CS148 Summer 2025 - Lecture 1

06/24/2025

CS148:
Introduction to Computer Graphics and Imaging

cs148.stanford.edu

Course Staff

Kevin Li

CS PhD in Ron's lab

Researches fluid simulation

Sarah Jobalia

CS PhD in Ron's lab

Researches hair modeling

Hannah Kim (CA)

CS Masters Student

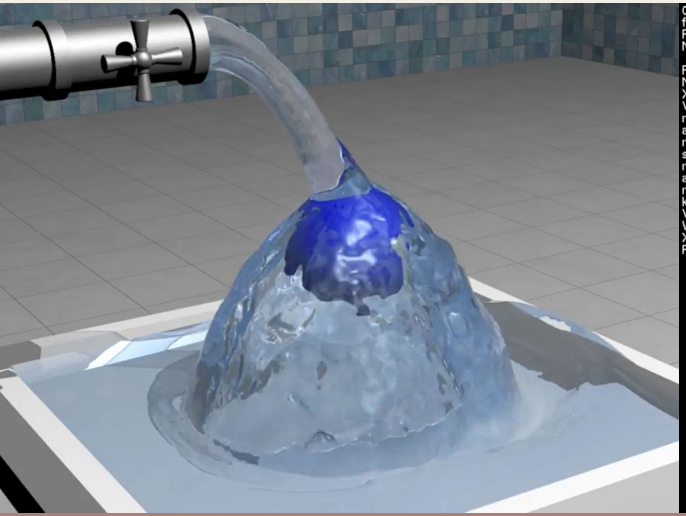
Course materials based off of Ron's slides and Yilin's assignments from Fall quarter CS148

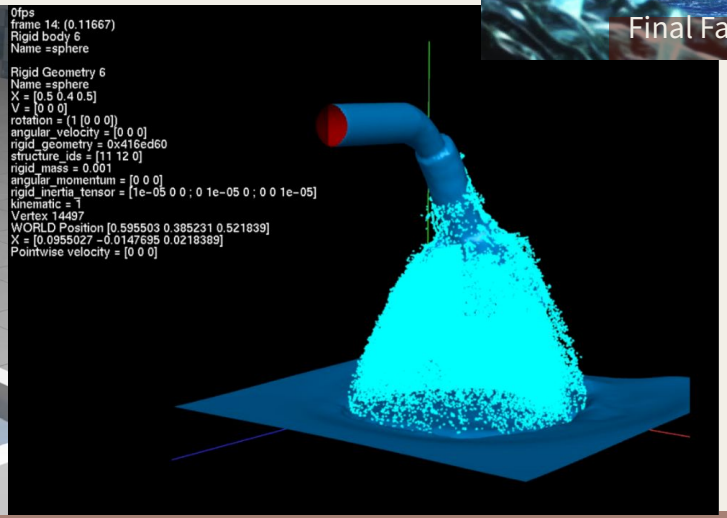
Preferred communication channel: Ed public/private posts

Kevin Li

Inspired by video games as a kid:

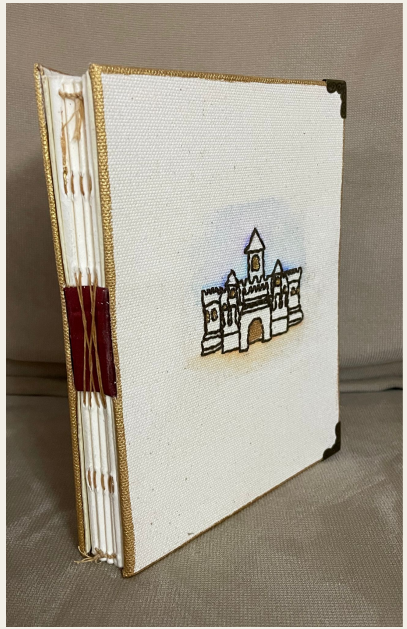
Now work on fluid simulation and modeling:





Sarah Jobalia

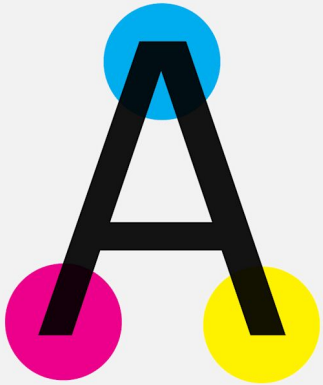
Sarah Jobalia

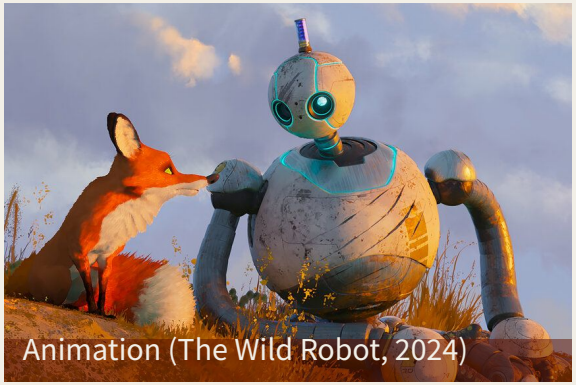


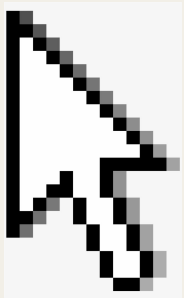
Lecture Outline

- Motivation and Applications
- High-level Topics
- Overview
- Logistics

What is Computer Graphics?







What is Computer Graphics?

What is Computer Graphics?

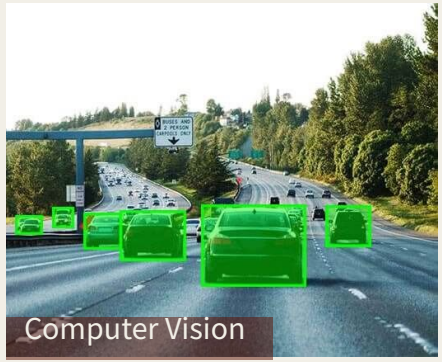

Tiktok filter


Taylor Swift, Eras tour


Museums and Planetariums


Pokemon Go


Educational Tools


Computer Vision

What is Computer Graphics?

Study of computer-generated imagery

- Movies
- Games
- 2D & 3D Design
- Scientific Visualization
- Synthetic data for AI

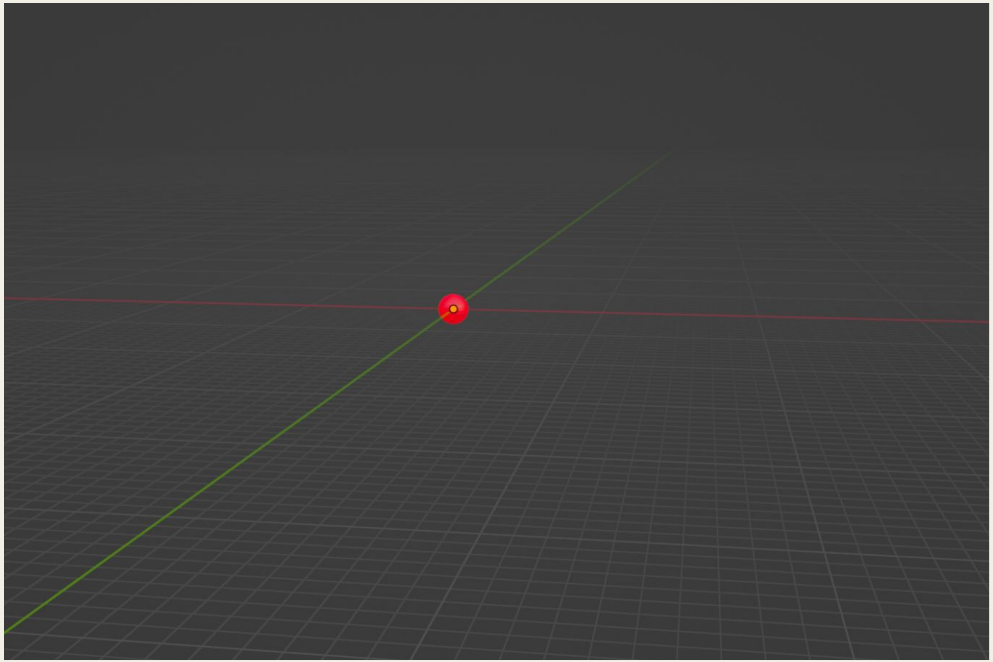

SD
640 x 480 px
Full HD
1920 x 1080 px
4K
3840 x 2160 px
8K
7680 x 4320 px
helpdeskgeek.com

