



CS334/ECE30834

Fundamentals of Computer Graphics

Spring 2022

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=3yuqdC8ld48>)

<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 (10-15 in CGVLAB)
 - Undergraduate students (1-3 per semester with me)
 - Postdocs and Visiting Professors
- Funding:
 - NSF, MTC, IARPA, Internet2, Microsoft, Google, Adobe, (Intel), and others

My Computer Graphics/Vision/Visualization Research (below links are to my web page)



- [3D urban modeling](#)
 - Developing novel 3D urban model acquisition methods, forward and inverse procedural modeling, and integration with urban design and planning
- [Projector-camera systems](#)
 - Investigating spatially-augmented reality and appearance editing of arbitrarily shaped and colored objects
- [3D digital fabrication](#)
 - Creating novel methods for digital manufacturing that embed into a physical object information for a variety of purposes, including genuinity detection, tamper detection, and multiple appearance generation



Course Mechanics

- CS334
 - <https://www.cs.purdue.edu/homes/aliaga/cs334-22spring/index.htm>
 - (see course summary + schedule)
- Brightspace
 - For assignments, etc.
- Piazza
 - For communication
- TAs (Chris, David) + instructor (Daniel)
 - For questions, grading, etc.



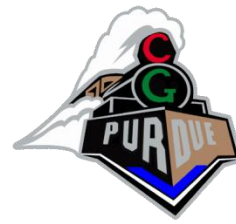
Best way to contact me

- 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:
 - What must be in subject of an email to me?
 - Answer: CS334



History of Computer Graphics

(slides courtesy of Marc Levoy)



Ivan Sutherland (1963) - SKETCHPAD

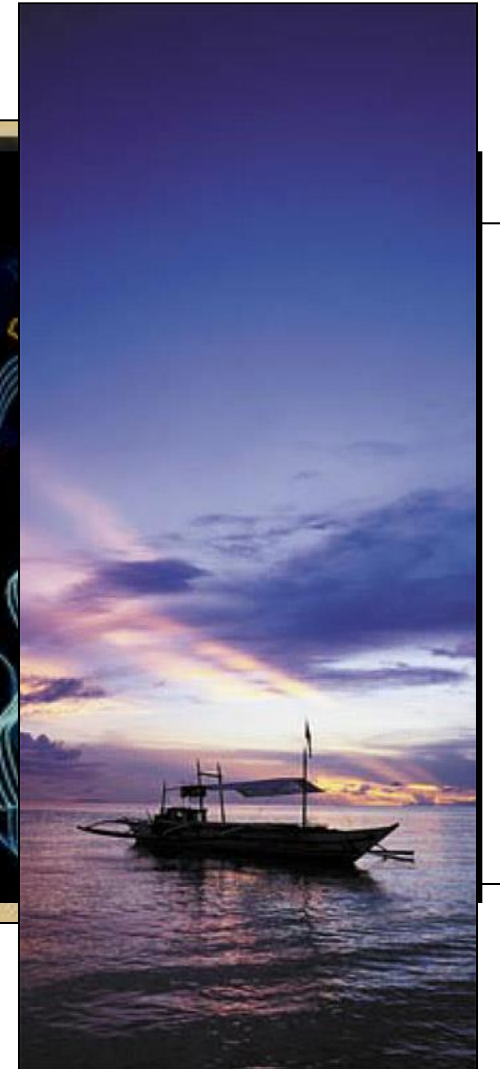
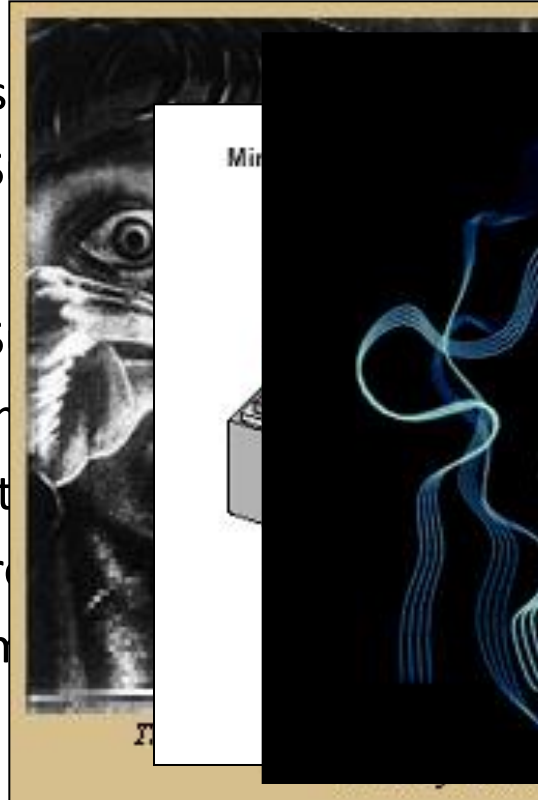


