IT-360
Fall 2021

Instructor Info —

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Virtual

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Programming for Computer Graphics

Computer graphics has become an important tool for both education and entertainment. Typically, computer graphics programming is concerned with the creation of virtual scenes, in a static and dynamic sense. For example, virtual characters locomote around, objects are manipulated due to physical constraints, entities are animated, and the camera moves through the scene.

The goal of the class is to learn about current techniques and foundational algorithms in graphics. During the course, we will first examine 2D graphics, color, images and image processing. Then, we will cover topics of interest in 3D graphics, including rendering technologies, ray tracing, rasterisation, opengl, physics-based simulation, animating virtual characters, and crowd simulation. Class includes several assignments and/or a final project. Students will also work with other students, connecting what they have read and heard with what they can see and implement in code, reinforcing the material.

Material

Recommended Text(s)

Gortler, Steven. *Foundations of 3D Computer Graphics* . 2012.
Marschner, Steve, and Peter Shirley. *Fundamentals of Computer Graphics* . 2015.

Other

Journal articles and book chapters will be provided as needed.

Grading Scheme

10%	Class participation
90%	Assignments and Projects

Grades will follow the following standard scale:

A = 89.5-100; B = 79.5-89.4; C = 69.5-79.4; D = 60-69.4; F $<$60.

Curving is at the discretion of the professor.

Learning Outcomes

- Understand images, color, and 2D graphics principles.
- Implement image processing algorithms.
- Get acquainted with the underlying geometry and mathematics for 2D and 3D graphics.
- Understand the rendering problem, and solutions.
- Be familiarized with ray tracing, and real-time rendering.
- Learn about game engine rendering, OpenGL and related visualization techniques.
- Understand the principles of particle and physics-based animation.
- Implement artificial intelligence algorithms for controlling the motion of virtual characters.
- Gain skills in programming and visualization of virtual scenes.
- Learn to critically review a paper and summarize it, as well as review and provide helpful criticism to your peers' work.

FAQs

Do we get to create fancy animations in this course?

Yes, but not exactly. You do get to learn and program the algorithms that create the underlying movement of the animation. More work is needed to then make such movement "look good".

What is computer graphics?

Computer graphics is a subfield of computer science which studies methods for digitally synthesizing and manipulating visual content. Although the term often refers to the study of three-dimensional computer graphics, it also encompasses two-dimensional graphics and image processing. See wikipedia (hyperlink) for more details.

What is your computer graphics area?

Crowd simulation, and algorithms for automatic computational 3D design.

I want to work in the computer graphics area. Can I work with you on research?

Maybe! If you impress in the class that will help. Get in touch so we can discuss your interests in more details.

Late Policy

Assignments are due typically 11:55pm on deadline date. Submitting homework afterward such deadline will constitute a full day penalty. Submitting homework n days late will lead to a 2^{n-1} penalty in home work grade. For example, assuming a 100% grade, and 5 days late, the final grade will be: $100 - 2^{5-1} = 100 - 16 = 84$

Make-up Policy

Make-up exams or assignment will only be allowed for students who have a substantiated excuse approved by the instructor *before the due date*. Leaving a phone message, online forum posting, or sending an e-mail without confirmation is not acceptable. Typically, a makeup assignment will be a 1000 word essay on an instructor selected topic.

Diversity and Inclusivity Statement

I consider this classroom to be a place where you will be treated with respect, and I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability - and other visible and non-visible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class.

Academic Integrity

The University Code of Academic Integrity is central to the ideals of this course. Students are expected to be independently familiar with the Code and to recognize that their work in the course is to be their own original work that truthfully represents the time and effort applied. Violations of the Code are most serious and will be handled in a manner that fully represents the extent of the Code and that befits the seriousness of its violation.

Tips to make sure you do not violate the academic integrity policy:

- Start on assignments right away so you do not find yourself in a desperate situation.
- If you are having trouble with an assignment, please email the professor and/or TAs.
- You may discuss the material with other students, the TAs, and the professor. Do not ask to see other students' code or solutions.
- Do not give your code or solutions to another student, even if the other student says they will not copy it.

