CS334/ECE30834
Fundamentals of Computer Graphics

Spring 2025

Daniel G. Aliaga

Who am I?

- Daniel G. Aliaga

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

  Associate 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

- CGVLAB

  http://www.cs.purdue.edu/cgvlab

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/cs334-25spring/index.htm

  (see course summary + schedule)
- Brightspace
  - For assignments, etc.
- Piazza
  - For communication
- TAs (Yuchen, Zhanyu) + instructor (Daniel)
  - For questions, grading, etc.
  - Office hours: Mon 4-7pm in LWSN 3130 and Th 1-2:30pm in LWSN 3130

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…

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

History of Computer Graphics

(slides courtesy of Marc Levoy)

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

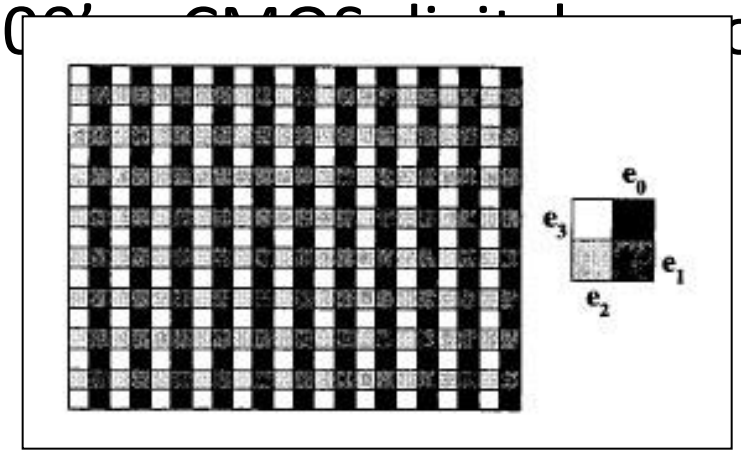
- 2D
  - light pen, tablet, mouse, joystick, track ball, touch panel, etc.
  - 1970s & 80s - CCD analog image sensor + frame grabber

Input hardware

- 2D
  -
  -

Input hardware

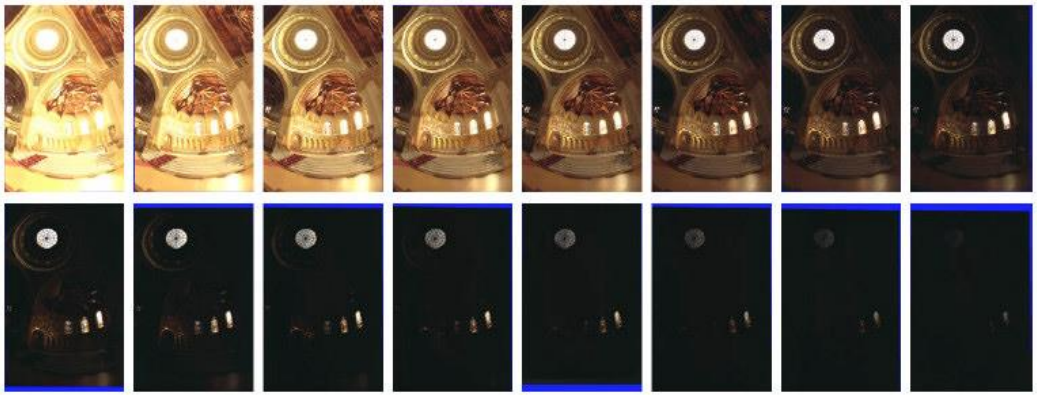
- 2D
  - light pen, tablet, mouse, joystick, track ball, touch panel, etc.
  - 1970s & 80s - CCD analog image sensor + frame grabber
  - 1990s & 200[illegible]or + in-camera processing

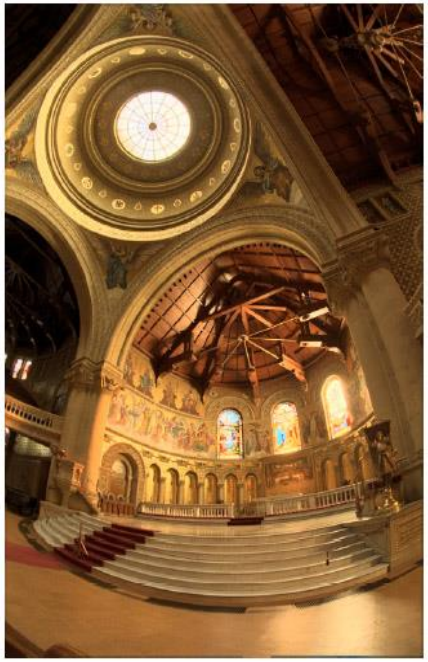


[Nayar00]

