COMP220: Graphics & Simulation

1: The graphics pipeline

Learning outcomes

By the end of today's session, you will be able to:

- **Recall** the key stages of the graphics pipeline
- **Explain** the differences between a CPU and a GPU
- **Write** basic programs using SDL and OpenGL

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Course introduction

From the module guide

This module will introduce you to the techniques of 3D graphics rendering and physics simulation used in modern computer games. Using the OpenGL library, you will develop an understanding of the 3D graphics pipeline, and how to program the GPU to produce advanced graphical effects.

Topic schedule

On LearningSpace...

Assignment 1: Portfolio task

First worksheet is due in week 4.

Assignment 2: Research journal/Mathematics Library

Work as a group on it **in parallel** to your portfolio task!
First component due in week 3.

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Don't forget to update the wiki!

Graphics and simulation hardware

CPUs vs GPUs

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  - Optimised for performing the same calculation on several thousand vertices or pixels at once

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Rock Solid · Heart Touching
PhysX P1
PCI
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Accelerate the New Reality in Gaming Physics

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- Ageia acquired in 2008 by Nvidia...
- Now PhysX is Nvidia's middleware for performing physics simulation on the GPU

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- Deep learning

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- Most general-purpose game engines (e.g. Unity, Unreal) support several graphics APIs
- On this module we will use **OpenGL** (but the principles are transferable)

The 3D graphics pipeline

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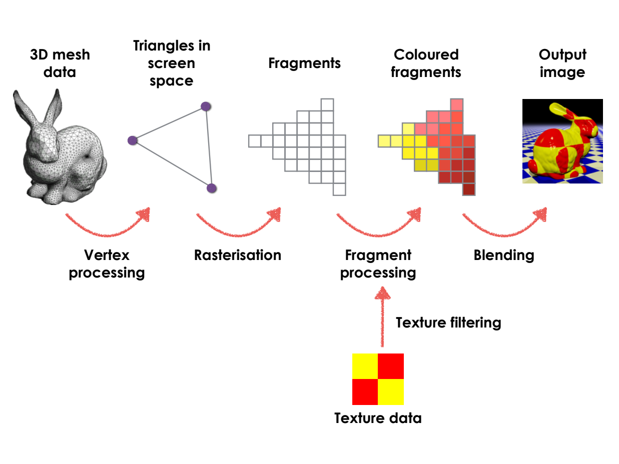
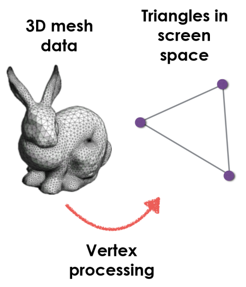


Vertex processing



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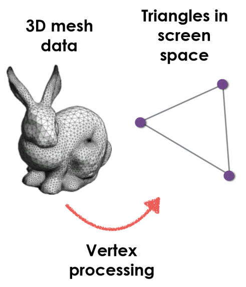

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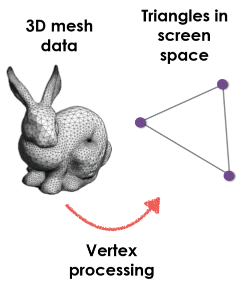

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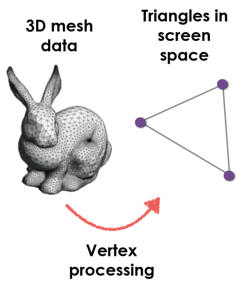

3D mesh data

Triangles in screen space

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- Vertex processor **transforms** (rotates, moves, scales) vertices and **projects** them into 2D screen space (*x*, *y*)

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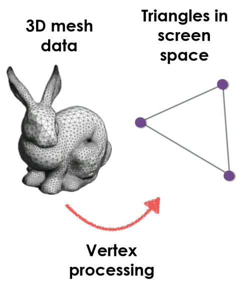

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- ► May also apply particle simulations, skeletal animations or deformations, etc.

