GAM250: Advanced Games Programming

3: Graphics Programming

Learning outcomes

- **Understand** the modern Programmable Graphics Pipeline
- **Understand** Unity's Material System
- **Write** shaders in Unity

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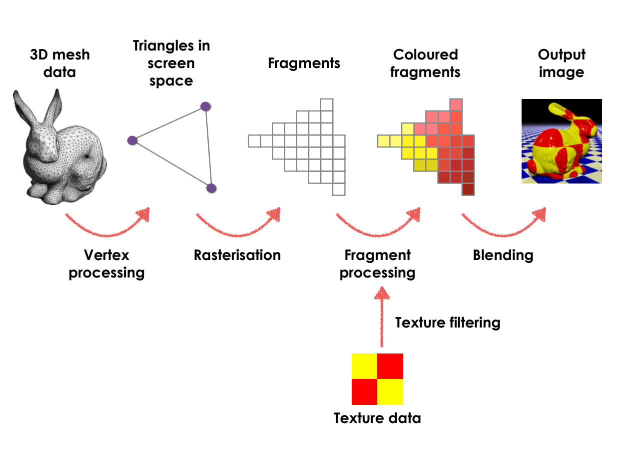
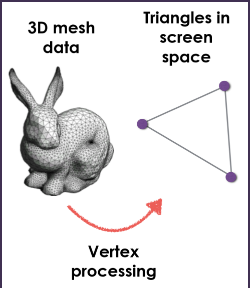
The Graphics Pipeline

The 3D graphics pipeline



Vertex processing



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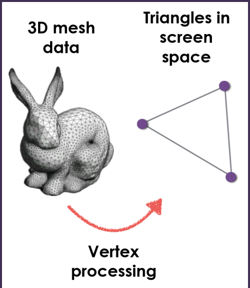

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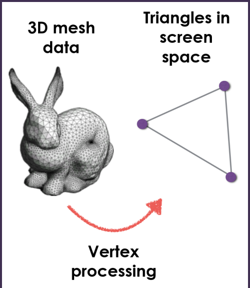

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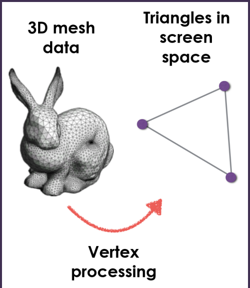

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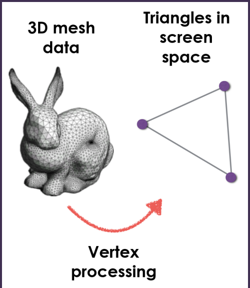

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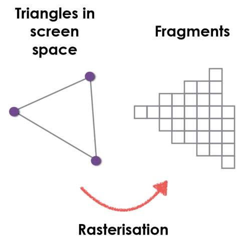
- May also apply particle simulations, skeletal animations or deformations, etc.

Rasterisation



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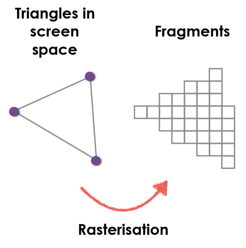

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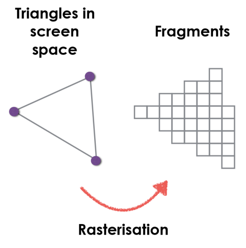

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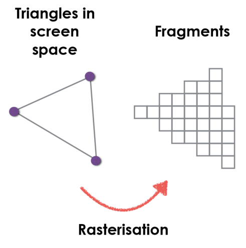

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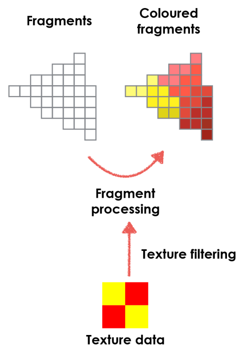
- Vertex processor can associate **data** with each vertex; this is **interpolated** across the fragments

Fragment processing



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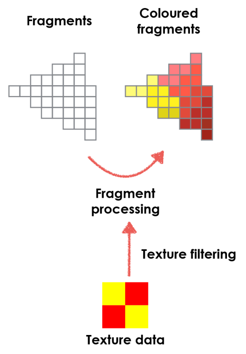

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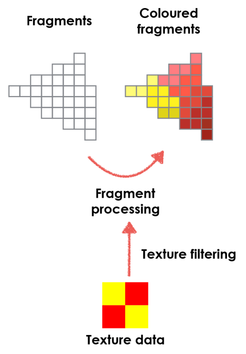

