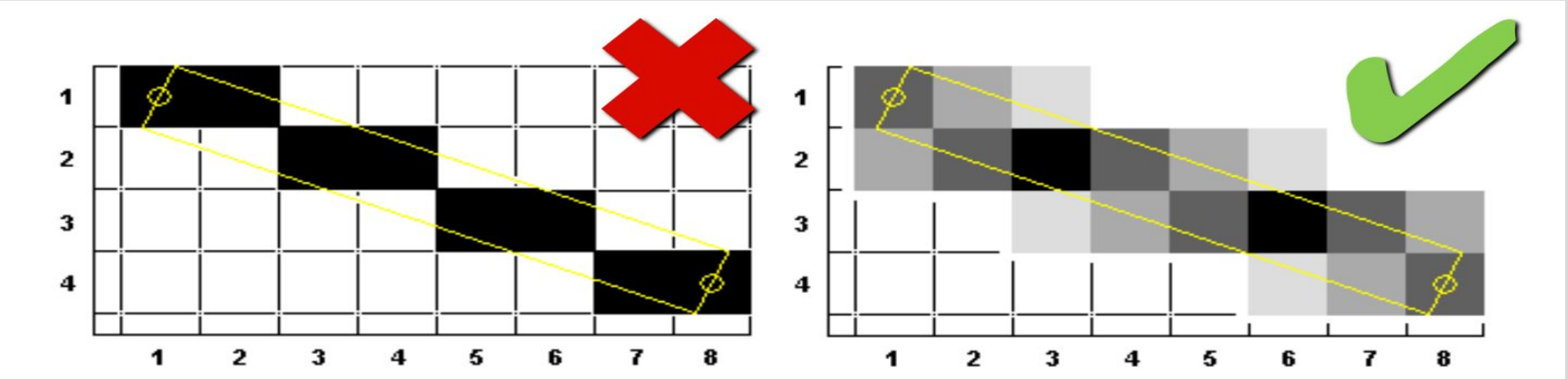
Texturing

- Paste images on object surfaces





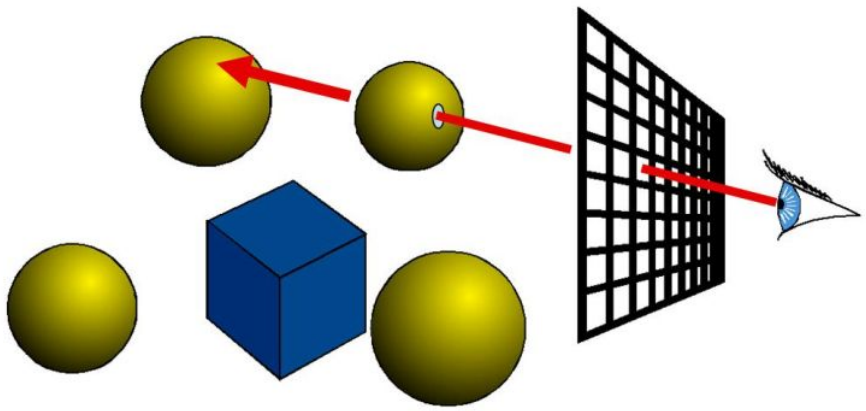
Sampling and Antialiasing



The Graphics Pipeline

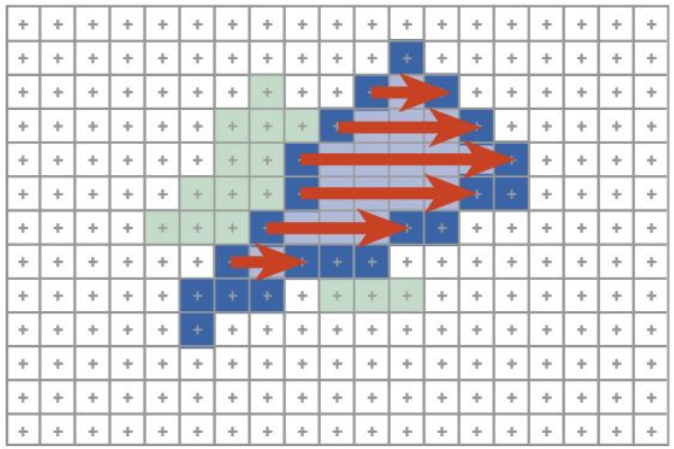
Ray Casting

```
For each pixel
    For each object
      Send pixels to scene
```



Rendering Pipeline

```
For each triangle
    For each projected pixel
        Project scene to pixels
```



The Graphics Pipeline

- Transformations
- Clipping
- Rasterization
- Visibility

LOGISTICS

Book

- Schaum's Outline of Computer Graphics (2nd Edition) by Zhigang Xiang, Roy A. Plastock
- Computer Graphics: Principles and Practice in C (2nd Edition) by James D. Foley, Andries van Dam, Steven K. Feiner, John F. Hughes
- Computer Graphics using OpenGL (2nd/3rd Edition) by Francis S Hill, Jr.

CSE 410 Sessional

- 3 Assignments

- Basic OpenGL
- Rasterization
- Ray Tracing

Thanks to…

- Lecture 01: Course Overview (CMU 15-462/662)
  https://www.youtube.com/watch?v=PhxV_JrXeVk
- Lecture 01: Introduction (MIT 6.837)
  https://www.youtube.com/watch?v=tPzC879i-ag
- Previous instructors of CSE 409

THE END