CS334/ECE30834
Fundamentals of Computer Graphics

Fall 2026

Daniel G. Aliaga

Who am I?

- Daniel G. Aliaga (aliaga@cs.purdue.edu)

  http://www.cs.purdue.edu/~aliaga

  Professor of CS doing Graphics

  Doctorate in Graphics

  Master's in Graphics

  Bachelors in Graphics

  High School Degree doing graphics/robots/science

  1980 (TRS80 Model I)

  Then: http://www.youtube.com/watch?v=3yuqdC8Id48)

  http://thinkingscifi.files.wordpress.com/2012/12/starwars-graphics.png

  Now: http://www.youtube.com/watch?v=QAEkuVgt6Aw

- URBX: https://www.cs.purdue.edu/urbx_lab/

My Computer Graphics/Vision/Visualization Research

- Workforce:
  - Graduate students (20+ in CGVLAB)
  - Undergraduate students (1-3 per semester with me)
  - Postdocs and Visiting Professors

- Funding:
  - NSF, MTC, IARPA, USDA, Internet2, Microsoft, Google, Adobe, (Intel), and others

My Computer Graphics/Vision/Visualization Research

- **Inverse Procedural Modeling**
  - Facilitate semi-automatic and controllable content creation and edition of large and complex geometric models for use in digital simulation, visualization, entertainment, education, and cultural heritage by converting unstructured data into organized and easily editable procedural representations
- **Urban Modeling and Simulation**
  - Collaborations with numerous experts in urban planning, atmospheric/geological sciences, civil engineering, architecture, hydrology, and transportation engineering to capture, simulate, and modify models of urban environments
- **Imaging and Reconstruction**
  - Develop multiple novel image processing and image-based 3D reconstruction methods

Course Mechanics

- CS334
  - https://www.cs.purdue.edu/homes/aliaga/cs334-26fall/index.htm

  (see course summary + schedule)
- Brightspace
  - For assignments, etc.
- Piazza
  - For communication
- TAs (Aocheng, Siyu) + instructor (Daniel)
  - For questions, grading, etc.
  - Office hours: TBD

Best way to contact me

- About class general tech questions: use Piazza
- About other stuff or me directly:
  - Email (yes, old fashioned)
  - Mandatory
    - Put CS334 in subject
    - Put CS334 in subject
    - Put CS334 in subject
    - Do NOT put “CS 334” in subject
    - Do NOT only put “Question” in subject, etc…
    - What if you are taking ECE30834?
      - Put CS334 in subject

Exam Question

- Q#1: What must be in subject of an email to me?
  - Answer: CS334
- Q#2: If you want to schedule a meeting with me, what should be in the subject of the email to me?
  - Answer: CS334

Cellphones / Laptops

- NONE
- We are here not elsewhere…
- Unless, you are <u>really really really</u> taking notes

There is an Elephant in the Room

- What?
- Where?

AI

History of Computer Graphics

A long time ago in a computer far, far inferior to your phone, it all began...

-Daniel Aliaga, August 25, 2020

Logic Theorist (1956)

- A program designed to mimic the problem-solving skills of a human
- Since then, however, AI flourished and failed and flourished and so on…

Perceptron (1958)

- The Perceptron: A Probabilistic Model for Information Storage and Organization in the Brain, F. Rosenblatt, Psychological Review, 65(6), 1958.

- Model based on the human visual system

Perceptron

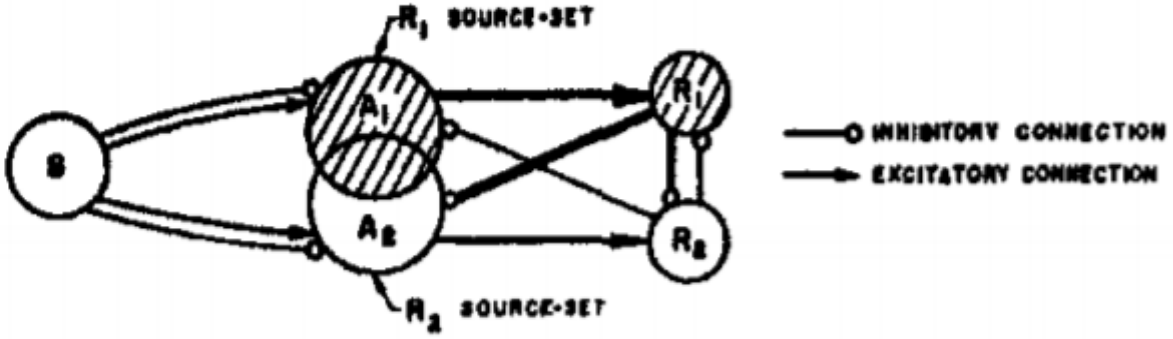
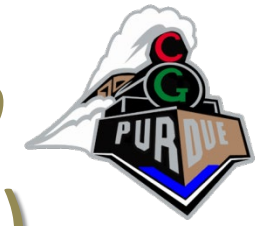


FIG. 2B. Venn diagram of the same perceptron (shading shows active sets for R_1 response).

Perceptrons: *An Introduction to Computational Geometry* (1969)



- Book by M. Minsky and S. Papert
- Commented on the limited ability of perceptrons and on the difficulty in training multi-layer perceptrons
- (Back propagation appeared in 1986 and helped a lot!)