→ high-dynamic range (HDR) imaging

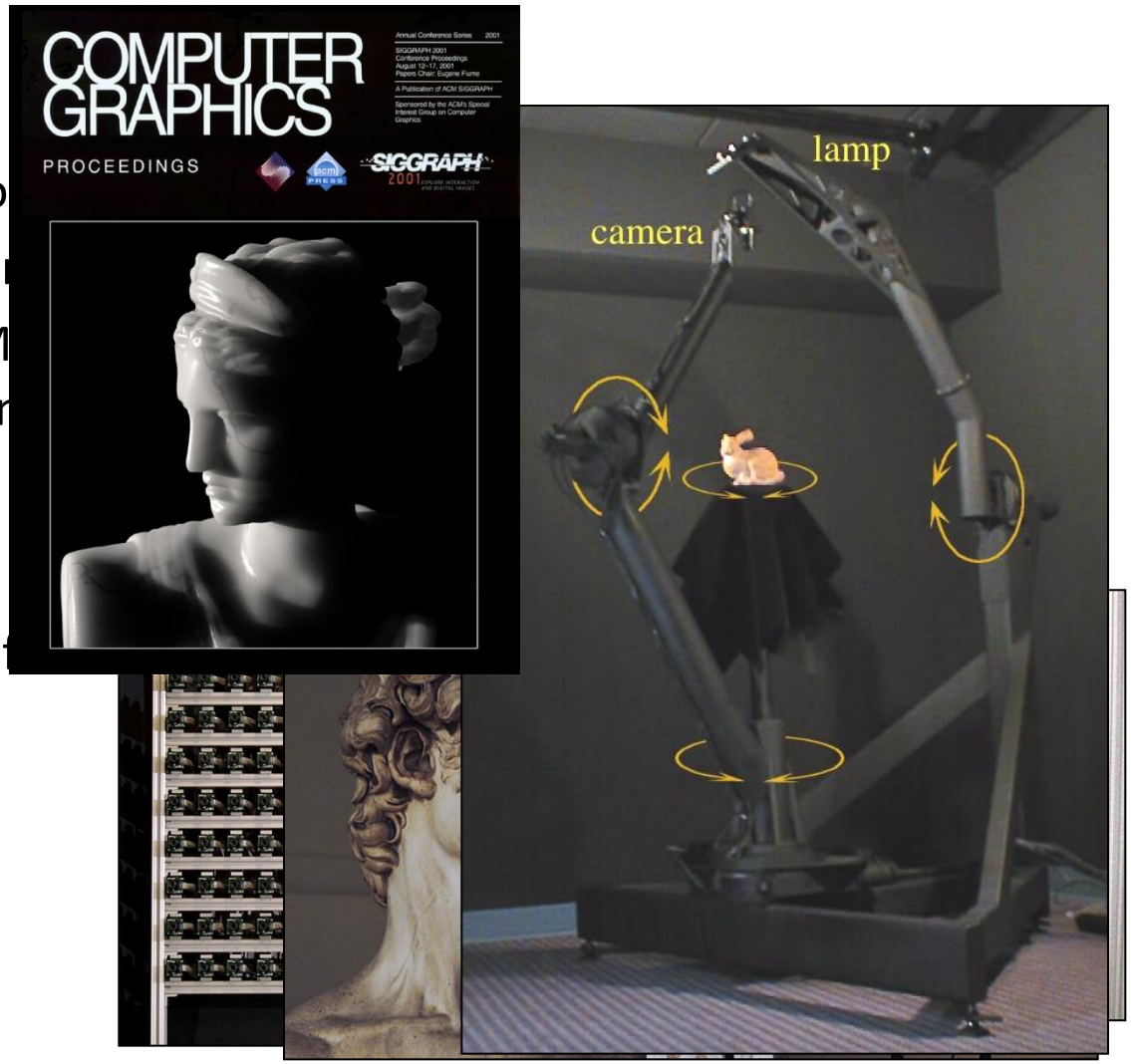
- negative film = 130:1 (7 stops)
- paper prints = 46:1
- [Debevec97] = 250,000:1 (18 stops)





