

CSci 4611: Programming Interactive Computer Graphics and Games

3 Credits

Offered Spring Semesters

Possible Professors: Dan Keefe, Stephen Guy, Victoria Interrante, Gary Meyer

Professor Office/Contact Hours: 2 hours per week

TA Office Hours: 2 hours per week

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.

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.

Prerequisites

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

Course Structure

Format and Assessment

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 week 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. An example formula that could be used to determine final grades for the course is:

- 45% -- Programming Assignments** (divided equally between each assignment)
- 25% -- Midterm or Quizzes**
- 25% -- Final Exam**
- 5% -- Participation in Classroom and Web-based activities**

Readings

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.

Example Week-by-Week Topics

Week 1: First hands-on graphics programming

- 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

Week 2: The History and 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

Week 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

Week 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

Week 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)

Week 6: Polygonal Modeling and Scene Graphs (Using C++ Toolkit)

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

Week 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

Week 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)

Week 9: Texture and 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

Week 10: Characters and Animation

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

Week 11: Lighting Design and Implementation

- Local vs. global illumination
- OpenGL shaders

Week 12: Designing for the User Experience in Games and 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

Week 13: Event Loops and Graphical User Interaction

- Implementing effective user interfaces with 3D graphics toolkits

Week 14: Physics Engines and Real-Time Simulation

- Integrating 2D and 3D physics toolkits with graphics toolkits
- How to manage your loops: rendering, physics, events, networking, etc.

Week 15: The Social Impact of Interactive Computer Graphics

- Games and graphics in our culture
- Games for healthcare
- 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 (3) a sketch-based gestural user interface.