CS 248, Winter 2012

# OpenGL Fundamentals

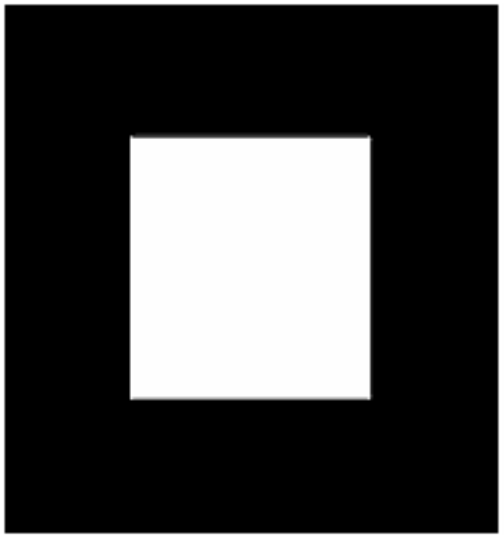
# Introduction

- OpenGL - draw primitives
- Procedural
- State machine
- Pipelined

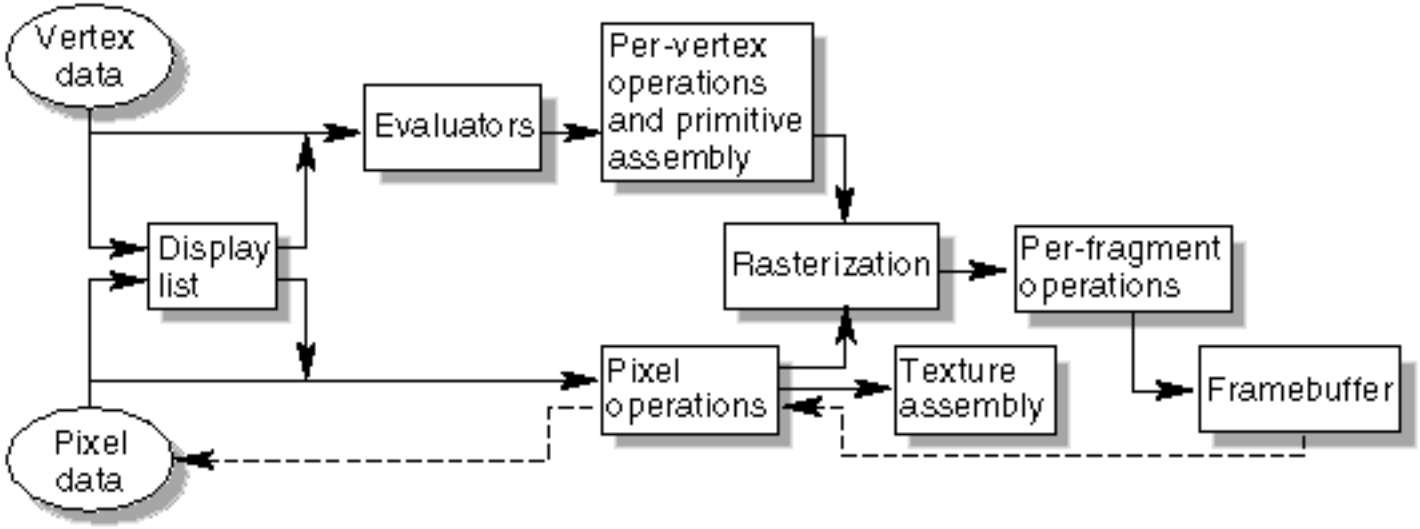
# OpenGL code

```
int main() {

   InitializeWindow();

   glClearColor (0.0, 0.0, 0.0, 1.0);
   glClear (GL_COLOR_BUFFER_BIT);
   glColor3f (1.0, 1.0, 1.0);
   glOrtho(0.0, 1.0, 0.0, 1.0, -1.0, 1.0);
   glBegin(GL_POLYGON);
      glVertex3f (0.25, 0.25, 0.0);
      glVertex3f (0.75, 0.25, 0.0);
      glVertex3f (0.75, 0.75, 0.0);
      glVertex3f (0.25, 0.75, 0.0);
   glEnd();
   glFlush();
   UpdateTheWindowAndCheckForEvents();
}
```