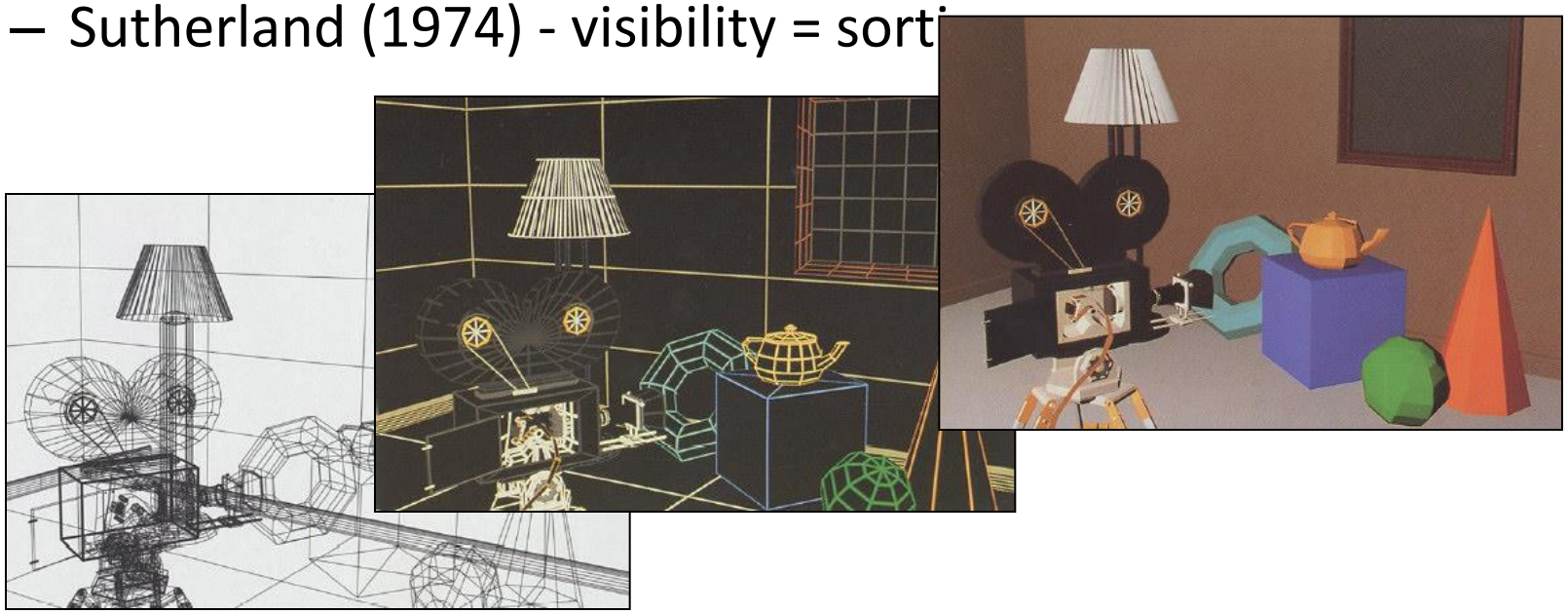
Input hardware

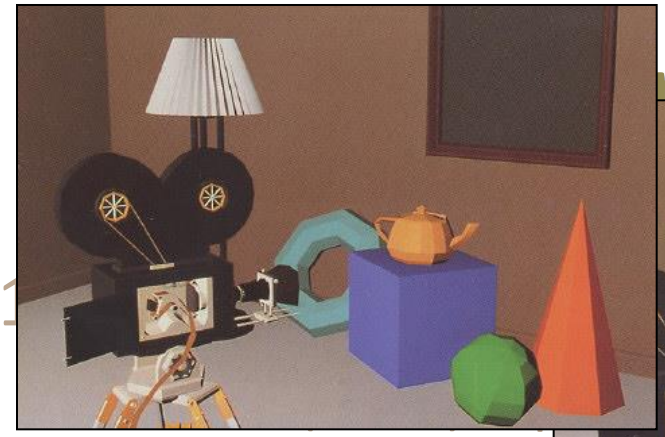
- 2D
  - light pen, tablet, mo
  - 1970s & 80s - CCD a
  - 1990s & 2000's - CM
    → high-dynamic ra
- 3D
  - 1980s - 3D trackers
  - 1990s - active range
- 4D and higher
  - multiple cameras
  - multi-arm gantries