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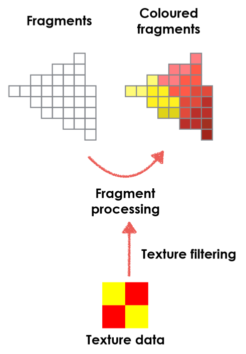

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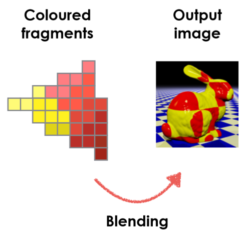
- Colour is calculated based on **texture**, **lighting** and other properties of the surface being rendered (e.g. shininess, roughness)

Blending



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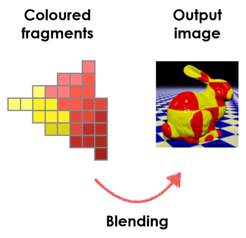

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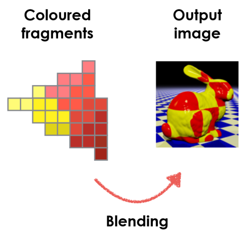

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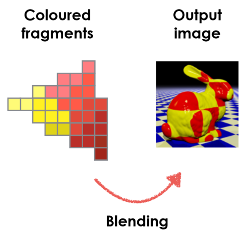

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- **Alpha blending**: combine the old and new colours for a semi-transparent appearance

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- **Fragment shader**: responsible for the visual appearance of the surface
- Vertex shader and fragment shader are separate programs, but the vertex shader can pass arbitrary values through to the fragment shader

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Subsurface Shaders

Shaders in Unity

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- Regardless of the shader type, your code will be wrapped in ShaderLab

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  - SubShaders - Is a list of pass or the surface shader code itself

Shading Languages

High Level Shading Language (HLSL)

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- But has data types that support mathematical operations

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- No `class`

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- **Arrays** of constant size e.g. `float myArray[10]`

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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

```
float3 a = float3(1.2, 3.4);
float3 b = float3(1); // same as float3(1, 1, 1)
float3 c = float3(a, 5.6); // same as float3(1.2, 3.4, 5.6)
```

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Most operations work **component-wise**:

```
float2 a = float2(1, 2);
float2 b = float2(3, 4);
float2 c = a + b; // c == float2(4, 6);
float2 d = a * b; // d == float2(3, 8);
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Can also multiply a **vector** by a **scalar**:

```
float2 e = 3.1 * a; // e == float2(3.1, 6.2)
```

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float4 a = float4(1, 2, 3, 4);
float b = a.y; // b == 2
float c = a.z; // c == 3
a.x = 5;       // a == float4(5, 2, 3, 4)
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Can also use `r g b a` (for colours) and `t u v w` (for texture coordinates)

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float3 c = a.zyz;    // c == float3(3, 2, 3)
a.xw = float2(5,6); // a == float4(5, 2, 3, 6)
a.xyzw = a.wzyx;   // a == float4(6, 3, 2, 5)
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- Can also use `r g b a` or `t u v w`, but can't mix them (e.g. `.gbr` is valid but `.gzx` is not)

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  - Cube Map - **samplerCube**

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- These are important for optimisation for mobile

Surface Shader

Live Coding

Exercise 1 - Surface Shaders

- Map two textures onto an object
- Tint the object with a colour
- Animate the texture coordinates for one of the textures
- Implement a dissolve effect

Exercise 2 - Surface Shader (Vertex Shader)

- Add a vertex shader to the Surface Shader, ensure it carries out the standard transformation
- Extrude the mesh based on the Vertex Normals
- Animate this extrusion based

Further Reading

- Shaders Overview - `https://docs.unity3d.com/Manual/ShadersOverview.html`
- Gentle Introduction to Shaders - `http://www.alanzucconi.com/2015/06/10/a-gentle-introduction-to-shaders-in-unity3d/`
- Learning Shaders - `https://www.alanzucconi.com/2018/01/03/learning-shaders/`
- HLSL Language Syntax - `https://msdn.microsoft.com/en-us/library/windows/desktop/bb509615(v=vs.85).aspx`
- HLSL Intrinsic Functions - `https://msdn.microsoft.com/en-us/library/windows/desktop/ff471376(v=vs.85).aspx`