Course Staff

Kevin Li
CS PhD in Ron’s lab
research focus: fluid simulation

Sarah Jobalia
CS PhD in Ron’s lab
research focus: hair modeling

Muhammed Khattak (CA)
CS Masters Student

Trevor Carrell (CA)
CS Masters Student

Course materials based off of Ron’s slides and Yilin’s assignments from fall quarter CS148
Preferred communication channel: Ed public/private posts
Lecture Outline

● Motivation and Applications
● High-level Topics
● Overview
● Logistics
What is Computer Graphics?

VFX (Avengers Infinity War, 2018)

Animation (Into the Spiderverse, 2018)

Gaming (Final Fantasy 16, 2023)
What is Computer Graphics?

- Tiktok filter
- Pokemon Go
- Taylor Swift, Eras tour
- Nasa VR Lab
- Unity, Airsim for Self Driving Cars / Drones
2D TEXT
VFX (Avengers Infinity War, 2018)
Virtual Space vs. Screen Space

Nowhere Dimension, (Spongebob, 1999)
Animal Crossing New Horizons
Virtual Time

Frame 1 + Frame 2 + Frame 3 + Frame 4 = Envato Tuts Animation tutorial

Frame 1
Virtual Time

The Incredibles, (The Science Behind Pixar)
Luca, (The Science Behind Pixar)
Modeling

Luca, (The Science Behind Pixar)
Texture and Materials

Luca, (The Science Behind Pixar)
Rigging

Luca, (The Science Behind Pixar)

Luca, (The Science Behind Pixar)
Rigging

Misters Inc. (Amt-lab, CMU)
Sets

Luca, (The Science Behind Pixar)
Sets
Animation

Luca, (The Science Behind Pixar)
Animation

The Incredibles, (The Science Behind Pixar)

Toy Story 3
Simulation

Luca, (The Science Behind Pixar)
Simulation

Brave, (The Science Behind Pixar)

The Good Dinosaur
Layout
Lighting

Luca, (The Science Behind Pixar)

Giorgio Lorenzetti, (The Rookies)
Rendering
Models  Textures  Rigging  Sets  Lights

Placing objects in the scene

Animation  Simulation  Layout

Moving objects over frames

Rendered Result
Luca, (The Science Behind Pixar)

The Incredibles, (The Science Behind Pixar)
Models
Textures
Rigging
Sets
Lights

Placing objects in the scene

Animation
Simulation
Layout

Moving objects over frames

Rendered Result
Visual Effects (VFX)

- VFX: photorealistic simulation and rendering

Davy Jones Ship (Pirates of the Caribbean)
Visual Effects (VFX)

- VFX: photorealistic simulation and rendering

Davy Jones (Pirates of the Caribbean)
What can I do with graphics?

- VFX: photorealistic simulation and rendering

  Water (The Day After Tomorrow)
  Fire (Harry Potter and The Goblet of Fire)
  Explosions (Transformers: Dark of the Moon)
  Cloth (Harry Potter and The Chamber of Secrets)
What can I do with graphics?

- VFX: creature modeling, motion capture and animation

Dinosaurs (Jurassic Park, 1993)
Facial Capture in Avatar
Gollum (Lord of the Rings)
Davy Jones (Pirates of the Caribbean)
What can I do with graphics?

- VFX: creature modeling, motion capture and animation
What can I do with graphics?

- Video Games

Elden Ring

Metaverse
What can I do with graphics?

- Games and ARVR

Example of cinematic model

Gollum Recreation (Lord of the Rings)

Sample of game model
What can I do with graphics?

- Not just entertainment,
- anything that has a GUI/visual component, really
What can I do with graphics?

- Scientific Visualization
  (outreach and funding!)

[Images of scientific visualizations from EHT and Nasa]

[Image of a molecular structure labeled "Fold it"]
What can I do with graphics?

- Synthetic data generation for AI/ML
Computer Graphics

- Very broadly, the study of computer-generated imagery
- What can I do with computer graphics?
  - Traditionally: Movies, Games, 2D & 3D Design, Scientific Visualization
  - More recently: Synthetic data for AI applications
Questions?
What should I get out of this class?

- Course Philosophy:
  Learn how to use interdisciplinary knowledge spanning mathematics, natural sciences, engineering, art and more.
Mathematics in Graphics

- e.g. analyzing flows (e.g. fluid flows) across geometric surfaces
- e.g. smoothing out high frequencies in noisy functions
- Any computations across space!
  - Linear Algebra for navigating 3D space
  - Monte Carlo for rendering
Natural Sciences in Graphics

- **Physics**: simulations; *light, optics*
- **Biology**: motion capture; *perceptual color*
- **Chemistry**: modeling; *object materials*
- Basically simulating + modeling the world!
Engineering in Graphics

- High performance computing + aggressive approximations
  *e.g. data structures for code acceleration*
- Optimized hardware (GPUs, cameras)
- Software systems (data management)
Art in Graphics

- At the end of the day, it has to look good :) 
- Artistry-driven engineering
Course Philosophy

- Learn how to use interdisciplinary knowledge spanning mathematics, natural sciences, engineering, art and more

- What we will focus on:
  - Understanding what it takes to create a well-composed 3D virtual scene and rendering it as a 2D image

- Examples of what we will not focus on:
  - 2D Graphic Design
  - Systems-level Graphics (CS 248)
  - Interactive Graphics / Video Game Design
Course Philosophy

● Breadth, limited depth
  ○ Gain high level knowledge on a broad set of topics
  ○ Implement low level details with simplifications and assumptions
  ○ Learn how to use software that has more complete implementations
  ○ Only 8 weeks!