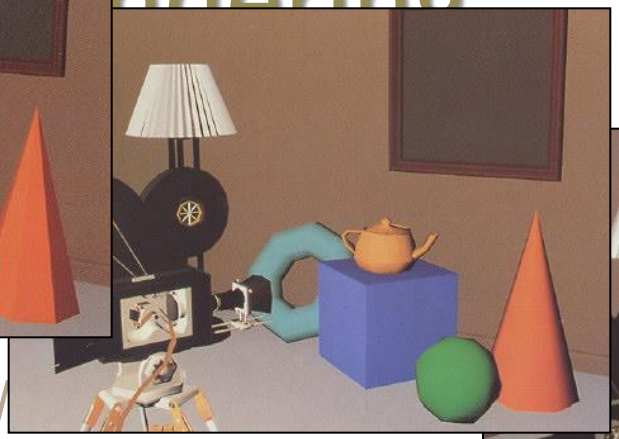


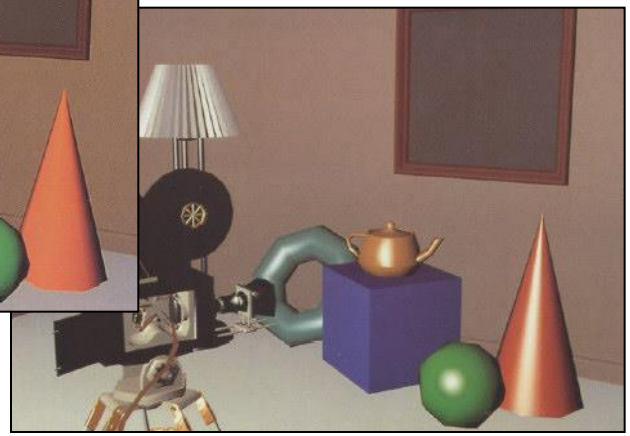
Rendering

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





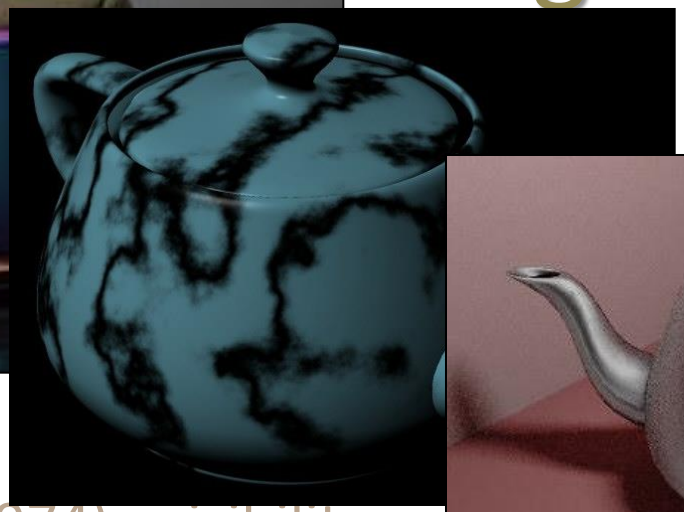




- 1
  - Warnock (1969), V
    algorithms
  - Sutherland (1974) - visibility = sorting