Forecasts…

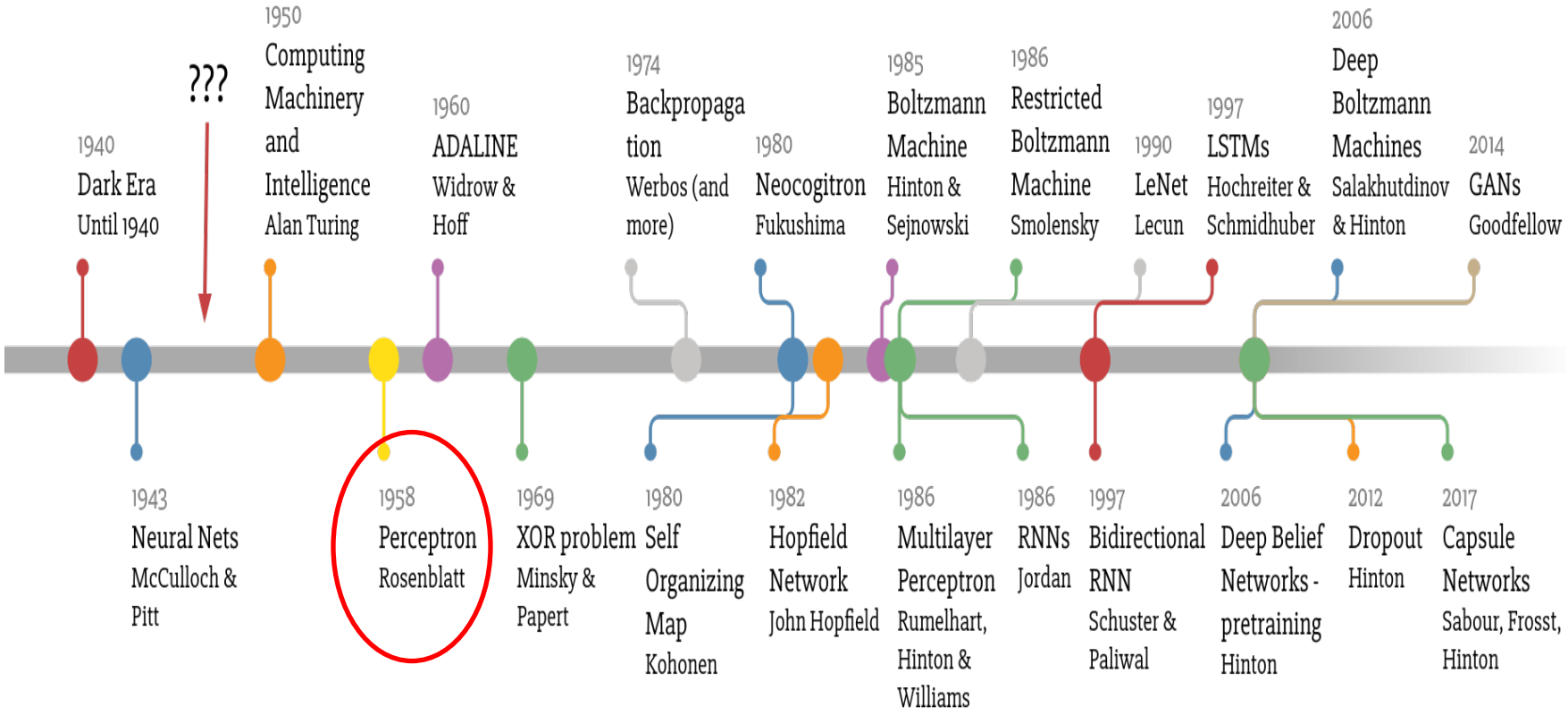
- In 1968, A. Clarke and S. Kubrik said “by the year 2001 we will have machines with intelligence that matches or exceeded humans’ ”

- In 1970, Marvin Minsky (MIT) said that in 3-8 years “we will have a machine with the general intelligence of an average human being”

1980s

- Expert systems became popular: dedicated systems
- “Deep learning techniques” was a coined phrase but with diverse meanings…
- I was around then, and even a paid undergraduate researcher in a major AI lab
  - our job was to create a robot that could be programmed remotely and could execute algorithms for navigating and deciding how to avoid obstacles (e.g., walls and boxes)

Deep Learning Timeline



Made by Favio Vázquez

Why am I telling you this?

"visual computing / graphics" → "perceptron"

and

"perceptron" → **AI today**

Graphics and AI

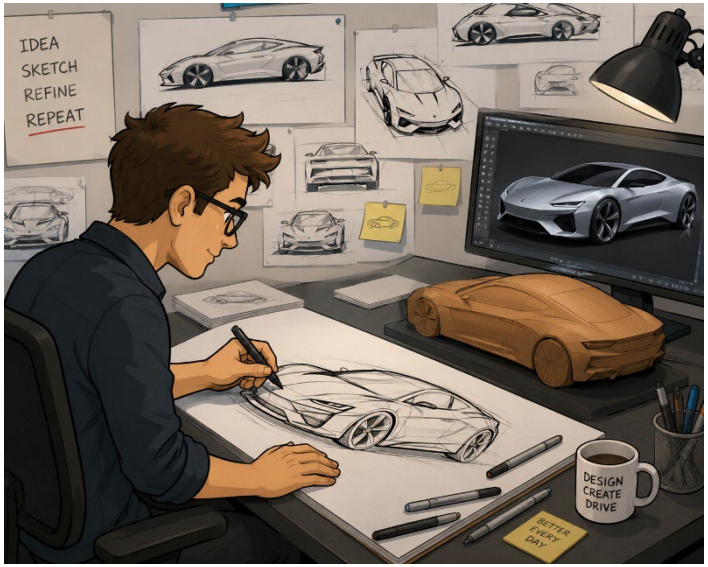
- They are deeply embedded
- Almost all modern AI research/methods in graphics use AI (in one of its many forms: CNNs, diffusion models, LLMs, and more)

