COMP220: Graphics & Simulation

2: Shader programs

Learning outcomes

By the end of this session, you should be able to:

- **Explain** the role of shaders in graphics programming
- **Distinguish** the roles of the vertex shader and the fragment shader
- **Write** simple shader programs in GLSL

Agenda

- Lecture / live coding: experimenting with shaders
- Exercise - Working with OpenGL and Shaders

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Assignments Reminder

Assignment 1

- Part A - Friday 5pm Week 3 - (feedback given in class)
- Worksheet A - Friday 5pm Week 4 (pull request)
- Worksheet B - Friday 5pm Week 7 (pull request)
- Worksheet C - Friday 5pm Week 9 (pull request)
- Worksheet D - Friday 5pm Week 12 (pull request)
- Final Handin - 7th of January 5pm (Learning Space)

Assignment 2

- Part A - Week 3 Workshop session (In class)
- Part B - 16th November 5pm (Learning Space)
- Part C - Viva 8th of January 5pm (Viva session)

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GLSL

OpenGL Shading Language (GLSL)

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OpenGL Shading Language (GLSL)

- Used for writing **shaders** for OpenGL applications
- C-like syntax
- GLSL compiler is part of the **graphics driver** on the **end user's machine**
  - Yes, you need to ship your shader source code with your game!

Basic vertex shader

```
#version 330 core

layout(location = 0) in vec3 vertexPos;

void main()
{
    gl_Position.xyz = vertexPos;
    gl_Position.w = 1.0;
}
```

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- Tells the compiler to use OpenGL 3.3 core functionality

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- Specifies **input values** to the vertex shader
- Corresponds with layout of **vertex buffers** in C++ program

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- Every shader program must define a `void main()` function

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- `gl_Position` is one of many **built-in** variables with special meaning
- See `https://www.opengl.org/wiki/Built-in_Variable_(GLSL)`

Basic fragment shader

```
#version 330 core

out vec3 color;

void main()
{
    color = vec3(1, 1, 0);
}
```

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- By convention, fragment shader should have **one output**, namely the fragment colour
- Doesn't have to be named `color` — could be any other non-reserved identifier

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- No `class`

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- **Arrays** of constant size e.g. `float myArray[10]`
- There's no such thing as **pointers** in GLSL (hooray!)

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- Used to represent **points** or **directions** in *n* dimensions
- Also used to represent e.g. colours in RGB(A) space

Constructing vectors in GLSL

```
vec2 a = vec2(1.2, 3.4);
vec3 b = vec3(1); // same as vec3(1, 1, 1)
vec3 c = vec3(a, 5.6); // same as vec3(1.2, 3.4, 5.6)
```

Vector maths

Vector maths

Most operations work **component-wise**:

```
vec2 a = vec2(1, 2);
vec2 b = vec2(3, 4);
vec2 c = a + b; // c == vec2(4, 6);
vec2 d = a * b; // d == vec2(3, 8);
```

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vec2 c = a + b; // c == vec2(4, 6);
vec2 d = a * b; // d == vec2(3, 8);
```

Can also multiply a **vector** by a **scalar**:

```
vec2 e = 3.1 * a; // e == vec2(3.1, 6.2)
```

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```
vec4 a = vec4(1, 2, 3, 4);
float b = a.y; // b == 2
float c = a.z; // c == 3
a.x = 5;       // a == vec4(5, 2, 3, 4)
a.w = a.y;     // a == vec4(5, 2, 3, 2)
```

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a.x = 5;       // a == vec4(5, 2, 3, 4)
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```

Can also use `r g b a` (for colours) and `s t p q` (for texture coordinates)

Swizzling

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```
vec4 a = vec4(1, 2, 3, 4);
vec2 b = a.xy;     // b == vec2(1, 2)
vec3 c = a.zyz;    // c == vec3(3, 2, 3)
a.xw = vec2(5,6); // a == vec4(5, 2, 3, 6)
a.xyzw = a.wzyx;   // a == vec4(6, 3, 2, 5)
```

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- Swizzling is generally **faster** than the equivalent code without swizzling

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```

- **Can** use the same component twice in the **right-hand side** of an assignment
- **Cannot** use the same component twice in the **left-hand side** of an assignment
- Swizzling is generally **faster** than the equivalent code without swizzling
- Can also use `r g b a` or `s t p q`, but can't mix them (e.g. `.gbr` is valid but `.gzx` is not)

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Variables in GLSL

Passing values from the application to the shader

There are two ways:

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- **Vertex attributes**

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- **Uniform variables**

Passing values from the application to the shader

There are two ways:

- **Vertex attributes**
  - Different values for each vertex
  - More on this later in the module
- **Uniform variables**
  - Constant across one `glDraw...` call

Uniform variables

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In GLSL (outside `main()`):

```
uniform vec3 myVariable;
```

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uniform vec3 myVariable;
```

In C++:

```
GLuint location
  = glGetUniformLocation(programID, "myVariable");
```

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uniform vec3 myVariable;
```

In C++:

```
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```

and then:

```
glUniform3f(location, 1, 2, 3);
```

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- Uniforms can be any GLSL type...
- ... but you must use the `glUniform...` function that matches the type

Passing values from the vertex shader to the fragment shader

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Define an `out` variable in the vertex shader:

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Define an `in` variable **of the same name** in the fragment shader:

Passing values from the vertex shader to the fragment shader

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```

Define an `in` variable **of the same name** in the fragment shader:

```
in vec4 myVariable;
```

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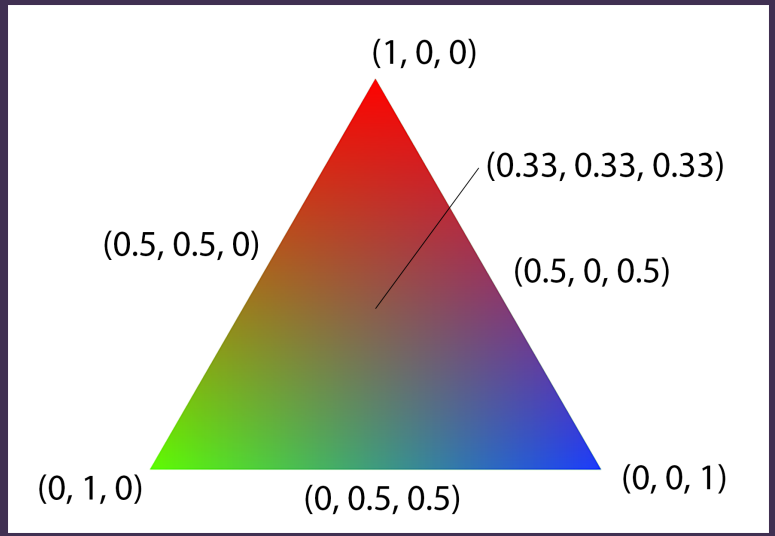

Exercise 1 - Shaders

- Make sure you can compile and run the demos from last week
- Bring in the shader loading code from the following - `http://www.opengl-tutorial.org/beginners-tutorials/tutorial-2-the-first-triangle/`
- Add in a basic Vertex and Fragment shader based on the above link
- Compile and run the application

Exercise 2 - Working with Uniform Variables

- Add in a Uniform variable to the fragment shader, this should be a vec4 representing the colour of the triangle
- Send the colour across from the Application side (C++), you can use an array of floats or GLM Library to represent the colour on the C++ side
- Compile and run the application