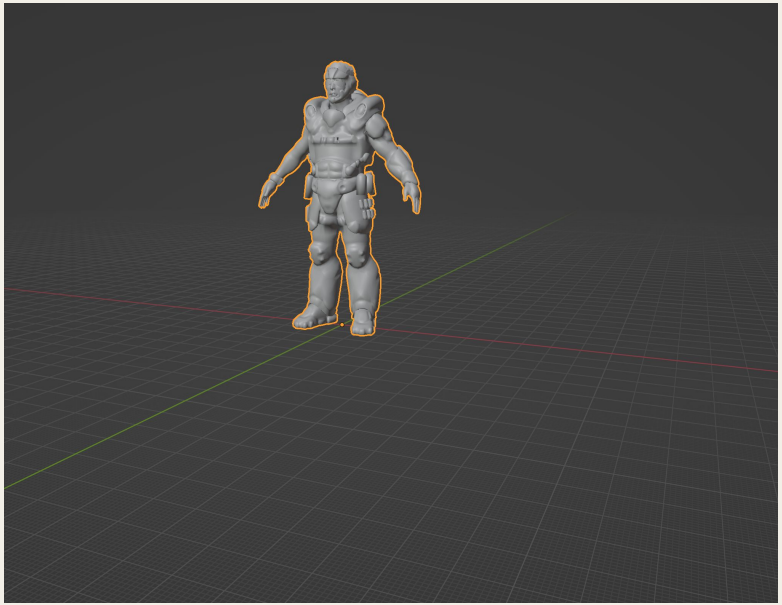
2D TEXT

VFX (Avengers Infinity War, 2018)

Virtual Space vs. Screen Space

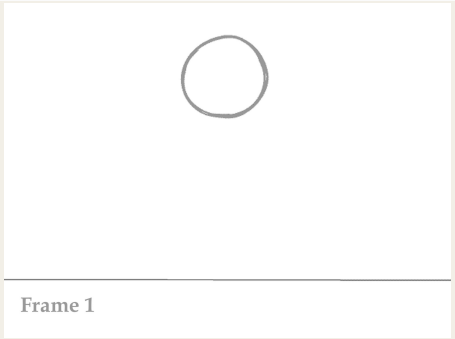
Nowhere Dimension, (Spongebob, 1999)






Hold
R Select Multiple
Animal Crossing New Horizons
Turn Guide Off
Camera
X Pockets
B Finish

Virtual Time



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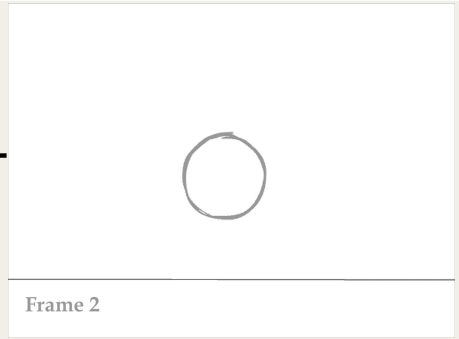

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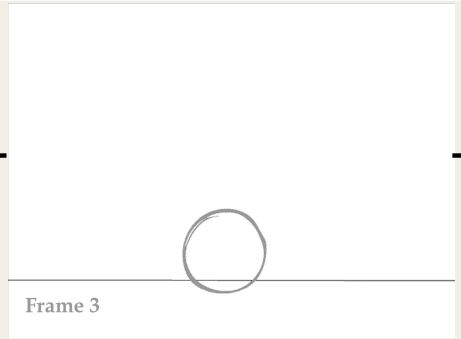

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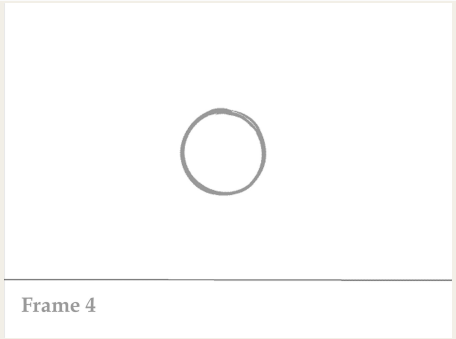

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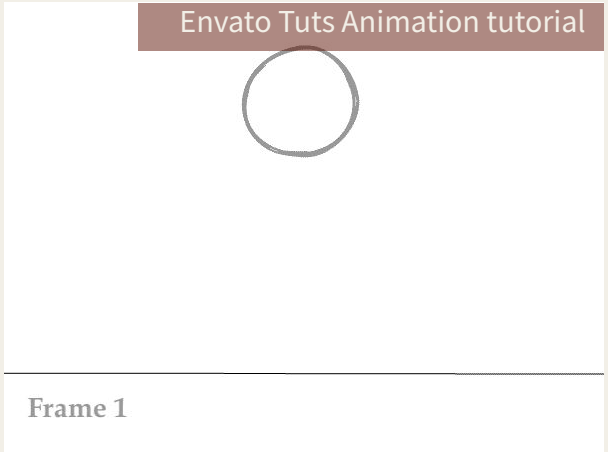

Virtual Time

Σ

The Incredibles, (The Science Behind Pixar)