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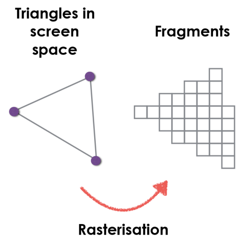

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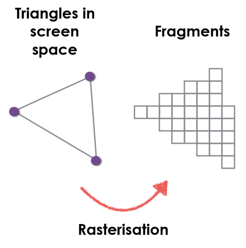

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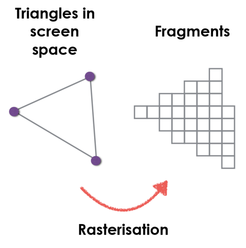

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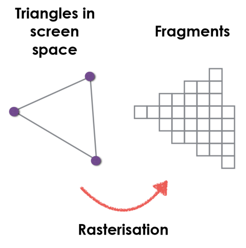

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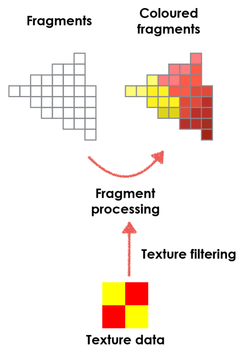
- In practical terms, "fragment" = "pixel"
- Vertex processor can associate **data** with each vertex; this is **interpolated** across the fragments

Fragment processing



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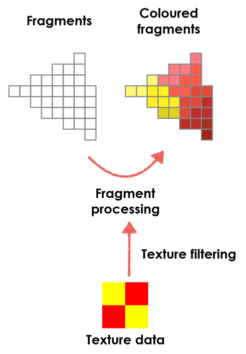

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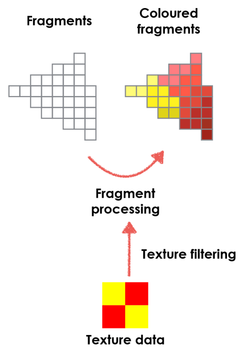

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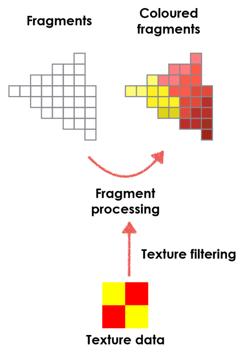
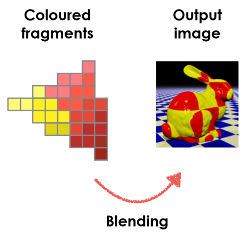


- Determine the **colour** of each fragment covered by the triangle
- **Textures** are 2D images that can be **wrapped** onto a 3D object
- Colour is calculated based on **texture**, **lighting** and other properties of the surface being rendered (e.g. shininess, roughness)

Blending



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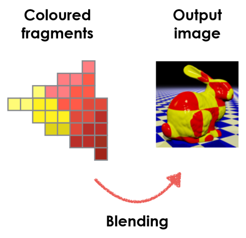

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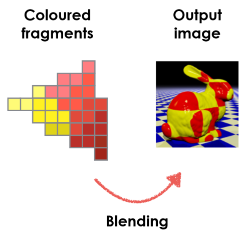

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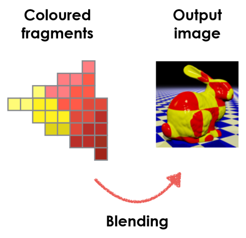

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- **Alpha blending**: combine the old and new colours for a semi-transparent appearance

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- **Vertex shader**: responsible for geometric transformations, deformations, and projection
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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

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Your first OpenGL program

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- We will use our old friend **SDL**

Live coding

https://github.com/Falmouth-Games-Academy/bsc-live-coding

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- ... but we do need `SDL_GLContext`

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With OpenGL:

```
glClearColor(1.0f, 0.5f, 0.0f, 1.0f);
glClear(GL_COLOR_BUFFER_BIT);
SDL_GL_SwapWindow(window);
```

Our first triangle

http://www.opengl-tutorial.org/beginners-tutorials/tutorial-2-the-first-triangle/

Debrief

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