

# **Using OpenGL**

**CSCI 4229/5229  
Computer Graphics  
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# Event Driven Programming

- Don't call us, we'll call you
  - register callbacks corresponding to events
  - similar to interrupt driven programs
- DO NOT explicitly call `display()`
  - request redisplay using `glutPostRedisplay()`
- NEVER call `sleep()`
  - use global/static variables and wall time for timing
  - use `glutTimerFunc()` for regular events
- Return control as soon as possible

# Types of Objects

- glBegin(type)
  - GL\_POINTS points
  - GL\_LINES lines between pairs of points
  - GL\_LINE\_STRIP series of line segments
  - GL\_LINE\_LOOP closed GL\_LINE\_STRIP
  - GL\_POLYGON simple polygon
  - GL\_TRIANGLES triangles between triples of points
  - GL\_TRIANGLE\_STRIP series of triangles
  - GL\_TRIANGLE\_FAN fan of triangles
- Set coordinates with glVertex
- glEnd()

# Qualifiers

- `glPointSize(float size)`
  - POINT size in pixels (default 1)
- `glLineWidth(float width)`
  - LINE width in pixels (default 1)
- `glLineStipple(int factor,unsigned short pattern)`
  - LINE type
  - Requires `glEnable(GL_LINE_STIPPLE)`

# Color

- Default is RGB color
  - X11 TrueColor
  - R,G,B 0-1 or integer range
    - glColor3f(1.0 , 0.0 ,0.0)
    - glColor3b(127 , 0 , 0);
    - glColor3ub(255 , 0 , 0);
    - glColor3fv(rgbarray);
- Color can also contain transparency (alpha)
  - glColor4f(1.0 , 0.0 , 0.0 , 0.5);
  - Default alpha=1 (opaque)
- Stays in effect until you change color

# Indexed Color

- X11 Direct Color
  - Based on a colormap
- Set color using `glIndexi(27)`
- Need to load colors into color map using `glutSetColor()`
- Use RGB color unless hardware constrain
- Deprecated in OpenGL 3 since it really is obsolete

# Displaying a scene

- Register using `glutDisplayFunc()`
- `glClear()`
- *Draw Something*
- `glFlush()`
- `glutSwapBuffers()`
- Schedule using `glutPostRedisplay()`

# Transformations

- Transformation apply to everything that follows
- Transformations are cumulative
  - Call `glLoadIdentity()` in `display()`
- Primitive operations
  - `glLoadIdentity();`
  - `glTranslate[fd](dx , dy , dz)`
  - `glScale[fd](Sx , Sy , Sz)`
  - `glRotate[fd](angle , Ux , Uy , Uz)`
- Compatibility profile in OpenGL4 still useful



# glTranslate[fd](dx , dy , dz);

- Move an object in three dimensions
- Allows you to easily produce multiple copies of an object
- Always takes 3D coordinates (float or double)

# glScale[f](Sx , Sy , Sz)

- Change the scale along the axes
- Multiplicative factors
  - $|S| < 1$  shrink
  - $|S| > 1$  expand
  - Negative values creates mirror image
- Allows you to easily create multiple copies of the same type at different sizes

# `glRotate[fd](angle , Ux , Uy , Uz)`

- Rotates around the origin and axis (Ux,Uy,Uz)
- Angle is measured in degrees
- The axis often a primary axis, but may be any axis
  - Undefined behavior if  $Ux=Uy=Uz=0$
- Allows you to create multiple copies of the same object viewed from different sides, or to view the scene from different positions

# Temporary Transformations

- `glPushMatrix()`
  - Saves the current transformation
- `glPopMatrix()`
  - Resets the transformation to what it was when you did the push
- Allows you to build complex transformations and then get them back

# Compound Transformations

- Rotate angle around the point (X,Y,Z) and axis (Ux,Uy,Uz)
  - `glTranslated(-X,-Y,-Z)`
  - `glRotated(angle,Ux,Uy,Uz)`
  - `glTranslated(X,Y,Z)`
- OpenGL does this intelligently

# Projections

- Orthographic
  - `glOrtho(left,right,bottom,top,near,far)`
  - Same size regardless of distance
  - Easiest to use
- Perspective
  - `glFrustum(left,right,bottom,top,near,far)`
  - Closer objects are bigger
  - GLU convenience functions
    - `gluPerspective(fov,aspect,Znear,Zfar)`
    - `gluLookAt(Ex,Ey,Ez , Cx,Cy,Cz , Ux,Uy,Uz)`

# Text

- OpenGL provides only hooks for fonts
- Stroked fonts
  - Lines and fills write the characters
- Bitmap (raster) fonts
  - Characters are raster images
- Orientation, size, etc. treated just like any other drawing elements

# Text using GLUT

- `glutBitmapCharacter(GLUT_FONTTYPE,ch)`
  - Single character
  - Limited font selection
- `glRasterPos3d(x,y,z)`
  - Sets position to write text in (x,y,z) coordinates
- `glWindowPos2i(x,y)`
  - Sets position to write text in pixels coordinates



# Registering Callbacks

- Display
  - glutDisplayFunc() Draw the scene
  - glutReshapeFunc() Window resized
  - glutIdleFunc() Nothing more scheduled
- User input
  - glutKeyboardFunc() Key pressed
  - glutSpecialFunc() Special key pressed
  - glutMouseFunc() Mouse button
  - glutMotionFunc() Mouse motion
- Many more

# Keyboard Input

- `special(int key,int x,int y)`
  - Cursor keys `GLUT_KEY_LEFT`, `GLUT_KEY_UP`,...
  - Function keys `GLUT_KEY_Fx`
  - Basically anything not an ASCII key
- `keyboard(char ch,int x,int y)`
  - Regular ASCII keystrokes
- `(x,y)` is the mouse position in pixels

# Setting Modes

- `glutInitDisplayMode`
  - Interfaces with the window manager to get the right kind of window (BE CAREFUL ABOUT DEFAULTS)
- `glEnable()` & `glDisable()`
  - Switches OpenGL into various modes
    - `GL_DEPTH_TEST`
    - `GL_ALPHA_TEST`
    - `GL_CULL_FACE`
    - `GL_LIGHTING`
  - Different modes for different objects

# Checking for Errors

- OpenGL fails silently
- Functions do not return an error code
- `glGetError()` must be called explicitly to check for errors
- A black screen is a sure signal of an error