# OpenGL code



# OpenGL pipeline




http://glprogramming.com/red/chapter01.html

# Drawing Primitives

- glBegin(Glenum *mode*)
  - Beginning of a group of primitives
  - *mode*: GL_TRIANGLES, GL_QUADS, etc
- glVertex3f(GLfloat *x*, GLfloat *y*, GLfloat *z*)
  - Draw one vertex; must be after glBegin()!
- glEnd()
  - End of a group of primitives

# Drawing Primitives

- glColor3f(GLbyte *red*, GLbyte *blue*, GLbyte *green*)
  - Set the color for vertices drawn after the call
- glNormal3f(GLfloat *nx*, GLfloat *ny*, GLfloat *nz*)
  - Set the normal vector
- glTexCoord2f(GLfloat *s*, GLfloat *v*)
  - Set the texture coordinates

# Transformations

- glMatrixMode(GLenum *mode*)
  - Sets the current matrix
  - *mode:* GL_MODELVIEW, GL_PROJECTION
- glLoadIdentity()
  - Loads the identity matrix into the current matrix
- glLoadMatrixf(GLfloat **matrix*)
  - Loads an arbitrary matrix
  - *matrix:* An array of values in column-major form; elements from same column are contiguous
- glGetFloatv(GL_MODELVIEW_MATRIX, *matrix*)
- glGetFloatv(GL_PROJECTION_MATRIX, *matrix*)

# Transformations

- glMultMatrixf(GLfloat **matrix*)
  - Multiplies an arbitrary matrix with the current matrix
- glTranslatef(GLfloat *x*, GLfloat *y*, GLfloat *z*)
  - Multiplies the current matrix by a translation matrix
- glRotatef(GLfloat *angle*, GLfloat *x*, GLfloat *y*, GLfloat *z*)
  - Multiplies the current matrix by a rotation matrix
  - *x*, *y*, *z*: Vector to rotate around
  - *angle:* How much to rotate, in degrees
- glScalef(GLfloat *x*, GLfloat *y*, GLfloat *z*)
  - Scales along the x, y, and z axis

# Transformations

- glFrustum(GLfloat *left*, GLfloat *right*,
  GLfloat *bottom*, GLfloat *top*, GLfloat *near*,
  GLfloat *far*)
  - Multiplies the current matrix by a perspective matrix (more detail in next session)
  - Parameters set up a viewing frustum (clipped pyramid) representing the visible space
- glOrtho(GLfloat *left*, GLfloat *right*,
  GLfloat *bottom*, GLfloat *top*, GLfloat *near*,
  GLfloat *far*)
  - Similar to glFrustum(), but sets up an orthographic projection instead

# Matrix Stack

- glPushMatrix()
  - Pushes a copy of the current matrix down on the matrix stack
  - There is one matrix stack per mode; GL_PROJECTION and GL_MODELVIEW each have their own stack
- glPopMatrix()
  - Replaces the current matrix with the top of the stack, and then pops the stack

# Lighting

- glEnable(GL_LIGHTING)
  - Enable lighting
- glEnable(GL_LIGHT*X*)
  - Enable light X
- glLightfv(GL_LIGHTo, GL_AMBIENT, GLfloat **params*)
- glLightfv(GL_LIGHTo, GL_SPECULAR, GLfloat **params*)
- glLightfv(GL_LIGHTo, GL_DIFFUSE, GLfloat **params*)
  - Sets the ambient, diffuse, specular light for light #o
  - *params:* 4-vector: [red, green, blue, alpha]

