GLSL Primer
(for version 3.3)

CS334

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GLSL Data Types

- Scalar types: `float, int, bool`
- Vector types: `vec2, vec3, vec4`
  `ivec2, ivec3, ivec4`
  `bvec2, bvec3, bvec4`
- Matrix types: `mat2, mat3, mat4`
- Texture sampling: `sampler1D, sampler2D, sampler3D, samplerCube`
- C++ Style Constructors

```
vec3 a = vec3(1.0, 2.0, 3.0);
mat4 b = mat4(5.0);  // fill the diagonal with 5.0
```

Operators

- Standard C/C++ arithmetic and logic operators
- Overloaded operators for matrix and vector operations

```
mat4 m;
vec4 a, b, c;

b = a*m;
c = m*a;
```

Components and Swizzling

- Access vector components using either:
  - [ ] (c-style array indexing)
  - `xyzw`, `rgba` or `strq` (named components)

- For example:

```
vec3 v;
```

`v[1], v.y, v.g, v.t` - all refer to the same element

- Component swizzling:

```
vec3 a, b;
a.xy = b.yx;
```

Qualifiers

- `in`, `out`
  - Copy vertex attributes and other variable into and out of shaders

```
in  vec2 texCoord;
out vec4 color;
```

- `uniform`
  - shader-constant variable from application

```
uniform float time;
uniform vec4 rotation;
```

Functions

- Built in
  - Arithmetic: `sqrt, pow, abs`
  - Trigonometric: `sin, asin, radians`
  - Graphical: `length, reflect, dot, normalize`
- User defined

Built-in Variables

- `gl_Position`
  - (required) output position from vertex shader
  - Receive homogeneous vertex position
- `gl_FragCoord`
  - input fragment position
- `gl_FragDepth`
  - input depth value in fragment shader

Simple Vertex Shader for Cube Example


```
#version 330 core

in vec4 vPosition;
in vec4 vColor;

out vec4 color;

void main()
{
    color = vColor;
    gl_Position = vPosition;
}
```

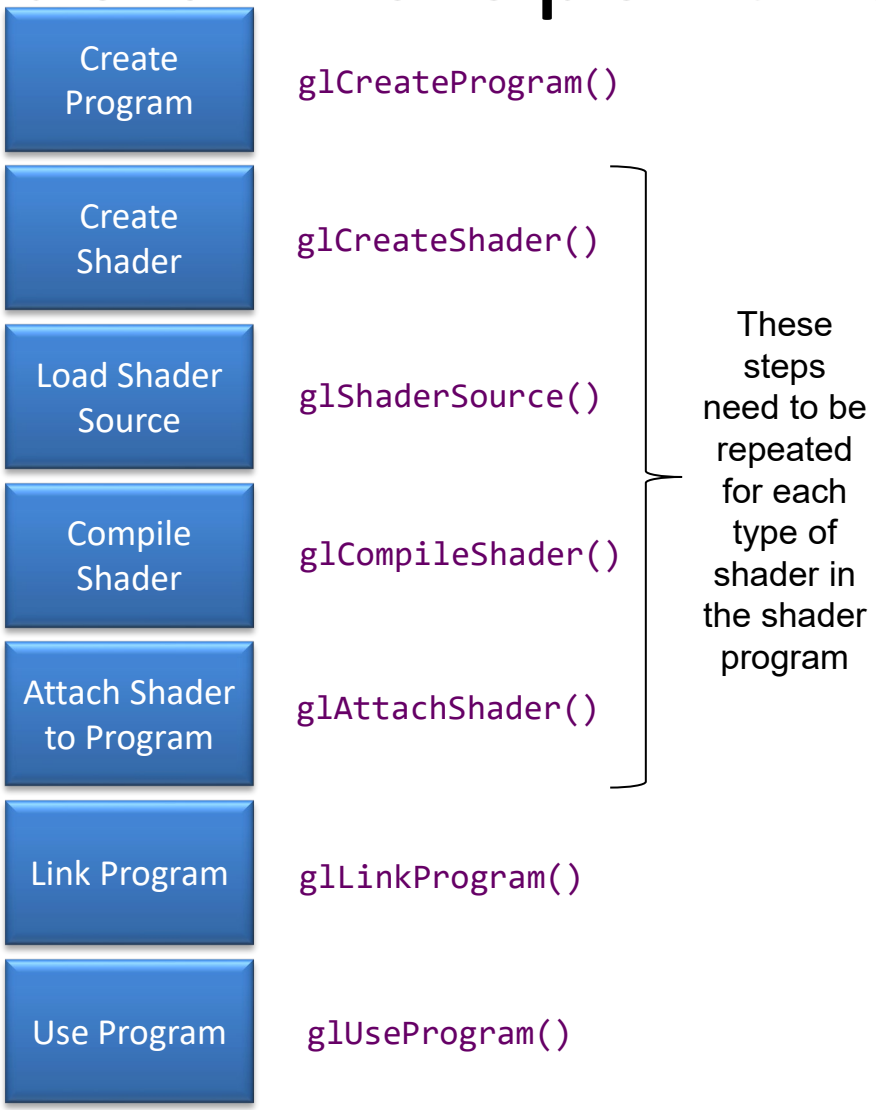
The Simplest Fragment Shader


```
#version 330 core

in vec4 color;

out vec4 fColor; // fragment's final color

void main()
{
    fColor = color;
}
```