- pop-up menus
- constraint-based drawing
- hierarchical modeling



Display hardware

- vector displays
 - 1963 – modified oscilloscope
 - 1974 – Evans and Sutherland
- raster displays
 - 1975 – Evans and Sutherland
 - 1980s – cheap frame buffers
 - 1990s – liquid-crystal displays
 - 2000s – micro-mirrors
 - 2010s – high dynamic range
- 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

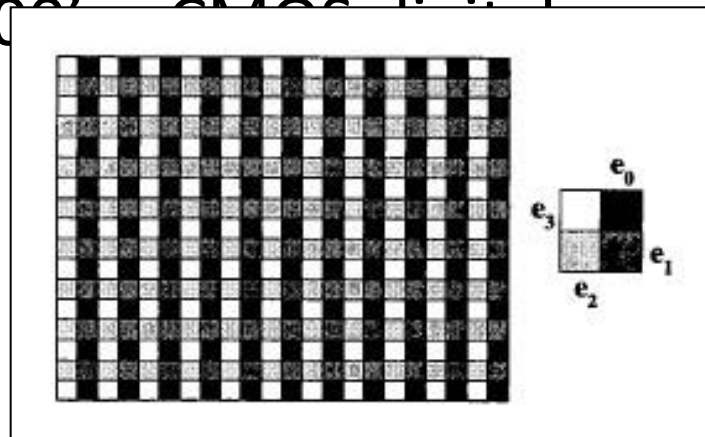
- 2D





Input hardware

- 2D
 - light pen, tablet, mouse, joystick, track ball, touch panel, etc.
 - 1970s & 80s - CCD analog image sensor + frame grabber
 - 1990s & 2000s - CMOS digital sensor + in-camera processing

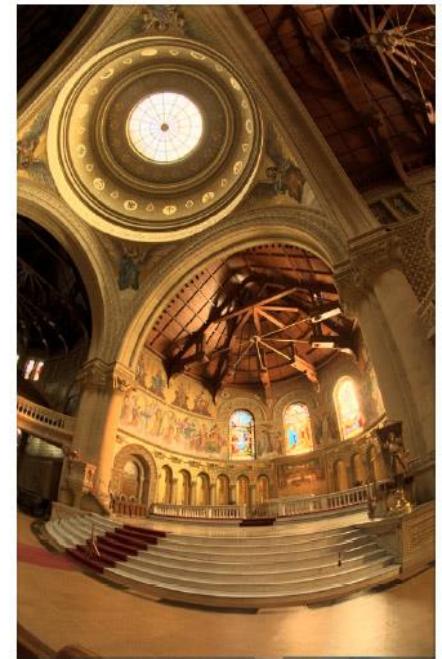
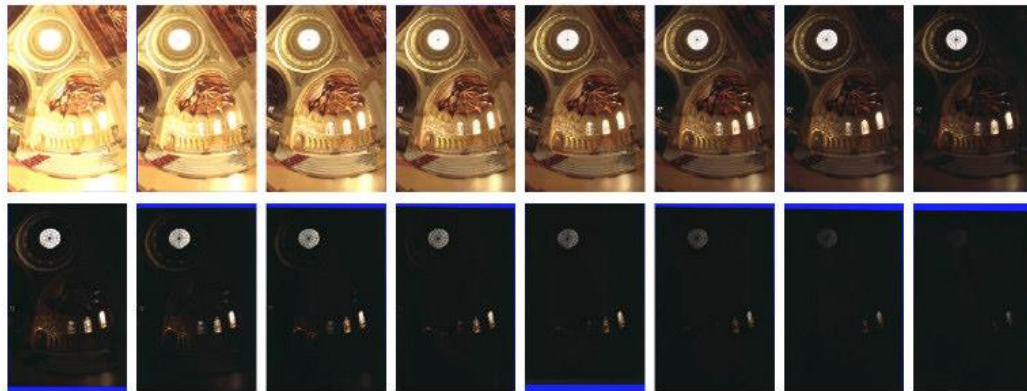