Class Schedule

MODULE 1: Life's Building Blocks

Week 1	History of the Earth - Fish Remix	Friedman, M. & Salland, L.C. (2012). Five hundred million years of extinction and recovery: A Phanerozoic survey of large-scale diversity patterns in fishes. *Palaeontology*, 55(4):707-742
	Stem & Extant Agnathans & Gnathostomes	DOF Ch. 11, pp. 169-179; Ch. 13, pp. 231-240 Brazeau, M.D. & Friedman, M. (2015). The origin and early phylogenetic history of jawed vertebrates. *Nature*, 520(7548): 490-497.
Week 2	Chondrichthyans I: Overview & Sharks	DOF Ch. 11, pp. 197-200; Ch. 12, pp. 205-227
	Chondrichthyans II: Batoids & Chimaeras	DOF Chapter 12, pp. 227-229
Week 3	Stem & Extant Sarcopterygians	DOF Ch. 11, pp. 179-185; Ch. 13, pp. 242-248
	Actinopts I: Overview	DOF Ch. 14 & Ch. 15
Week 4	Actinopts II: Basal Actinopts & Teleostei	DOF Ch. 11, pp. 185-197; Ch. 13, pp. 248-259, Ch. 14, pp. 261-266
	Actinopts III: Otocephalan Fishes	DOF Ch. 14, pp. 267-275
Week 5	Actinopts IV: Freshwater Fishes	DOF Ch. 16, pp. 339-354; Ch. 18, pp. 410-414, 417-421
	Actinopts V: Deep Sea Fishes	DOF Ch. 18, pp. 393-401 Davis, M.P., Sparks, J.S., & Smith, W. L. (2016). Repeated and widespread evolution of bioluminescence in marine fishes. *PLOS One*.
Week 6	Actinopts VI: Coral Reef Fishes	Bellwood, D.R. & Wainwright, P.C. (2002). The History and Biogeography of Fishes on Coral Reefs. *Coral Reef Fishes: Dynamics and Diversity in a Complex Ecosystem*, 5-32.
	Actinopts VII: Pelagic Fishes	DOF Ch. 18, pp. 401-405
Week 7	Review	Module 1
	EXAM	MIDTERM 1

MODULE 2: What Makes a Fish

Week 8	Respiration	DOF Ch. 5
	Cardiovascular Systems	DOF Ch. 4, pp. 45-48
Week 9	Homeostasis	DOF Ch. 4, pp. 52; Ch. 7, pp. 101-105.
	Feeding Mechanisms	DOF Ch. 4, pp. 41-42; Ch. 8, pp. 119-126
Week 10	Sensory Systems	DOF Ch. 6
	Buoyancy	DOF Ch. 4, pp. 50-52 & Ch. 5, pp. 68-70

Week 11	Locomotion I - Undulatory Propulsion	Webb, P.W. (1984). Form and function in fish swimming. *Sci. Amer.*, 251(1): 72-83.
	Locomotion II - Oscillatory Propulsion	Daniel, T.L. (1984). Unsteady Aspects of Aquatic Locomotion. *Amer. Zoo.*, 24: 121-134.
Week 12	Communication & Reproduction	DOF Ch. 22, pp. 477-485
		DOF Ch. 21
	Review	Module 2
Week 13	EXAM	MIDTERM 2
	Holiday	Thanksgiving

MODULE 3: There Goes the Neighborhood

Week 14	Symbiotic Relationships	DOF Ch. 22, 492-497
	Behavior	DOF Ch. 23
Week 15	Ecology	DOF Ch. 25
	Conservation Efforts	DOF Ch. 26
Week 16	FINAL EXAM	Date & Time & Location

Lab Schedule

Week 2	Chondrichthyan Fishes	Students enjoy a two part lab: first, they examine specimens across the Chondrichthyan phylogeny; second, they dissect a small spiny dogfish shark.
Week 3	Harvard Natural History Museum	Students walk through the HMNH and the fossil collection, inspecting various fossil fishes.
Week 4	Basal Teleosts & Otocephalan Fishes	Students explore specimens across the basal Teleost phylogeny.
Week 5	Freshwater & Deep-Sea Fishes	Students explore specimens from a diverse group of fishes, and try to place each group in the broader phylogeny.
Week 6	Coral Reef & Pelagic Fishes	Students explore specimens from a diverse group of fishes, and try to place each group in the broader phylogeny.
Week 7	No Lab	
Week 8	Internal Systems	Students dissect fish specimens, probing and examing key internal systems.
Week 9	Jaw Dissections	Students again dissect their fish specimens, taking apart and visualizing the jaws of their fish.
Week 10	Sensory Systems & Buoyancy	Students again enjoy a two-part lab: first, examining a broad selection of specimens, comparing and contrasting sensory system apparatuses; and then conducting a series of small experiments to better understand the difficulties associated with buoyancy control in the water.
Week 11	Locomotion	Students dissect fish specimens, looking at muscular and structure of the body and fins. Students also participate in demonstrations designed to elucidate the concept of lift.
Week 12	Review Paper Projects	Students bring electronic devices and/or paper printouts of 2-3 paper choices, and will select peer reviewers. TAs will be available to assist students in choosing a paper and begin reviewing it.
Week 13	No Lab	
Week 14	No Lab	
Week 15	Final Exam Review Sessions	Review Paper Project Due