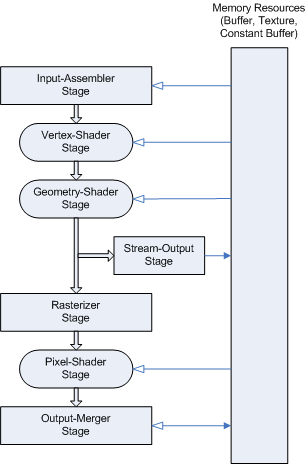
**Report**

Computer shaders are programmes used to render scenes and they run on the GPU. With the help of shaders, the stages of the graphics pipeline can be controlled. They can be programmed in assembly language or shading languages, like HLSL. Graphics APIs, like DirectX and OpenGL support shaders. Before shaders there was a fixed function pipeline, which wasn’t possible to program. It was based on user provided configuration and lacked flexibility. (Heergarden, 2011; OpenGL)

A screenshot of a cell phone

Description automatically generated

Figure 1: Fixed function pipeline (Bailey and Cunningham, 2009)

Figure 2: Programmable pipeline (Microsoft, 20218)

There are three main types of shaders: vertex shader, pixel shader and geometry shader. (Heergarden, 2011)

Vertex shaders operate on each vertex. It is used to transform the vertex’s 3D position into 2D viewport space. Normal mapping, manipulating textures and the position of the vertices can be done in the vertex shader too. (OpenGL, Bailey and Cunningham, 2009, Heergarden, 2011)

Pixel shaders (or fragment shaders) operate on each pixel. It can calculate the colour and transparency of each pixel, calculate lighting, shadows, and depth of field. (Bailey and Cunningham, 2009)

Geometry shaders can generate new primitives from the primitives that were sent to it. It is optional. (OpenGL) It was introduced in DirectX 10. (Anguelov, 2011)

**Techniques used in my shaders:**

The camera can be controlled with WASD and the arrow keys.

**Lighting**

There are 5 point lights and one spot light in the scene.

There are three types of light effects.

The parts of a models that is pointing towards the light is lit by **diffuse light**.

**Ambient light** lights everything evenly to a constant colouor.

**Specular light** is a reflection of the light source. It creates a shiny reflection on smooth surfaces.

The effect of all the lights is calculated in the pixel shader.

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Ambient light is defined in Scene.cpp.

Pulsating light

This pulsating effect is done in the UpdateScene function. By using a boolean and increasing and decreasing the strength of the light and the size of the flare model.

A screen shot of a social media post

Description automatically generated

Colour cycling light

The colour of the light is continuously updated in the UpdateScene function. The RGB values are changed gradually, so that it cycles through all values.

Point light

Light is emitting in all directions from a single point. There is attenuation with distance. The calculation of the lighting effects is done in the pixel shader (ShadowMapping\_ps).

Spot light

Light is constrained to a cone. A pixel will only be lit if it is insid the light cone. The calculations are done in the pixel shader (ShadowMapping\_ps).

**Changing texture colours**

(Cube\_vs, Cube\_ps)

Two textures are fading from one to the other on a cube.

A screen shot of a person

Description automatically generatedTwo diffuse maps have to be passed to the shader. In the pixel shader the lerp function blends the textures. Both textures have to be used in the lighting calculation.

**Wiggling Sphere**

(Sphere\_ps, Sphere\_vs)

A sphere model is performing a wiggling motion while the texture is rotating.

“*Very trippy.*”

* a friend

The vertices of the model are manipulated in the vertex shader using sin and cosine to achieve the pulsating motion. The wiggle variable is used to control the speed.

A screenshot of a cell phone

Description automatically generated

The texture coordinates are scrolled in the pixel shader to make the sphere appear rotating.

A close up of a clock

Description automatically generated

**Blending**

(Blending\_ps)

Blending combines the viewport pixels with the source pixels.

**Additive**

Additive blending can be used for a lightening effect. Can be used for lights, fire etc.

The equation: ***Final.Red = Bitmap.Red + Viewport.Red***

I implemented the additive blending state in State.cpp.