[Nayar00]

→ high-dynamic range (HDR) imaging



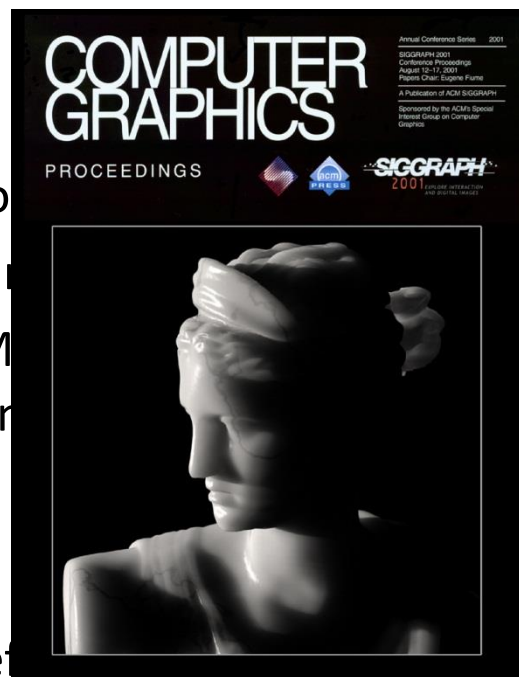
- negative film = 130:1 (7 stops)
- paper prints = 46:1
- [Debevec97] = 250,000:1 (18 stops)





Input hardware

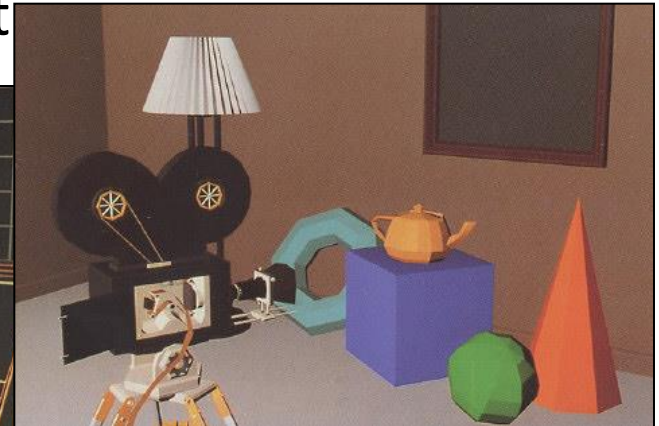
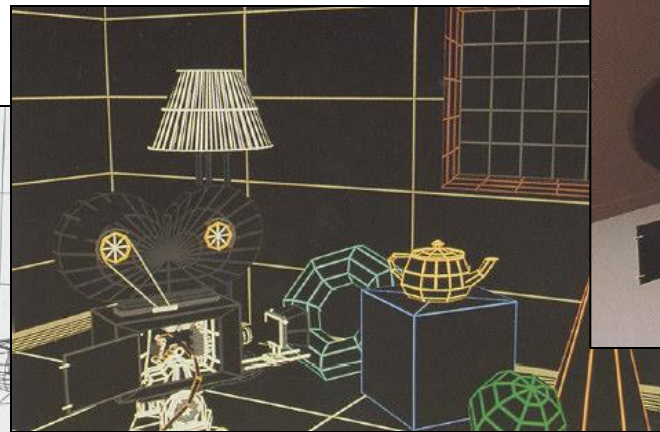
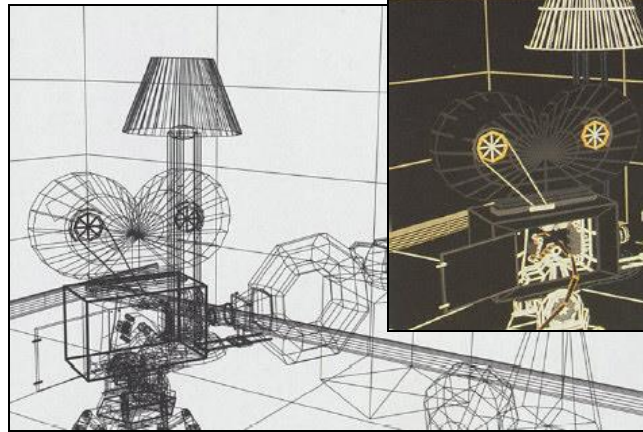
- 2D
 - light pen, tablet, mo
 - 1970s & 80s - CCD a
 - 1990s & 2000's - CM
 - high-dynamic ran
- 3D
 - 1980s - 3D trackers
 - 1990s - active range
- 4D and higher
 - multiple cameras
 - multi-arm gantries