AI Usage in Graphics/Course

- You cannot avoid
- HOWEVER:

We will **not** teach you to drive a car…instead:

Drive a car…

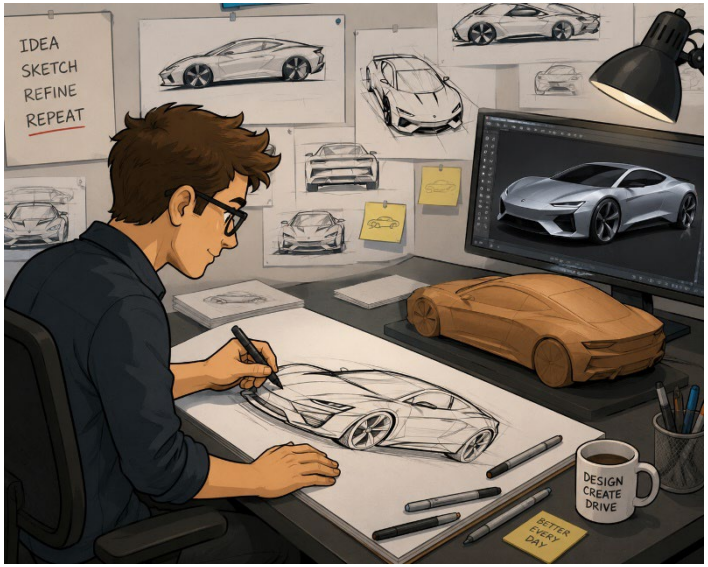


Design a car…

AI Usage in Graphics/Course

- You cannot avoid
- HOWEVER:

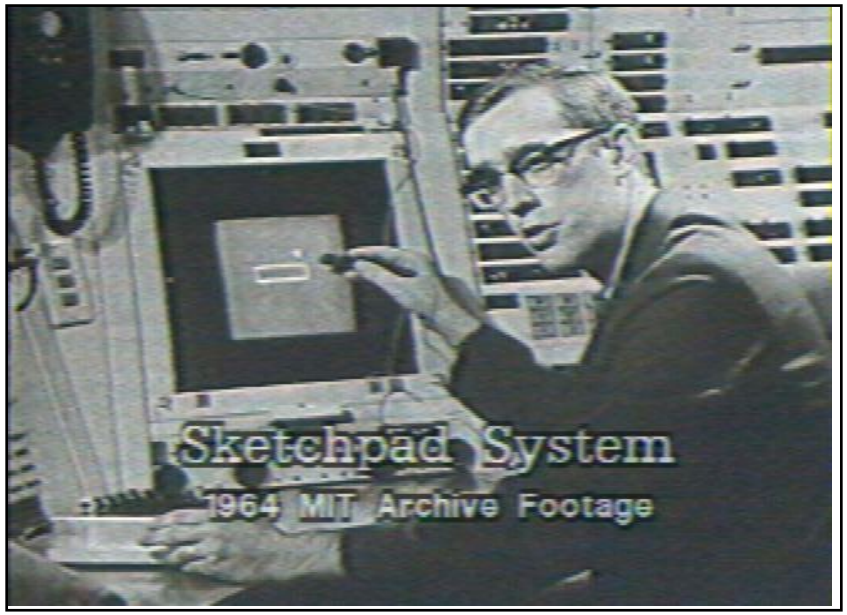
use “ChatGPT” for graphics



make better/new graphics (with AI and all tools possible)

Lets get back to some history…

Ivan Sutherland (1963) - SKETCHPAD



- pop-up menus
- constraint-based drawing
- hierarchical modeling

Display hardware

- vector displays
  - 1963 – modified os
  - 1974 – Evans and S
- raster displays
  - 1975 – Evans and S
  - 1980s – cheap fram
  - 1990s – liquid-cryst
  - 2000s – micro-mirr
  - 2010s – high dynan
- other
  - stereo, head-mounted displays
  - autostereoscopic displays

Input hardware

- 2D
  - light pen, tablet, mouse, joystick, track ball, touch panel, etc.
  - 1970s & 80s - CCD analog image sensor + frame grabber

Input hardware

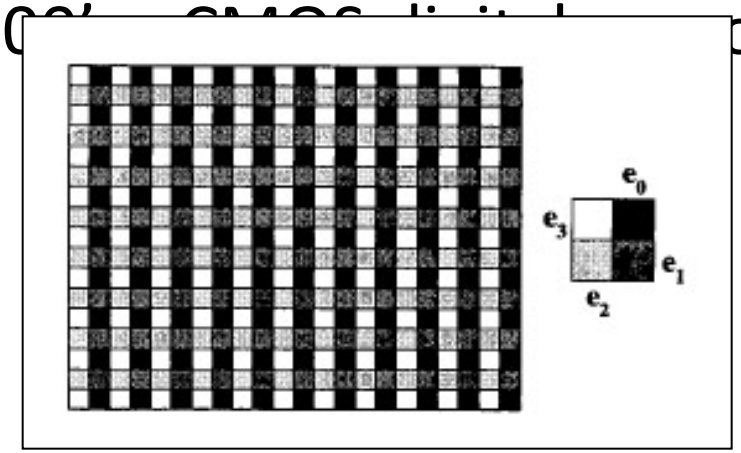
- 2D
  -
  -

GigaPan Cameras

- (demo)

