



COMP220: Graphics & Simulation
08: Post-processing

Learning outcomes

- ▶ **Understand** Post-processing in computer graphics
- ▶ **Implement** graphical effects from COMP120 in realtime
- ▶ **Implement** other Post-processing effects in your application

Introduction



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- ▶ We then use a shader to implement a post-processing effect
- ▶ We then map the processed texture onto a full screen quad, which is rendered to the backbuffer

Rendering To Texture



Brief Overview

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3. Create a Framebuffer Object (FBO)
4. Bind the texture and the Depth Buffer Object into the FBO
5. Bind the FBO to the pipeline
6. Render the scene to the new framebuffer

Creating a Texture

```
//The texture we are going to render to
GLuint renderTextureID;
 glGenTextures(1, &renderTextureID);

//Bind Texture
 glBindTexture(GL_TEXTURE_2D, renderTexture);

//fill with empty data
 glTexImage2D(GL_TEXTURE_2D, 0, GL_RGB, 840, 680, 0, ←
 GL_RGB, GL_UNSIGNED_BYTE, 0);

//Add any texture states (filtering etc)
```

Creating Depth Buffer Object

```
//The depth buffer
GLuint depthBufferID;
 glGenRenderbuffers(1,&depthBufferID);

//Bind the depth buffer
 glBindRenderbuffer(GL_RENDERBUFFER, depthBufferID) ←
 ;
 //Set the format of the depth buffer
 glBindRenderbufferStorage(GL_RENDERBUFFER, ←
 GL_DEPTH_COMPONENT, 840, 680);
```

Creating Frame Buffer

```
//The framebuffer
GLuint frameBufferID;
 glGenFramebuffers(1,&frameBufferID);
```



Bind Texture and Depth Buffer

```
//Bind the framebuffer
glBindFramebuffer(GL_FRAMEBUFFER, frameBufferID);

//Bind the texture as a colour attachment 0 to the ←
//active framebuffer
glFramebufferTexture(GL_FRAMEBUFFER, ←
    GL_COLOR_ATTACHMENT0, renderTextureID, 0);

//Bind the depth buffer as a depth attachment
glFramebufferRenderbuffer(GL_FRAMEBUFFER, ←
    GL_DEPTH_ATTACHMENT, GL_RENDERBUFFER, ←
    depthBufferID);

if (glCheckFramebufferStatus(GL_FRAMEBUFFER) != ←
    GL_FRAMEBUFFER_COMPLETE)
{
    //error message!
}
```

Render to Framebuffer

```
//Bind the framebuffer
glBindFramebuffer(GL_FRAMEBUFFER, frameBufferID);

//Drawn everything as normal!
```

Using Our Texture



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- ▶ We need to map this texture onto a surface
- ▶ This is usually a screen-aligned quad, but it can be any 3D object!
- ▶ In the fragment shader, we can do some processing

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2. Create a Vertex Array Object (VAO)
3. Load in a 'pass through' Vertex Shader and a Fragment shader which takes in a texture
4. Render the quad and send across the texture that was bound to the framebuffer

Creating our Vertex Buffer Object

```
float vertices[] =
{
    -1, -1,
    1, -1,
    -1, 1,
    1, 1,
};

GLuint screenQuadVBOID;
 glGenBuffers(1, &screenQuadVBOID);
 glBindBuffer(GL_ARRAY_BUFFER, screenQuadVBOID);
 glBufferData(GL_ARRAY_BUFFER, 8 * sizeof(float), ←
    vertices, GL_STATIC_DRAW);
```

Creating our Vertex Array

```
GLuint screenVAOID;  
glGenVertexArrays(1, &screenVAOID);  
 glBindVertexArray(screenVAOID);  
 glBindBuffer(GL_ARRAY_BUFFER, screenQuadVBOID);  
  
 glEnableVertexAttribArray(0);  
 glVertexAttribPointer(0, 2, GL_FLOAT, GL_FALSE, 0, ←  
 NULL);
```

Pass Through Vertex Shader

```
#version 330 core

layout(location=0) in vec2 vertexPosition;

out vec2 textureCoords;

void main()
{
    //Calculate Texture Coordinates for the Vertex
    textureCoords = (vertexPosition + 1.0) / 2.0;
    gl_Position = vec4(vertexPosition, 0.0, 1.0);
}
```

Example Fragment Shader

```
#version 330 core

out vec4 color;
in vec2 textureCoords;

uniform sampler2D texture0;

void main()
{
    //Read the texture and do some processing!
    color = texture(texture0, textureCoords);
}
```

Rendering

```
glBindFramebuffer(GL_FRAMEBUFFER, 0);  
glBindVertexArray(screenVAOID);  
  
//Bind our Postprocessing Program  
  
//Send across any values to the shader  
  
//Draw the quad!
```

Live Coding

Post Processing Setup

COMP120 Refresher



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- ▶ Some of the algorithm you learned in COMP120 can be applied to GLSL
- ▶ The only difference is we don't use an array to access the pixel data
- ▶ Remember that a Texture Lookup uses the texture coordinates passed to the fragment shader
- ▶ Additionally, the fragment shader only processes a one fragment at a time

COMP120 Techniques

- ▶ Colour Replacement
- ▶ Luminance calculation
- ▶ Colour Correction
- ▶ Black & White and Sepia Tone
- ▶ Edge Detection

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- ▶ Remember we can't access a pixel array, we use the texture coordinates
- ▶ If we want to access a pixel adjacent to the current one, we can offset the current texture coordinates
- ▶ This is especially useful for edge detection
- ▶ Lastly, GLSL has lots of inbuilt functions (e.g distance) which can aid in creating post-processing effects

Other Post Processing Techniques



Colour Correction

some text here some text
here some text here some
text here some text here



Colour Correction Again

some text here some text
here some text here some
text here some text here



Motion Blur

some text here some text
here some text here some
text here some text here



Depth of Field

some text here some text
here some text here some
text here some text here



Bloom

some text here some text
here some text here some
text here some text here



Debrief



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- ▶ Essentially we keep rendering to a texturing using different fragment shaders each time
- ▶ These could be stored in a data structure such as a stack
- ▶ Once we have completed the last effect on the stack, we then switch to normal rendering and display the result

Exercise



Exercise 1 - COMP120 Algorithms

Implement the following algorithms:

1. Colour replacement
2. Black & white
3. Sepia Tone
4. Posterisation

Exercise 2 - Other Effects

Implement the following algorithms:

1. Blur (if you have camera controls, try to also implement motion blur)
2. Screen tear (hint. You will need to animate the texture coordinates using time)
3. Screen Static (hint. You will need some noise and the current time)