

CS4202 - Lecture 1

Introduction to Computer Graphics and Imaging

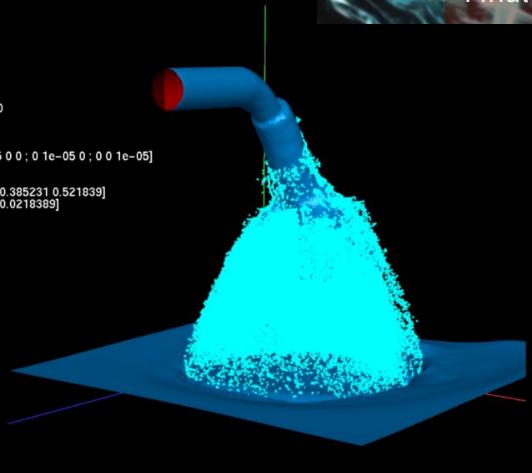
Kevin Li

Inspired by video games as a kid:

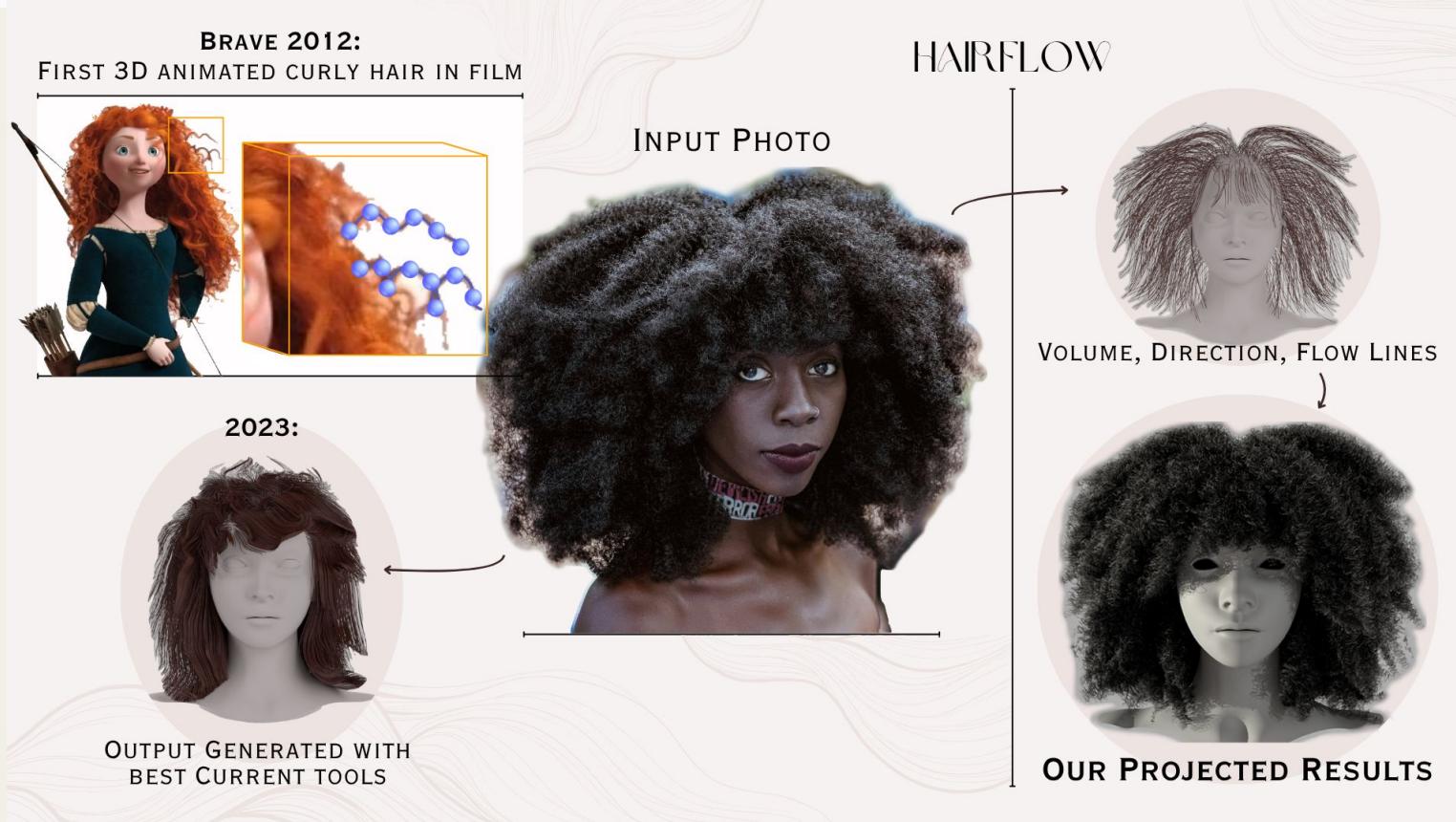
Now work on fluid simulation and modeling:



```
0fps  
frame 14: (0.11667)  
Rigid body 6  
Name =sphere  
  
Rigid Geometry 6  
Name =sphere  
X = [0.0 0.0 0.5]  
Y = [0.0 0]  
rotation = (1 [0 0 0])  
angular_velocity = [0 0 0]  
rigid_geometry = 0x416ed60  
structure_ids = [11 12 0]  
rigid_mass = 0.001  
angular_momentum = [0 0 0]  
rigid_inertia_tensor = [1e-05 0 0 , 0 1e-05 ; 0 0 1e-05]  
kinematic = 1  
Vertex 14497  
WORLD Position [0.595503 0.385231 0.521839]  
X = [0.0955027 -0.0147695 0.0218389]  
Pointwise velocity = [0 0 0]
```



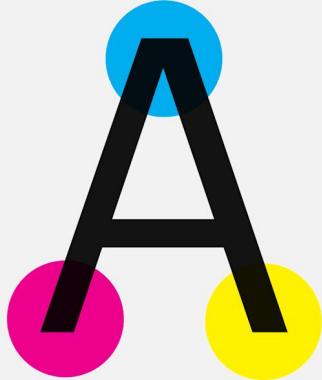
Sarah Jobalia



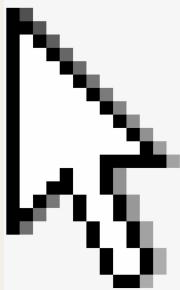
Sarah Jobalia



What is Computer Graphics?



What is Computer Graphics?



CS148: Introduction to Computer Graphics and Imaging

5



VFX (*The Last of Us*, 2025)

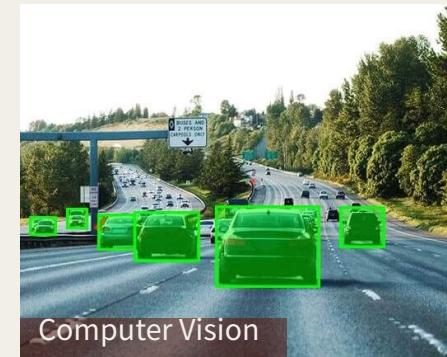
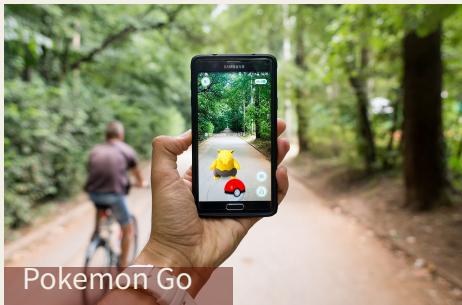
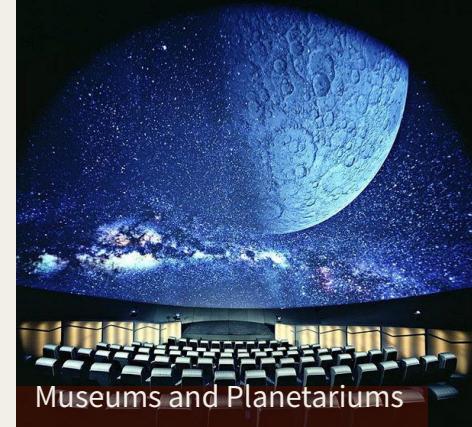


Animation (*The Wild Robot*, 2024)



Gaming (*Clair Obscur: Expedition 33*, 2025)