Input hardware

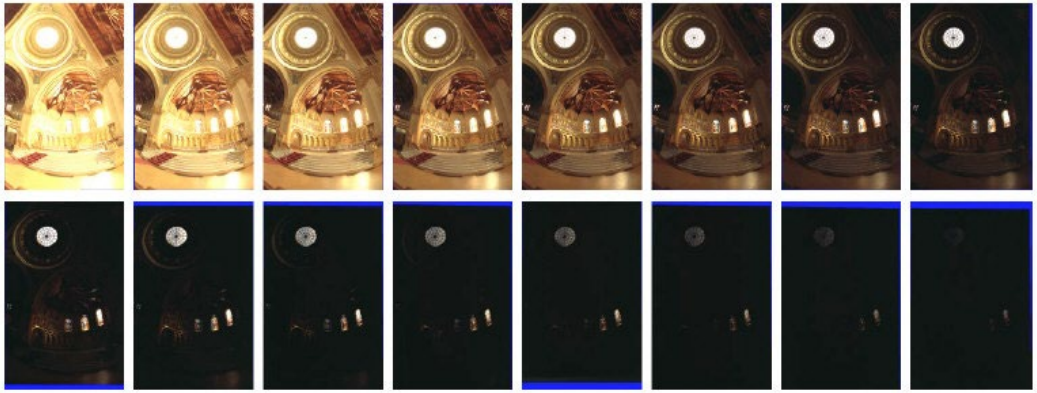
- 2D
  - light pen, tablet, mouse, joystick, track ball, touch panel, etc.
  - 1970s & 80s - CCD analog image sensor + frame grabber
  - 1990s & 200[illegible]or + in-camera processing



[Nayar00]

→ high-dynamic range (HDR) imaging

- negative film = 130:1 (7 stops)
- paper prints = 46:1
- [Debevec97] = 250,000:1 (18 stops)



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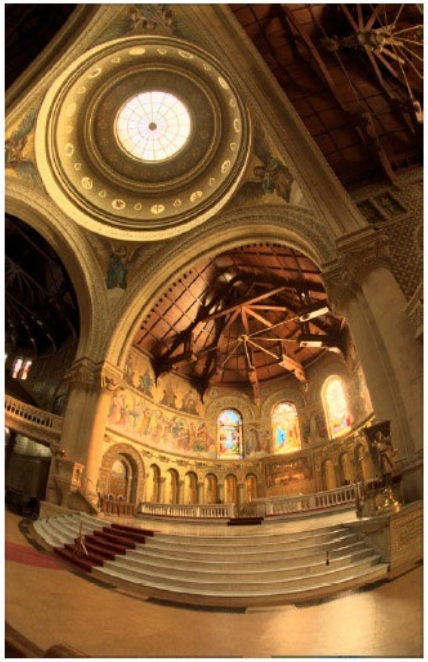
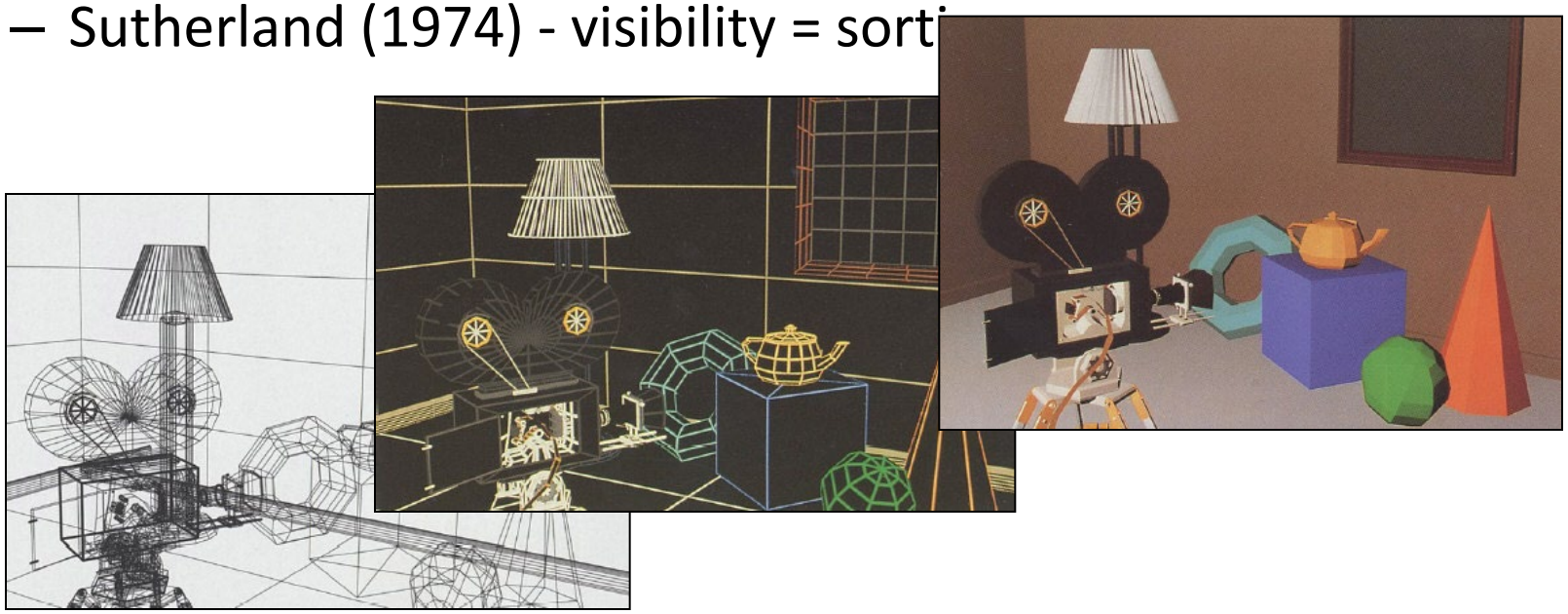