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SAN GIORGIO

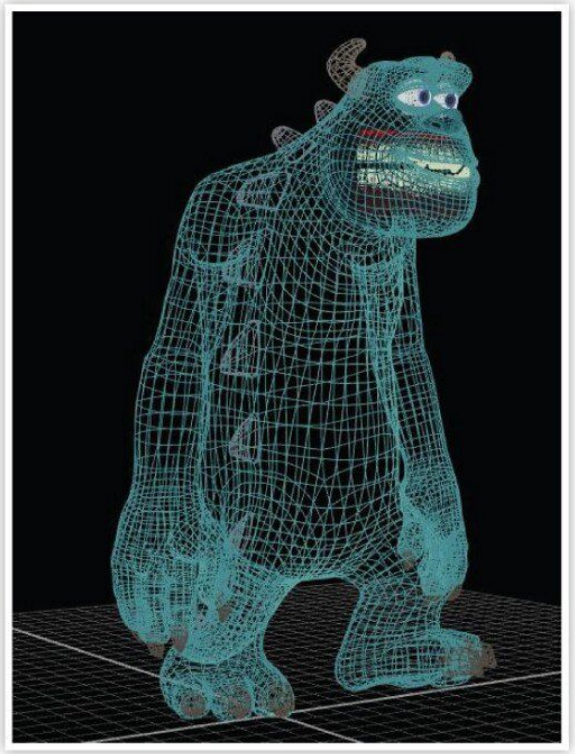
Storyboard

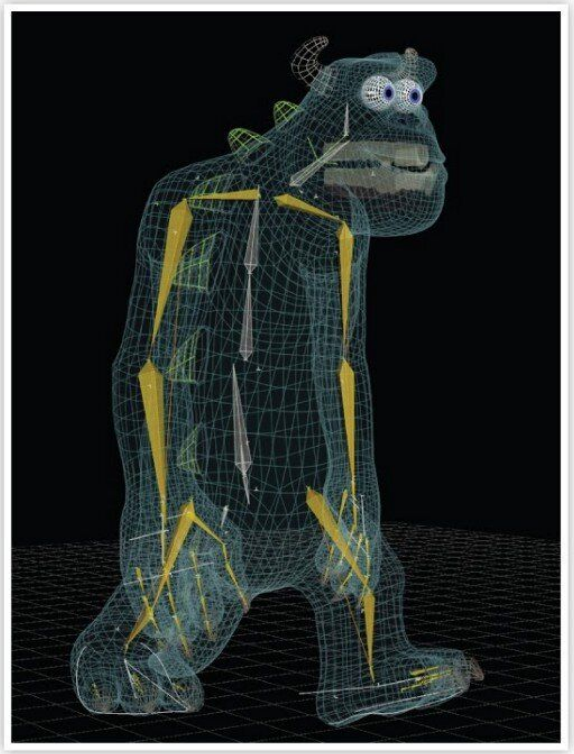
Modeling

Texturing

Rigging

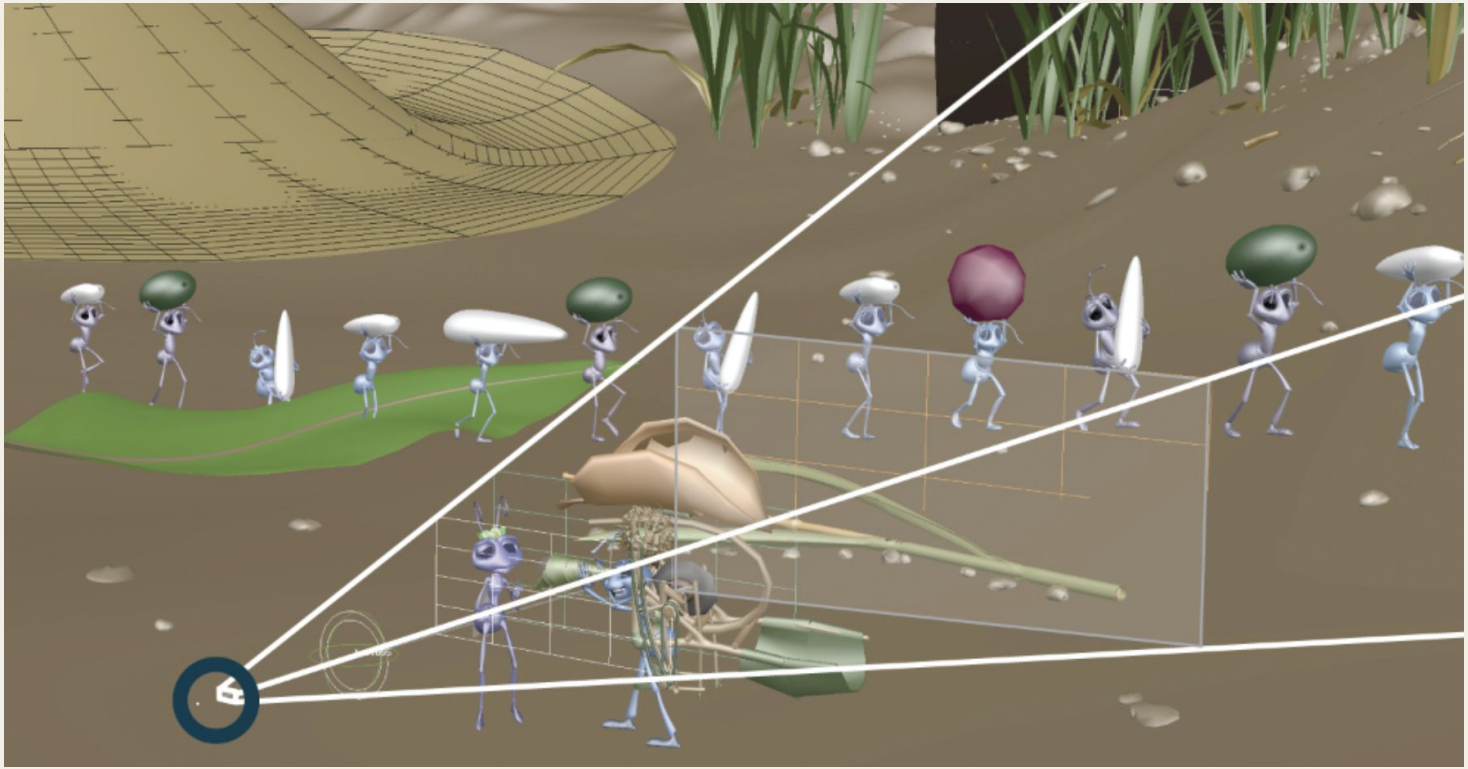
Rigging



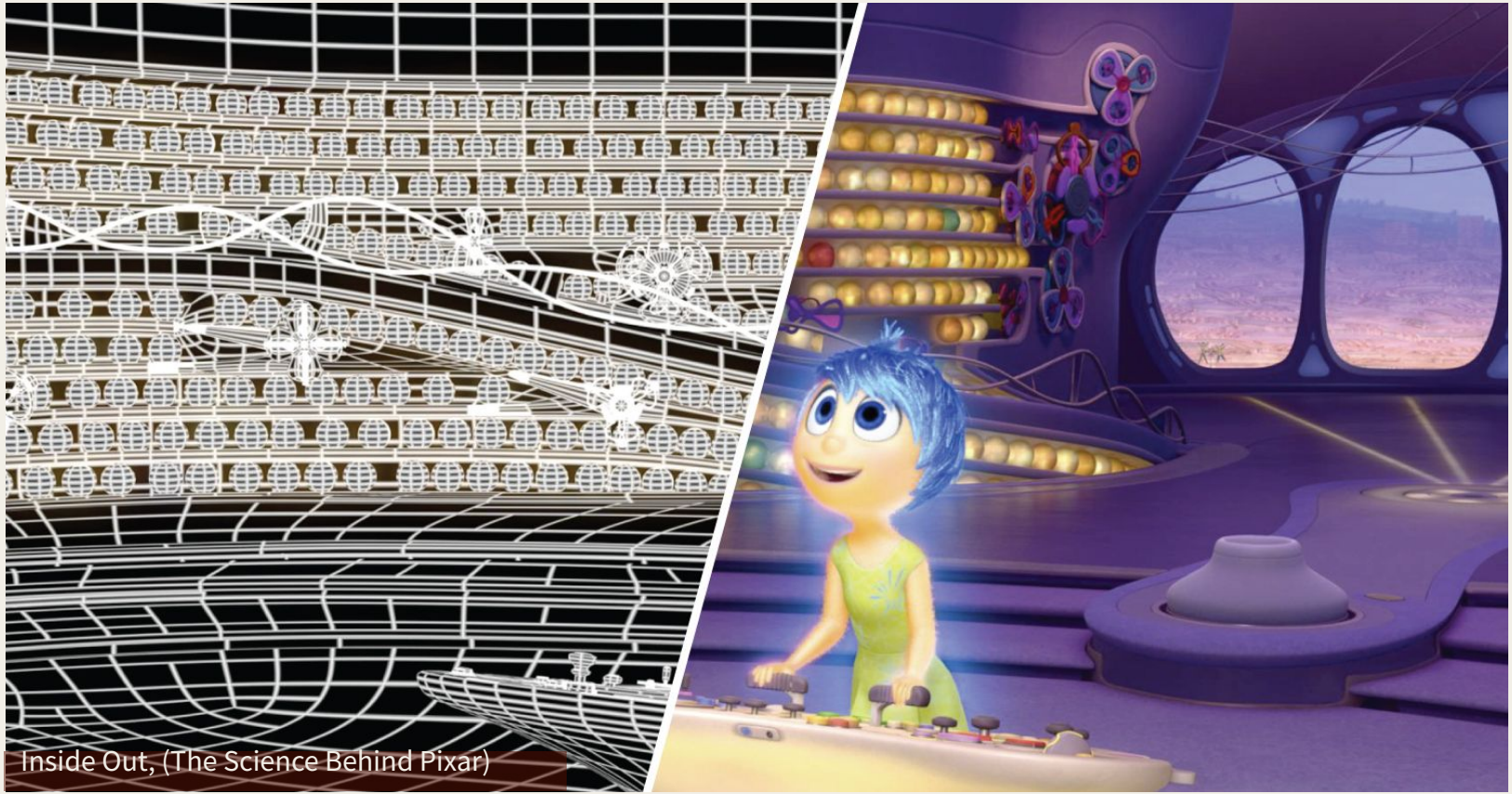


Mosters Inc. (Amt-lab, CMU)