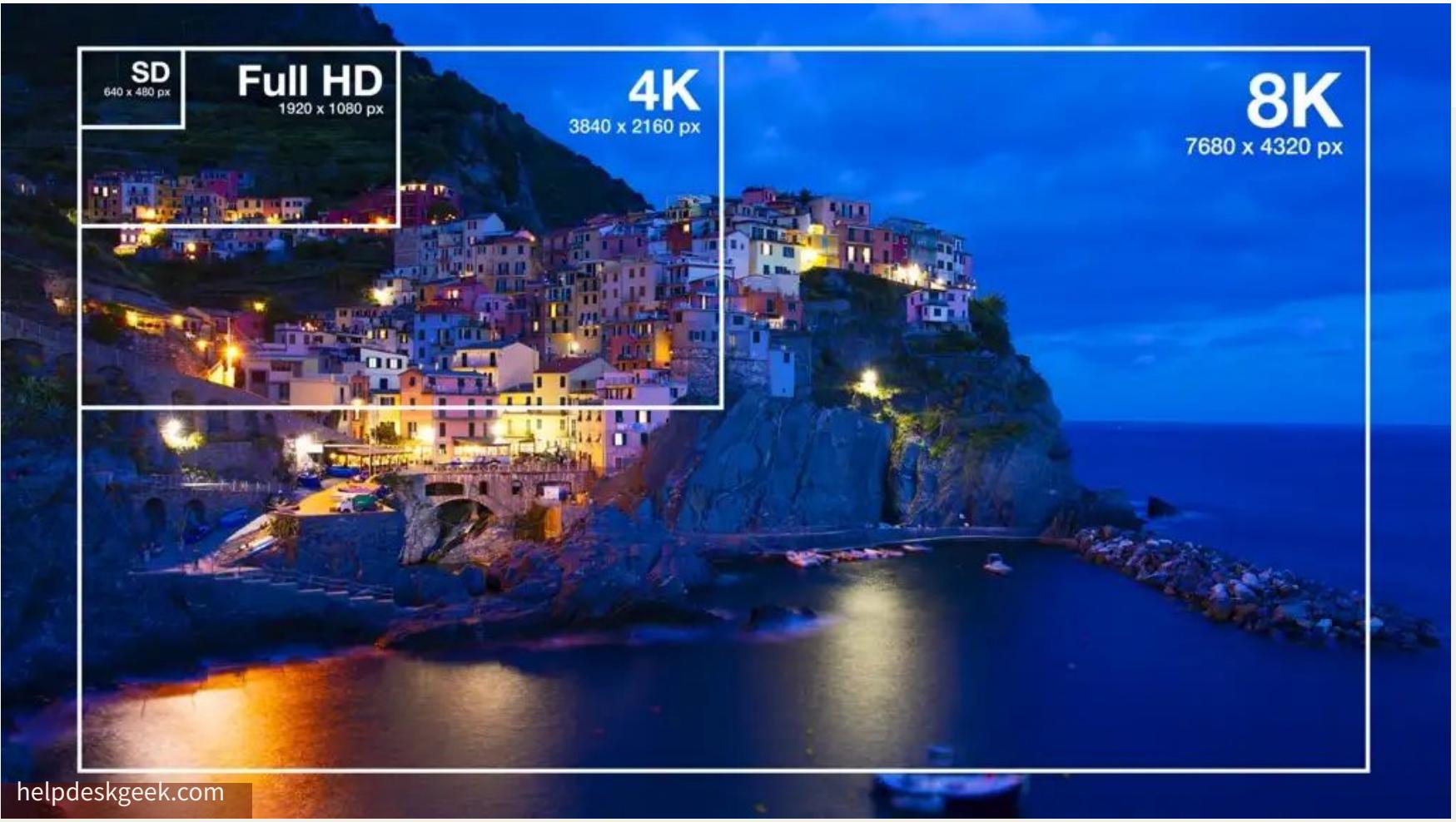
What is Computer Graphics?



What is Computer Graphics?

