CS 148: Introduction to Computer Graphics and Imaging

Creative Expression (CE) WAYS course
(only if taken for a Letter Grade)
This year only - can take CR/NC and count toward WAYS

Ron Fedkiw
cs148.stanford.edu
Tuesday and Thursday
12 noon to 1:20pm
12:30pm to 1:50pm (recorded via SCPD)
Graphics is Pervasive

• Computer graphics is all around us!
• No one wants a boring *text only* interface when interacting with a computer, cell phone, DVD player, ATM, or a car
  • And even text is visualized via graphics based fonts
• Thus, learning at least a little bit about graphics is highly useful for all computer scientists!
What can I do with graphics?

• At the very least, improve your presentation/communication skills
• make demos, visualizations, etc. for your other work
• that is, make better use of everyday tools
• consider a cell phone:
  • (with its) user interface, camera, 2D image processing, etc
Smartphones (& Cameras)... obviously!

- Sales of smartphones outweigh sales of cameras by a factor of 3
- Most smartphones have cameras
- 5 billion mobile phones are in use worldwide
  - 4.4 billion camera phones and 1.2 billion smartphones
- World population is 7 billion
User Interfaces

Ivan Sutherland, Sketchpad, Light-pen, vector display

Apple iPad

Console Controller
2D Image Processing
Digital Media Technologies

- Digital photography
- Inkjet and laser printers
- Digital video and HDTV
- Electronic books
- Graphics on the web:
  - Photos (flickr)
  - Videos (youtube)
What can I do with graphics?

- Scientists/Engineers need graphics too
- Visualization of various phenomena, computer aided design (CAD), virtual prototyping, simulation, etc.
Scientific Visualization

The Virtual Human
Karl-Heinz Hoehne

Outside-In
The Geometry Center
Computer-Aided Design (CAD)

Sketchup

ProEngineer
Visual Simulation and Training

- Apollo spacecraft
- Flight simulators
- Driving simulators
- Surgical simulation

Davinci surgical robot
Intuitive Surgical

Driving simulator
Toyota Higashifuji Technical Center
What can I do with graphics?

• Check off a box on the bucket list!
• That is, learn more about the video games that lured many to computers and computer science in the first place
• AR/VR too...
Graphics Hardware

NVIDIA Fermi

NVIDIA OptiX
Virtual (and Augmented) Reality

Ivan Sutherland: Head-mounted displays, with mechanical tracker

Oculus Rift
What can I do with graphics?

- Of course, Hollywood Visual Effects!
- Often cannot film various real-world situations required in order to tell a story
  - The situation may be too dangerous, impractical, expensive, or rare
  - Or the situation doesn’t exist in reality, only in an alternative reality
VFX: Liquids

Battleship

The Day After Tomorrow

Terminator 2
VFX: Gases

Harry Potter and the Order of the Phoenix

Star Wars Episode III

Terminator 3
VFX: Solids

- Destruction: fracture, explosions, etc.

Super 8

2012
VFX: CG Creatures

Yoda, Star Wars Episode II

Sméagol/Gollum, The Lord of the Rings
VFX: Digital Doubles

The Curious Case of Benjamin Button
Motion Capture Technology

Facial capture in Avatar

Motion capture of Olympic swimmer Dana Vollmer by Manhattan Mocap
(technology transition)
What can I do with graphics?

• Animated Films!
• Instead of adding computer generated elements to real world film footage, create a whole new digital world
  • often with its own set of rules
Animated Films

Toy Story 3

Monsters, Inc.
Graphics at Stanford
Overview of the Graphics Track

1. **CS 148** (core class)
   A. Using the computer to draw pictures
   B. Theoretical background (math/physics) for the technical aspects of drawing pictures
   C. Coding: You write code but do not submit any code; instead, *you give live demos of working code*

Creative Expression (CE) WAYS course
Overview of the Graphics Track

A. Core Courses CS 148, 248, 348B
B. Special Topics: CS 448
C. Math (e.g. CS205L), Geometry (e.g. CS348A)
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
CS148
(more details...)
Ray Tracing!
Class Re-organization...

