COMP3320 Introduction to OpenGL

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Based on the work provided at www.learnopengl.com

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Vertex Attributes

- Allows us to specify auxiliary data for each vertex
- Specify offset and stride using ☞ glVertexAttribPointer
- An example specifying vertex colour information

```
    float vertices[] = {
         0.5f, -0.5f, 0.0f,  1.0f, 0.0f, 0.0f,
        -0.5f, -0.5f, 0.0f,  0.0f, 1.0f, 0.0f,
         0.0f,  0.5f, 0.0f,  0.0f, 0.0f, 1.0f };
```

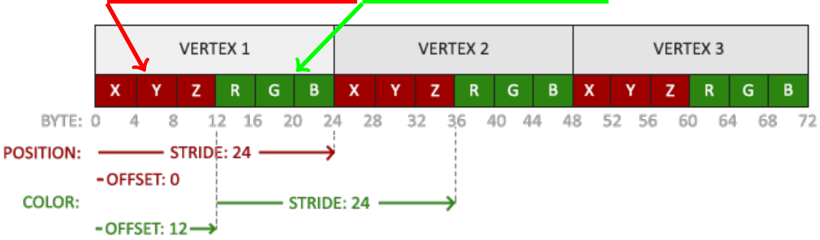
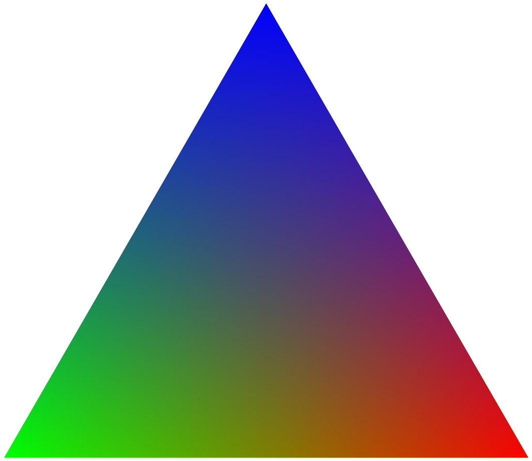

VERTEX 1
VERTEX 2
VERTEX 3
X Y Z R G B X Y Z R G B X Y Z R G B
BYTE: 0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72
POSITION:
STRIDE: 24
OFFSET: 0
COLOR:
STRIDE: 24
OFFSET: 12

Figure: Image sourced from learnopengl.com/Getting-started/Shaders

Vertex Attributes

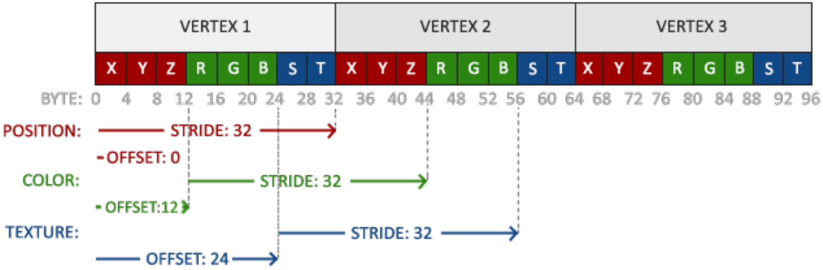
Result should look like this



Textures

- Rather than using colours to add detail to an object, use an image
- Easier to add a lot of detail to an object
- To apply a texture we just need to assign texture coordinates to each vertex

```
float vertices[] = {
     0.5f, -0.5f, 0.0f,   1.0f, 0.0f, 0.0f,   1.0f, 0.0f,
    -0.5f, -0.5f, 0.0f,   0.0f, 1.0f, 0.0f,   0.0f, 0.0f,
     0.0f,  0.5f, 0.0f,   0.0f, 0.0f, 1.0f,   0.5f, 1.0f };
```



VERTEX 1
VERTEX 2
VERTEX 3
X Y Z R G B S T X Y Z R G B S T X Y Z R G B S T
BYTE: 0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72 76 80 84 88 92 96
POSITION:
STRIDE: 32
OFFSET: 0
COLOR:
STRIDE: 32
OFFSET:12
TEXTURE:
STRIDE: 32
OFFSET: 24

Figure: Image sourced from `learnopengl.com/Getting-started/Textures`

Texture Wrapping

- Texture coordinates range from $(0, 0) \rightarrow (1, 1)$
- What should happen if coordinates outside this range are specified?