Layout



Sets



Sets and Layout

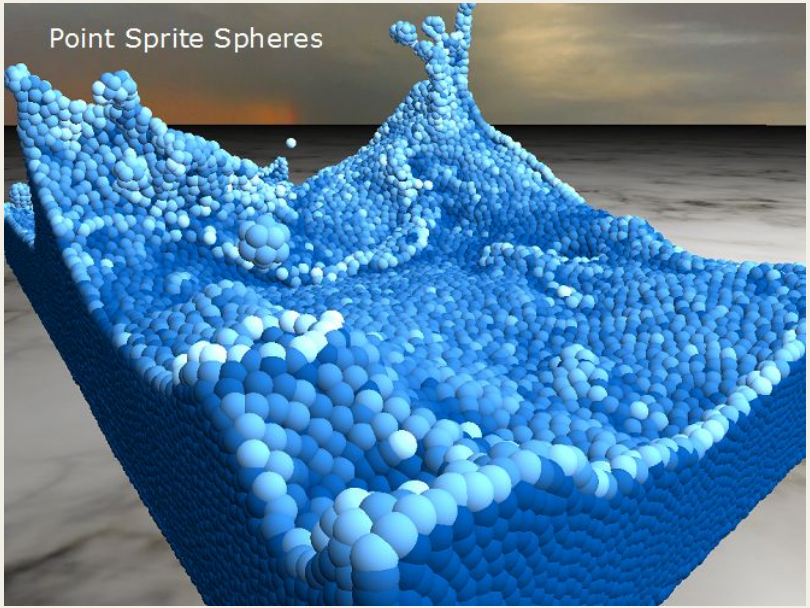
Animation

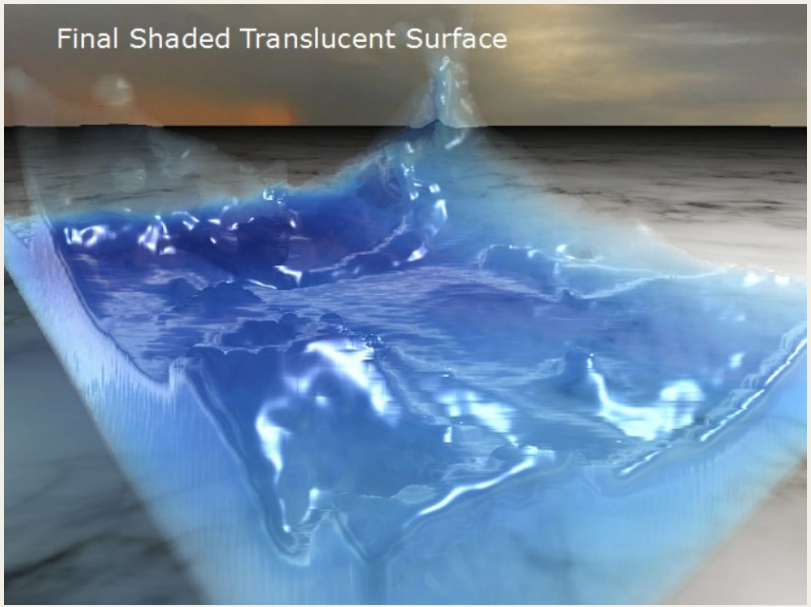
The Incredibles, (The Science Behind Pixar)

Toy Story 3

Animation

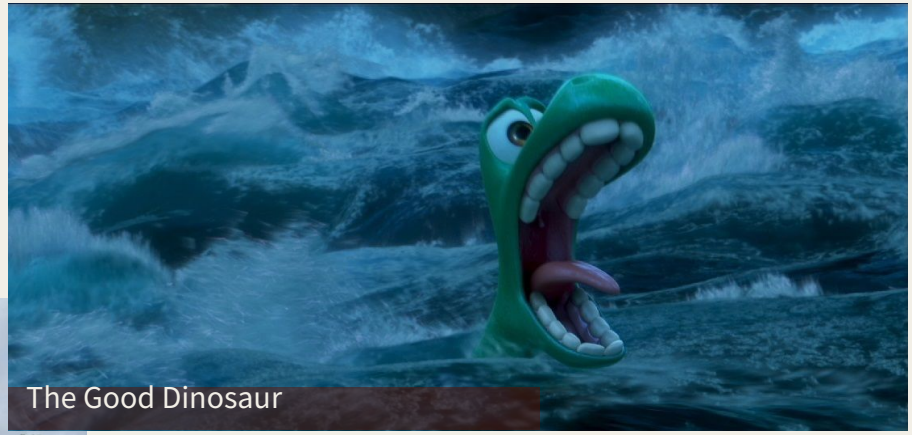
Simulation





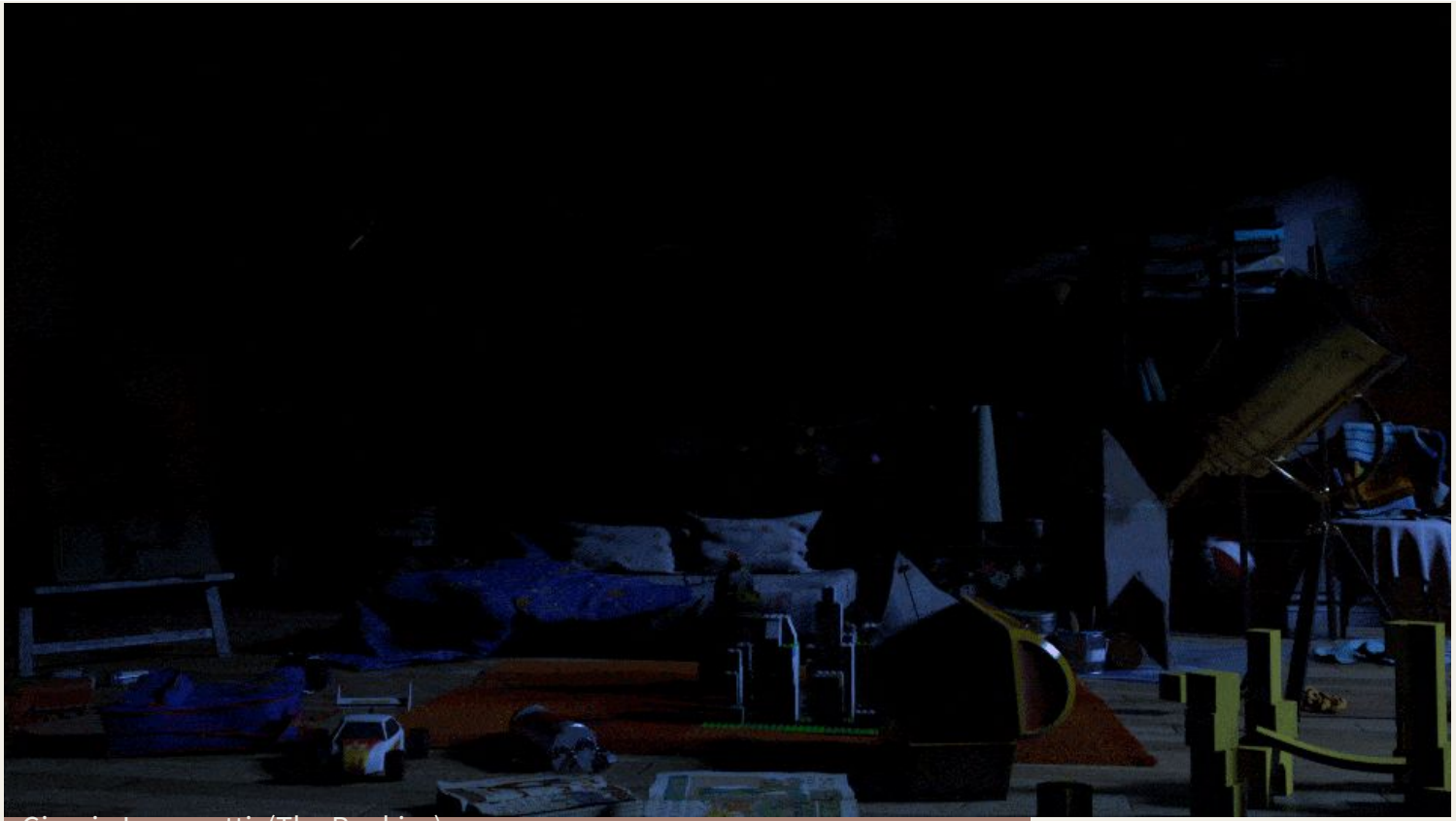
Simulation

Simulation


The Good Dinosaur


Brave, (The Science Behind Pixar)

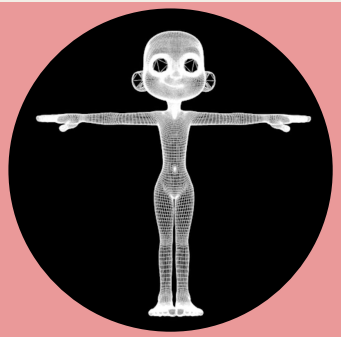
Lighting



Giorgio Lorenzetti, (The Rookies)