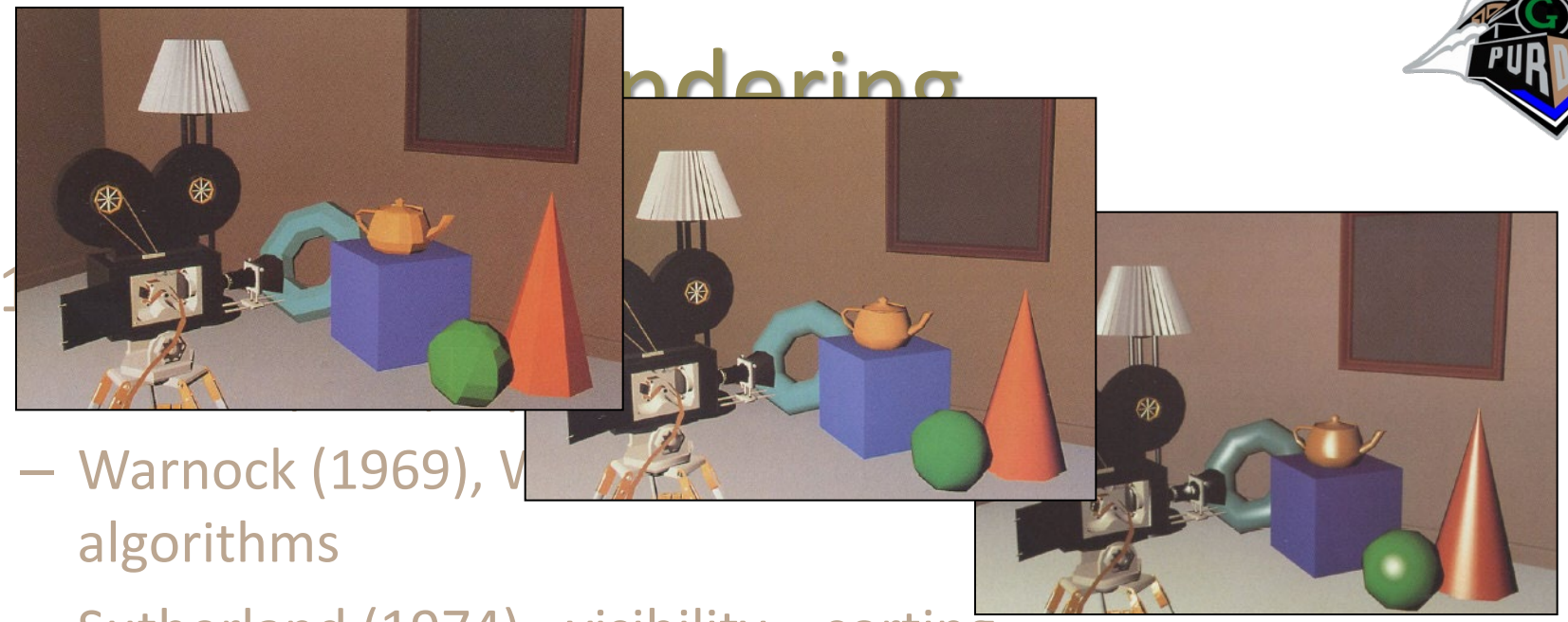
Input hardware

- 2D
  - light pen, tablet, mo
  - 1970s & 80s - CCD a
  - 1990s & 2000's - CM
    → high-dynamic ra
- 3D
  - 1980s - 3D trackers
  - 1990s - active range
- 4D and higher
  - multiple cameras
  - multi-arm gantries

Rendering

- 1960s - the visibility problem
  - Roberts (1963), Appel (1967) - hidden-line algorithms
  - Warnock (1969), Watkins (1970) - hidden-surface algorithms
  - Sutherland (1974) - visibility = sorti

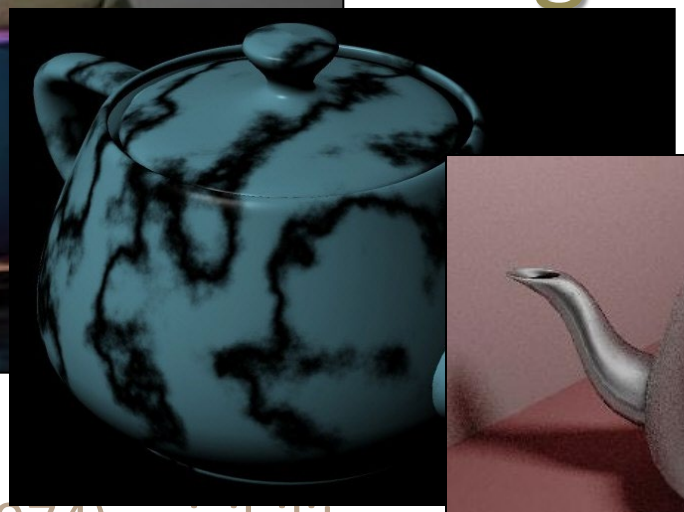




- 1
  - Warnock (1969), V
    algorithms
  - Sutherland (1974) - visibility = sorting