# Lighting

- glLightfv(GL_LIGHTo, GL_POSITION, GLfloat *_params_)
  - Sets the light position or direction
  - *params:* 4-vector: [x, y, z, point?]; if last argument is non-zero then the light is a point light

- glMaterialfv(GL_FRONT, GL_AMBIENT, GLfloat *params)
- glMaterialfv(GL_FRONT, GL_SPECULAR, GLfloat *param)
- glMaterialfv(GL_FRONT, GL_DIFFUSE, GLfloat *params)
  - Sets the ambient, diffuse, and specular material colors
  - *params:* 4-vector: [red, blue, green, alpha]

- glMaterialf(GL_FRONT, GL_SHININESS, GLfloat param)
  - Sets the hardness/shininess (size of specular highlights)

# Other

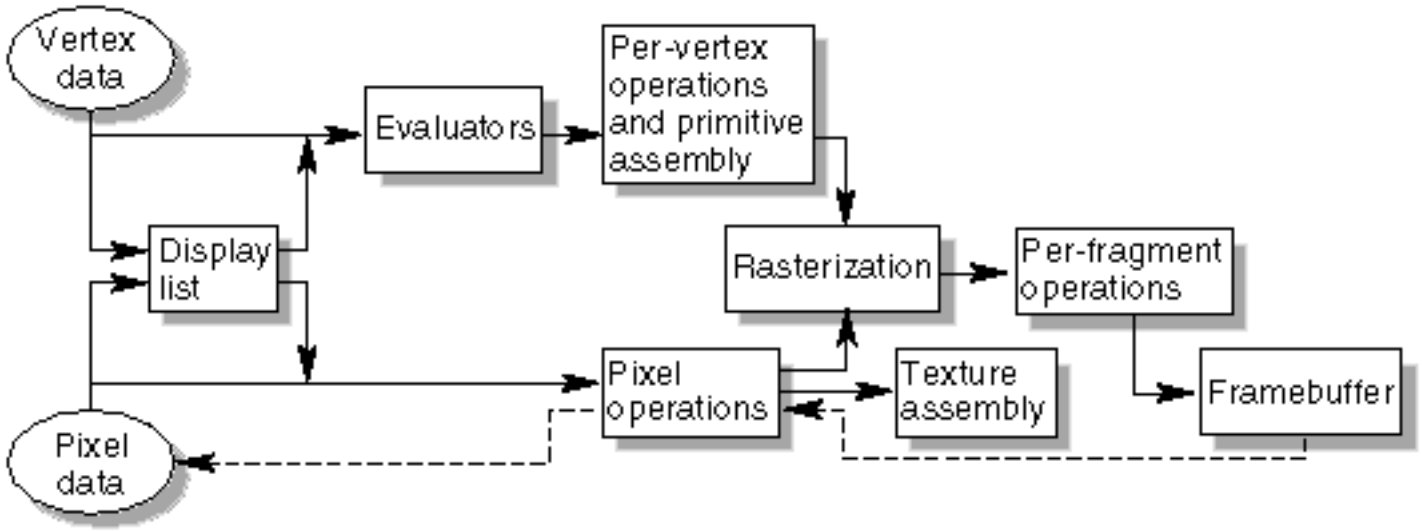
- glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT)
  - Must call at the beginning of each frame
- glEnable(GL_DEPTH_TEST)
  - Enable depth-testing using depth buffer

# Other

- These functions let you draw from arrays, rather than using glColor, glVertex, etc.
  - glEnableClientState(GL_VERTEX_ARRAY)
  - glEnableClientState(GL_NORMAL_ARRAY)
  - glEnableClientState(GL_COLOR_ARRAY)
  - glVertexPointer()
  - glNormalPointer()
  - glColorPointer()
  - glDrawArrays()

# Programmable pipeline

- Programmable pipeline
- Shaders for per vertex, per pixel operations



# Libraries

- GLU
- GLUT - OpenGL Utility Toolkit (glutCreateWindow, etc.)