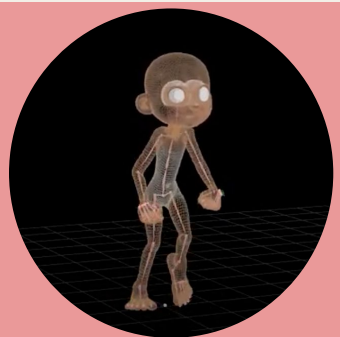
Lighting


SAN GIORGIO

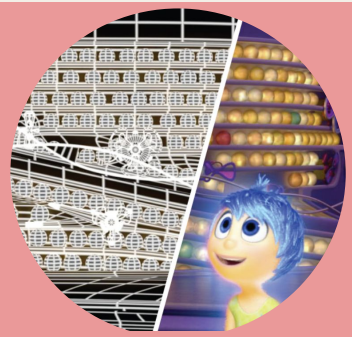


Models

Textures



Rigging



Sets

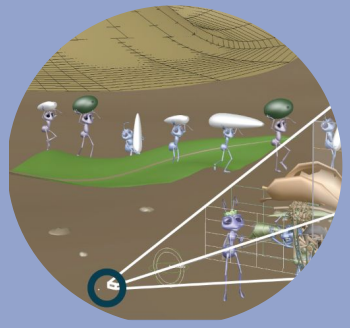
Lights

Placing objects in the scene

Moving objects over frames

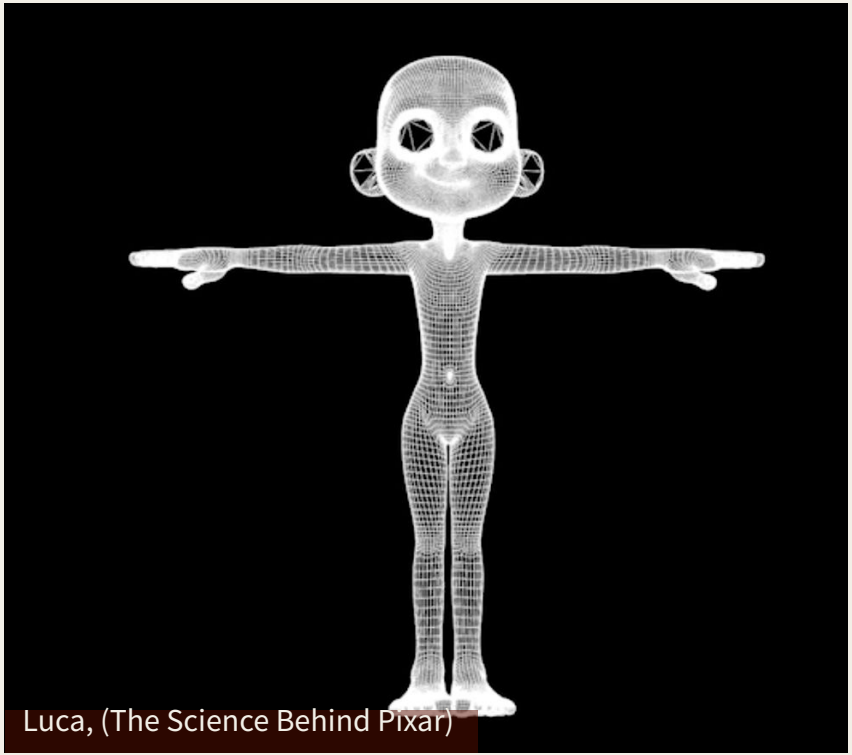
Animation

Simulation



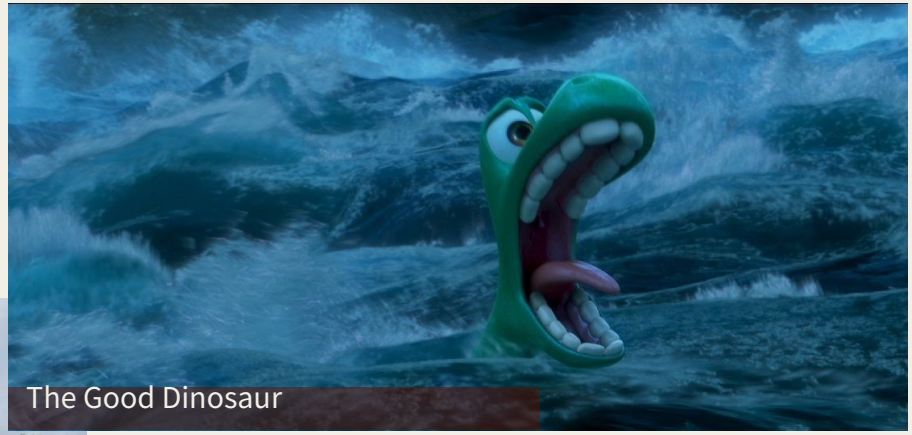
Layout

Rendered Result

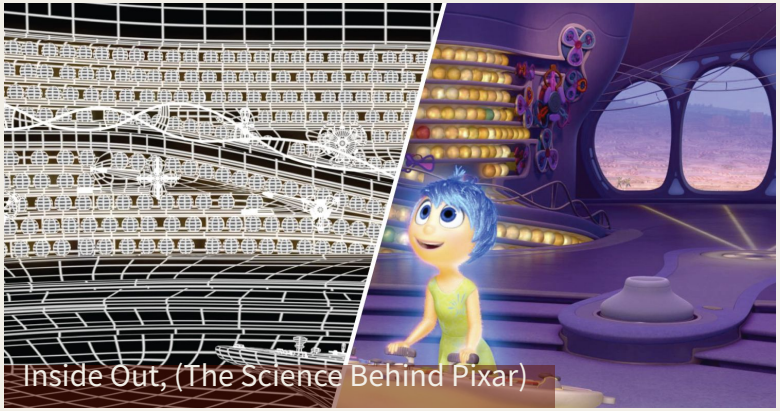


Luca, (The Science Behind Pixar)

The Incredibles, (The Science Behind Pixar)


The Good Dinosaur

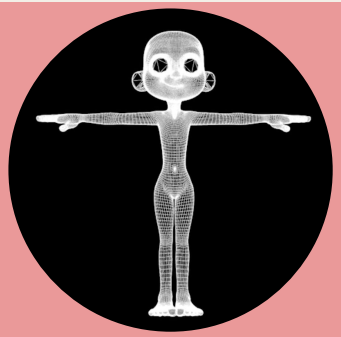

Brave, (The Science Behind Pixar)


Inside Out, (The Science Behind Pixar)


Moana

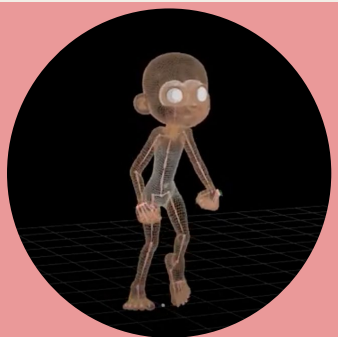
Luca, (The Science Behind Pixar)

Frozen

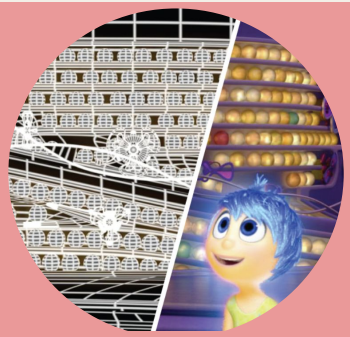


Models

Textures



Rigging



Sets

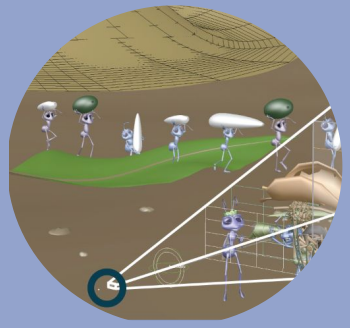
Lights

Placing objects in the scene

Moving objects over frames

Animation

Simulation



Layout

Rendered Result

Questions?

What components make up this scene?

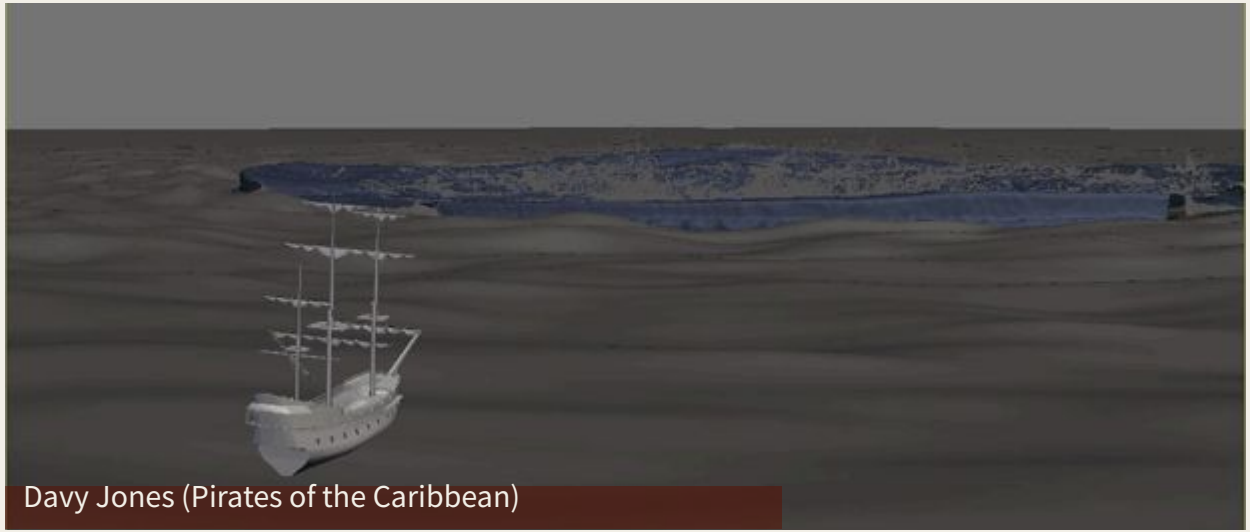
Visual Effects (VFX)

