

Kutztown University
Kutztown, Pennsylvania
Computer Science Department
College of Liberal Arts and Sciences

I. Course Description: CSC 480: Selected Topics in Computer Science
Topic: Advanced Graphical Programming

This course increases breadth and depth of knowledge for students with experience in object-oriented programming for multimedia systems. Advanced topics include working with camera point-of-view and lighting sources for 3D graphics, recursive shapes and fractals, pixel-level image processing, and animated video composition. Students will program graphical images, video streams, audio signals, physical devices containing electronic sensors and effectors, and combinations of these media. There will be solo and team programming projects.

3 s.h. 3 c.h. Prerequisites: CSC220 with a grade of C or better.

II. Course Rationale

Multimedia digital systems are ubiquitous in entertainment systems including cinema and gaming, in scientific educational settings, in marketing, in social media, and in data visualization and sonification. At Kutztown University, prerequisite course CSC220 is a major elective in the Computer Science, Information Technology, and Applied Digital Arts majors. The rationale for offering this Selected Topics course is to educate students in advanced topics and projects for multimedia programming, and to explore curricular and pedagogical approaches that may be appropriate for a more permanent, advanced course.

III. Course Objectives

Upon completion of the course the student will be able to:

- A. Apply camera point-of-view, graphical lighting, and 3D to 2D mapping in student projects for building and navigating simulated three-dimensional spaces.
- B. Create recursive functional programs for generating scale-invariant recursive graphical shapes in two and three dimensions..
- C. Manipulate pixel-level data from photographs and generated images for aesthetic and data visualization applications.
- D. Load, manipulate, and save 2D and 3D vector graphical data constructs.
- E. Apply software tools for the creation of video recordings with audio.
- F. Create a graphical remote control app on a mobile device for a multimedia application.

IV. Course Assessment

The course assessment will be a subset of tests, projects, papers, presentations, quizzes, homework, team assignments and final exam.

V. Course Outline

- A. Three-dimensional graphics programming
 1. Perspective and orthographic projection to two-dimensional display
 2. Manipulating simulated camera point-of-view for navigating a 3D space
 3. Applying ambient and directional lighting effects
 4. Effects of stacking order for semi-transparent surfaces in 3D graphics
 5. Avoiding unnecessary overhead in graphical data processing
- B. Recursive graphics programming
 1. Application of recursive programming to generative graphics
 2. Self-similar, scale-invariant shapes
 3. Interactive degrees of freedom in recursive shape templates
 4. Varying stroke and fill properties by depth of recursion
 5. Tessellation of two-dimensional images
 6. Iterated function systems and breadth first processing in elaborating recursive images
- C. Pixel-level data processing
 1. Loading and updating pixel frame buffers
 2. Mapping between 2D and 3D object coordinates and pixel array indices
 3. Extracting and updating color and transparency properties of pixels
 4. Offloading image loading and pixel manipulation to parallel threads for performance
 5. Avoiding unnecessary overhead in pixel processing
- D. Vector graphics programming
 1. Creating and displaying vector graphical shapes programmatically
 2. Loading and storing vector graphical shapes on the file system
 3. Composing with groups of vectors as grouped objects
 4. Modifying visual properties of vector objects on the fly
- E. Video processing
 1. Real-time capture of generated video sequences in the absence of rendering bottlenecks
 2. Postprocessing of generated image sequences in the presence of rendering bottlenecks
 3. Using software tools for video processing
- F. Remote control via mobile devices
 1. Using a network protocol for communication between a graphical server and mobile remote control devices
 2. Text-based user interface on a mobile device
 3. Custom graphical user interface on a mobile device
 4. Avoiding unnecessary network communication overhead while syncing devices

VI. Instructional Resources

Akenine-Moller, Haines, Hoffman, Pesce, Iwanicki, Hillaire. *Real-time Rendering*, Fourth Edition. CRC Press. 2018.

Arduino embedded microcontroller, <http://www.arduino.cc/>. February, 2019.