• Modified ordering of lectures to move Ray Tracing near the beginning (of the course), allowing key concepts to be covered simultaneously for both Scanline Rendering and Ray Tracing
• Moved Geometric Modeling and Texturing towards the end of the course, so that one can focus on project oriented goals during these homeworks/lectures
• Will use Blender for the homework assignments as it supports both Scanline Rendering and Ray Tracing
  • No longer using the (aging) OpenGL code base or the (not always popular) Ray Tracing code base from prior years
  • CS248 is graphics engine implementation heavy!
Blender

• We will use Blender in this course, so that you have a real-world working graphics engine at your disposal
  • Blender is open source so you can see all the code and how it works
  • Blender uses a Scanline Rendering implemented via OpenGL for previz, which enables real time scene design and manipulation
  • Blender uses a Ray Tracer to render the final images, so they can be quite advanced/impressive

• Since this is a CS course, we will dig in and modify code in Blender in order to illustrate various concepts
  • This will require one to understand scanline rendering, ray tracing, and the underlying mathematics
  • We will cover this in the lectures
  • Watch the lectures in order to acclimate yourself to the material *before* doing the homework and speaking with the CAs
  • The remote nature of this class will unfortunately(!) limit CA interactions to some degree
# Lectures & HW

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2020: No lectures the last 2 weeks; instead, extra CA (and Ron) office hours to help with projects (in this shortened quarter).
Assignments & Grading
50% final project & 50% homework

• The weekly graded homeworks are designed as building blocks towards the final project, which is a single ray traced image

• You may have a partner for both the homeworks and the final project
  • you may change partners as often as you wish throughout the quarter

• Homework is assigned Tuesday and due the following Monday from 3-7pm

• Grading is done via live demos (using Nooks this quarter) with the CAs
  • The CAs will/may ask you various questions about the code
  • Make sure you can answer questions about all parts of the code, regardless of which parts you or your partner may have done individually

• Grading is based on a 0-5 point grading scale
  • If your homework grades are not going well, do not be surprised if your final image grade is lower than you might expect
  • Working with *feedback* is very important in computer graphics!

• (New for 2020): Quiz Questions: As part of each HW grading session, there will be 1 (or more) random quiz question(s), which you and your partner should prepare for ahead of time (collective answers on the quiz questions are fine/allowed/encouraged)
How To Approach This Course

• This is (essentially) a project based course
• Your goal is to explore digital image creation via various computer graphics techniques
  • The course is supposed to be fun!
  • It’s not supposed to be a programming course or a math course, except that programming and math are necessary enablers for success
• The instructor and CAs are your guides
• Lectures are meant to lead you in the right direction --- just to get your started
  • They are not meant to tell you everything
  • You should utilize the reference reading materials
  • You should utilize the CAs, your classmates, online resources, and your imagination

• WARNING: There are limited options to explore creativity and artistry in CS courses; exploit this one... 😊
Don’t do this...
Reasons to take this class

• Creativity
  • this class counts as a CE, creative expression, WAYS course
  • this class encourages/rewards creativity above all else; albeit, technical skills are taught/required
  • very few other classes in CS encourage/reward creativity; this is one of your only options
  • academic/industry research requires creativity, so it’s good to develop
  • by mixing visual artistry and computer science, one hopes to learn how to better use their creativity in their everyday technical approaches

• Machine Learning
  • CNNs are built off the human visual system and follow the nonlinear projection space used by one’s eyes
  • Computer Vision is one of the main application areas for machine learning, and this class discusses light, geometry, materials, cameras, etc. in a way that adds more insight to computer vision
  • GANs and similar ideas were developed intuitively by thinking about human vision and photographs (material covered in this class)
  • Graphics is full of procedural methods for texture, geometry, etc. which are all good candidates for machine learning (good research topics)

• Computer Graphics
  • Introductory course for the sequence
Project Proposal (Bonus Points!)

- Find a motivational image (or a couple), and write a short Project Proposal (approximately 1 paragraph) explaining the goals for your project as motivated by the image(s)

- This proposal can be handed in at any point in THE FIRST 7 WEEKS of the course, and can be iterated on or modified as the course proceeds (no late days!)

- Work with your partner, the CAs, etc. on this proposal, and make sure that you and your partner agree

- The Project Proposal will be graded on a 0-5 scale, similar to the HW assignments, and those points will count as extra credit towards your HW assignment grade (which is clamped at 5 times the total HWs, i.e. 40 point max)

- Some sample motivation images...
Projects

• See the handouts!

Here are some projects from prior years...
A 348B image...