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

ering



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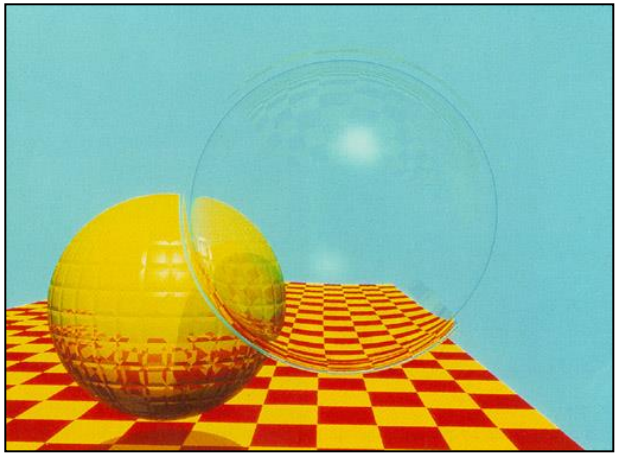
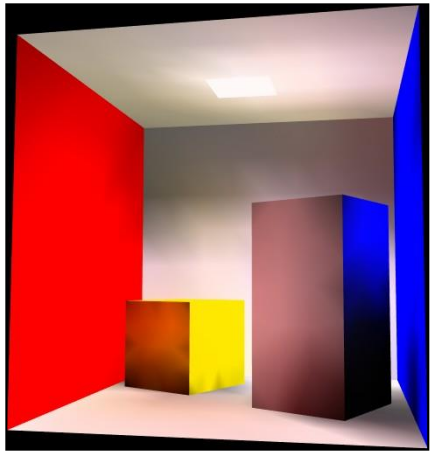
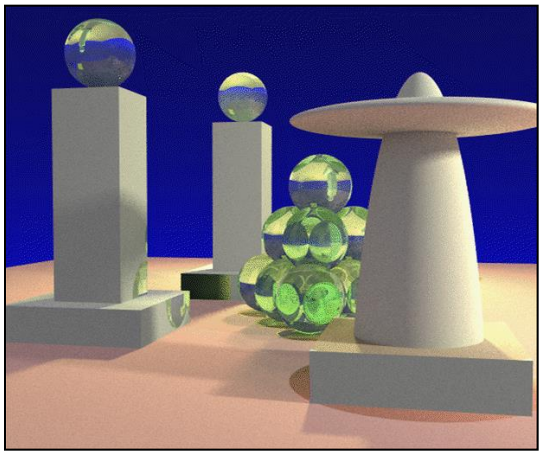
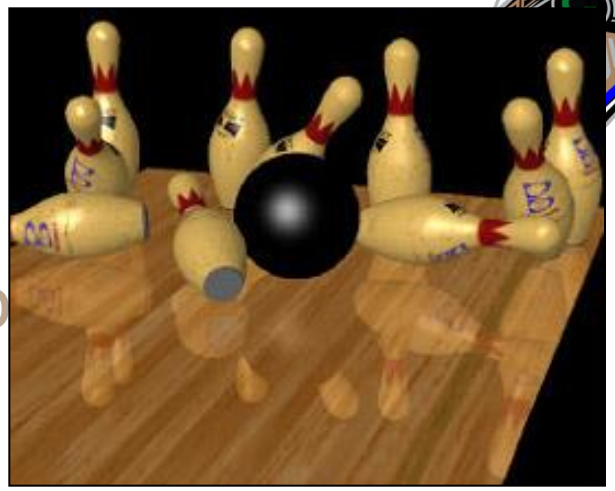
  - algorithms
  - Sutherland (1974) - visibility = s
- 1970s - raster graphics
  - Gouraud (1971) - diffuse lighting
  - Phong (1974) - specular lighting
  - Blinn (1974) - curved surfaces, texture
  - Catmull (1974) - Z-buffer hidden-surface algorithm
  - Crow (1977) - anti-aliasing

