11B1WCI611: Computer Graphics

Course Credit: 4
Semester: VI

Introduction

This course presents an introduction to computer graphics designed to give the student an overview of fundamental principles. It covers the fundamental concepts in creating graphical images on the computer. Computer graphics uses ideas from Art, Mathematics, and Computer Science to create images. Course work stresses the reduction of concepts to practice in the form of numerous programming assignments. The course will include an overview of common graphics hardware, 2D and 3D transformations and viewing, and basic raster graphics concepts such as scan-conversion and clipping. Methods for modeling objects as polygonal meshes or smooth surfaces, and as rendering such as hidden-surface removal, shading, illumination, and shadows will be investigated.

Course Objectives (Post-conditions)

Knowledge objectives:

1. This course is designed to provide a comprehensive introduction to computer graphics leading to the ability to understand contemporary terminology, progress, issues, and trends.
2. A thorough introduction to computer graphics techniques, focusing on 3D modelling, image synthesis, and rendering. We will look at raster scan graphics including line and circle drawing, polygon filling, anti-aliasing algorithms, clipping, hidden-line and hidden surface algorithms including ray tracing and, of course, rendering - the art of making photo realistic pictures with local and global illumination models.
3. The interdisciplinary nature of computer graphics is emphasized in the wide variety of examples and applications.

Application objectives:

A successful student will:

1. Know and be able to understand the core concepts of computer graphics.
2. Know and be capable of using OpenGL to create interactive computer graphics.
3. Know and be able to understand a typical graphics pipeline.
4. Know and be able to make interactive graphics applications in C++ using one or more graphics application programming interfaces.
5. Know and be able to demonstrate an understanding of the use of object hierarchy in graphics applications.
6. Know and be able to write program functions to implement visibility detection.
7. Know and be able to make pictures with their computer.
8. Know and be able to describe the general software architecture of programs that use 3D computer graphics.

1. Know and be able to discuss hardware system architecture for computer graphics. This includes, but is not limited to: graphics pipeline, frame buffers, and graphic accelerators/co-processors.
2. Know and be able to use a current 3D graphics API (e.g., OpenGL or DirectX).
3. Know and be able to use the underlying algorithms, mathematical concepts, supporting computer graphics. These include but are not limited to:
    - Composite 3D homogeneous matrices for translation, rotation, and scaling transformations.
    - Plane, surface normals, cross and dot products.
    - Hidden surface detection / removal.
    - Scene graphs, display lists.
4. Know and be able to select among models for lighting/shading: Color, ambient light; distant and light with sources; Phong reflection model; and shading (flat, smooth, Gourand, Phong).
5. Know and be able to use and select among current models for surfaces (e.g., geometric; polygonal; hierarchical; mesh; curves, splines, and NURBS; particle.
6. Know and be able to design and implement model and viewing transformations, the graphics pipeline and an interactive render loop with a 3D graphics API.
7. Be able to design and implement models of surfaces, lights, sounds, and textures (with texture transformations) using a 3D graphics API.
8. Be able to discuss the application of computer graphics concepts in the development of computer games, information visualization, and business applications.
9. Be able to discuss future trends in computer graphics and quickly learn future computer graphics concepts and APIs.

Expected Student Background (Preconditions)

Elementary Knowledge about the Topics Introduction to Programming is required.

Topics Outline:

S NO	Topics	Hrs
1	Introduction to Computer Graphics Overview of Computer Graphics, Computer Graphics Application and Software, Description of some graphics devices, Input Devices for Operator Interaction, Active and Passive Graphics Devices, Display Technologies, Storage Tube Graphics Displays, Calligraphic Refresh Graphics Displays, Raster Refresh (Raster-Scan) Graphics Displays, Cathode Ray Tube Basics, Color CRT Raster Scan Basics, Video Basics, The Video Controller, Random-Scan Display Processor, LCD displays, Graphics Primitives.	4
2	Two-Dimensional Transformations Transformations and Matrices, Transformation Conventions, 2D Transformations, Homogeneous Coordinates and Matrix Representation of 2D Transformations, Translations and Homogeneous Coordinates, Rotation, Reflection, Scaling, Combined Transformation, Transformation of Points, Transformation of The Unit Square, Solid Body Transformations, Rotation About an Arbitrary Point, Reflection through an Arbitrary Line, A Geometric	8

	Interpretation of Homogeneous Coordinates, The Window-to-Viewport Transformations.	
3	Three-Dimensional Transformations and Viewing in 3D Introduction, Three-Dimensional Scaling, Three-Dimensional Shearing, Three-Dimensional Rotation, Three-Dimensional Reflection, Three-Dimensional Translation, Multiple Transformation, Rotation about an Arbitrary Axis in Space, Reflection through an Arbitrary Plane, Matrix Representation of 3D Transformations, Composition of 3D Transformations, Affine and Perspective Geometry, Perspective Transformations, Techniques for Generating Perspective Views, Vanishing Points, the Perspective Geometry and camera models, Orthographic Projections, Axonometric Projections, Oblique Projections, View volumes for projections.	10
4	Scan conversion – lines, circles and Ellipses; Filling polygons and clipping algorithms Scan Converting Lines, Mid-point criteria, Problems of Aliasing, end-point ordering and clipping lines, Scan Converting Circles, Scan Converting Ellipses, Filling Polygons, edge data structure, Clipping Lines algorithms– Cyrus-Beck, Cohen-Sutherland and Liang-Barsky, Clipping Polygons, problem with multiple components.	10
5	Solid Modeling Representing Solids, Regularized Boolean Set Operations, Primitive Instancing, Sweep Representations, Spatial-Partitioning Representations - Octree representation, B-Reps, Constructive Solid Geometry, Comparison of Representations.	4
6	Plane Curves and Surfaces Curve Representation, Nonparametric Curves, Parametric Curves, Parametric Representation of a Circle, Parametric Representation of an Ellipse, Parametric Representation of a Parabola, Parametric Representation of a Hyperbola, A Procedure for using Conic Sections, The General Conic Equation; Representation of Space Curves, Cubic Splines, , Bezier Curves, B-spline Curves, B-spline Curve Fit, B-spline Curve Subdivision, Parametric Cubic Curves, Quadric Surfaces. Bezier Surfaces.	5
7	Image Manipulation and Storage What is an Image? Digital image file formats, Image compression standard – JPEG, Image Processing - Digital image enhancement, contrast stretching, Histogram Equalization, smoothing and median Filtering.	Self-Learning
	Total	42

References

1. Donald Hearn and M. Pauline Baker. “Computer Graphics with OPENGL” 3rd Edition Pearson Publishers, 2011.
2. James D. Foley, Van Adams, K.Fenier and F. Hughes, “Computer Graphics-Principle and Practices”, 3rd Edition Pearson Publishers , 2002.
3. Computer Graphics using OpenGL , F.S. Hill Jr. Pearson Publishers, 2nd Edition.

4. Harrington, S. (1983). “Computer Graphics: A Programming Approach” Mc-Graw Hill Book Co.

Evaluation Scheme:

S.No	Examination	Marks
1	T-1	15
2	T-2	25
3	T-3	35
4	*Internal Marks	25

*Internal Marks Breakdown:

Assignments 9 marks (3x3)

Quizzes 12 marks (3x4)

Regularity 4 Marks