Study of computer-generated imagery

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



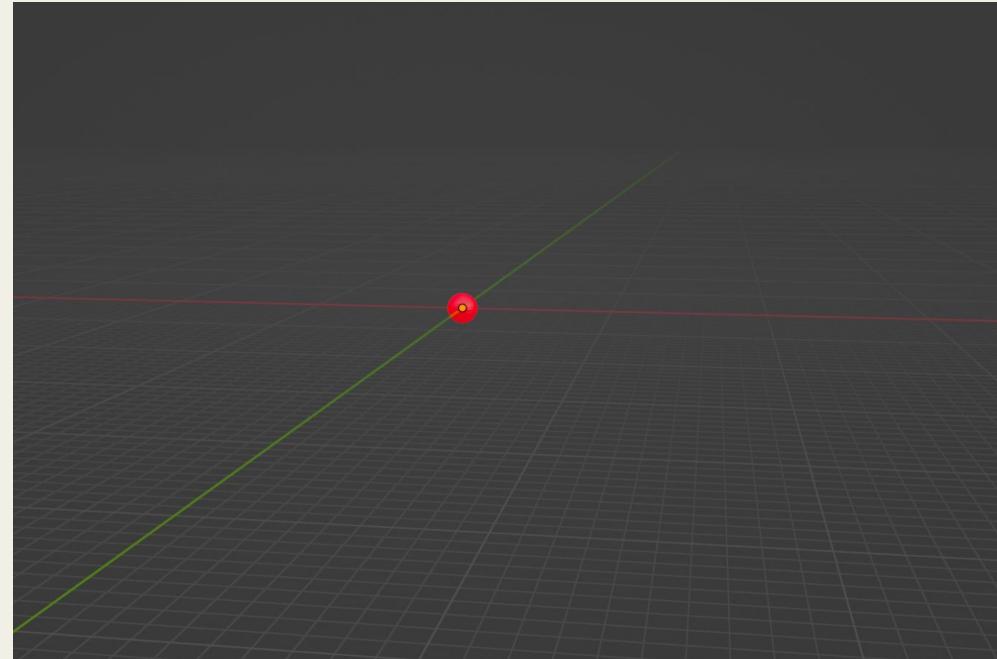
helpdeskgeek.com

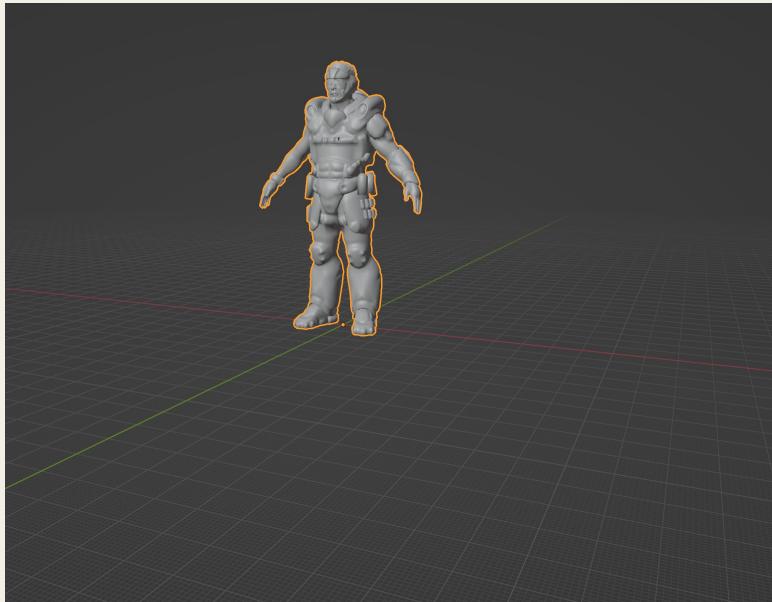
2D TEXT



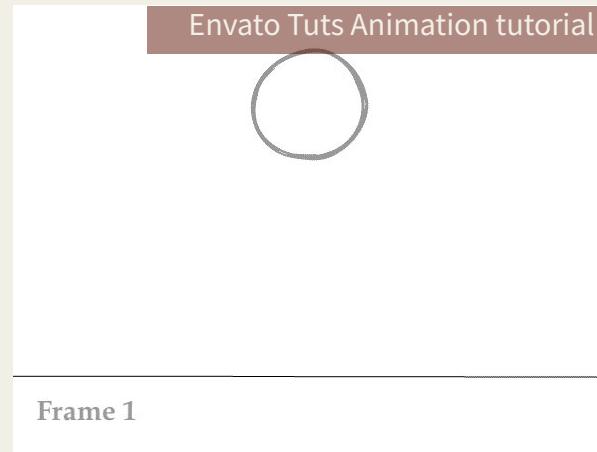
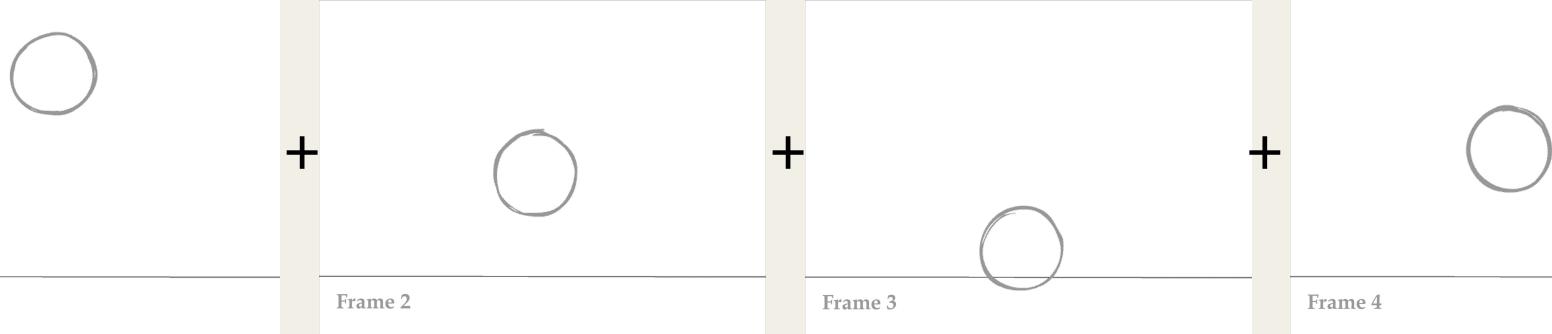
VFX (Avengers Infinity War, 2018)

Virtual Space vs. Screen Space





Virtual Time



Virtual Time



Σ

=



The Incredibles, (The Science Behind Pixar)



Storyboard



Modeling



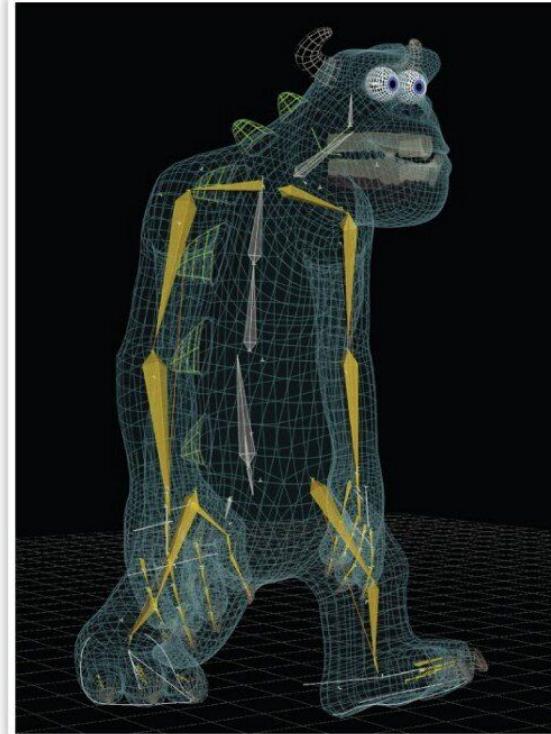
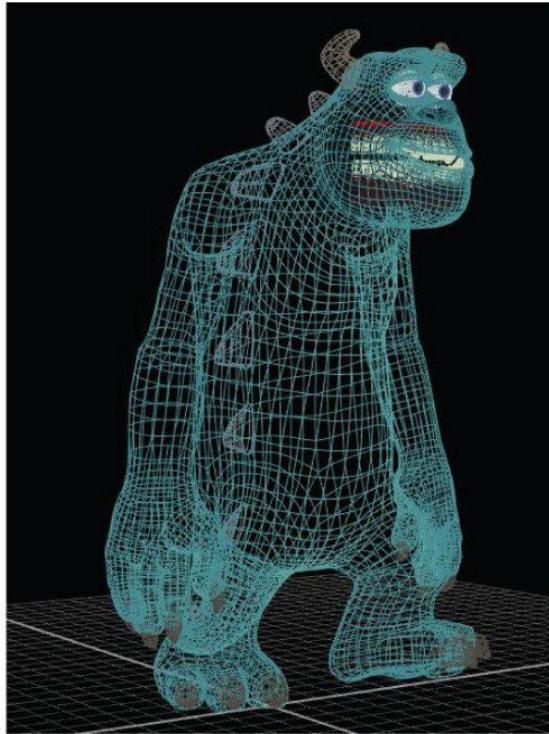
Texturing