Rendering

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

→ shaders

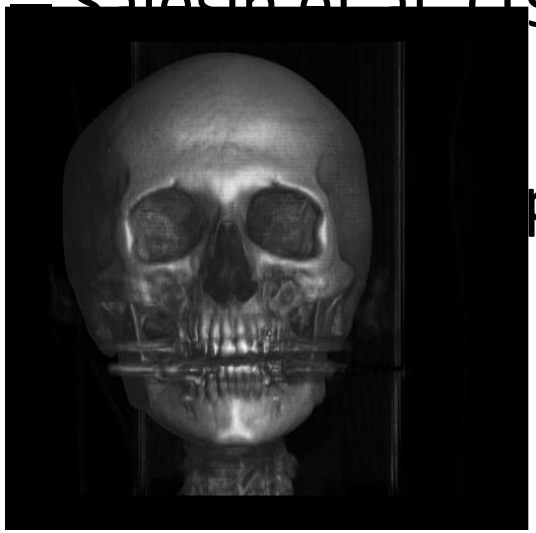
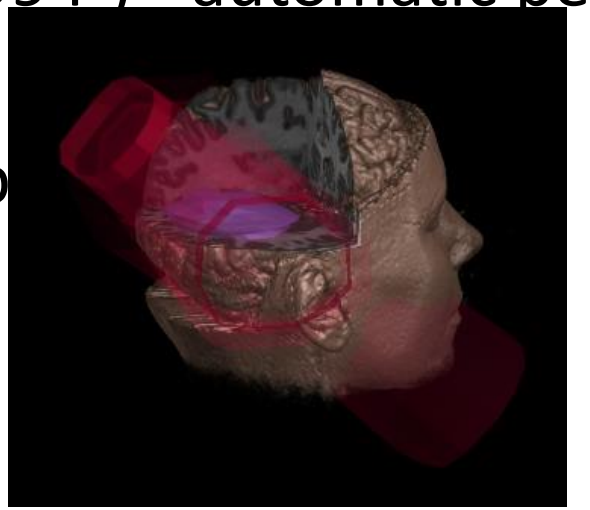
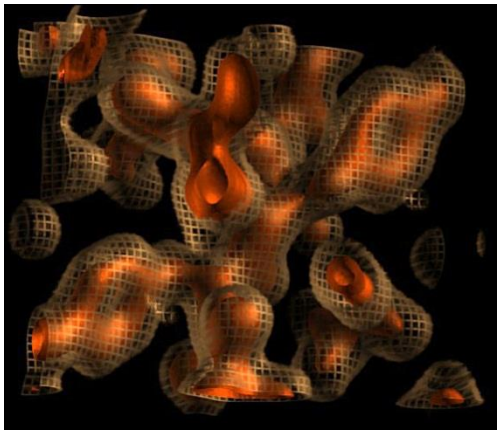


- e[illegible]b[illegible]o
  - [illegible] -
  - Goral, Torrance e[illegible]ohen (1985) - radiosity
  - Kajiya (1986) - the rendering equation

- 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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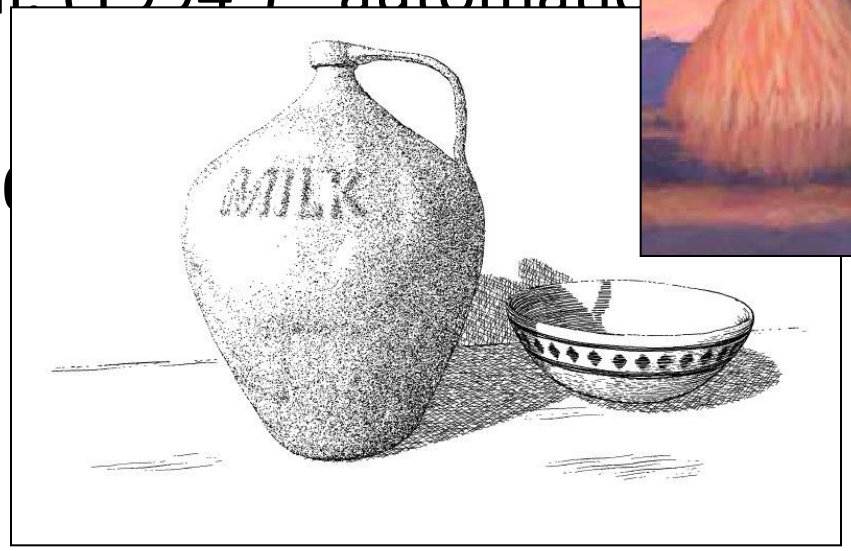
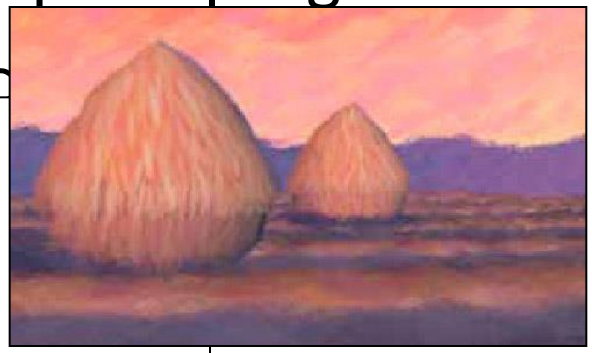




