Lecture 20:

Course Summary +
Graphics at Stanford Today

Interactive Computer Graphics
Stanford CS248, Winter 2022
As accomplished CS248 students you’ve now learned the basics of drawing shapes, representing surfaces/light/materials/motion, and manipulating images, etc...

(and have been introduced to core graphics ideas like sampling, anti-aliasing, acceleration data structures, etc.)

What’s Next?
More graphics classes at Stanford

SPRING

CS348B: “Image Synthesis Techniques”, theory and practice of realistic, physically-based rendering (Fatahalian, James, Pharr) - TTh 3:15pm
CS348K: “Visual Computing Systems”, creating efficient systems for computational photography, 3D graphics, and AI (Fatahalian) - TTh 1:30pm
CS348E: “Character Animation: Modeling, Simulation, and Control of Human Motion” (Liu) - MW 3:15pm
EE267: “Virtual Reality”, focuses on display and tracking hardware for VR (Wetzstein) - MW 9:45am

FALL

CS 448B: “Data Visualization” (Agrawala)

WINTER

CS348C: “Animation and Simulation”, deep dive into animation and simulation techniques (James)
EE367/CS448i: “Computational Imaging and Display”, advanced course on display design (Wetzstein)
CS205L: “Continuous Mathematical Methods with an Emphasis on Machine Learning” (Fedkiw)
CS348B (Fatahalian, James, Pharr)

Rendering realistic images by modeling the physical process of light interacting with materials

With ray tracing as the mechanism to simulate these phenomenon
Graphics Research at Stanford Today
Maneesh Agrawala

Visual Rhythm and Beat [Davis et al.]
Many current projects on video editing and manipulation

<table>
<thead>
<tr>
<th>Scene</th>
<th>Edit</th>
<th>Clips</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STACY</strong></td>
<td>I am not buying that kid a Christmas gift.</td>
<td></td>
</tr>
<tr>
<td><strong>RYAN</strong></td>
<td>Stacy.</td>
<td></td>
</tr>
<tr>
<td><strong>STACY</strong></td>
<td>He is a bad kid.</td>
<td></td>
</tr>
<tr>
<td><strong>RYAN</strong></td>
<td>He’s family.</td>
<td></td>
</tr>
<tr>
<td><strong>STACY</strong></td>
<td>Are you certain that your cousin is his real father? Because I’m pretty sure that kid is the spawn of Satan.</td>
<td></td>
</tr>
<tr>
<td><strong>RYAN</strong></td>
<td>Come on now, that’s a bit dramatic.</td>
<td></td>
</tr>
<tr>
<td><strong>STACY</strong></td>
<td>Or really?</td>
<td></td>
</tr>
<tr>
<td><strong>RYAN</strong></td>
<td>Yes. You’re going to make me regret saying that, aren’t you?</td>
<td></td>
</tr>
</tbody>
</table>
Maneesh Agrawala

A. Original body layers
B. Original accessory layers
C. Deformed body layers
D. Deformed accessory layers, no rigging
E. Deformed accessory layers, our rigging
F. Original accessory layers
G. Original accessory layers
H. Original accessory layers
I. Deformed accessory layers, our rigging

Stanford CS248, Winter 2022
- Simulation techniques (often) targeted at film and game production
- Now exploring use of machine learning to augment or improve physical simulations
Segmentation Masks of Stereo Footage

Left Camera

Right Camera
Ron Fedkiw
Example: Pouring Faucet

Frequency-domain radiation [Langlois et al. 2016]

Time-domain radiation [Our approach]
Leo Guibas
Geometry processing and analysis

PointNet: Deep Learning on Point Clouds

Shape Similarity and Correspondence
Front Wheel Pivot
(BMX Bike)
Gordon Wetzstein
Computational imaging and computational displays

"Seeing around corners
"Confocal non-line-of-sight imaging based on the light cone transform"
“Hybrid Optical-Electronic Convolutional Neural Networks”

Using carefully designed optics to compute the early layers of a CNN prior to digital processing
Karen Liu

Interests in animation, simulation, and control
A completely computer generated Wimbledon point.
A completely computer generated Wimbledon point.
Example getting-started-in-the-lab project idea

- Take the technology shown on the previous slide and make an interactive “Wimbledon point creator” where folks can visit a web site, click where they want the ball to go, and then download a resulting video.
- I bet it would be a hit if you could get it done and online before Wimbledon 2022
Ray tracing large scenes using 7,500 AWS lambda cores in the cloud
Can we redesign a game engine to achieve much higher performance for ML training workloads?

[Render → DNN inference → DNN train] in 3D scanned environments at 19,200 fps per GPU!
We are now interested in ray tracing simulated environments at similar rates!
Accurate lighting simulation
Example getting-started-in-the-lab project idea

- Work with my Ph.D. student to add a feature (new light type, load new type of geometry, etc) to our Vulcan renderer that’s designed for ML use cases

- Other getting started ideas:
  - Write a CSGO bot (Counterstrike) that plays the game and generates training data for ML projects
Virtual is a new medium. Let’s figure out virtual.

Highly customizable platform support: What are system abstractions and services that should be provided by: “Unity for live virtual and hybrid events”

What are effective social protocols in these environments? (Both virtual and hybrid)

How can we create tools that help people design virtual interactions: Example: automatically analyze the design of virtual spaces to predict social awkwardness? Defy privacy expectations?
Other popular research topics in computer graphics...
Creating physically plausible models

- Via 3D printing, fabrication
- Creatures that locomotes, furniture that stands, etc.