Barnsley, M. *Fractals Everywhere*. Dover. 2012.

Beyer, J. *Designing Tessellations: The Secrets of Interlocking Patterns*. McGraw-Hill. 1999.

Bohnacker, Gross, Laub, Lazzeroni. *Generative Design: Visualize, Program, and Create with Processing*. Princeton Architectural Press. 2012.

Clayson, J. *Visual Modeling with Logo : a structured approach to seeing*. MIT Press. 1988.

Colubri, A. *Processing for Android*. Apress. 2017.

Cook, P. *Real Sound Synthesis for Interactive Applications*. A.K. Peters. 2009.

Fhala, B. *HTML5 Graphics & Data Visualization Cookbook*. Packt Publishing. 2012.

Fiskwick, P. (ed.). *Aesthetic Computing*. MIT Press. 2006.

Franson, D. *2D Artwork and 3D Modeling for Game Artists*. Premier. 2003.

Frantz, M. and Crannell, A. *Viewpoints: Mathematical Perspective and Fractal Geometry in Art*. Princeton University Press. 2011.

Gortler, S. *Foundations of 3D Computer Graphics*. MIT Press. 2012.

Greenberg, I., Xu, D., Kumar, D. *Processing: Creative Coding and Generative Art in Processing 2*. friendsofED. 2013.

Haverkamp, M. *Synesthetic Design : Handbook for a Multisensory Approach*. Birkhaeuser. 2013.

Igoe, T. *Making Things Talk, Practical Methods for Connecting Physical Objects*. O'Reilly Media. 2007.

International Journal of Computer Graphics & Animation. Academy & Industry Research Collaboration Center. 2011-2019.

Journal of Visual Languages and Computing. Academic Press. 1995-2019.

Lengyel, E. *Mathematics for 3D Game Programming and Computer Graphics*, Third Edition. Course Technology. 2012.

Lukac, R., editor. *Computational Photography, Methods and Applications*. CRC Press. 2011.

Majumder, A. and Gopi, M. *Introduction to Visual Computing, Core Concepts in Computer Vision, Graphics, and Image Processing*. CRC Press, 2018.

McReynolds, T and Blythe, D. *Advanced graphics programming using OpenGL*. Morgan Kaufmann. 2005.

Musical Instrument Digital Interface standards, <http://www.midi.org/techspecs/>. February, 2019.

Ohlson de Fine, M. *Python 2.6 Graphics Cookbook*. Packt Publishing. 2010.

Open Processing home page: <http://www.openprocessing.org/>. February, 2019.

Pajankar, A. *Raspberry Pi Image Processing Programming*. Apress. 2017.

Schattschneider, D. *M.C. Escher: Visions of Symmetry* (New Edition). Harry N. Abrams. 2004.

Open Sound Control, <http://opensoundcontrol.org/>. February, 2019.

Pearson, M. *Generative Art: A Practical Guide Using Processing*. Manning. 2011.

Processing home page: <https://www.processing.org/>. February, 2019.

Raspberry PI embedded microcontroller, <http://www.raspberrypi.org/>. February, 2019.

Reas, C. and Fry, B. *Processing: A Programming Handbook for Visual Designers and Artists*. MIT Press. 2007.

Roads, C. *The Computer Music Tutorial*. MIT Press. 1996.

Shiffman, D. *The Nature of Code: Simulating Natural Systems with Processing*. The Nature of Code. 2012.

Shiffman, D. *Learning Processing: A Beginner's Guide to Programming Images, Animation and Interaction*. Morgan Kaufmann. 2008.

Vantomme, J. *Processing 2: Creative Programming Cookbook*. Packt Publishing, 2012. Vaughan, W. *Digital Modeling*. New Riders. 2012.

Weinmann, E. and Lourekas, P. *Illustrator CC : for Windows and Macintosh*. Peachpit Press. 2014.

Weinmann, E. and Lourekas, P. *Photoshop CC : for Windows and Macintosh*. Peachpit Press. 2015.