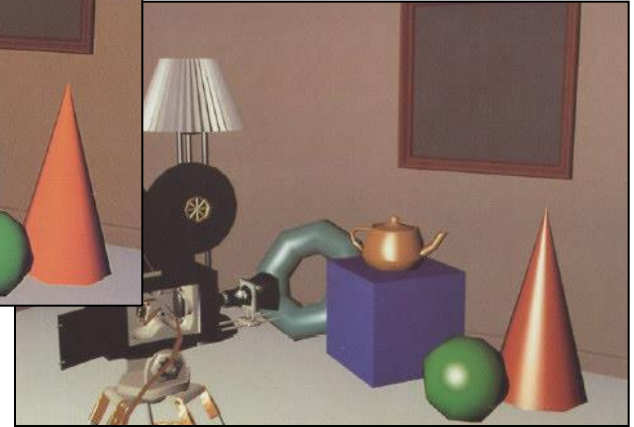
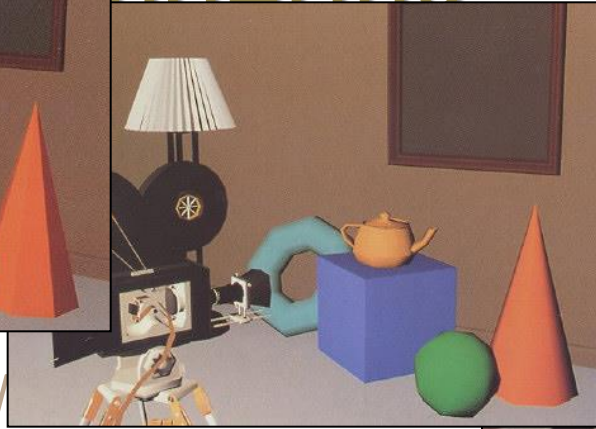
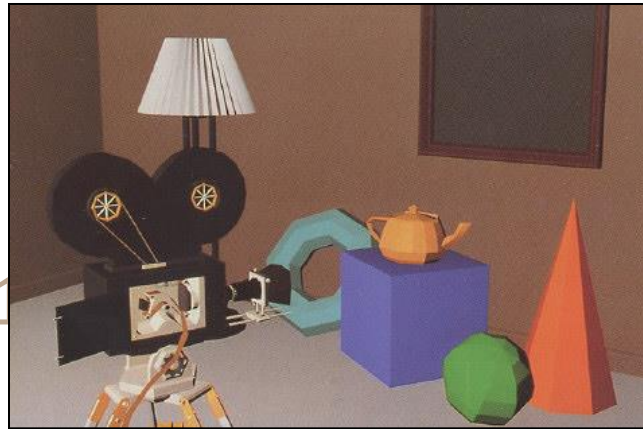




