GAM250: Advanced Games Programming

4: Graphics Programming

Learning outcomes

- **Understand** the modern Programmable Graphics Pipeline
- **Understand** Unity's Material System
- **Write** Surface and Image Effect Shaders in Unity

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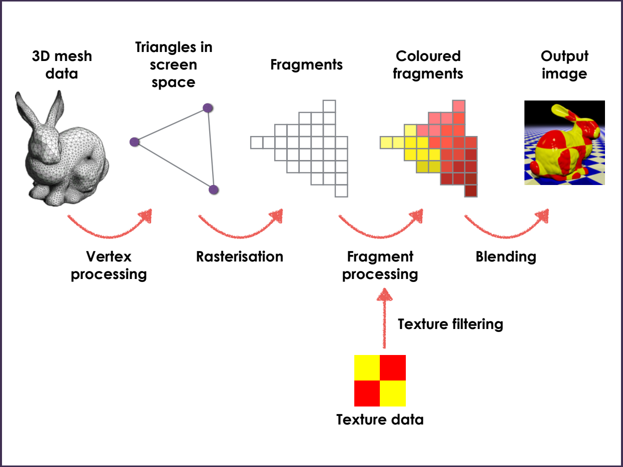
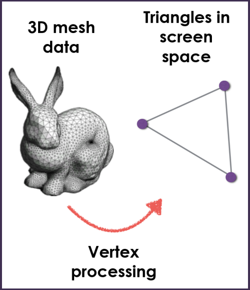
The Graphics Pipeline

The 3D graphics pipeline



Vertex processing



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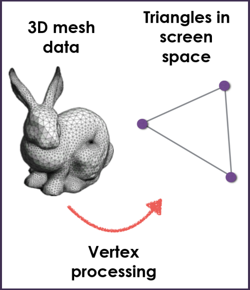

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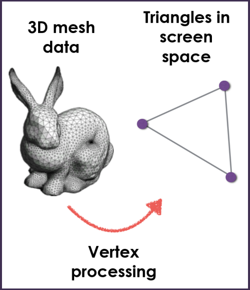

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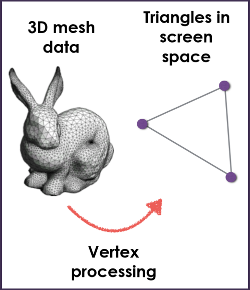

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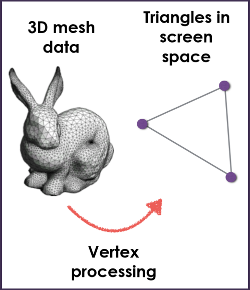

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- May also apply particle simulations, skeletal animations or deformations, etc.

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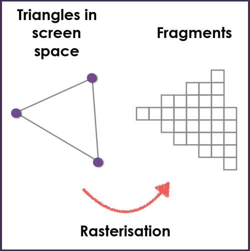

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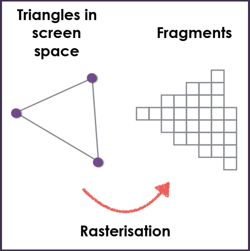

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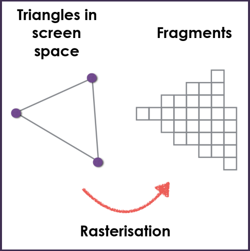

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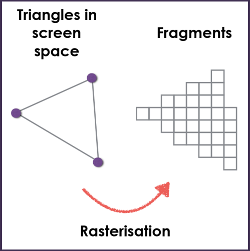

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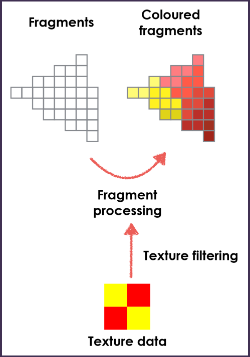
- Vertex processor can associate **data** with each vertex; this is **interpolated** across the fragments

Fragment processing



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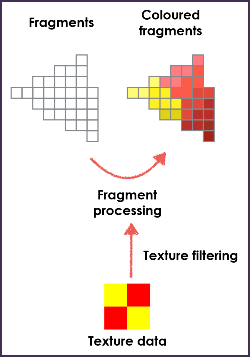

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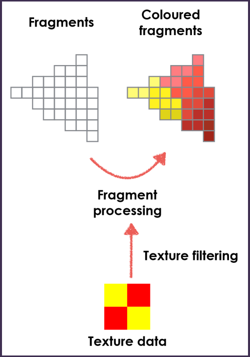

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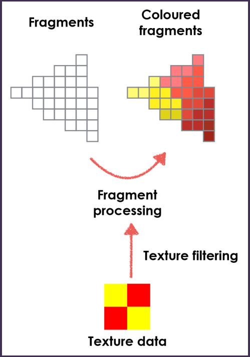

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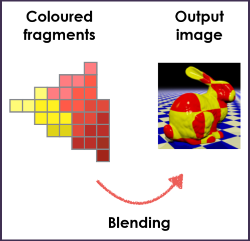
- Colour is calculated based on **texture**, **lighting** and other properties of the surface being rendered (e.g. shininess, roughness)

Blending



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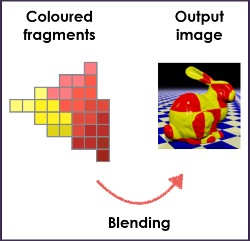

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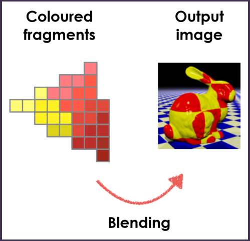

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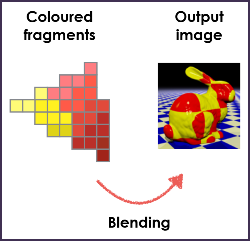

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- **Alpha blending**: combine the old and new colours for a semi-transparent appearance

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- Vertex shader and fragment shader are separate programs, but the vertex shader can pass arbitrary values through to the fragment shader

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**:

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    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
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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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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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  - Cube Map - **samplerCube**

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Surface Shader

Live Coding

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- Attach the script to the camera

Post-Processing Live Coding

Further Reading

- Game Programming Patterns - `http://gameprogrammingpatterns.com/contents.html`
- Game Programming Patterns in Unity - `http://www.habrador.com/tutorials/programming-patterns/`
- Unity Design Patterns - `https://github.com/Naphier/unity-design-patterns`