● Equal emphasis on technical and practical knowledge
# Syllabus (details may change)

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<th>Week</th>
<th>Tuesday Lecture</th>
<th>Thursday Lecture</th>
<th>Homework due (Friday)</th>
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<td>Introduction</td>
<td>Geometry &amp; Transformations</td>
<td>Installation &amp; Setup *</td>
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<td>Rasterization &amp; Shading *</td>
<td>Color, Images &amp; Cameras</td>
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<td>Raytracing II</td>
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<td>Final Project Tips</td>
<td>Simulation &amp; Animation I</td>
<td>Lighting &amp; Texturing Project Proposal</td>
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<td>6</td>
<td>Simulation &amp; Animation II</td>
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<td>Guest Lecture</td>
<td>Final Project Workshop</td>
<td>Project Progress</td>
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<td>8</td>
<td>Final Project Workshop</td>
<td>Final Project Workshop</td>
<td>Project Submission</td>
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Practical Component

- We use Blender in this course
  - **Scanline Rendering**
    Implemented via *OpenGL* for previz, enabling real time scene design
  - **Ray Tracing**
    Used to render final, high-quality images
  - **Why not X/Y/Z?**
    Less steep learning curve compared to other software, but also more limited/barebones

In spite of its limitations, people have still managed to make entire movies within Blender
Generally use a combination of more specialized software though
Technical Component

- You will write minimal but fully functional graphics applications
  - Mini assignments where you write code in Python, e.g. your own raytracer
  - Get a sense of what’s going on under the hood in e.g. Blender
  - Not what you’d see in real-life production settings
    -- practical concerns for optimization, interface design, data management
  - Meant to be a “hook” for more advanced topics and courses (CS X48)
    -- choose your own adventure!
    will talk more about this at the end of the course,
    but also feel free to discuss with us in office hours
Stanford Graphics Faculty

Leo Guibas
Geometry/ML

Pat Hanrahan
Rendering/Viz

Ron Fedkiw
Physics/ML

Maneesh Agrawala
HCI/Media

Doug James
Simulation/Interactivity

More recently:

Kayvon Fatahalian
Systems/ Scalability

Karen Liu
Animation/Robotics

Gordon Wetzstein
AR/VR
Questions?
Communication

● Office Hours:
  ○ Start Week 2
  ○ Both in-person and over Zoom
  ○ Schedule with location and Zoom links will be posted on Canvas when finalized
  ○ See pinned Ed post for more details

● Ed:
  ○ Will be used for all announcements
  ○ Primary means of contact with the course staff
  ○ See website (cs148.stanford.edu) for link if you’re not in already
  ○ Ask questions, share resources, find partners!
## Logistics

- **Evaluation**: 50% assignment, 10% quiz, 40% final project
- **Assignments and Quiz questions** released each Thursday
- **Live grading** the Friday of the next week

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<th>SUN</th>
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Assignments (50%)

- Due via live grading on Fridays (both in-person and online option)
- See Canvas calendar for times with locations + Zoom link
- Short mini presentation of your HW results (~5 min max)

- Allowed to work with 1 partner, but each person must be prepared to answer any questions individually about the work!

- Homework 0 (Installation & Setup) is out on the course website Soft deadline this Friday; not graded, but needed for HW1, etc.
Quiz (10%)

- Occurs during live grading after the HW is graded
  - Quizzes are expected to take only a few minutes (~3 max)
  - See pinned Ed post for more details

- Not meant to be difficult
- All questions released ahead of time; one gets randomly asked!
- **If you’re working in partners, then both partners get asked a different question that they have to answer individually**

- Reach out to us at least **a day in advance** for alternative arrangements if you cannot make the grading sessions!
Final Project (40%)

- Can work with 1 partner
- See [cs148.stanford.edu/showcase](cs148.stanford.edu/showcase) for past project writeups
Final Project (40%)

- Can work with 1 partner
- See cs148.stanford.edu/showcase for past project writeups

Luna Yang and Xuelin Yang, Fall 2021

Sreya Halder, Fall 2020
Final Project (40%)

- Can work with 1 partner
- See cs148.stanford.edu/showcase for past project writeups

Po-Ya Wu, Fall 2021

Lingjie Kong and Yanjia Li, Fall 2020
Final Project (40%)

- Can work with 1 partner
- See cs148.stanford.edu/showcase for past project writeups

Anthony Xie, Fall 2021

Yifan Wang, Fall 2020
Final Project (40%)

- Can work with 1 partner
- See cs148.stanford.edu/showcase for past project writeups

Bihan Liu and Yixin Liu, Fall 2022
Labib Rahman, Fall 2022
Questions?