Rendering

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

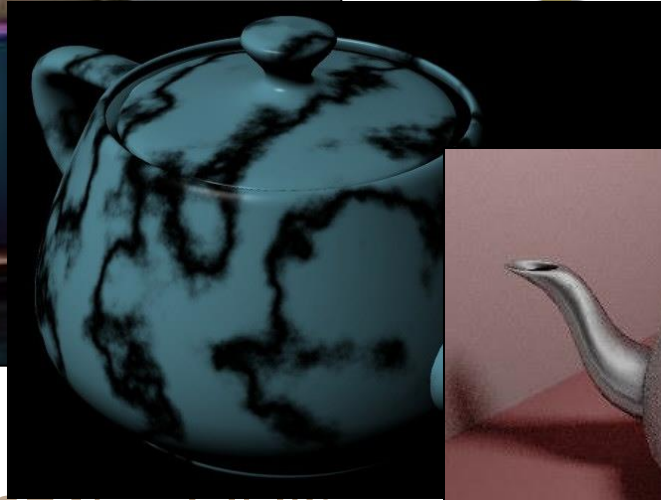




- - Warnock (1969), visibility algorithms
 - Sutherland (1974) - visibility = sorting
- 1970s - raster graphics
 - Gouraud (1971) - diffuse lighting
 - Phong (1974) - specular lighting
 - Blinn (1974) - curved surfaces, texture
 - Crow (1977) - anti-aliasing



ering



algorithms

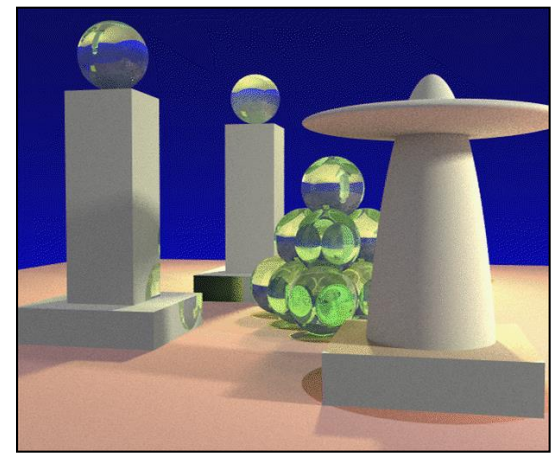
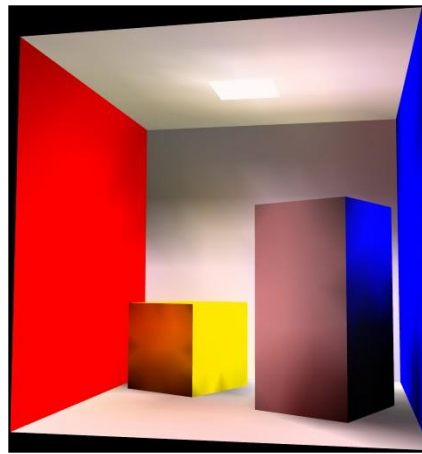
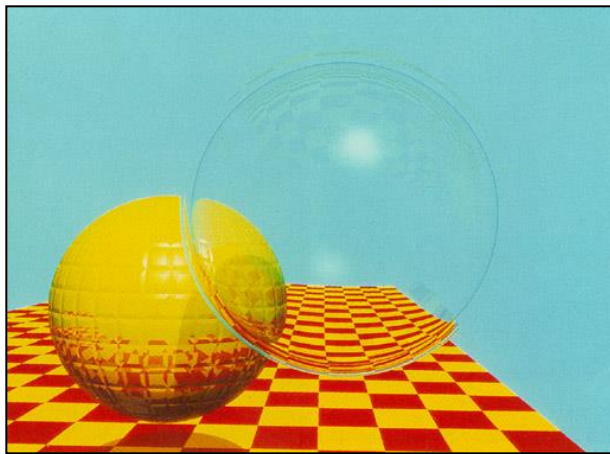
– Sutherland (1974) - visibility = s