- 1970s - raster graphics
  - Gouraud (1971) - diffuse lighting
  - Phong (1974) - specular lighting
  - Blinn (1974) - curved surfaces, texture
  - Crow (1977) - anti-aliasing

ering



- 1
  - algorithms
  - Sutherland (1974) - visibility = s
- 1970s - raster graphics
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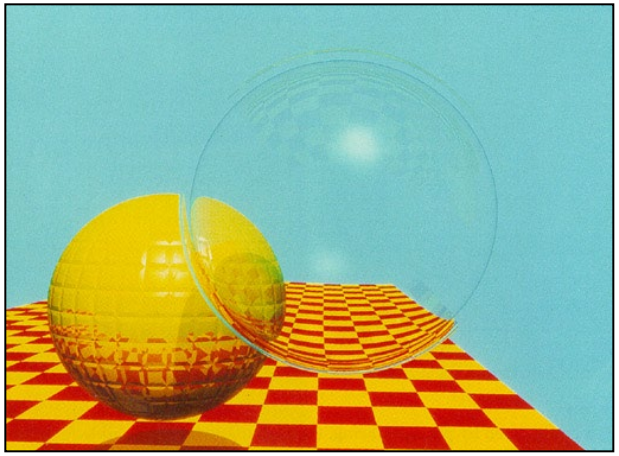
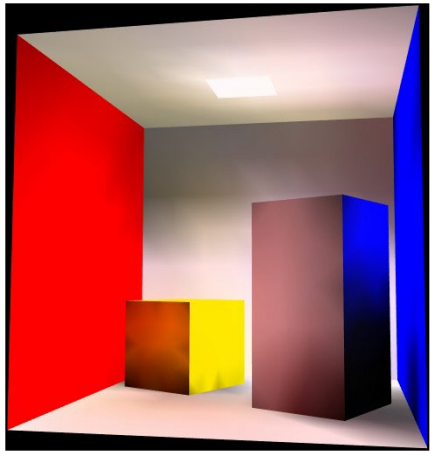
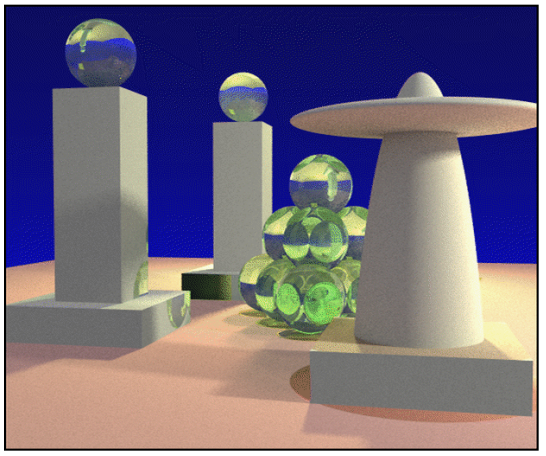
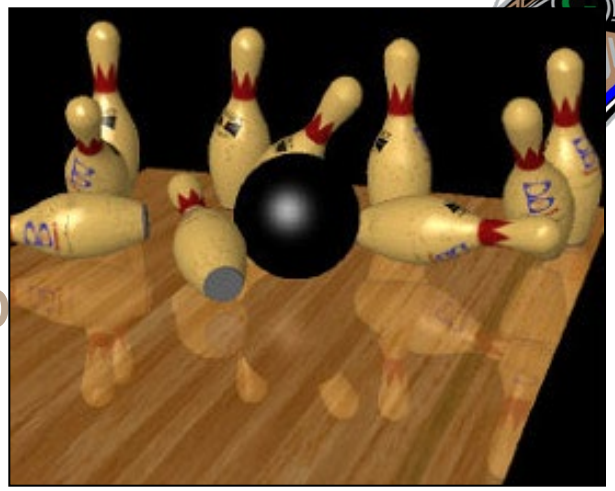
  - Blinn (1974) - curved surfaces, texture
  - Catmull (1974) - Z-buffer hidden-surface algorithm
  - Crow (1977) - anti-aliasing

Rendering

- early 1980s - global illumination
  - Whitted (1980) - ray tracing
  - Goral, Torrance et al. (1984), Cohen (1985) - radiosity
  - Kajiya (1986) - the rendering equation

