CS334/ECE30834
Fundamentals of Computer Graphics

Spring 2023

Daniel G. Aliaga
Who am I?

- Daniel G. Aliaga
  - [http://www.cs.purdue.edu/~aliaga](http://www.cs.purdue.edu/~aliaga) and [aliaga@cs.purdue.edu](mailto: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](http://www.youtube.com/watch?v=3yuqdC8ld48))

Then: [http://www.youtube.com/watch?v=3yuqdC8ld48](http://www.youtube.com/watch?v=3yuqdC8ld48)
  - [http://thinkingscifi.files.wordpress.com/2012/12/starwars-graphics.png](http://thinkingscifi.files.wordpress.com/2012/12/starwars-graphics.png)

Now: [http://www.youtube.com/watch?v=QAEkuVgt6Aw](http://www.youtube.com/watch?v=QAEkuVgt6Aw)

- CGVLAB
  - [http://www.cs.purdue.edu/cgvlab](http://www.cs.purdue.edu/cgvlab)
• Workforce:
  – Graduate students (20+ 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
• 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
    (see course summary + schedule)

• Brightspace
  – For assignments, etc.

• Piazza
  – For communication

• TAs (Yichen, David) + 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 really really really taking notes
History of Computer Graphics
Ivan Sutherland (1963) - SKETCHPAD

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

• vector displays
  – 1963 – modified oscilloscope
  – 1974 – Evans and Sutherland Picture System
• raster displays
  – 1975 – Evans and Sutherland frame buffer
  – 1980s – cheap frame buffers
  – 1990s – liquid-crystal displays
  – 2000s – micro-mirror projectors
  – 2010s – high dynamic range displays
• 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
  → 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, mouse, joystick, track ball, touch panel, etc.
  – 1970s & 80s - CCD analog image sensor + frame grabber
  – 1990s & 2000’s - CMOS digital sensor + in-camera processing
  → high-dynamic range (HDR) imaging

• 3D
  – 1980s - 3D trackers
  – 1990s - active rangefinders

• 4D and higher
  – multiple cameras
  – multi-arm gantries
Rendering

• 1960s - the visibility problem
  – Roberts (1963), Appel (1967) - hidden-line algorithms
  – Sutherland (1974) - visibility = sorting
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  – Roberts (1963), Appel (1967) - hidden line 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
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Rendering

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

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

→ shaders
• 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 illustration
• early 1990s - non-photorealistic rendering
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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=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
• 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=bBQQEcfkJoE
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!

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

  - Hughes, van Dam, McGuire, Sklar, Foley, Feiner, and Akeley