A screen shot of a computer

Description automatically generated

Then I set the blending state before rendering the model in Scene.ccp

**Multiplicative**

Multiplicative blending can be used for a darkening effect, good for glass, smoke and shadow.

The equation: ***Final.Red = Source.Red \* Destination.Red***

Implementation in State.cpp

A screen shot of a person

Description automatically generated

And setting the blending state in Scene.cpp



**Alpha Testing**

(AlphaTesting\_ps, contains a certain purple man)

It allows us to check the alpha value of polygons before rendering. A cut-out effect can be achieved. Sorting problems don’t affect it as they do alpha blending.

Alpha testing can be done in the pixel shader.

A screenshot of a cell phone

Description automatically generated

Before rendering the right pixel shader has to be set.

The alpha testing cube can be controlled with I-J-K-L.

**Specular Map**

(Specular\_ps, Specular\_vs)

It is used to adjust the shininess of a surface. It can control how much specular light affects areas. A specular map and diffuse map can be stored together. In that case the specular map is stored in the alpha channel so it can’t be used for transparency.

**Normal Mapping**

(NormalMapping\_ps, NormalMapping\_vs, the bigger cube in the scene)

This is a light effect that creates the illusion of bumpiness on a model. It requires a normal map in addition to the base texture.

A screen shot of a computer

Description automatically generatedThe normals have to be transformed on to the mesh. The calculations are done in the pixel shader:

Both the normal map and the diffuse specular map have to be sent to the shader before rendering and the right shaders have to be set.

A close up of a sign

Description automatically generated

**Parallax Mapping**

(Parallax\_ps, Parallax\_vs, the smaller cube in the scene)

This effect creates bumpiness but also depth on the model. It needs a height map which is stored in the alpha channel of the normal map. The normal map has to be sent to the shader.

The calculations are done in the pixel shader:

A screenshot of a cell phone

Description automatically generated

A picture containing photo, black, red, sign

Description automatically generatedThe right shaders also have to be set before rendering.

**Normal mapping and changing texture colours combined**

(Change\_ps, changes from purple to yellow, next to big normal map cube)

In this case two diffuse maps and a normal map has to be passed to the shader, and we need to make sure that they are in the right slot.

The same calculations are done in the pixel shader as with a *normal* normal map. The two textures have to be blended with the lerp function.

In the light calculation both textures need to be used.

A screen shot of a person

Description automatically generated

**Cell Shading**

(CellShading\_ps, CellShadingOutline\_ps, CellShadingOutline\_vs)

A cartoon effect can be achieved with this. The model is rendered twice. First, a slightly bigger, inside-out black model for the outline, and then the coloured version. The colours are narrowed to a smaller set of values.

**Dynamic Shadow mapping**

(ShadowMapping\_ps, ShadowMapping\_vs)

Allows to cast a shadow from moving models. First, the scene has to be rendered from the light’s point of view to a texture. Then the scene is rendered normally and each pixel is checked against the shadow map. According to the map the pixel gets diffuse or specular lighting or is not lit if it’s in the shadow.

The calculations are done in the pixel shader. The setup and rendering is in Scene.cpp

A screenshot of a cell phone

Description automatically generated

**Cube mapping**

(CubeMap\_ps)

Cube mapping can be used to make a skybox or to create environment reflections on a model. For static cube mapping an environment map is needed, which consists of six images taken 90 degrees apart horizontally and then up and down.

A picture containing clock

Description automatically generated

Figure 3. Environment map (Richards, 2013)

Cube maps cannot be sampled using the UVs, instead a 3D lookup vector is needed which originates from the centre of the cube map. This is done in the pixel shader:



**Improvements**

I would like to implement dynamic environment mapping. Instead of a premade cube map it uses a dynamically created cube map that updates every frame.

Environment refraction would be something interesting to work on. It works the same way as static or dynamic cube mapping, but different calculations are needed that take Snell’s law into account.

Lighting could be added to the wiggling sphere model. A directional light could also be added.

The cube mapping sphere should definitely be made shinier. A skybox could be added so it looks like a reflection.

Did you find the Toblerone?

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