Sampling of Computer Graphics Today

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

Mona Lisa

- https://www.youtube.com/watch?v=Uun5B1hHmds

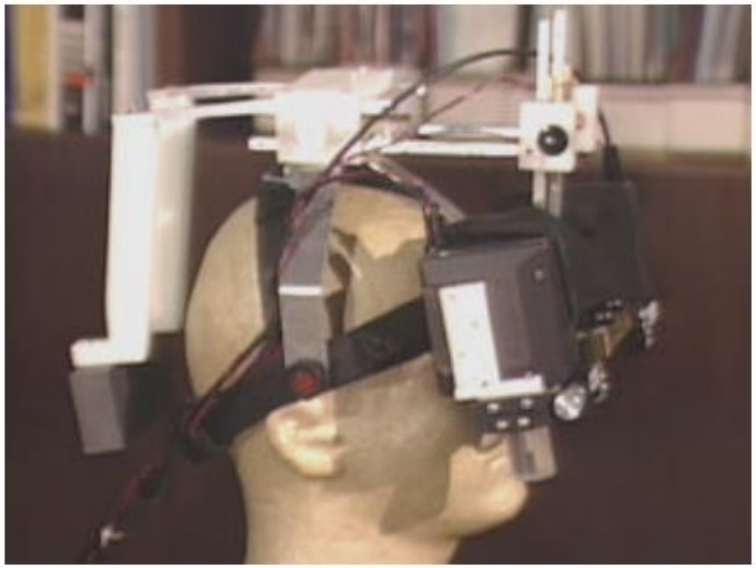
Games, of course

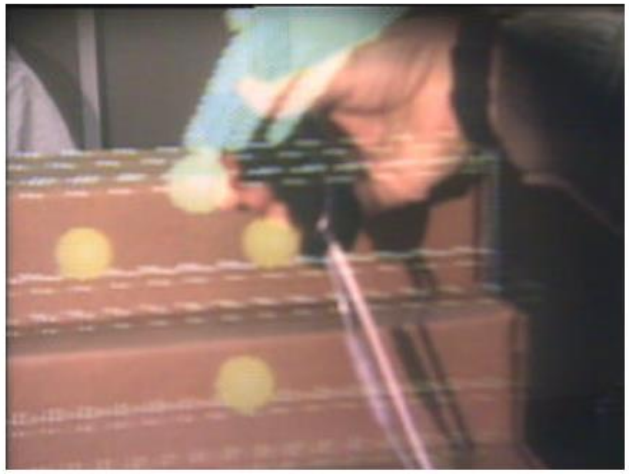
- https://www.youtube.com/watch?v=6kqe2ICmTxc

AI Based

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

Augmented Reality





Augmented Reality

Virtual Reality

3D Displays

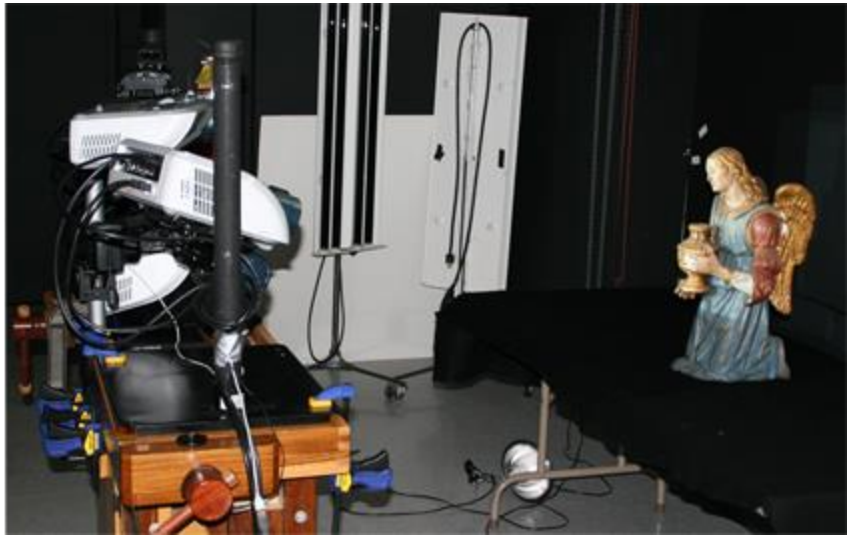
- Simple
  - https://www.youtube.com/watch?v=bBQQEcfkHoE

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=Ki8UXSJmrJE
- 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**