Rigging

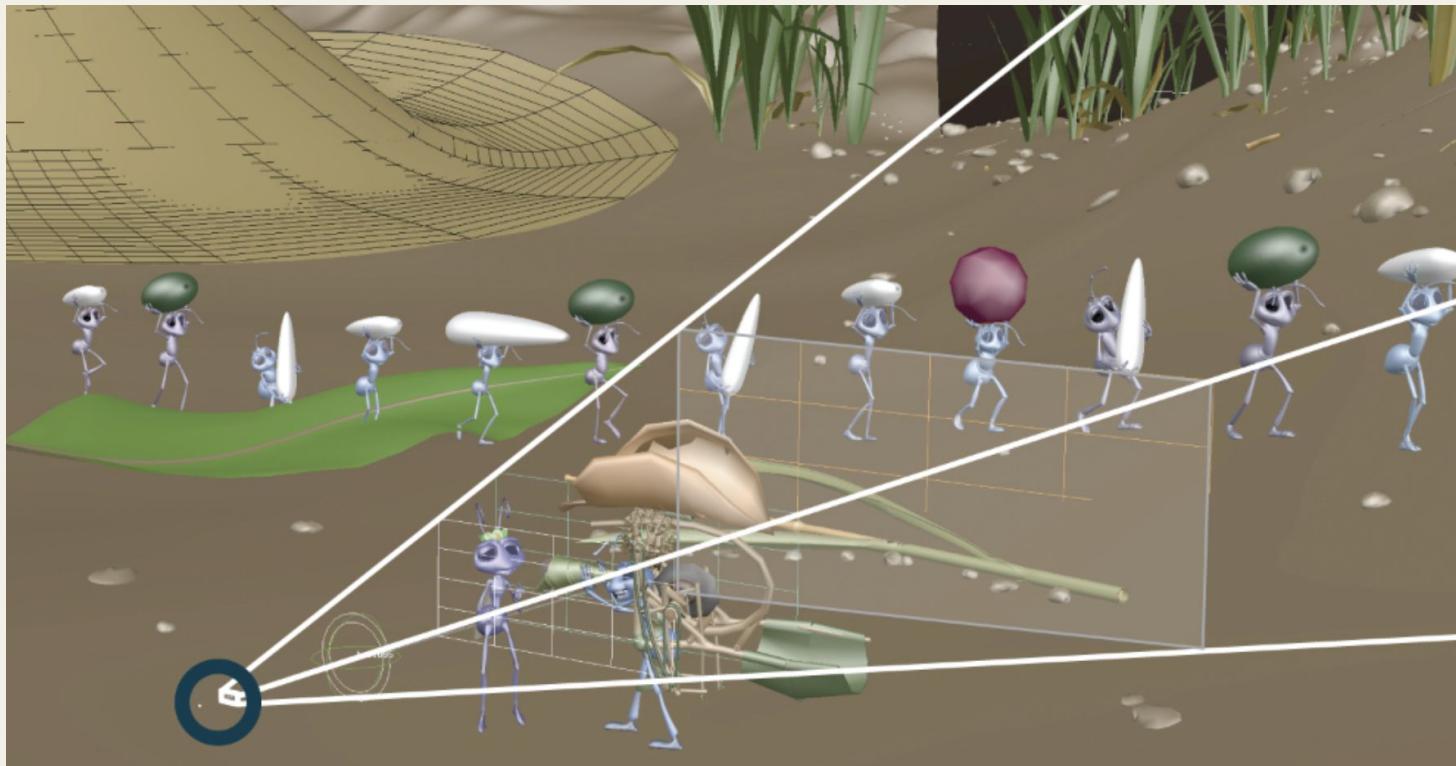


Rigging

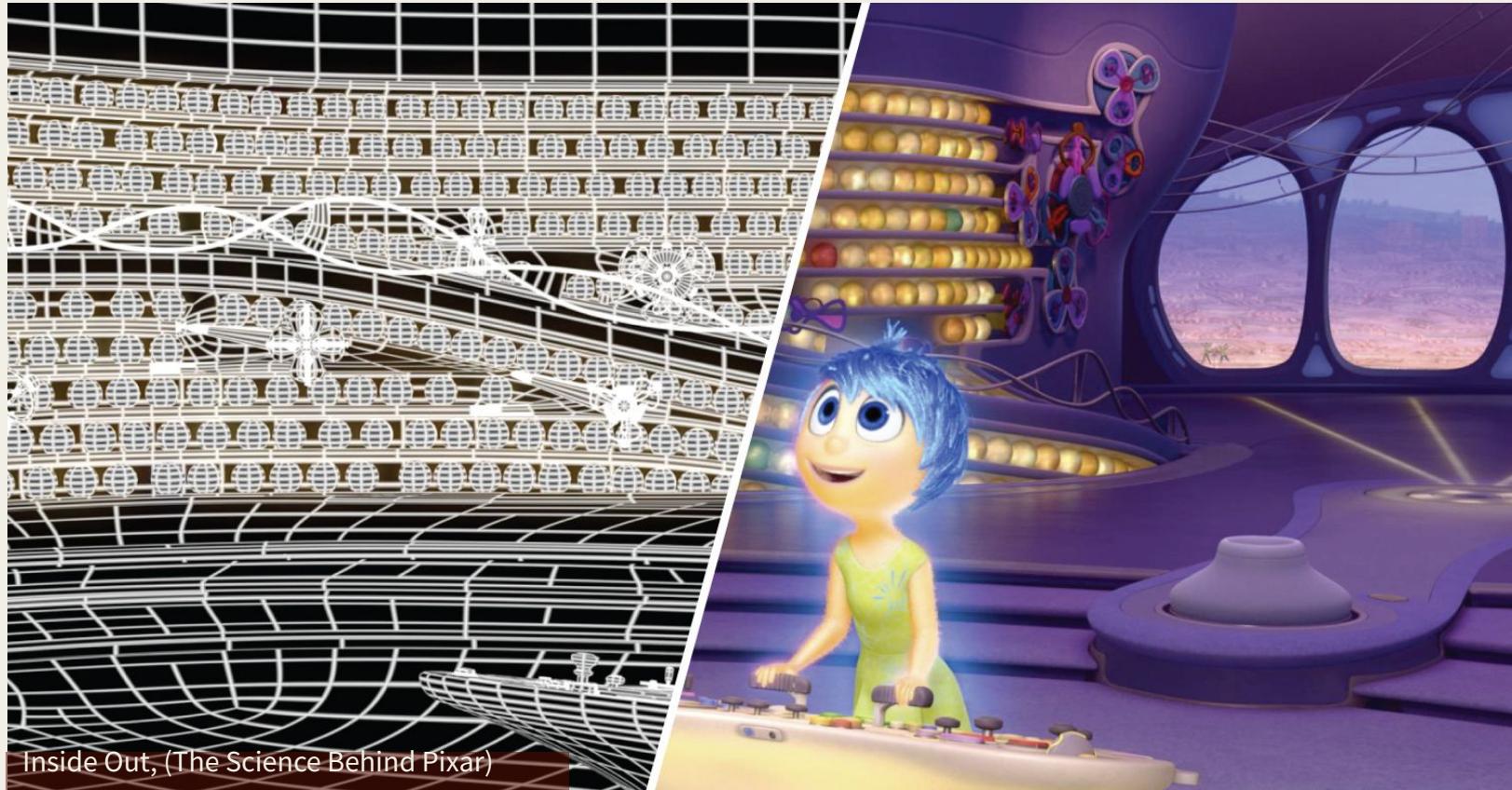


Monsters Inc. (Amt-lab, CMU)

Layout



Sets



Sets and Layout



Animation



The Incredibles, (The Science Behind Pixar)

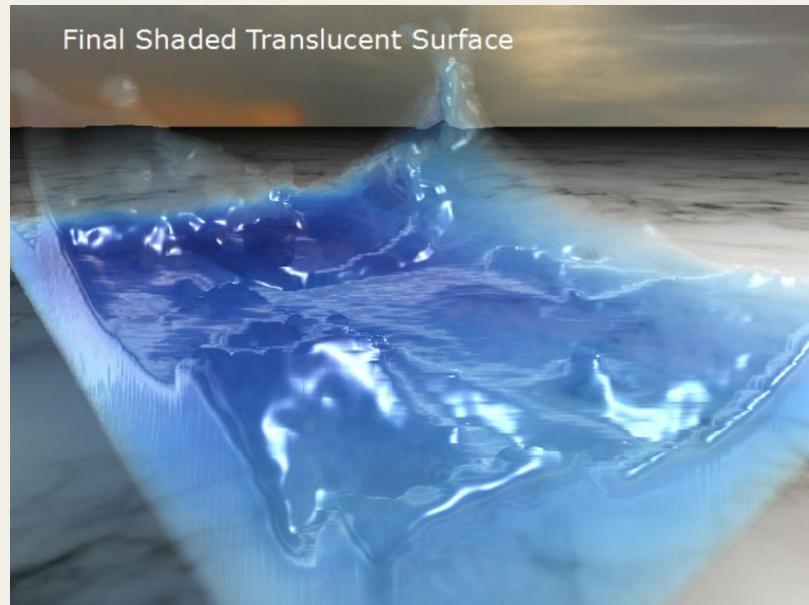
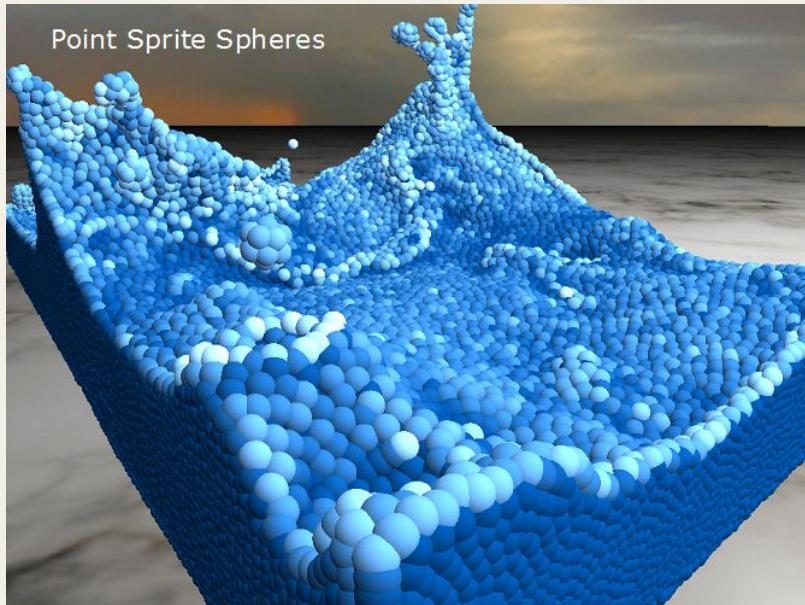