- 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

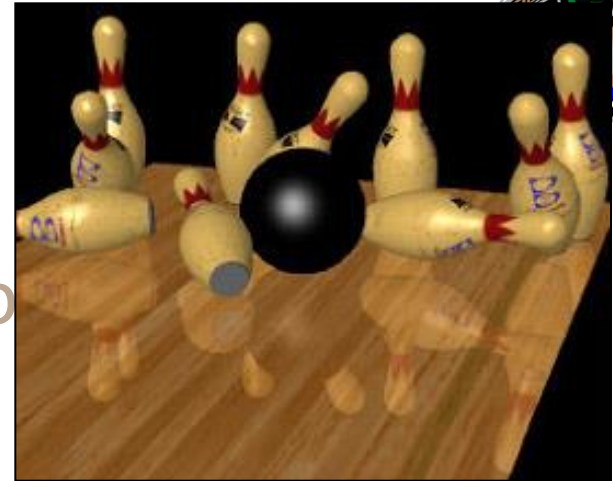


Rendering

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



→ shaders

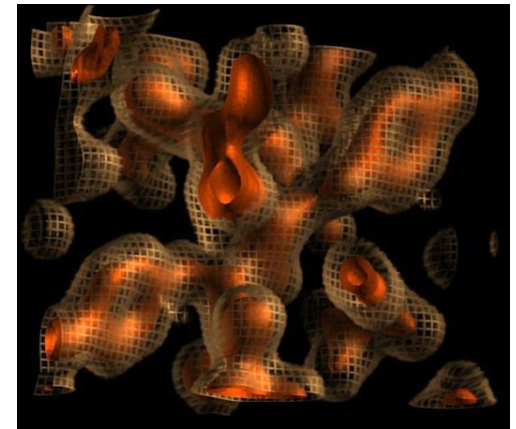
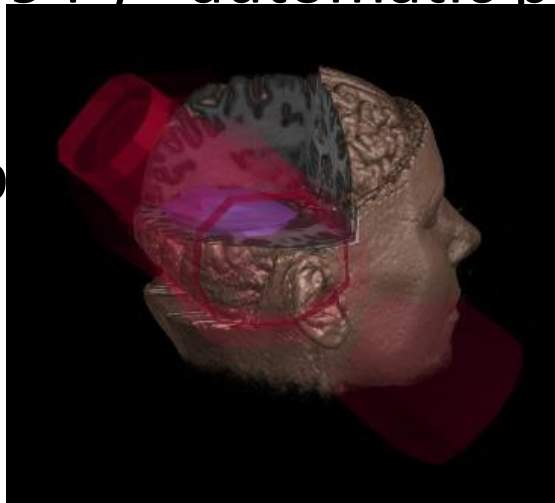
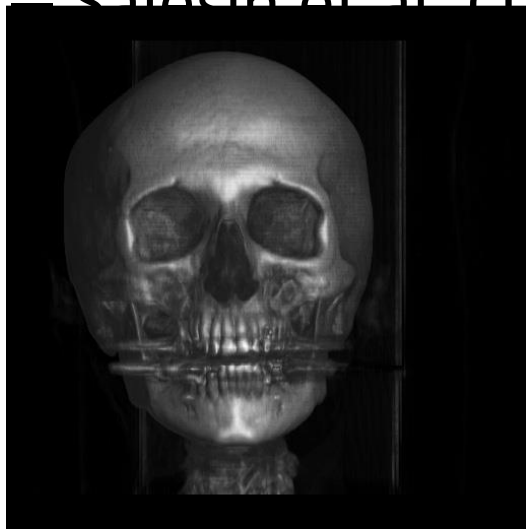


- e - b o
 - Goral, Torrance and Whitted (1985) - radiosity
 - Kajiya (1986) - the rendering equation
- late 1980s - photorealism
 - Cook (1984) - shade trees
 - Perlin (1985) - shading languages
 - Hanrahan and Lawson (1990) - RenderMan



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





Rendering

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



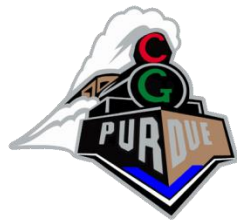


Sampling of Computer Graphics Today



Faces a while ago...

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



Faces no too long ago...

- <https://www.youtube.com/watch?v=Qevnfvplbpw>



Faces today!

- <https://thispersondoesnotexist.com/>
- (courtesy of Deep Learning & NVIDIA)



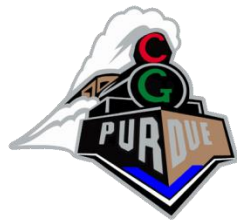
Even Presidents!