Fabricate models that are balanced to stand

Fabricate robots that can balance and move
Computational photography

Using computation (and increasingly machine learning) to make more aesthetic photographs, simulate behavior of more complex lenses, etc.

Google Pixel 2 Portrait mode

Advanced geometry processing

Fundamental questions about alignment, similarly, symmetry, etc…
Advanced displays/rendering for VR/AR

Near eye light field display
AI for lower cost content creation and capture

Manipulating actors by performance capture

Audio input to mesh animation
The other direction: graphics helping machine learning

Grand Theft Auto Screenshots

Synthesized "photorealistic" image

Stanford CS248, Winter 2022
A fun resource
Ke-sen Huang’s famous site with all the SIGGRAPH papers!
http://kesen.realtimerendering.com/

SIGGRAPH 2020 papers on the web

ANIMATION/SIMULATION

A Level-Set Method for Magnetic Substance Simulation
Xingyi Ni (CTCS, Peking University and AICPSE, Beijing Film Academy), Bo Zhu (Gartmouth College), Bin Wang (AICPSE, Beijing Film Academy), Bazquan Chen (CTCS, Peking University and AICPSE, Beijing Film Academy)

A Massively Parallel and Scalable Multi-GPU Material Point Method
Xiong Wu (Zhejiang University and University of Pennsylvania), Yaxing Qiu (University of California, Los Angeles and University of Pennsylvania), Stuart Slattery (Oak Ridge National Laboratory), Yu Fang, Minchen Li (University of Pennsylvania), Song-Chun Zhu, Yuan Yao (University of California, Los Angeles), Min Yang (Zhejiang University), Siyuan Bian (University of Maryland), Chunfeng Jiang (University of Pennsylvania) (Equal contribution)

A Model for Soap Film Dynamics with Evolving Thickness
Saihshek Fatima, Peter Symes (UIE Austria), Purnima Nazir (Unaffiliated), Toshiya Hachisuka (The University of Tokyo), Chris Wojte (UIE Austria) (Joint first authors)

A Practical Octree Liquid Simulator with Adaptive Surface Resolution
Ryoichi Ando (National Institute of Informatics). Christopher Burty (University of Washington)

A Scalable Approach to Control Diverse Behaviors for Physically Simulated Characters
Jungroim Won, Deepak Gopinath, Jessica Hudgins (Facebook AI Research)

A System for Efficient 3D Printed Stop-Motion Face Animation
Ritai Abdurahman, Alex Jacobson, Karan Sriniv (University of Toronto)

Accurate Face Rig Approximation With Deep Differential Subspace Reconstruction
Steven L. Song* (Blue Sky Studios), Woon Sit* (Yale University), Michael Reed (Blue Sky Studios) (Authors contributed equally)

Adaptive Merging for Rigid Body Simulation
Eyal Cohen, Omer Behichevski, Paul G. Key (McGill University)

An Implicit Compressible SPH Solver for Smoke Simulation
Christoph Gissler (University of Freiburg and EITI Technology), Andreas Herms (EITI Technology), Stefan Baland (University of Freiburg), Andreas Peer (EITI Technology), Matthias Tieschke (University of Freiburg)

Anisotropic Animating Anistropic Damage Mechanics
Yashika Wolfer, Yosua Chen, Minchen Li, Yu Fang, Ziyun Qi, Zongdong Lu, Mengjie Chong, Chunfeng Jiang (University of Pennsylvania)

Capturing Subjective First-Person View Shots With Drones for Automated Cinematography
Amirrezae Arastui (KAVST), Stefan Stavitski (ETH Zurich), Tobias Nageli (ETH Zurich) and Thayna Lohs, Omar Hiliges (ETH Zurich), Joan-Charles Buzin (KAVST)

CARS: Controllable Agent with Reinforcement Learning for Quadruped Locomotion
Ying-Sheng Lin*, Jonathan Hart Souza*, Fitrin Pic-Chun Chen (Univeristy Corp), Wai Chin Chen (Univeristy Corp, and Skywanch Innovation Inc) (Joint first authors)
Discussion: graphics jobs
Discussion: how to get involved in graphics at Stanford

- Email your graphics professors and ask to talk to them about independent study
  - Although to be honest… the best intro line is ("I took and loved your 300-level graphics class and did well and want to keep going")

- A common way to get started
  - Hack code to contribute to a Ph.D. student’s research project
Why research (or independent study)?

- You will learn way more about a topic than in any class.

- You think your undergrad friends are very smart? Come hang out with Stanford Ph.D. students! (you get to work side-by-side with them and with faculty). Imagine what level you might rise to.

- It’s way more fun to be on the cutting edge. Industry might not even know about what you are working on. (imagine how much more valuable you are if you can teach them)

- It widens your mind as to what is possible.
Maybe you might like research and decide you want to go to grad school

Pragmatic comment: Without question, the number one way to get into a top grad school is to receive a strong letter of recommendation from faculty members. You get that letter only from being part of a research team for an extended period of time.

DWIC letter: ("did well in class" letter) What you get when you ask for a letter from a faculty member who you didn’t do research with, but got an ‘A’ in their class. This letter is essentially thrown out by the Ph.D. admissions committee at good schools.
A very good reference

CMU Professor Mor Harchol-Balter’s writeup:
“Applying to Ph.D. Programs in Computer Science”

http://www.cs.cmu.edu/~harchol/gradschooltalk.pdf
Thanks for being a great class!

Good luck finishing projects.
Make sure you have fun, that’s the point!
And, above all else, do your best to stay healthy, and keep others healthy.