Toy Story 3

Animation



Simulation



Simulation



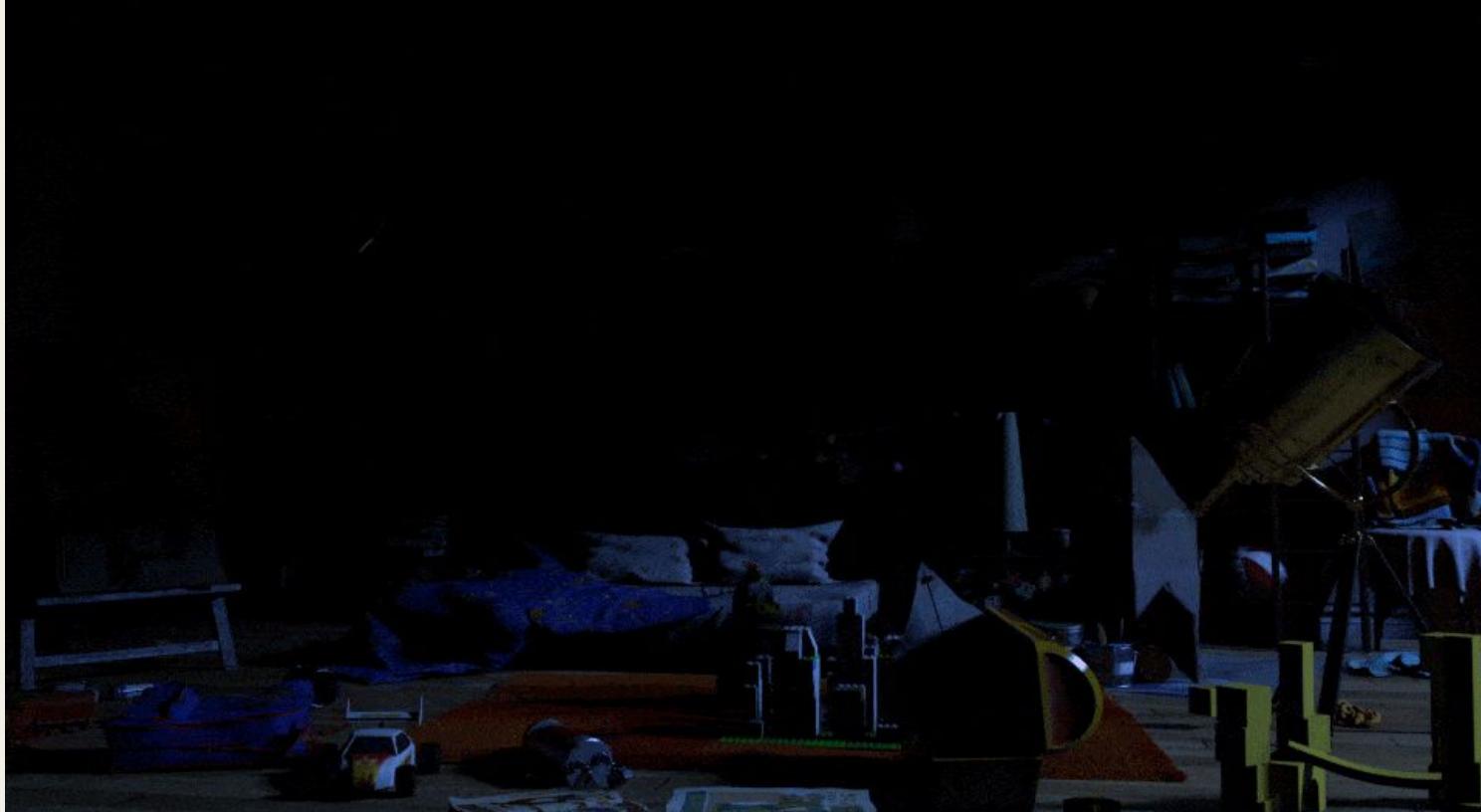
Simulation



Brave, (The Science Behind Pixar)

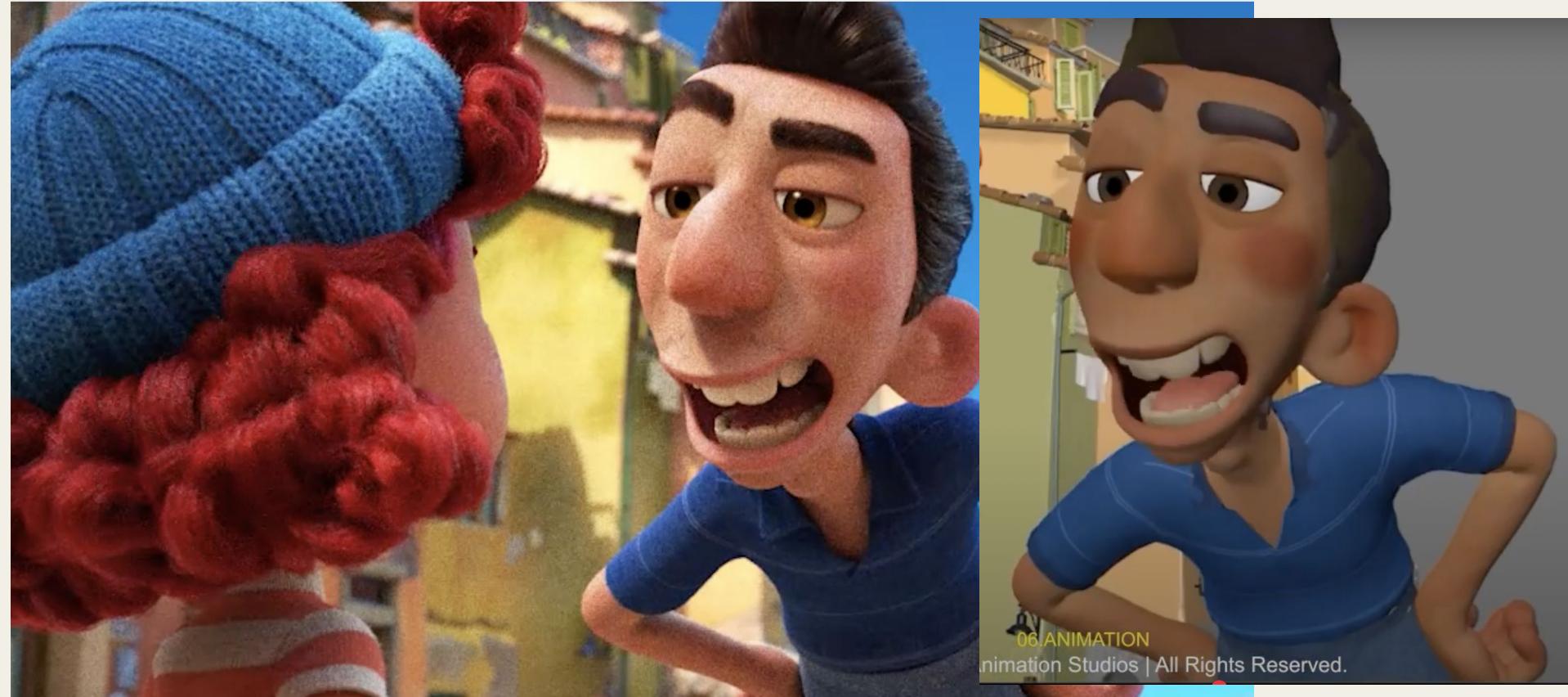


Lighting



Giorgio Lorenzetti, (The Rookies)