→ shaders

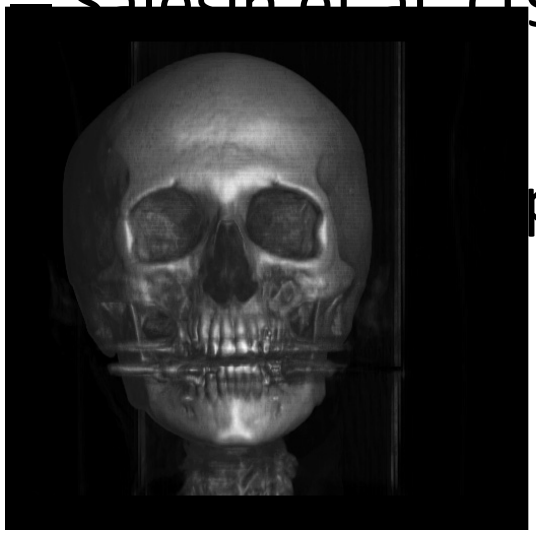
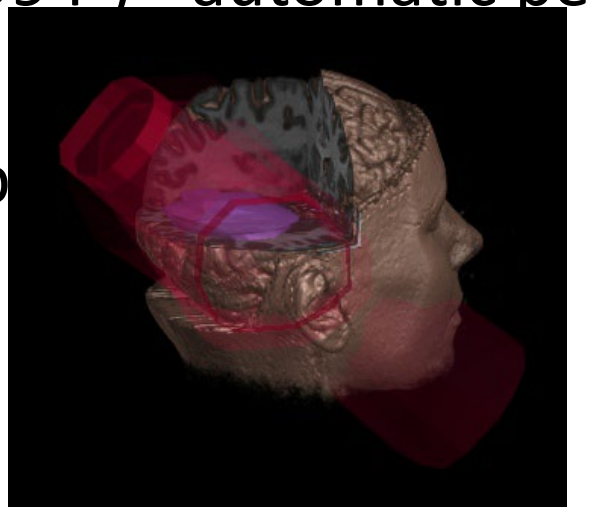
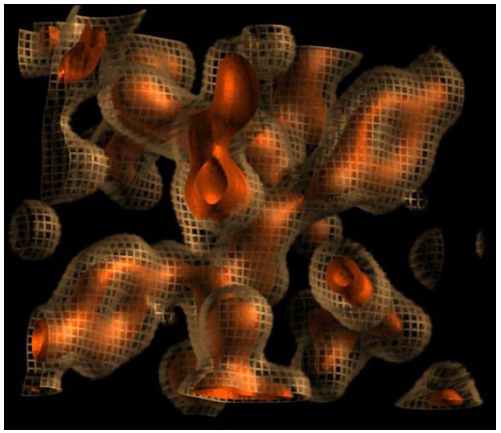


- e[illegible]b[illegible]o
  - [illegible] (1985) -
  - Goral, Torrance e[illegible]ohen (1985) - radiosity
  - Kajiya (1986) - the rendering equation

- late 1980s - photorealism
  - Cook (1984) - shade trees
  - Perlin (1985) - shading languages
  - Hanrahan and Lawson (1990) - RenderMan

Rendering

- early 1990s - non-photorealistic rendering
  - Drebin et al. (1988), Levoy (1988) - volume rendering
  - Haeberli (1990) - impressionistic paint programs
  - Salesin et al. (1994-) - automatic pen-and-ink

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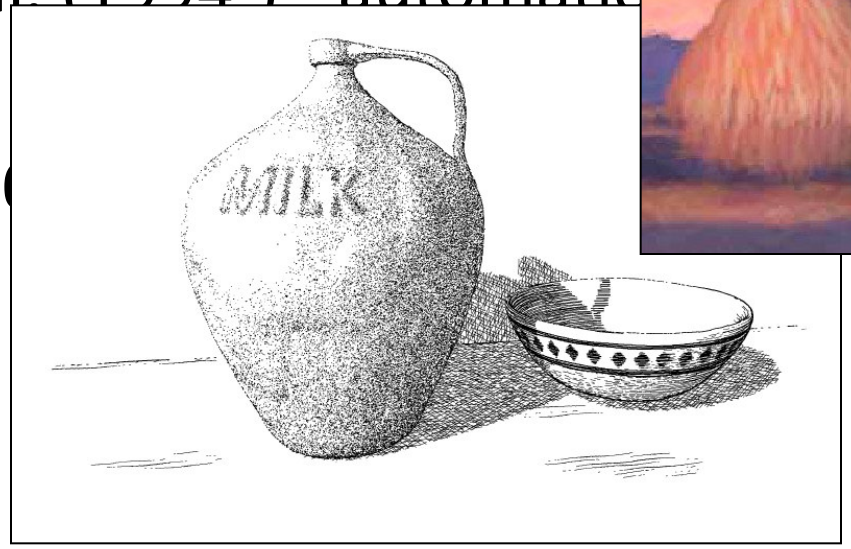
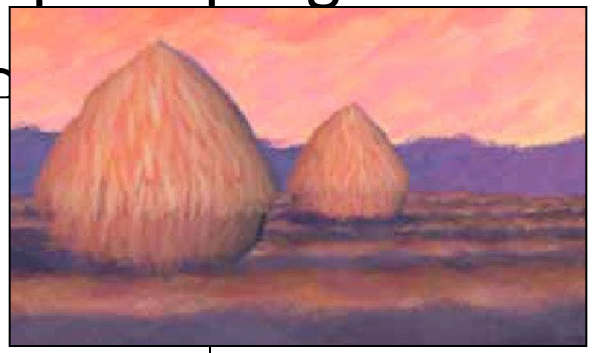




Sampling of Computer Graphics Today

Faces a while ago…

- https://www.youtube.com/watch?v=-CbyAk3Sn9I

Faces no too long ago…

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

Faces today!

- https://thispersondoesnotexist.com/

- (courtesy of Deep Learning & NVIDIA)

Even Presidents!

