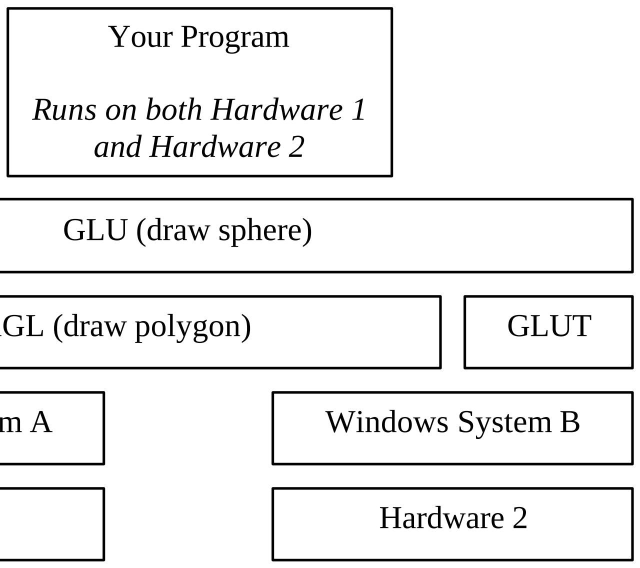
CSC 418. Tutorial 1

OpenGL

OpenGL:

- A high-performance, window-system independent, software interface to graphics hardware.



- GLU (Provides helper routines built on top of OpenGL rendering capabilities)
- GLUT (Provides and easy access to the underlying windowing system – creating windows and looking for mouse and keyboard events etc.)

Overview of an OpenGL program

- Main
    - Open window and configure frame buffer (using GLUT for example)
    - Initialize GL states and display (Double buffer, color mode, etc.)
- Loop
    - Check for events

```
if window event (resize, unhide, maximize etc.)
    modify the viewport
    and Redraw
else if input event (keyboard and mouse etc.)
    handle the event (such as move the camera or change the state)
    and usually draw the scene
```

- Redraw
    - Clear the screen (and buffers e.g., z-buffer)
    - Change states (if desired)
    - Render
    - Swap buffers (if double buffer)

OpenGL order of operations

- Construct shapes (geometric descriptions of objects – vertices, edges, polygons etc.)
- Use OpenGL to
    - Arrange shape in 3D (using transformations)
    - Select your vantage point (and perhaps lights)
    - Calculate color and texture properties of each object
    - Convert shapes into pixels on screen

OpenGL Syntax

- All functions have the form: gl*
    - glVertex3f() – 3 means that this function take three arguments, and f means that the type of those arguments is float
    - glVertex2i() – 2 means that this function take two arguments, and i means that the type of those arguments is integer
- All variable types have the form: GL*
    - In OpenGL program it is better to use OpenGL variable types (portability)
        - GLfloat instead of float
        - Glint instead of int

OpenGL primitives

- Drawing two lines

```
glBegin(GL_LINES);
  glVertex3f(_,_,_); // start point of line 1
  glVertex3f(_,_,_); // end point of line 1
  glVertex3f(_,_,_); // start point of line 2
  glVertex3f(_,_,_); // end point of line 2
glEnd();
```

We can replace GL_LINES with GL_POINTS, GL_LINELOOP, GL_POLYGON etc. (See OpenGL API for a complete lis).

OpenGL states

- On/off (e.g., depth buffer test)
    - `glEnable( GLenum )`
    - `glDisable( GLenum )`
    - Examples:
        - `glEnable(GL_DEPTH_TEST);`
        - `glDisable(GL_LIGHTING);`
- Mode States
    - Once the mode is set the effect stays until reset

- Examples:
  - `glShadeModel(GL_FLAT)` or `glShadeModel(GL_SMOOTH)`
  - `glLightModel(…)` etc.

