CMPE 466 COMPUTER GRAPHICS

Chapter 3

Computer Graphics Software

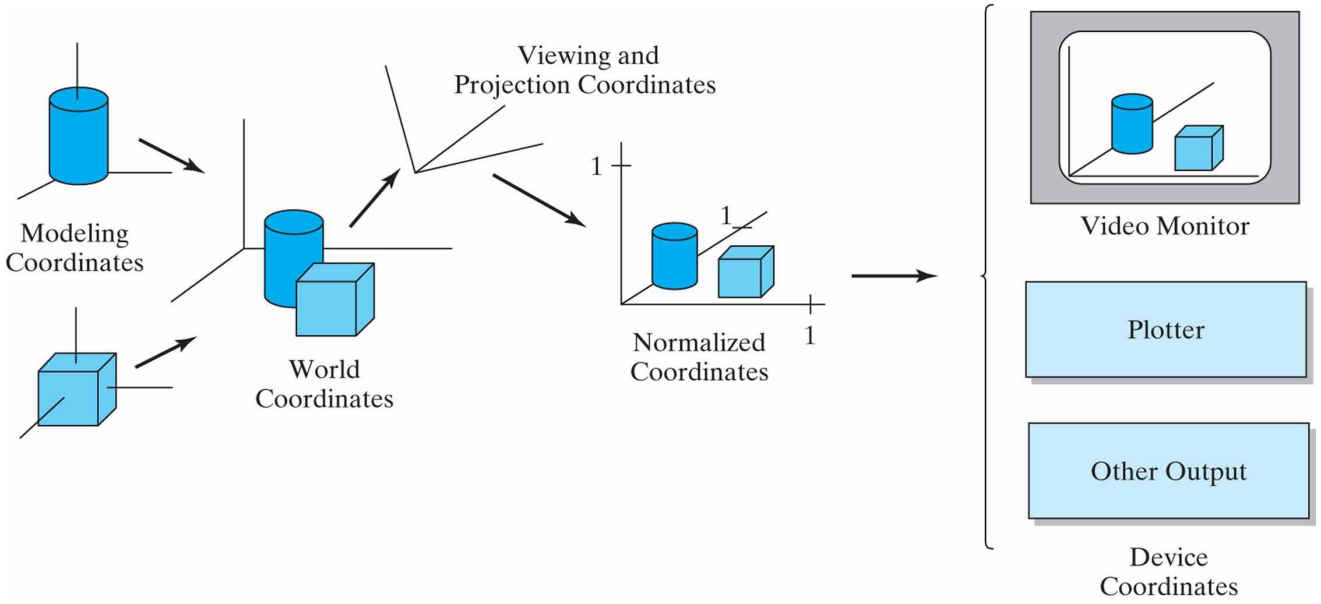
Instructor: D. Arifler

Material based on

- *Computer Graphics with OpenGL®,* Fourth Edition by Donald Hearn, M. Pauline Baker, and Warren R. Carithers
- *Fundamentals of Computer Graphics*, Third Edition by by Peter Shirley and Steve Marschner

Coordinate representations

Figure 3-1 The transformation sequence from modeling coordinates to device coordinates for a three-dimensional scene. Object shapes can be individually defined in modeling-coordinate reference systems. Then the shapes are positioned within the world-coordinate scene. Next, world-coordinate specifications are transformed through the viewing pipeline to viewing and projection coordinates and then to normalized coordinates. At the final step, individual device drivers transfer the normalized-coordinate representation of the scene to the output devices for display.



Right-handed vs. left-handed coordinate reference frame

Graphics functions

- Output primitives: plot character strings, points, straight lines, curved lines, polygons, etc.
- Attributes: set properties of output primitives such as color specifications, line styles, fill patterns, etc.
- Geometric transformations: change size, position, orientation of an object
- Viewing transformations: select a view of the scene, type of projection to be used, location on video monitor where the view is to be displayed
- Input functions: control and process the data flow from interactive devices
- Control operations: house-keeping tasks such as clearing a screen display area

Software standards

- Primary goal: Portability
- Graphical Kernel System (GKS)
- Programmer's Hierarchical Interactive Graphics System (PHIGS) and PHIGS+
- Graphics Library (GL)
- OpenGL (hardware-independent version of GL)

Language binding

- A language binding is defined for a particular high-level programming language
- This binding gives the syntax for accessing various graphics functions
- OpenGL bindings for C and C++ are the same
- OpenGL bindings are also available for Java and Python

Other graphics packages

- Open Inventor
- Virtual Reality Modeling Language (VRML)
- Java 2D
- Java 3D
- RenderMan Interface
- Libraries for Mathematica, MATLAB, and Maple

OpenGL

- OpenGL basic (core) library
  - Function names start with “gl”
- OpenGL Utility (GLU) library
  - Constants and data type names begin with “GL”
  - Function names start with “glu”
- Window management operations are device-dependent
  - OpenGL extensions to the X Windows System (GLX)
  - Apple GL (AGL)
  - Windows GL (WGL)
- OpenGL Utility Toolkit (GLUT) library
  - Library of functions for interacting with any windowing system
  - Functions are prefixed with “glut”

OpenGL header files

- Windows

  #include <windows.h>

  #include <GL/gl.h>

  #include <GL/glu.h>

  - or simply

  #include <GL/glut.h>

  - GLUT ensures that gl.h and glu.h are included

- Apple OS X

  #include <GLUT/glut.h>

An example program

Figure 3-2 A 400 by 300 display window at position (50, 100) relative to the top-left corner of the video display.