- VFX: photorealistic simulation and rendering

Davy Jones Ship (Pirates of the Caribbean)

Visual Effects (VFX)

- VFX: photorealistic simulation and rendering



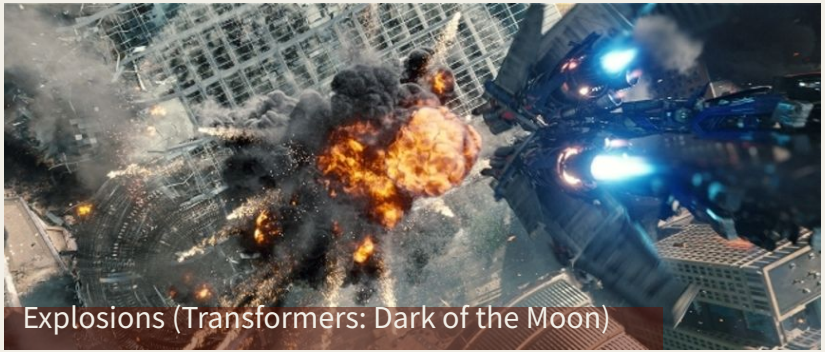
Davy Jones (Pirates of the Caribbean)

What can I do with graphics?

- VFX: photorealistic simulation and rendering


Water (The Day After Tomorrow)


Fire (Harry Potter and The Goblet of Fire)

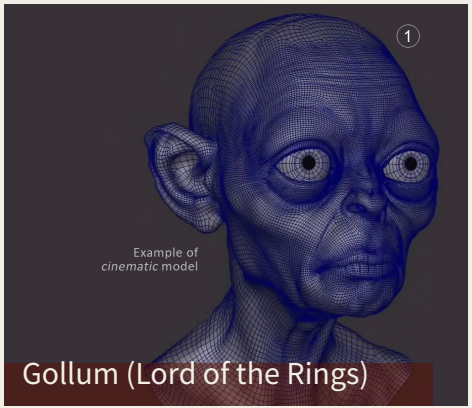

Explosions (Transformers: Dark of the Moon)


Cloth (Harry Potter and The Chamber of Secrets)

What can I do with graphics?

- VFX: creature modeling, motion capture and animation


Facial Capture in Avatar



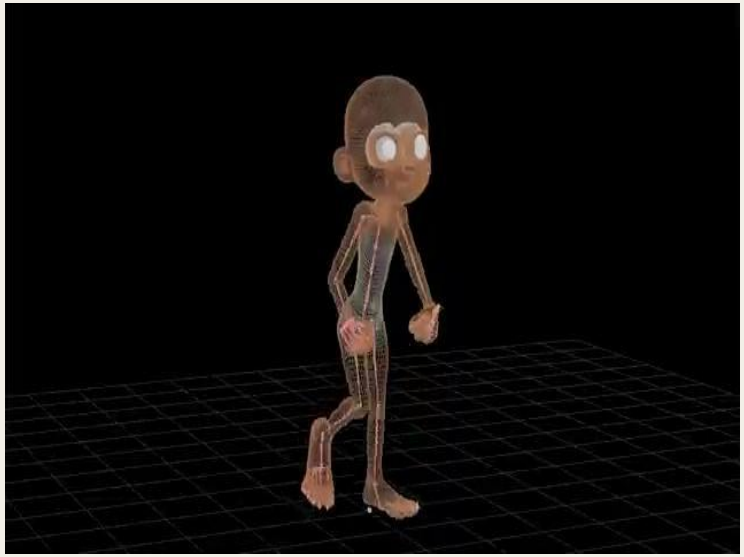
Gollum (Lord of the Rings)


Dinosaurs (Jurassic Park, 1993)


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

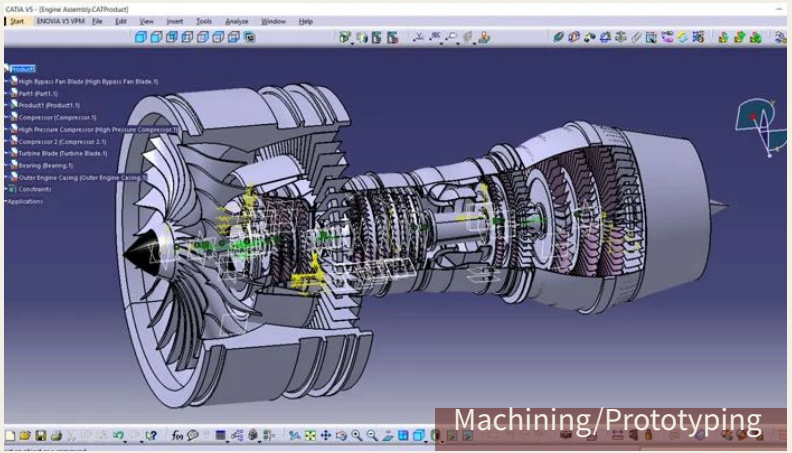
Metaverse

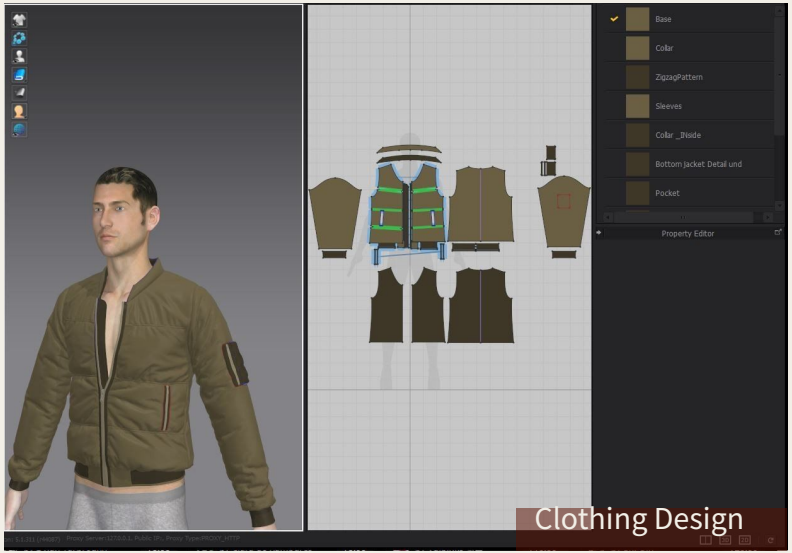
What can I do with graphics?

- Games and ARVR

What can I do with graphics?

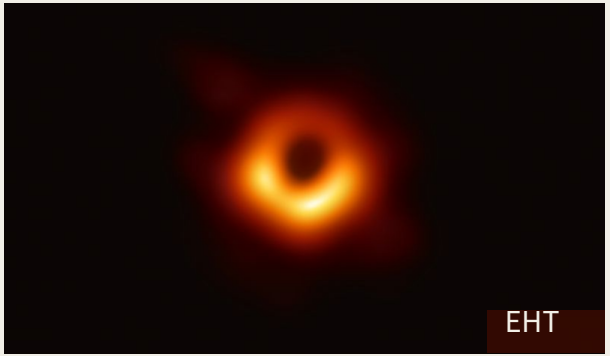
- Not just entertainment,
- anything that has a GUI/visual component, really

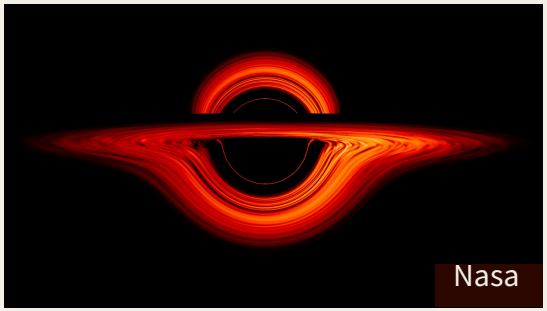


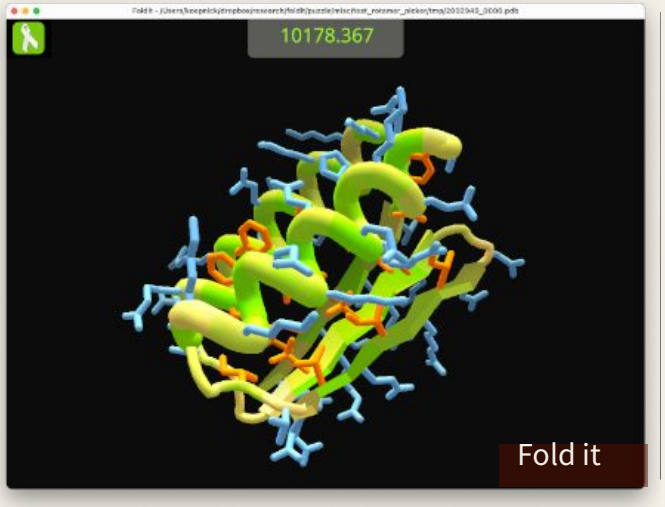


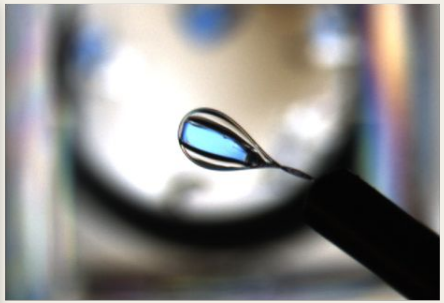
What can I do with graphics?