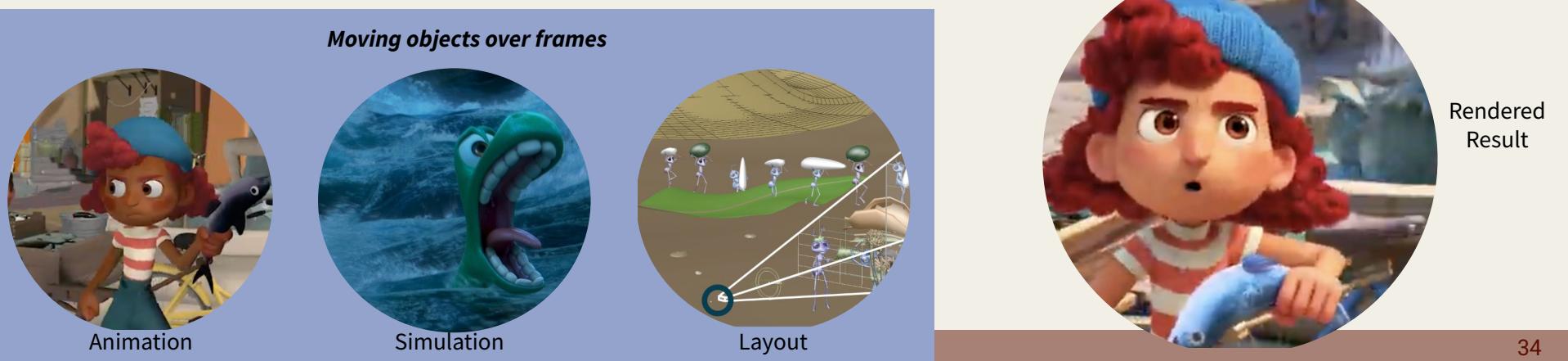
Lighting

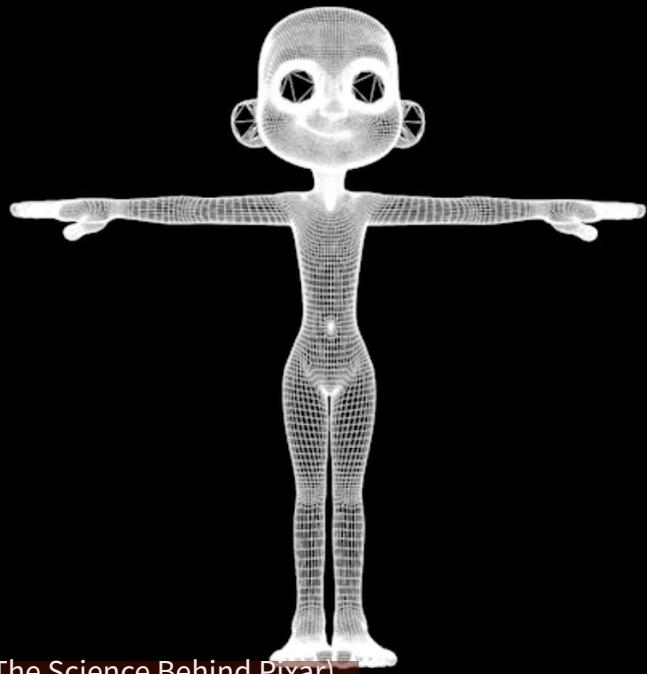


06.ANIMATION

animation Studios | All Rights Reserved.





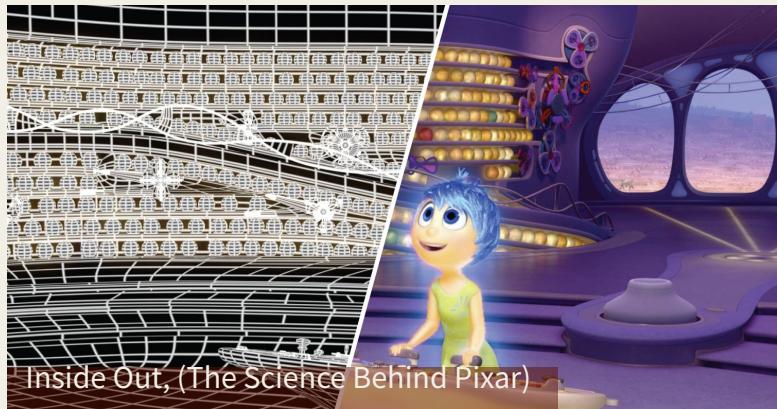


Luca, (The Science Behind Pixar)



The Incredibles, (The Science Behind Pixar)





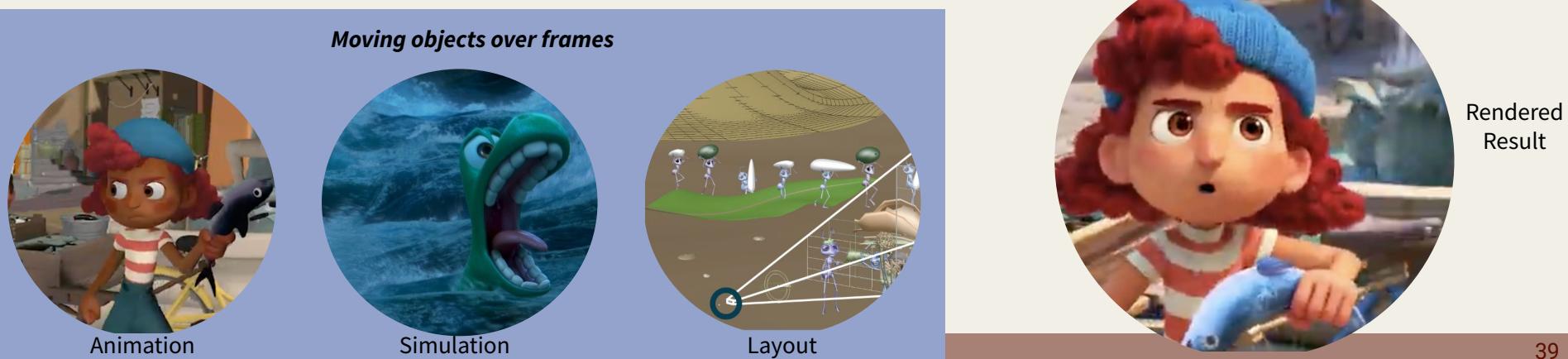


Luca, (The Science Behind Pixar)





Placing objects in the scene



Questions?

What components make up this scene?



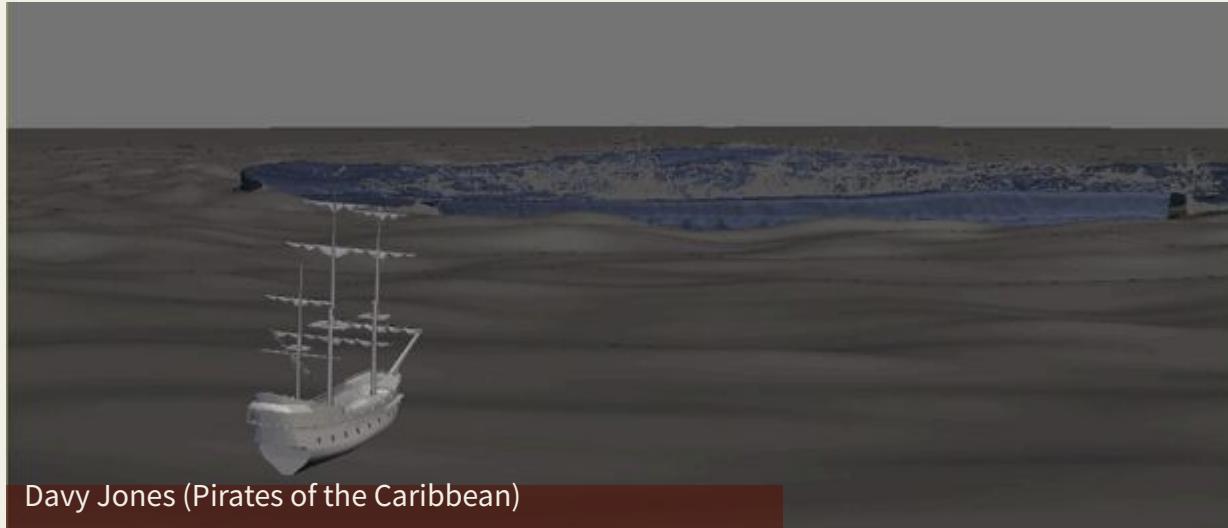
Visual Effects (VFX)

- VFX: photorealistic simulation and rendering



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



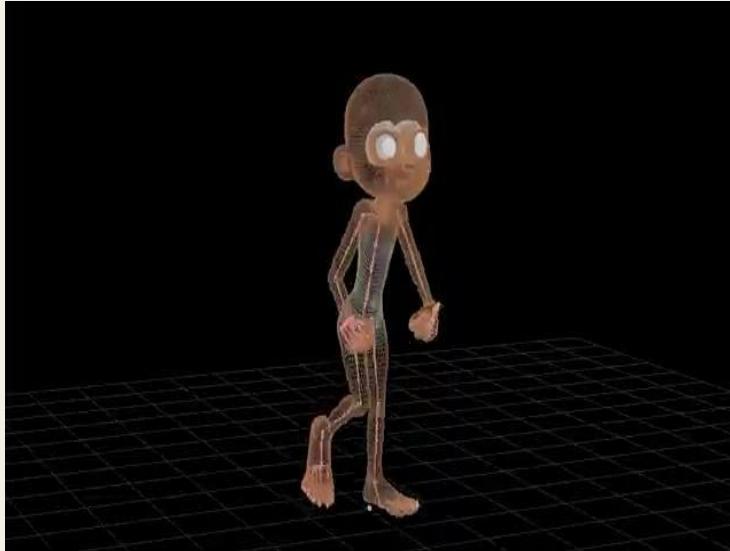
What can I do with graphics?

- VFX: creature modeling, motion capture and animation



What can I do with graphics?