- https://www.youtube.com/watch?v=Jd38tSubiR4

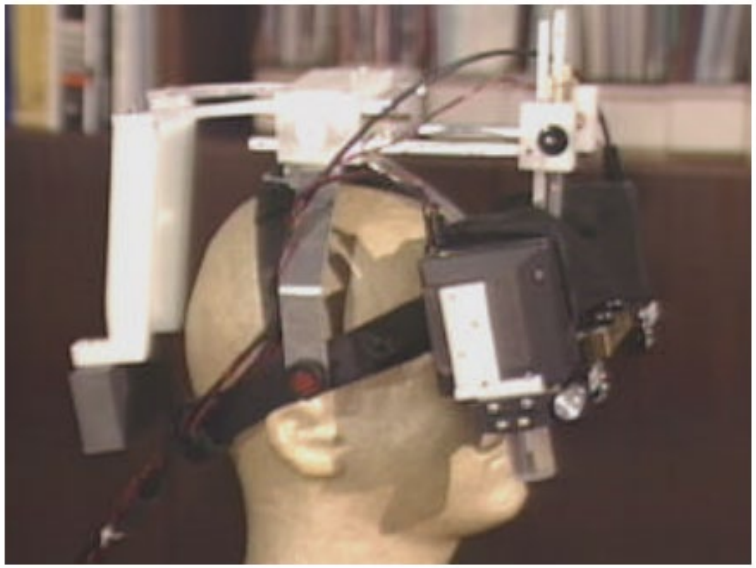
Games, of course

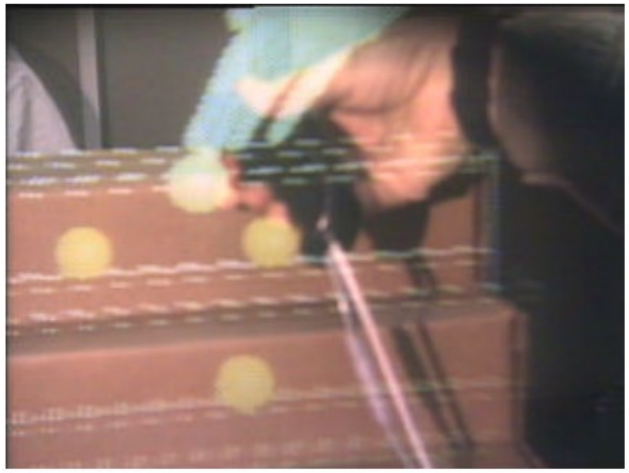
- https://www.youtube.com/watch?v=6kqe2ICmTxc

Trained AIs

- Diffusion based generation (creator.nightcafe.studio)
- I wrote “Mountain with trees and a bicycle”
- I got:

Augmented Reality





Augmented Reality

Virtual Reality

3D Displays

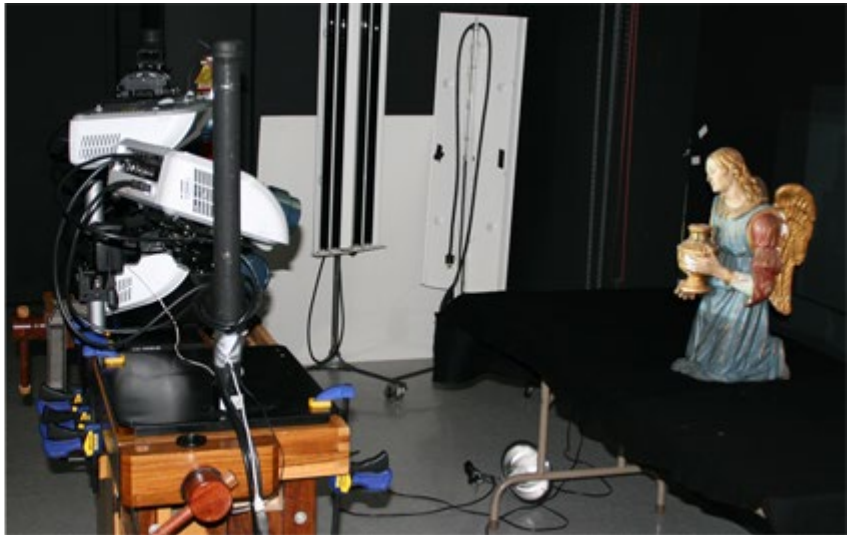
- Simple
  - https://www.youtube.com/watch?v=bBQQEcfkHoE

3D Displays

- Complex
  - https://www.youtube.com/watch?v=YKCUGQ-uo8c
  - https://www.youtube.com/watch?v=CfHw8NA75Xc

(careful with Hollywood tricks…)

Projection Based Displays



Projection Based Displays

Dynamic Projection Based Displays

- https://www.youtube.com/watch?v=j9JXtTj0mzE

And More!

- https://www.nvidia.com/en-us/research/ai-playground/

Books for your enjoyment
(I have a copy of these books if you wish to preview)

- "Interactive Computer Graphics"
  - Angel and Shreiner, pub: Addison Wesley
- "3D Computer Graphics"
  - Watt, pub: Addison Wesley
- "Real-time Rendering"
  - Moller and Haines, pub: AK Peters
- "3D Game Engine Design"
  - Eberly, pub: Morgan Kaufmann
- "Level of Detail for 3D Graphics"
  - Luebke, Reddy, Cohen, Varshney, Watson, and Huebner, pub: Morgan Kaufmann
- **"Computer Graphics: Principles and Practice, 3rd edition**
  - **Hughes, van Dam, McGuire, Sklar, Foley, Feiner, and Akeley**