LEARNING ABROAD CENTER
UNIVERSITY OF MINNESOTA

In Partnership With

FOM
FUNDACIÓN JOSÉ ORTEGA Y GASSET - GREGORIO MARAÑÓN

Programming Interactive Computer Graphics & Games

Course Details

Course Designator & Number: MADR 4611
Number of Credits: 3
Language of Instruction: English
Contact Hours: 45
Instructor: Onsite Faculty

Course Description

Computer graphics is an exciting field within computer science that has seen dramatic recent growth. The impact of graphics on our culture and on our daily lives is far-reaching, as we can see through applications in art, design, education, games, movies, science, and medicine. This course covers the tools and techniques used today for programming games and other interactive computer graphics applications. Some of the core concepts covered include: event loops, rendering and animation, polygonal models, texturing, and physical simulation. This is a heavy programming course, and there is an emphasis on graphics toolkits. Other topics briefly covered include the history and future of computer games technologies and the social impact of interactive computer graphics.

Course Objectives

Learning Outcomes

In this course, you will learn to:

- Understand basic concepts and algorithms relevant to computer graphics programming.
- Identify, define, and solve 2D and 3D graphics programming problems.
- Critically evaluate and select the right graphics toolkit to solve new problems.

- Communicate information through visual means using computers.

Course Prerequisites

The prerequisite for the course is CSci-2021. Contact the instructor if you have any questions about whether the course is a good fit for your interests and background.

Course Structure

The course will typically meet for lecture/discussion twice per week. Since this is a programming-heavy course, much of the learning will come through a series of individual programming assignments. These are typically 2–3 weekly assignments, and there may be 5–6 of these in a given semester. Students' learning will be assessed through performance on these assignments along with exams.

Required Reading / Materials

Weekly readings will come from a main technical text and also from complementary materials that focus on contemporary topics in game design. An estimate of 20–30 pages of reading per week is expected. Example texts that could be used effectively in this course are listed below.

Examples for Main Text:

1. Interactive Computer Graphics: A Top-Down Approach with Shader-Based OpenGL, 6th Edition by Edward Angel and Dave Shreiner.

2. 3D Graphics for Game Programming, by JungHyun Han, CRC Press, 2011.

Example Complementary Text:

1. The Art of Game Design: A book of lenses, by Jesse Schell, Morgan Kaufmann, 2008.

Grading

Grading Rubric

Letter Grade	Score or Percentage	Description
A	93–100	Achievement that is outstanding relative to the level necessary to meet course requirements.
A-	90–92	Achievement that is significantly above the level necessary to meet course requirements.
B+	87–89	
B	83–86	
B-	80–82	Achievement that meets the course requirements in every respect.
C+	77–79	
C	73–76	
C-	70–72	Achievement that is worthy of credit even though it fails to fully meet the course requirements.
D+	67–69	
D	60–66	
F	0–59	Represents failure (or no credit) and signifies that the work was either (1) completed but at a level of achievement that is not worthy of credit or (2) was not completed and there was no agreement between the instructor and the student that the student would be awarded an I.

Summary of How Grades Are Weighted

Assignments	**Percentage of Grade**
Programming assignments	45%
Midterm or quiz	25%
Final exam	25%
Participation in classroom and web-based activities	5%
Overall grade	**100%**

Course Content

Example week-by-week topics:

Unit 1

First Hands-On Graphics Programing

- Use of a lightweight graphics scripting toolkit, such as Processing.org
- Graphics primitives: points, lines, polygons
- Representing color in computer graphics
- Responding to user input

Unit 2

The History & Future of Computer Graphics and Games

- Ivan Sutherland and the history of computer graphics
- Early games
- Current trends in graphics hardware
- The future of real-time graphics and futuristic human-computer interfaces

Unit 3

Intro to a commercial-level C++ based toolkit (e.g., Ogre, G3D)

- Practical introduction to programming with a major graphics toolkit used in games or related industries
- Hands-on experience

Unit 4

Visual Debugging with Graphics Toolkits

- Software engineering concepts and tools for computer graphics
- Emphasis on using visual outputs to understand the function of programs

Unit 5

Graphics Math in More Detail/Linear Algebra Refresher

- Refresher on transformation matrices

- Advanced graphics math at the toolkit level (e.g., ray-triangle intersection routines, object vs. world space)

Unit 6

Polygonal Modeling & Scene Graphs (Using C++ Toolkit)

- Mesh and spatial data structures
- Scene graphs and hierarchical transformations

Unit 7

Creating Effective Virtual Worlds

- Schell's elemental triad for effective game design
- The relationship between characters, scenes, and worlds
- Automated terrain generation and other technical tools for building worlds

Unit 8

Realism in Interactive Computer Graphics

- Tradeoffs between speed and realism
- Current trends in industry and real-world applications
- Serious games
- Intro to part 2 of the course viewed as many forms of realism (texture, animation, physics, user experience)

Unit 9

Texture & Bump Mapping for Realism (Using C++ Toolkit)

- Texture coordinates and different forms of texture mapping
- Impact of speed and realism
- Artistic use of texturing/contemporary texturing in the games