- Scientific Visualization
  (outreach and funding!)









What can I do with graphics?

- Synthetic data generation for AI/ML

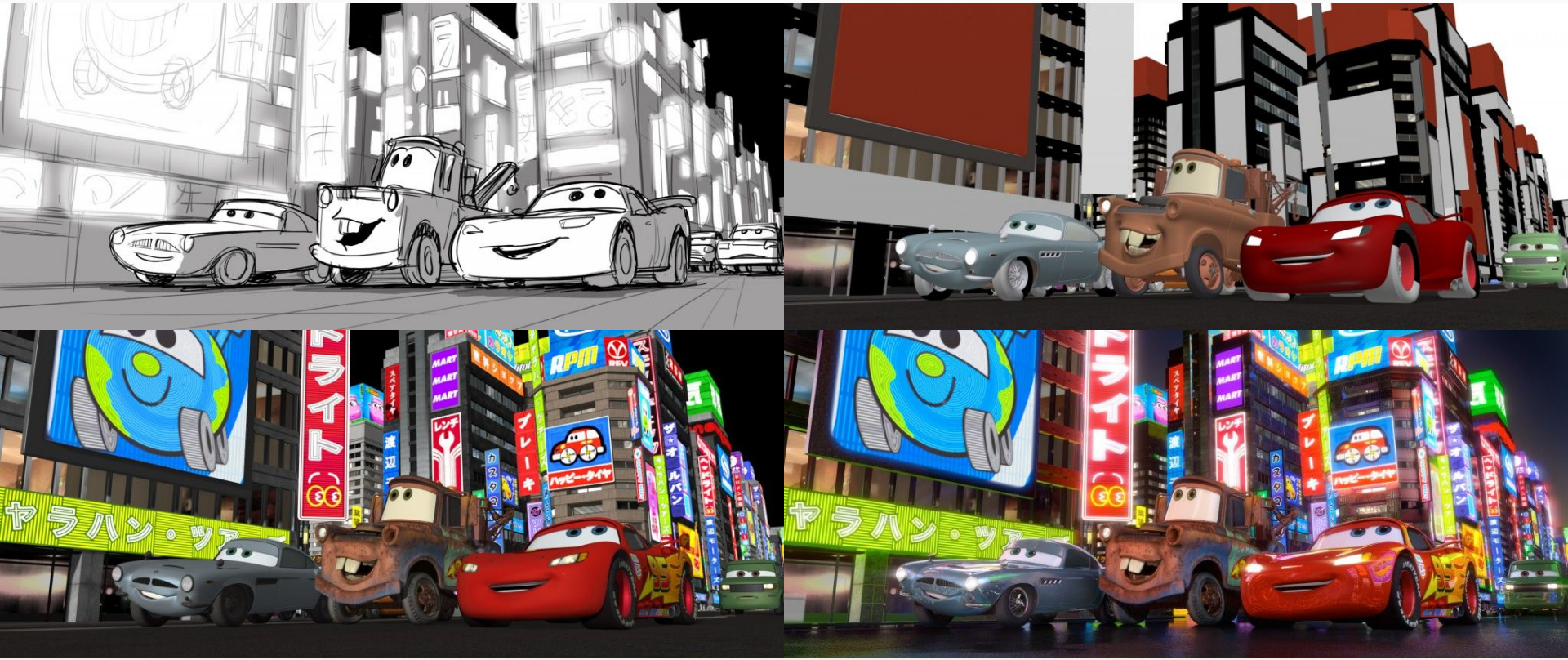
What is Computer Graphics?

Study of computer-generated imagery

- Movies
- Games
- 2D & 3D Design
- Scientific Visualization
- Synthetic data for AI

Questions?

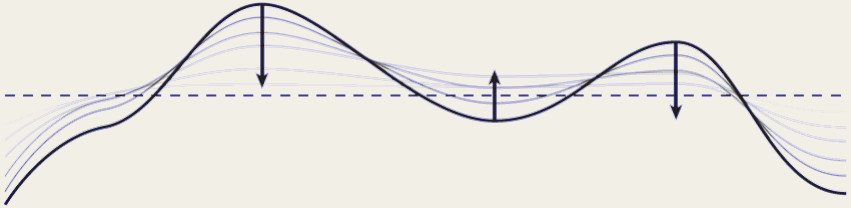
What should I get out of this class?

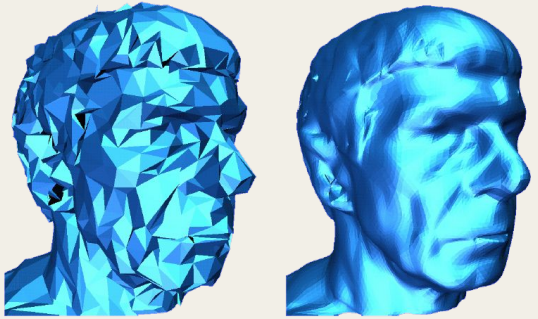


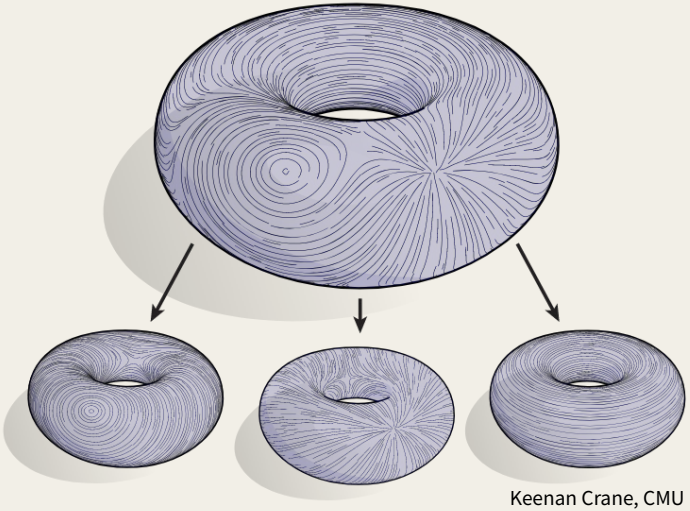
Regardless of your major/focus, CG has something for everyone!