Examples

Specify texture wrapping behaviour using ☞ `glTexParameteri`

Examples

Specify texture border colour using ☞ `glTexParameterfv`

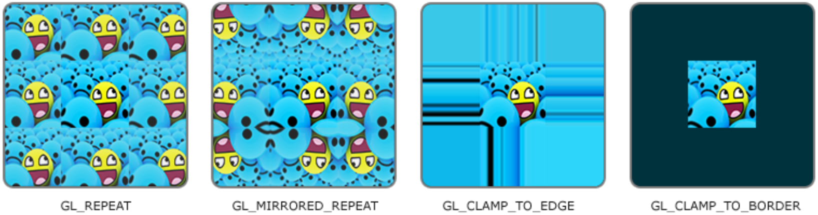


Figure: Image sourced from `learnopengl.com/Getting-started/Textures`

Texture Filtering

- Floating-point coordinates are mapped to integer coordinates
- What should happen if texture coordinates have a fractional component? For example, $(0.75, 0.0) \to (480.3, 300)$
- Behaviour can be specified for both minifying and magnifying operations

Examples

Specify texture filtering behaviour using ☞ `glTexParameteri`

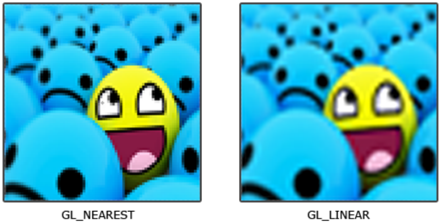


Figure: Image sourced from `learnopengl.com/Getting-started/Textures`

MipMaps

- No need to use a high resolution image to texture an object a long distance away
- Can also result in undesirable artifacts on small objects
- The solution?
    - Create multiple scaled down versions of the high resolution image
    - Select a different scaled down texture based on the distance from the camera
- Behaviour can be specified for both minifying and magnifying operations

Examples

OpenGL will generate mipmaps for you. Use ☞ `glGenerateMipmaps`

MipMaps

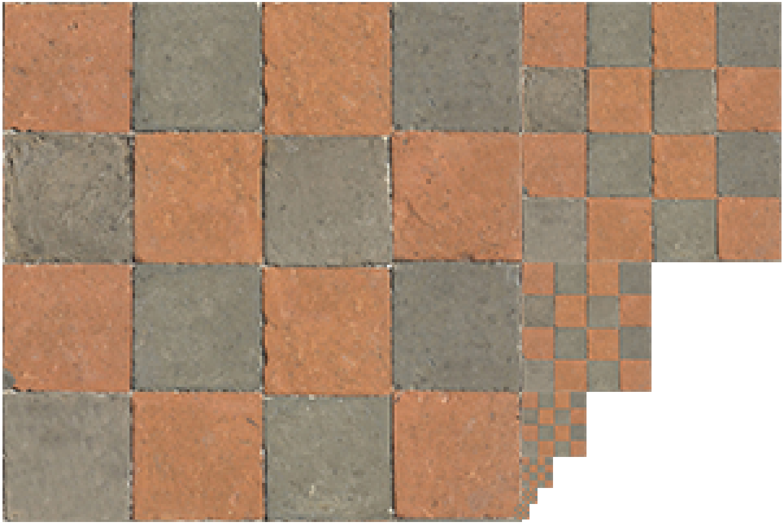


Figure: Image sourced from `learnopengl.com/Getting-started/Textures`

Loading Textures

- A number of C/C++ libraries available for loading images
- SOIL is a common library specifically targetting OpenGL

Examples

Generate a OpenGL texture object using ☞ `glGenTextures`

Examples

Bind a texture object and make it the active texture using ☞ `glBindTexture`

Examples

Use ☞ `glTexImage2D` to attach the raw texture data to the currently active texture unit. After this you can delete any pointers to your raw texture data

Texture Units

- Multiple textures can be used in a single program
- Each texture needs to be attached to a different texture unit

Examples

Query `GL_MAX_TEXTURE_IMAGE_UNITS` using ☞`glGetIntegerv` to find the maximum available on your hardware

Examples

Use ☞`glActiveTexture` to select currently active texture unit

Textures

Result should look like this

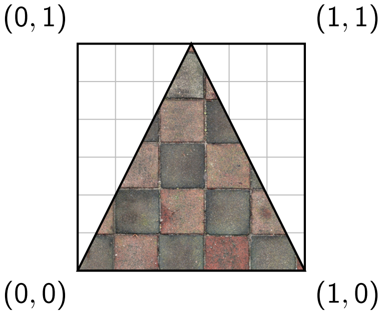


Figure: Brick wall image sourced from `learnopengl.com/Getting-started/Textures`