Note: gl_FragColor used to be the output color but that is deprecated in the latest version…

Getting Your Shaders into OpenGL

- Shaders need to be compiled and linked to form an executable shader program
- OpenGL provides the compiler and linker
- A program must contain
  - vertex and fragment shaders
  - other shaders are optional



Associating Shader Variables and Data

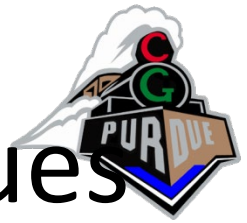
- Need to associate a shader variable with an OpenGL data source
  - vertex shader attributes → app vertex attributes
  - shader uniforms → app provided uniform values
- OpenGL relates shader variables to indices for the app to set
- Two methods for determining variable/index association
  - specify association before program linkage
  - query association after program linkage

Determining Locations After Linking

- Assumes you already know the variables' names

```
GLint loc = glGetAttribLocation(
program, “name” );

GLint loc = glGetUniformLocation(
program, “name” );
```

Initializing Uniform Variable Values



- Uniform Variables

```
glUniform4f( index, x, y, z, w );

GLboolean  transpose = GL_TRUE;

// Since we're C programmers
GLfloat  mat[3][4][4] = { … };
glUniformMatrix4fv( index, 3, transpose,
mat );
```

A Cube Program


```
int main( int argc, char **argv )
{
    glutInit( &argc, argv );
    glutInitDisplayMode( GLUT_RGBA | GLUT_DOUBLE |GLUT_DEPTH );
    glutInitWindowSize( 512, 512 );
    glutCreateWindow( "Color Cube" );

    glewInit();
    init();

    // Setup SHADERS
    // ...
    // ...

    glutDisplayFunc( display );
    glutKeyboardFunc( keyboard );
    glutMainLoop();

    return 0;
}
```

Cube Program's GLUT Callbacks


```
void display( void )
{
    glClear( GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT );
    glDrawArrays( GL_TRIANGLES, 0, NumVertices );
    glutSwapBuffers();
}

void keyboard( unsigned char key, int x, int y )
{
    switch( key ) {
        case 033: case 'q': case 'Q':
            exit( EXIT_SUCCESS );
            break;
    }
}
```

Vertex Shader Examples

- A vertex shader is initiated by each vertex output by `glDrawArrays()`
- A vertex shader must output a position in clip coordinates to the rasterizer
- Basic uses of vertex shaders
  - Transformations
  - Lighting
  - Moving vertex positions

Demos

- http://glslsandbox.com/