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



Mona Lisa

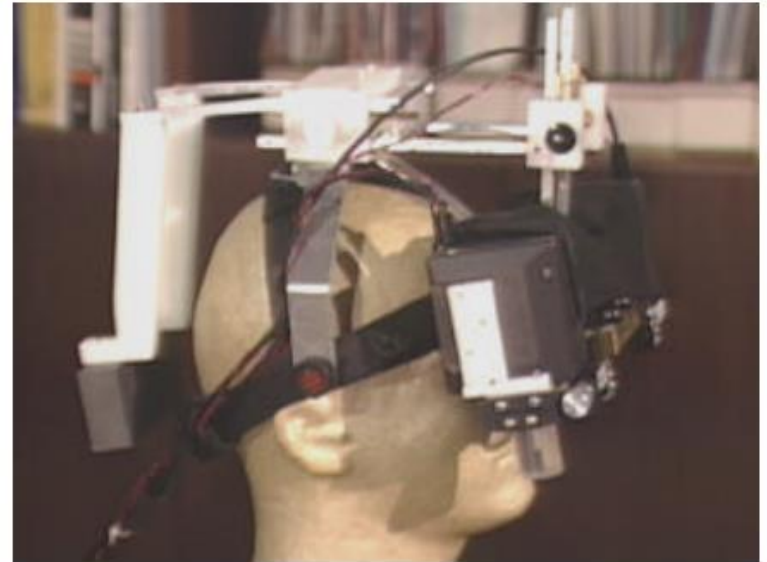
- <https://www.youtube.com/watch?v=Uun5B1hHmds>



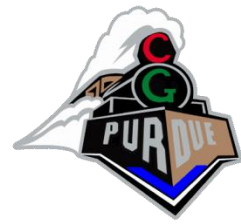
Games, of course

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

Augmented Reality



Augmented Reality



Microsoft
HoloLens

SLASH GEAR Windows 10



Virtual Reality





3D Displays

- Simple

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



3D Displays

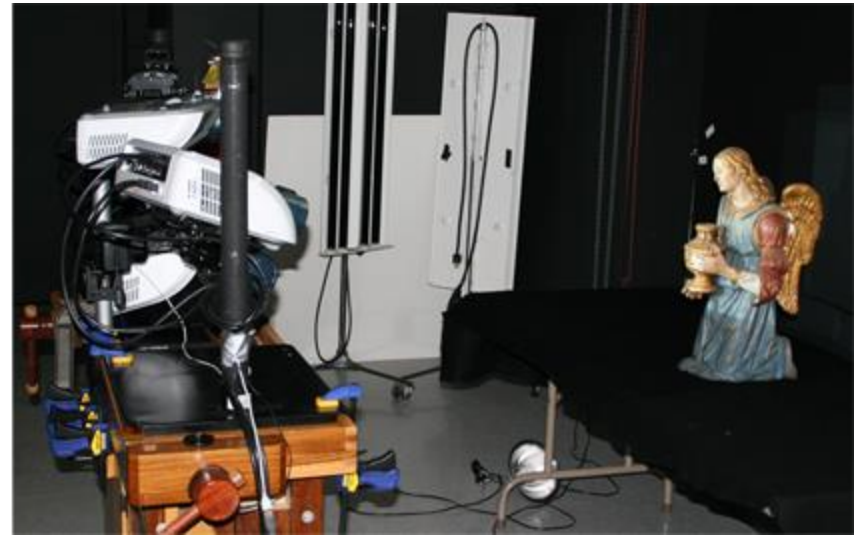
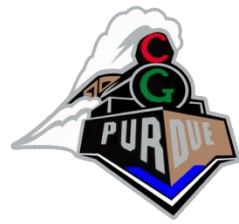
- Complex

- <https://www.youtube.com/watch?v=YKCUGQ-u08c>

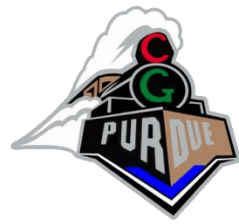
- <https://www.youtube.com/watch?v=CfHw8NA75Xc>

(careful with Hollywood tricks...)

Projection Based Displays



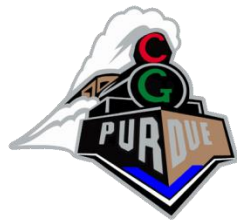
Projection Based Displays



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/>