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*





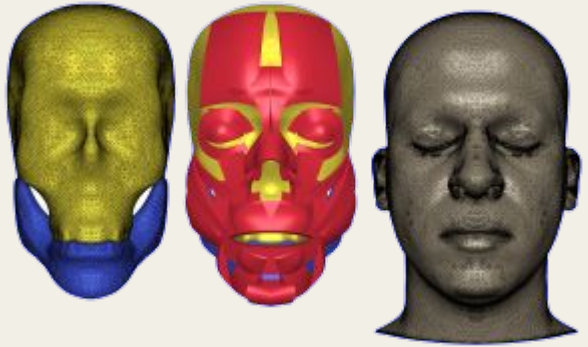


Keenan Crane, CMU

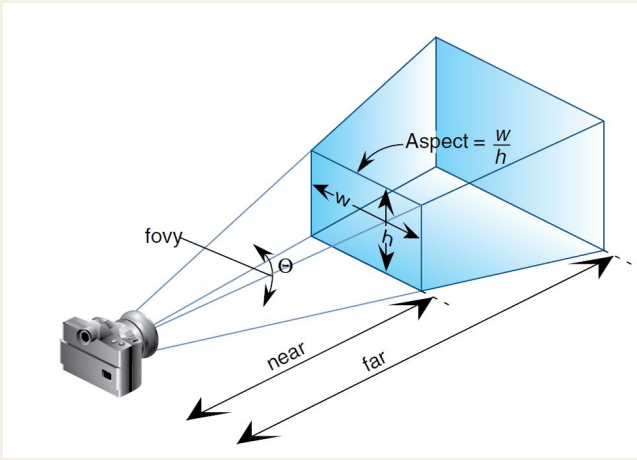
Alan Barr, Caltech

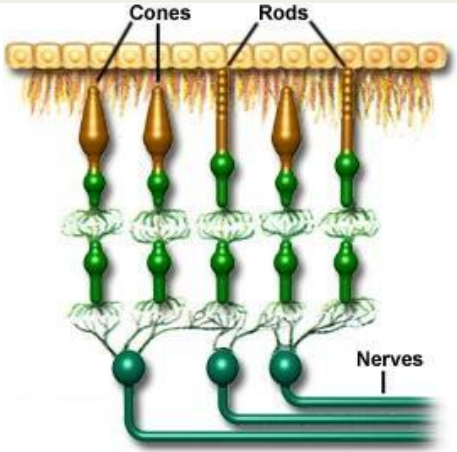
Natural Sciences in Graphics

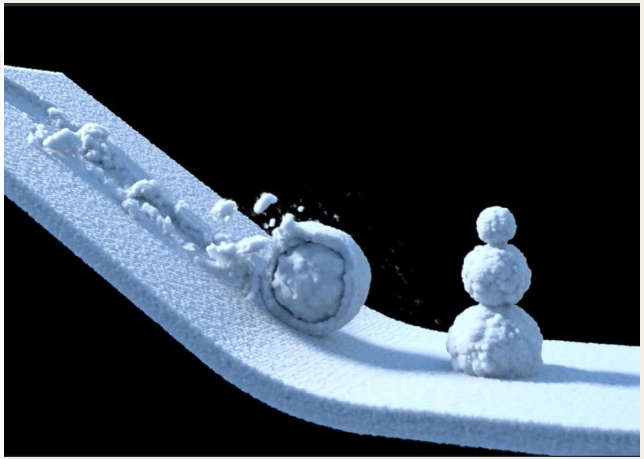
- **Physics:** simulations; *light, optics*
- **Biology:** motion capture; *perceptual color*
- **Chemistry:** modeling; *object materials*
- Basically simulating + modeling the world!



Matthew Cong, Stanford/NVIDIA



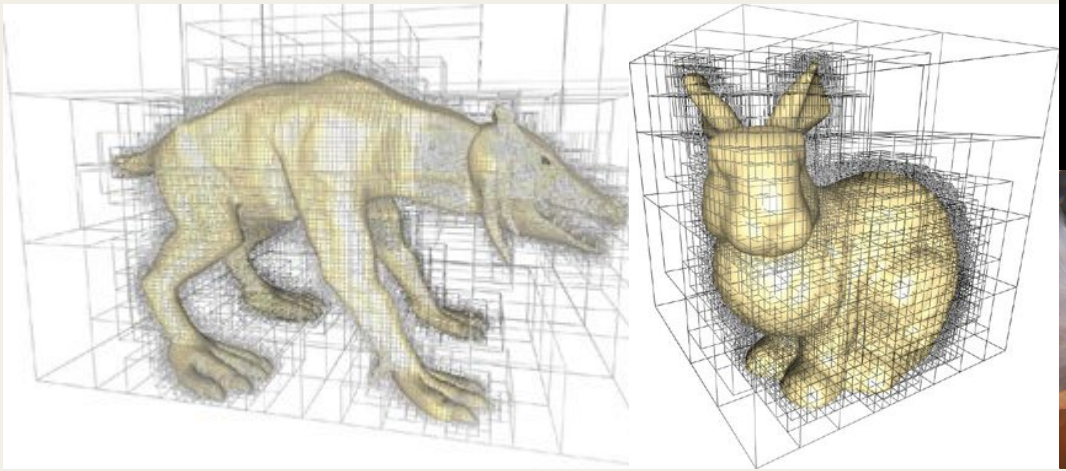




Disney

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

Kate Eselius and Jamie Ullman, Fall 2022

Yan (Mia) Miao, Summer 2022

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

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)

	Tuesday Lecture	Thursday Lecture	Homework due (Thursday)
Week 1	Introduction	Geometry & Transformations	*Installation & Setup* *
Week 2	Rasterization & Shading	Color, Images & Cameras	Geometry & Transformations
Week 3	Light & Optics	Raytracing I	Shading & Cameras
Week 4	Raytracing II	Sampling & Texturing	Raytracing
Week 5	Final Project Expectations	Simulation & Animation I	Lighting & Texturing
Week 6	Simulation & Animation II	Guess Lecture	Simulation & Advanced Rendering
Week 7	Advanced Topics	Final Project Workshop	
Week 8	Art of Images	Next Steps in Graphics	Project Submission

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?**
    Mostly an arbitrary choice that students have found easy to learn in the past. If you can pick up Blender, then you can likely pick up any of the other softwares.

In spite of its limitations, people have still managed to make entire movies within Blender!
People 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 will be posted on website when finalized

- 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 Thursday afternoon of the next week 2-5 PM

SUN	MON	TUE	WED	THU	FRI	SAT
				release		
				live grading		

Assignments (50%)

- Due via live grading on Thursdays
- 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)

- 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 for past project writeups

Kate Eselius and Jamie Ullman, Fall 2022

Yan (Mia) Miao, Summer 2022

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%)

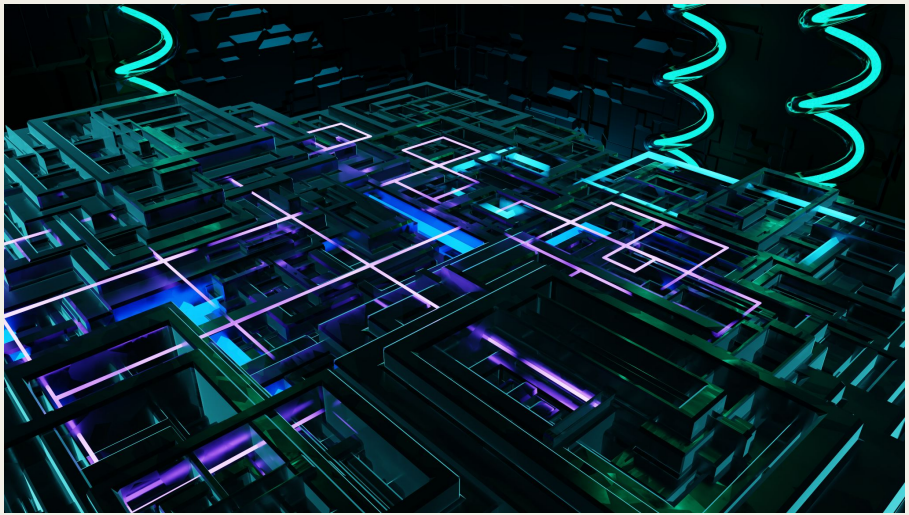
- Can work with 1 partner
- See cs148.stanford.edu/showcase for past project writeups

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

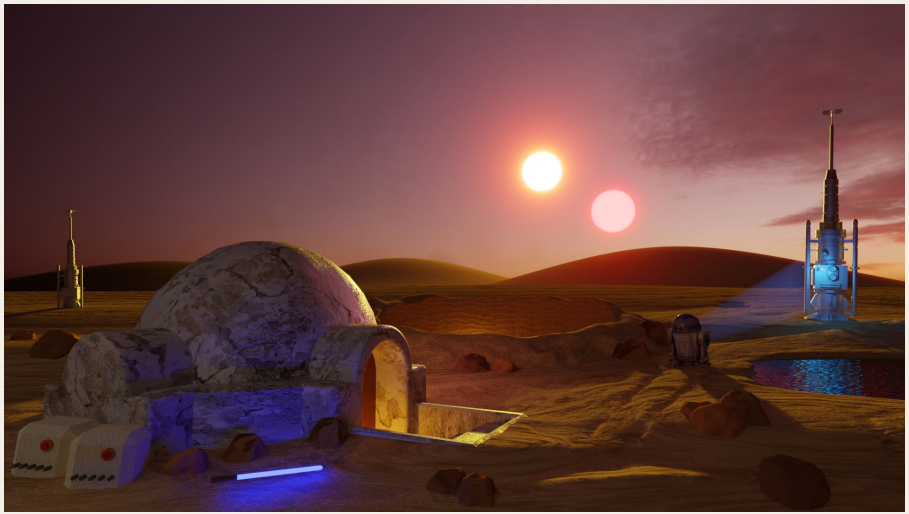


Anthony Xie, Fall 2021

Yifan Wang, Fall 2020

Final Project (40%)

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



Alberto Mancarella & Max Mayberg, Fall 2023

Rachel Han and Yunong Liu, Fall 2024

Questions?