Drawing in 3D

- Depth buffer (or z-buffer) allows scene to remove hidden surfaces. Use `glEnable(GL_DEPTH_TEST)` to enable it.
- `glPolygonMode( Face, Mode )`
  - Face: `GL_FRONT, GL_BACK, GL_FRONT_AND_BACK`
  - Mode: `GL_LINE, GL_POINT, GL_FILL`
- `glCullFace( Mode )`
  - Mode: `GL_FRONT, GL_BACK, GL_FRONT_AND_BACK`
- `glFrontFace( Vertex_Ordering )`
  - Vertex Ordering: `GL_CW or GL_CCW`

Viewing transformation

- glMatrixMode (Mode)
  - Mode: `GL_MODELVIEW, GL_PROJECTION,` or `GL_TEXTURE`
- `glLoadIdentity()`
- `glTranslate3f(x,y,z)`
- `glRotate3f(angle,x,y,z)`
- `glScale3f(x,y,z)`

3D Projection (i.e., virtual camera)

- Perspective
  - glFrustum(
```
    GLdouble left,
    GLdouble right,
    GLdouble bottom,
    GLdouble top,
    GLdouble znear,
    GLdouble zfar
 );
```
  - Also look at: `gluPerspective()`
- Orthographic
  - glOrtho(
```
    GLdouble left,
    GLdouble right,
    GLdouble bottom,
    GLdouble top,
    GLdouble zNear,
    GLdouble zFar
 );
```

Lighting

- Direction light source
- Position light source
- glLightfv(Light#, Attribute, …)
    - o `GLfloat position[] = {10, 10, 10, W}`
      `glLightfv(GL_LIGHT0, GL_POSITION, position)`
      If (W) is zero the position is treated as a direction (a 1x3 vector); otherwise, it is treated as a position (a 1x4 vector)
- `glEnable(GL_LIGTHING)`
- `glEnable(GL_LIGHT0)`

A program (Objects, Lights, Camera and ….)

```
#include        <stdio.h>
#include        <stdlib.h>
#include        <string.h>
#include        <math.h>
#include        <sys/types.h>
#include        <GL/gl.h>
#include        <GL/glu.h>
#include        <GL/glut.h>


int main(int argc,char **argv)
{

  /* initialize GLUT, OpenGL */
  glutInit(&argc,argv);

  /* set the window pos---let the windowing system determine */
  glutInitWindowPosition(-1,-1);

  /* set the window size */
  glutInitWindowSize(250,250);

  /* set the window display modes (hopefully supported)
     GLUT_DOUBLE: double-buffered
     GLUT_RGBA:   rgba colors (no colormap)
     GLUT_DEPTH:  z-buffering
  */
  glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGBA | GLUT_DEPTH);

  /* create the window */
  glutCreateWindow("test");

  glClearColor(0.0,0.0,0.0,0.0);
  glShadeModel(GL_FLAT);
  glEnable(GL_DEPTH_TEST);

  glutDisplayFunc(do_redraw);
  glutReshapeFunc(do_resize);
  glutKeyboardFunc(keyboard);
```

```
  /* let it go! */
  glutMainLoop();
}
```

```
/* Glut callback function */
void do_resize(int w, int h)
{
  glViewport(0,0,(GLsizei)w,(GLsizei)h);
  glMatrixMode(GL_PROJECTION);
  glLoadIdentity();
  gluPerspective(60.0,(GLfloat)w/(GLfloat)h,1.0,30.0);
  glMatrixMode(GL_MODELVIEW);
  glLoadIdentity();
  glTranslatef(0.0,0.0,-3.6);
}
```

```
/* Actual scene drawing */
void do_redraw(void)
{
  /* clear back buffer */
  glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);

  glEnable( … );

  glBegin(GL_POLYGON);
  glVertex3f(0,0,0);
  glVertex3f(10,0,0);
  glVertex3f(10,10,0);
  glEnd();
  glFlush();

  glDisable( … );

  /* swap buffers */
  glutSwapBuffers();
}
```

```
/* handling input */
void keyboard(unsigned char key, int x, int y)
{
  switch(key) {
    case 'q':
    case 27:
      exit(0);
      break;
    default:
      break;
  }
}
```