CPSC 436D
Video Game Programming

OpenGL/Shaders

Opengl RENDERING PIPELINE

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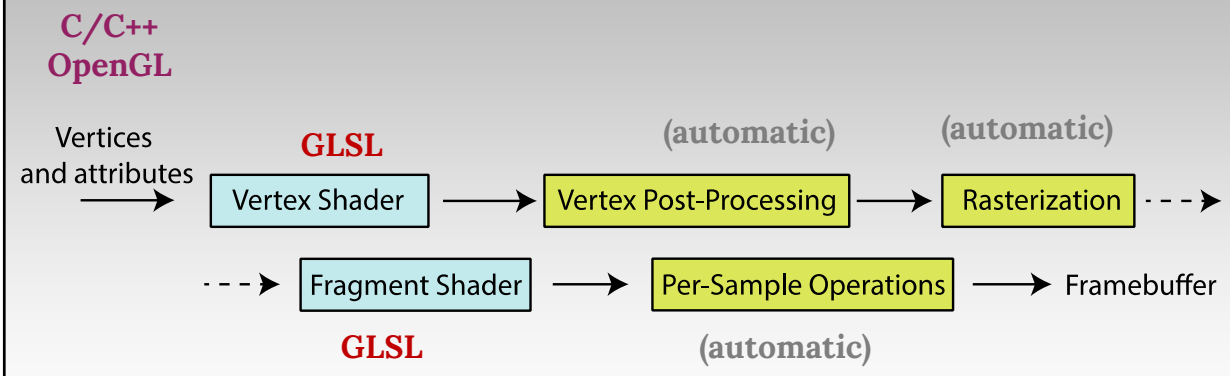


openGL

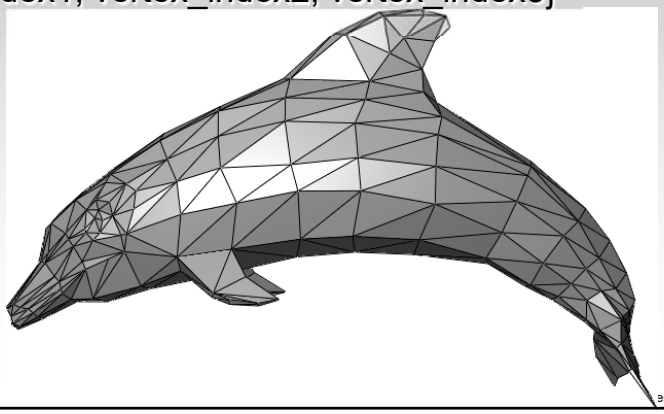
- Low-level graphics API
- C Interface accessed from C++

- Mesh: **Vertex Buffers** and **Index Buffers**
- Materials: **Shaders**, **Textures**, **Samplers** and **Uniforms**
- Camera: **(View)** and **(Projection)** matrices

GEOMETRY

Triangle meshes

- Set of vertices
- Triangle defines as {vertex_index1, vertex_index2, vertex_index3}

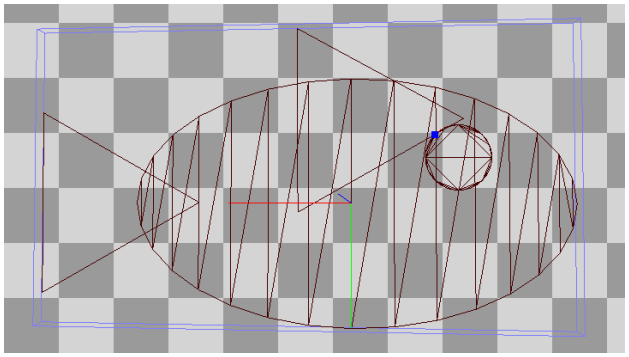


```
vertices[0].position = { -0.54, +1.34, -0.01 };
vertices[1].position = { +0.75, +1.21, -0.01 };
..
vertices[150].position = { -1.22, +3.59, -0.01 };

uint16_t indices[] = { 0, 3, 1,.. , 152, 150 };
Gluint ibo, vbo;
glGenBuffers(vbo);
glBindBuffer(vbo);
glBufferData(vbo, vertices);

glGenBuffers(ibo);
glBindBuffer(ibo);
glBufferData(ibo, indices);
```

GEOMETRY
C/C++ OPENGL



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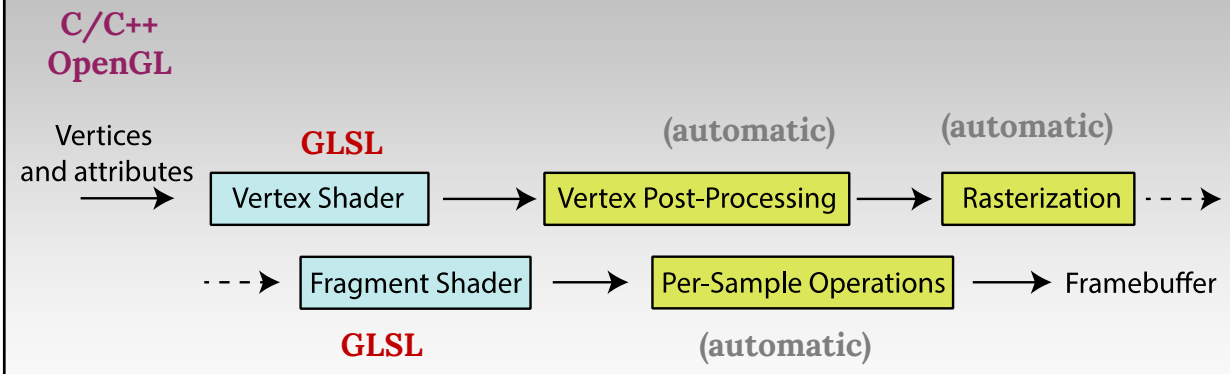
Opengl RENDERING PIPELINE