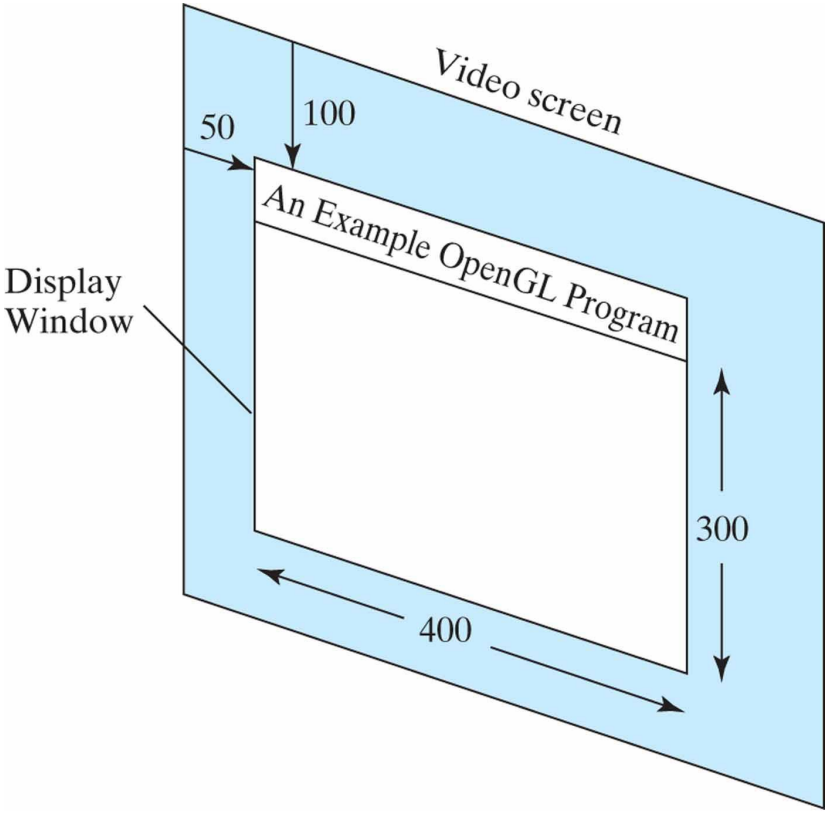
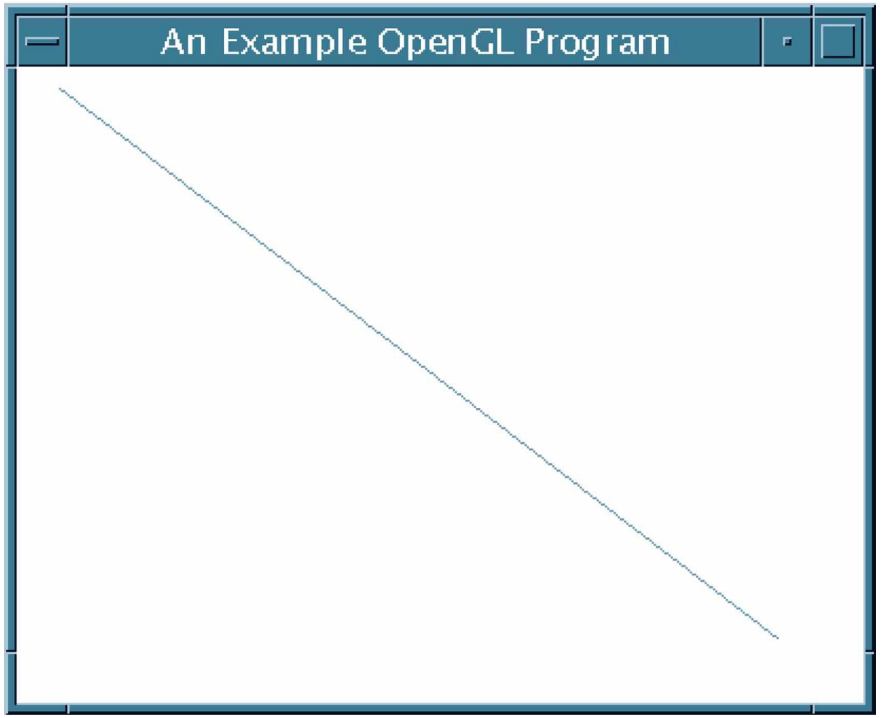


Figure 3-3 The display window and line segment produced by the example program.



An example program

```
#include <GL/glut.h>      // (or others, depending on the system in use)

void init (void)
{
    glClearColor (1.0, 1.0, 1.0, 0.0);  // Set display-window color to white.

    glMatrixMode (GL_PROJECTION);       // Set projection parameters.
    gluOrtho2D (0.0, 200.0, 0.0, 150.0);
}

void lineSegment (void)
{
    glClear (GL_COLOR_BUFFER_BIT);  // Clear display window.

    glColor3f (0.0, 0.4, 0.2);      // Set line segment color to green.
    glBegin (GL_LINES);
        glVertex2i (180, 15);       // Specify line-segment geometry.
        glVertex2i (10, 145);
    glEnd ( );

    glFlush ( );     // Process all OpenGL routines as quickly as possible.
}
```

An example program

```
void main (int argc, char** argv)
{
    glutInit (&argc, argv);                              // Initialize GLUT.
    glutInitDisplayMode (GLUT_SINGLE | GLUT_RGB);    // Set display mode.
    glutInitWindowPosition (50, 100);    // Set top-left display-window position.
    glutInitWindowSize (400, 300);       // Set display-window width and height.
    glutCreateWindow ("An Example OpenGL Program"); // Create display window.

    init ( );                                 // Execute initialization procedure.
    glutDisplayFunc (lineSegment);        // Send graphics to display window.
    glutMainLoop ( );                         // Display everything and wait.
}
```