- VFX: creature modeling, motion capture and animation



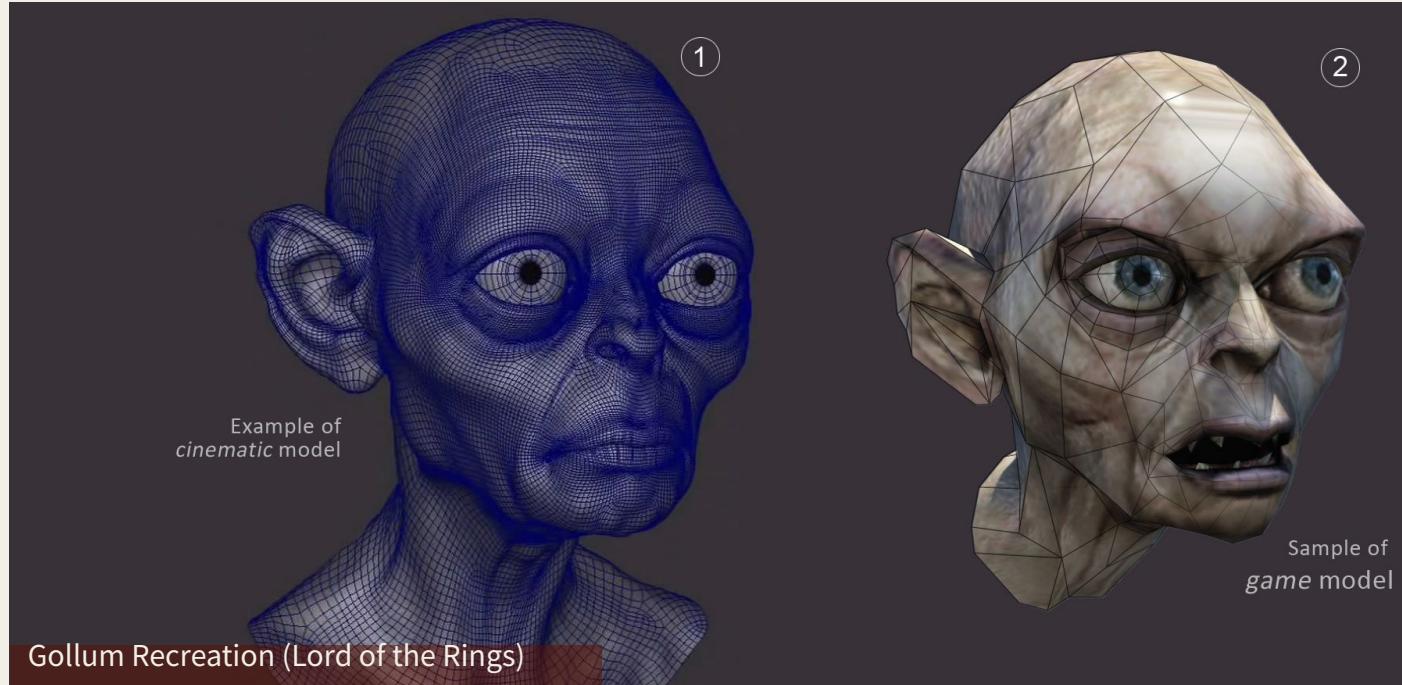
What can I do with graphics?

- Video Games



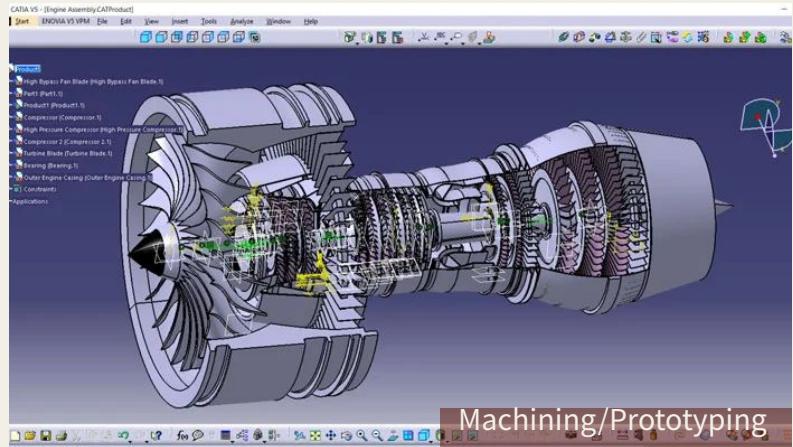
What can I do with graphics?

- Games and AR/VR



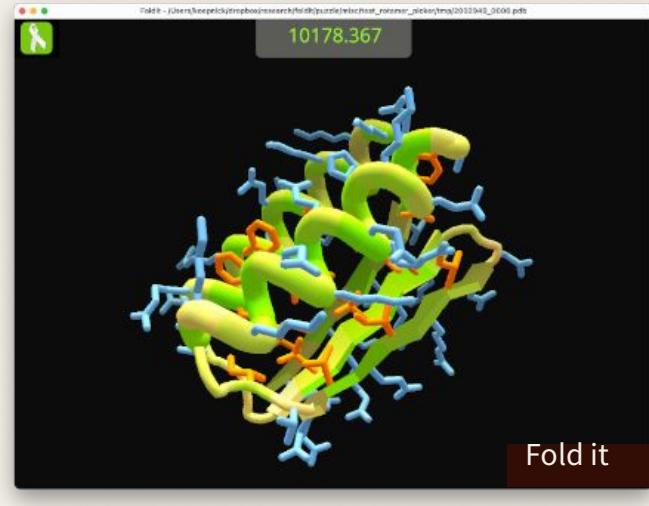
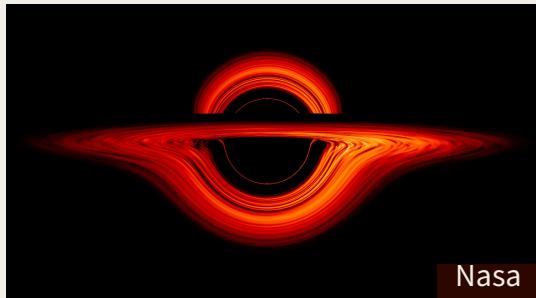
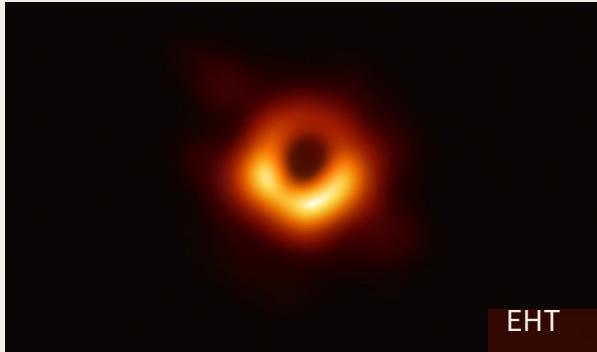
What can I do with graphics?

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



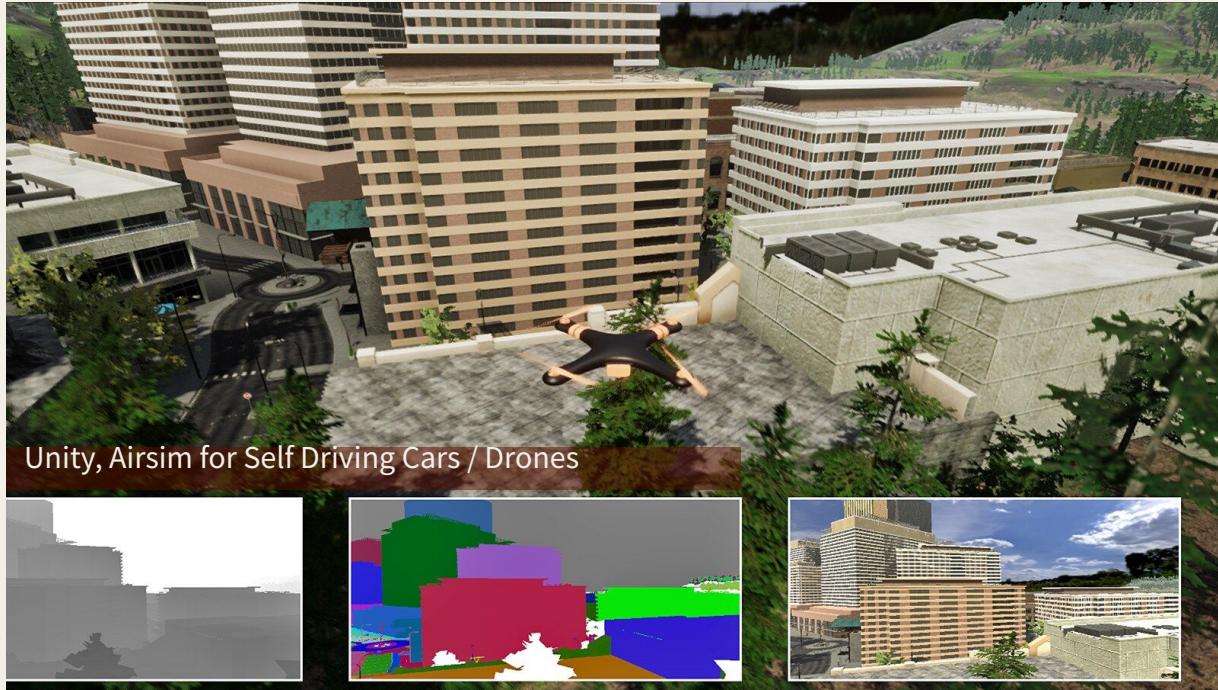
What can I do with graphics?