GLSL

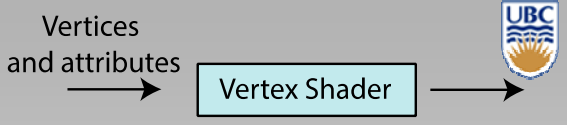
OpenGL shading language

Used for Fragment and Vertex shaders

Lots of useful stuff:

- vec3, vec4, dvec4, mat4, sampler2D
- mat*vec, mat*mat
- Reflect, refract
- vec3 v(a.xy, 1)

Vertex Shader



- Called SEPARATELY for each vertex
- Default: No connectivity info
- **Input:** vertex coordinates in Object Coordinate System
- **Main goal:** set **gl_Position**

Object coordinates -> WORLD coordinates -> VIEW coordinates

FRAGMENT SHADER

- ***Common Tasks:***
  - texture mapping
  - per-pixel lighting and shading
- ***Fragment Shader = Pixel Shader***

Minimal Vertex Shader

```
void main()
{
    // Transforming The Vertex
    vec3 out_pos = projection * transform * vec3(in_pos.xy, 1.0);
    gl_Position = vec4(out_pos.xy, in_pos.z, 1.0);
}
```


Minimal Vertex Shader

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    // Transforming The Vertex
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Passed from C++

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Passed from C++

$$\begin{pmatrix} x \\ y \\ z \\ (w) \end{pmatrix}$$

Minimal Vertex Shader

```
void main()
{
    // Transforming The Vertex
    vec3 out_pos = projection * transform * vec3(in_pos.xy, 1.0);
    gl_Position = vec4(out_pos.xy, in_pos.z, 1.0);
}
```

Passed from C++

View coordinate system

$$\begin{pmatrix} x \\ y \\ z \\ (w) \end{pmatrix}$$

Minimal Fragment Shader

```
void main()
{
    // Setting Each Pixel To ???
    gl_FragColor = vec4(1.0, 0.0, 0.0, 1.0);
}
```


Minimal Fragment Shader

```
void main()
{
    // Setting Each Pixel To ???
    gl_FragColor = vec4(1.0, 0.0, 0.0, 1.0);
}
```

Red, Green, Blue, Alpha

Vertex SHADER – Example 2

```
uniform float uVertexScale;
in vec3 vColor;  // attribute in older GLSL versions
out vec3 fColor; // varying in older GLSL versions

void main()
{
      gl_Position = vec4(position.x * uVertexScale, position.y, 0.0,1.0);
      fColor = vColor;
}
```


Variable Types

uniform

- same for all vertices

out (varying)

- computed per vertex, automatically interpolated for fragments

In (attribute)

- values per vertex
- available only in Vertex Shader

CREATING SHADER OBJECTS

```
vertexShader = glCreateShader(GL_VERTEX_SHADER);
glShaderSource(vertexShader, 1, sourceCode, sourceCodeLength);
fragmentShader = glCreateShader(GL_FRAGMENT_SHADER);
glShaderSource(fragmentShader, 1, sourceCode, sourceCodeLength);
```

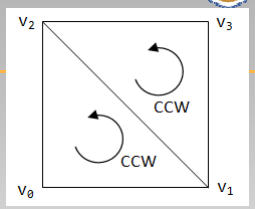
COMPILING

```
glCompileShader(vertexShader); glCompileShader(fragmentShader);
```


LINKING

```
program = glCreateProgram();
glAttachShader(program, vertexShader);
glAttachShader(program, fragmentShader);
glLinkProgram(program);
```

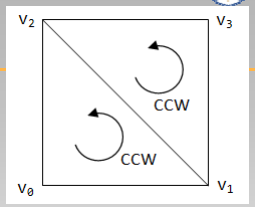
SPRITES: CREATION



Create Quad Vertex Buffer

```
VertexPosTexCoord vertices[] = { v0, v1, v2, v3 };
glGenBuffers(1, &vbo);
glBindBuffer(GL_ARRAY_BUFFER, vbo);
glBufferData(GL_ARRAY_BUFFER, vertices_size, vertices,
GL_STATIC_DRAW);
```


SPRITES: CREATION



Create Quad Index Buffer

```
uint16_t indices[] = { 0, 1, 2, 1, 3, 2 };
glGenBuffers(1, &ibo);
glBindBuffer(GL_ELEMENT_ARRAY_BUFFER,ibo);
glBufferData(GL_ELEMENT_ARRAY_BUFFER, indices_size,
indices, GL_STATIC_DRAW);
```

Load Texture

```
glGenTextures(1, &id);
glBindTexture(GL_TEXTURE_2D, id);
glTexImage2D(GL_TEXTURE_2D, GL_RGBA, width, height, .., data);
```

SPRITES: RENDERING

Bind Buffers

```
glBindVertexArray(vao);
glBindBuffer(GL_ARRAY_BUFFER, vbo);
glBindBuffer(GL_ELEMENT_ARRAY_BUFFER, ibo);
```

Enable Alpha Blending

```
glEnable(GL_BLEND);
glBlendFunc(GL_SRC_ALPHA, GL_ONE_MINUS_SRC_ALPHA); // Alpha
Channel Interpolation
```


SPRITES: RENDERING

Bind Texture

```
glActiveTexture(GL_TEXTURE0);
glBindTexture(GL_TEXTURE_2D, turtle_texture.id);
```

Draw

```
glDrawElements(GL_TRIANGLES, 6, ..); // Number of
Indices
```