Unit 10

Characters & Animation

- Simulation and animation loops/threads
- Motion capture vs. physically-based simulation vs. key-frame animation
- Developing effective characters

Unit 11

Lighting Design & Implementation

- Local vs. global illumination
- OpenGL shaders

Unit 12

Designing for the User Experience in Games & Interactive Graphics

- Interdisciplinary design practices in game development
- Interface genres and input available during game play
- Examples from outside of games: virtual reality, CAD tools, 3D modeling tools

Unit 13

Event Loops & Graphical User Interaction

- Implementing effective user interfaces with 3D graphics toolkits

Unit 14

Physics Engines & Real-Time Simulation

- Integrating 2D and 3D physics toolkits with graphics toolkits

Unit 15

The Social Impact of Interactive Computer Graphics

- Games and graphics in our culture
- Games for health care
- Online and multi-player games
- The cognitive psychology of avatars
- Anthropological Examples, e.g., Coming of Age in Second Life

Example Assignments (2–3 weeks each)

Assignment 1: Use Processing.org toolkit to create an interactive art installation similar to Text Rain by Camille Utterback & Romy Achituv,1999.

Assignment 2: Implementing billiards (animation, simulation, and collision detection) in a modern graphics toolkit.

Assignment 3: Rendering and navigating the Earth (polygonal modeling of terrain, texture mapping, camera controls).

Assignment 4: Controlling and animating characters (skeleton-based animation of skinned game characters using motion capture data, details of transitioning between motions).

Assignment 5: Crayon physics: implement a game similar to crayon physics (www.crayonphysics.com). Combines several skills/areas of study throughout the semester: (1) geometric modeling, (2) shaders for non-photorealistic rendering, (3) physics-based simulation, and (4) a sketch-based gestural user interface.

Policies

Attendance Policy

Students are expected to be on time and attend all classes while abroad. Many instructors assess both attendance and participation when assigning a final course grade. Attendance alone does not guarantee a positive participation grade; the student should be prepared for class and engage in class discussion. See the on-site syllabus for specific class requirements.

All students must attend the lab section and take exams at the scheduled time. The exception to this policy is for make-up labs and exams, which require explicit prior permission from the class instructor (see make-up policy below).

Make-up exams will only be offered for legitimate absences defined by University policies. For a make-up exam to be given, the student must contact the instructor via email a week prior to the start of the exam.

Lecture Material

Some course material will be presented during lecture that is not covered in the textbook. Students will be responsible for the material presented in class, so it is very important to attend all lectures.

Late Policy for Assignments

Completed assignments must be submitted by the due date. You can submit your work up to one week after the due date for partial credit. No partial credit will be given for work submitted more than a week late. No late assignment will be accepted after the last scheduled day of class. If there is some reason why you cannot complete an assignment on time (e.g., illness) you must obtain prior permission from the instructor to have your assignment accepted at a later time without penalty.

Incompletes

Incompletes will be given only in very rare instances when an unforeseeable event causes a student who has completed all the coursework to date to be unable to complete a small portion of the work (typically the final assignment or exam).

Incompletes will not be awarded for foreseeable events including a heavy course load or poorer-than-expected performance. Verifiable documentation must be provided for the incomplete to be granted, and arrangements for the incomplete should be made as soon as such an event is apparent.

University of Minnesota Policies & Procedures

Academic integrity is essential to a positive teaching and learning environment. All students enrolled in University courses are expected to complete coursework responsibilities with fairness and honesty. Failure to do so by seeking unfair advantage over others or misrepresenting someone else's work as your own can result in disciplinary action. The University Student Conduct Code defines scholastic dishonesty as follows:

Scholastic Dishonesty

Scholastic dishonesty means plagiarizing; cheating on assignments or examinations; engaging in unauthorized collaboration on academic work; taking, acquiring, or using test materials without faculty permission; submitting false or incomplete records of academic achievement; acting alone or in cooperation with another to falsify records or to obtain dishonestly grades, honors, awards, or professional endorsement; altering forging, or misusing a University academic record; or fabricating or falsifying data, research procedures, or data analysis.

Within this course, a student responsible for scholastic dishonesty can be assigned a penalty up to and including an "F" or "N" for the course. If you have any questions regarding the expectations for a specific assignment or exam, ask.

Although you are free to discuss assignments with others, the work you submit for grading must represent your own efforts only. Exams are closed book and note and are to be completed using only your own knowledge of the course material. The experience gained from the labs will be very helpful for the exams and future labs may build on previous ones, so put in the effort needed to fully understand the solutions. Cheating on quizzes or exams is a serious offense, and will be dealt with as such. Additionally, labs are done in groups of two, but collaboration with others outside your group of two is prohibited. Homework assignments are individual efforts. You may discuss (in a general way) labs and homework problems with others, but you may not collaborate by writing code or specific solutions with others (with the exception of your lab partner in the case of labs). Copying other's answers, or letting another person copy your answers (either intentionally or as a result of negligence) is a serious situation and can result in failing the course. If you have any questions about what is and is not allowable in this class, ask the course instructor.

Student Conduct

The University of Minnesota has specific policies concerning student conduct. This information can be found on the Learning Abroad Center website.