- 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
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Questions?

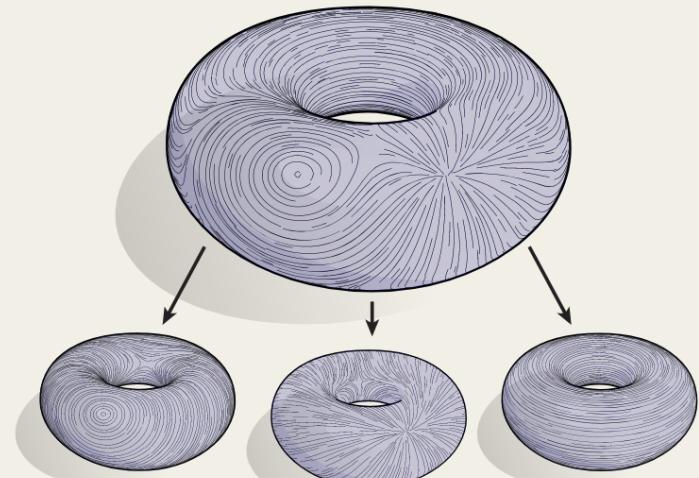
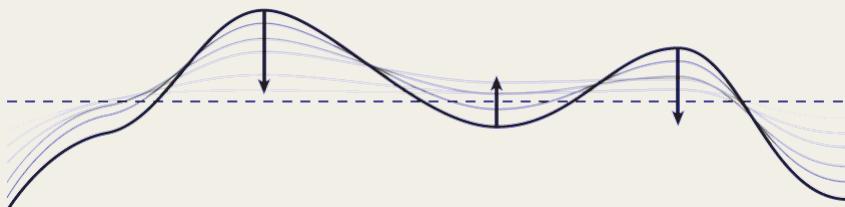
What should I get out of this class?



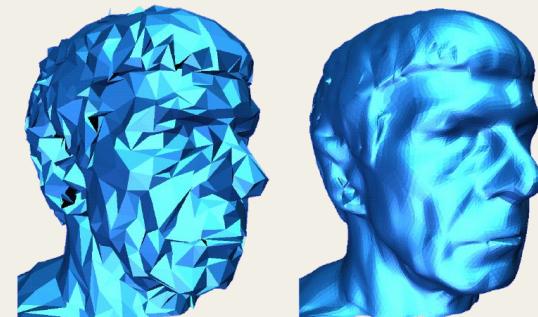
Regardless of your major/focus, CG has something for everyone!

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



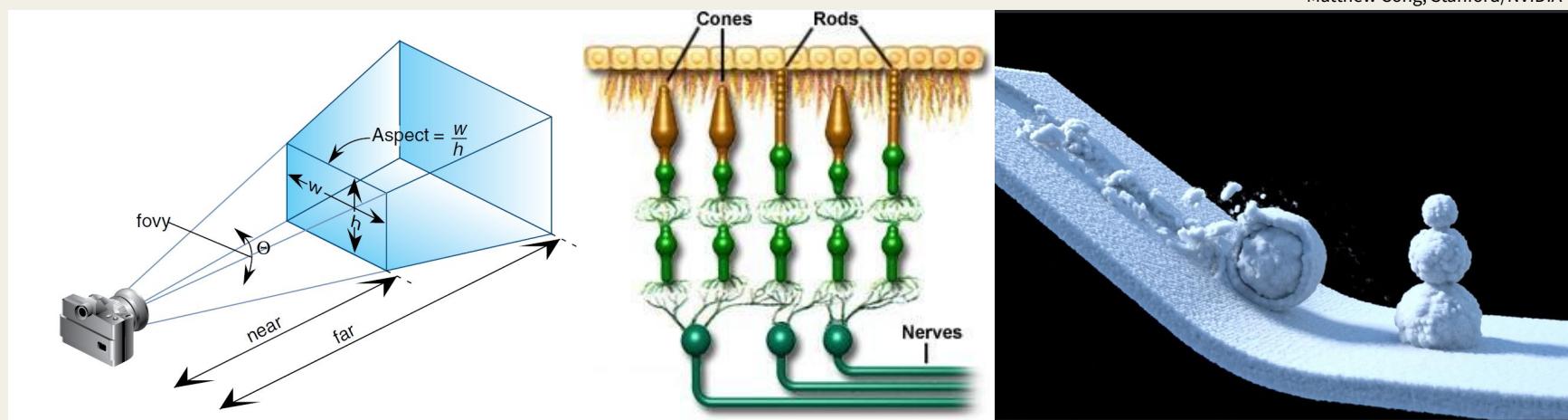
Alan Barr, Caltech

Natural Sciences in Graphics

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



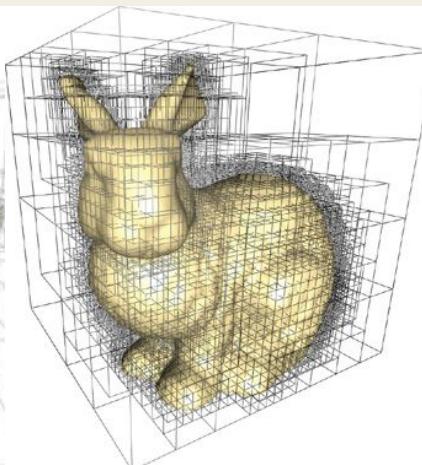
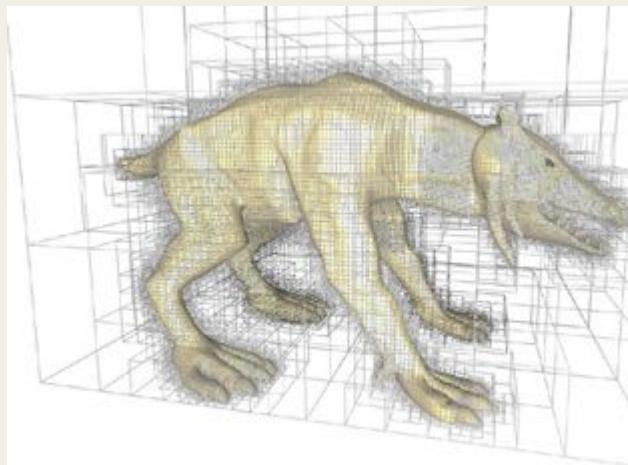
Matthew Cong, Stanford/NVIDIA



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	<i>Installation & Setup</i> *
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.



versus



versus



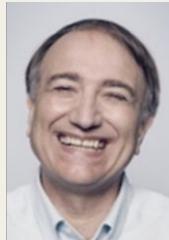
Technical Component

- 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

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Luna Yang and Xuelin Yang, Fall 2021



Sreya Halder, Fall 2020

Final Project (40%)

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Po-Ya Wu, Fall 2021



Lingjie Kong and Yanjia Li, Fall 2020

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Anthony Xie, Fall 2021



Yifan Wang, Fall 2020

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- See cs148.stanford.edu/showcase for past project writeups



Alberto Mancarella & Max Mayberg, Fall 2023



Rachel Han and Yunong Liu, Fall 2024

Questions?