CS 148: Introduction to Computer Graphics and Imaging

Creative Expression (CE) WAYS course (only if taken for a Letter Grade)

Ron Fedkiw
cs148.stanford.edu
Tuesday and Thursday
12:00pm to 1:20pm
What can I do with graphics?
Hollywood Visual Effects

• One often cannot film various real-world situations required in order to tell a story
  – Some times the situation is too dangerous, impractical, expensive, or rare
  – Other times the situation doesn’t actually exist, except in an alternative reality
Visual Effects: Liquids

Battleship

Terminator 2

The Day After Tomorrow
Visual Effects: Gases

Harry Potter and the Order of the Phoenix

Terminator 3

Star Wars Episode III
Visual Effects: Solids

• Destruction: fracture, explosions, etc.

Super 8

2012
Visual Effects: Digital Doubles

The Curious Case of Benjamin Button
Visual Effects: CG Creatures

Yoda, Star Wars Episode II

Sméagol/Gollum, The Lord of the Rings
Motion Capture

Facial capture in Avatar

Motion capture of Olympic swimmer Dana Vollmer by Manhattan Mocap (technology transition)
Animated Films & Video Games

• Not just adding computer generated elements to real world film footage, but creating a whole new digital world
  – often with its own set of rules
• Can be quite immersive
Animated Films

Toy Story 3

Monsters, Inc.
Video Games

Spore

Crysis

Braid
What can I do with graphics?
Graphics is Pervasive

- Computer graphics is already all around us!
- How many people actually want to interact with their computer, cell phone, DVD player, ATM, or car by entering text?
  - Ntm, even the text is visualized via graphics based fonts
- Learning at least a little bit about a graphics is highly useful for all computer scientists...
Virtual (and Augmented) Reality

Ivan Sutherland: Head-mounted displays, with mechanical tracker

Oculus Rift
• 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)
Graphics Hardware

NVIDIA Fermi

NVIDIA OptiX
Scientists/Engineers need graphics too

• Visualization of various phenomena, computer aided design, virtual prototyping, simulation, etc.

• Learning at least a little bit about a graphics is highly useful for most scientists and engineers as well...
Scientific Visualization

The Virtual Human
Karl-Heinz Hoehne

Outside-In
The Geometry Center
Computer-Aided Design

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
Overview of the Graphics Track

Creative Expression (CE) WAYS course

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 will write code but will not submit any code. Instead, you will give live demos of working code
Overview of the Graphics Track

2. **CS 248** (creating a videogame)
   A. Now that you know how to draw a picture (CS 148), we cover many other aspects of graphics using the specific example of a video game
   B. Topics include: Platforms, game design, artificial intelligence, UIs/GUIs, computational geometry, computer animation, simulation, etc.
   C. You may write a 2D game if your game is a mobile or web game; this doesn’t stress rendering which is the topic of CS 148 but covers everything else
Overview of the Graphics Track

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Overview of the Graphics Track

3. Other Courses
   A. Rendering CS 348B
   B. Special Topics: CS 448
   C. Cameras: CS 178, CS 478
   D. Math: **CS 205L**, CME 102, CME 104, CME 108, MATH 113
   E. Geometry: CS 164, CS 268, CS 348A, CS 468
   F. Computer Vision: CS 231A, CS 231B
   G. Image Processing EE 368/CS 232
   H. Robotics: CS 223A, CS 225A, CS 327A
   I. Mobile Devices: CS 193I, CS193P
Graphics Faculty

Leo Guibas
Pat Hanrahan
Marc Levoy
Ron Fedkiw

More recently:
Maneesh Agrawala
Doug James
Kayvon Fatahalian
CS 148 final project

Scanline Render: *Portal, Valve Corporation*

Raytraced Render: *San Miguel Scene, PBRT*

Math and Optics

\[
L_o(x, \omega_o, \lambda, t) = L_e(x, \omega_o, \lambda, t) + \int_{\Omega} f_r(x, \omega_i, \omega_o, \lambda, t) L_i(x, \omega_i, \lambda, t) (\omega_i \cdot n) \, d\omega_i
\]
## CS148 Course Outline

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Assignments and Grading

50% final project, 32% homework, 18% “engagement”

• The weekly graded homeworks are designed as building blocks towards the final project, which is a single ray traced image
  – We will first learn to do some things using openGL in real time for more efficient scene design
  – Then we will move on to the ray tracer and work towards the final scene
• You may use a partner for both the homeworks and the images
  – 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 with the CAs
  – The CAs will/may ask you various questions
  – 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 0-4 point grading scale
  – If your homework grades are not going well, do not be surprised if your final image grade is lower than you expect
  – Feedback is very important in computer graphics!
Admittedly, it is entirely possible to learn any highly technical subject matter at home, without attending class or even going to college for that matter. However, as a general education WAYS class, CS148 aims to increase those additional things learned (even often about the technology itself) through social interactions. In fact, one should be interacting quite a bit with others when trying to create compelling imagery as there is an artistic component - this will be salient for the class final project/image.

As such, we aim to increase one’s “engagement” in this course by allowing the use of a partner, having in-person grading sessions, and by promoting class attendance and discussion. In particular, there will be a number of in class exercises that are meant to encourage following along in lecture, thinking about the material in real time, and discussions with others both inside and outside of class. To encourage these interactions, these “engagement” exercises will consist of 18% of the final grade.

Optionally, if you have to miss some classes for whatever reason, we will aim to address your WAYS liberal arts “engagement” experience with an alternative writing assignment meant to promote both brainstorming and thinking about and/or summarizing the course material. We refer to these as LONG FORM alternatives to the SHORT FORM engagement exercises carried out in class. Generally speaking, a LONG FORM writing assignment should be about 500-1000 words in length (which is 1-2 reasonably typed pages).

SCPD students will do the SHORT FORM assignments, or a similarly constructed alternative.
Class Engagement 18%

• Nothing today (Lecture 1)
• 1 point each (1%) for the 15 lectures from Lecture 2 to Lecture 16 inclusive
• Lecture 17 on Advanced Rendering is optional
• 1-3 points (1-3%) for submitting an image for Lecture 18  
  – Start looking for good images now…
• Lecture 19 and 20 are optional
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 or math course, except that programming and math are necessary enabling technologies
• 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 and rewards creativity above all else; albeit, technical skills are taught and required
  - very few other classes in CS (except CS248) encourage and reward creativity; this is one of your only options
  - academic and 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 the 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)

- **Graphics**
  - CS248 make a video game – for many, understanding how this is done satisfies a core reason they were interested in computer science
Some Images from Prior Years…
A 348B image...