CS4533 Lecture 5 Slides/Notes

Programmable Shaders and Shader-Based OpengGL
(Handout, Ch 1, 6, Appendix A)

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CS4533 Handout: Programmable Shaders and Shader-Based OpenGL

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Programmable Shaders and Shader-Based OpenGL: Overview

Old OpenGL (before version 3.1) v.s. **Shader-Based OpenGL** (version 3.1 and later) --- 2 major differences

1. Standard way of rendering geometric primitives (points, polygons, etc.):

Immediate mode

```
display(){
   …
 glBegin()
   glVertex()
   …
 glEnd()
```

Repeat for each frame:
the geometric data of all objects are sent to GPU for rendering

Slow

Vertex buffer objects (VBO)

Initially, data of each geom. obj is organized into a VBO and **sent to GPU once** then stored in GPU.

In each frame, send **a few transf. matrices** to GPU to operate on the stored VBOs

Much Faster

*** Data transfer between CPU & GPU is the speed bottleneck!**

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Programmable Shaders and Shader-Based OpenGL: Overview (cont.)

Old OpenGL (before version 3.1) v.s. **Shader-Based OpenGL** (version 3.1 and later) --- 2 major differences

2. Processing Pipeline:

Fixed-Function Commands	**Programmable Shaders**
(fixed functions, software support)	(programmable GPU, hardware support)
	Much more flexible & powerful (for tasks done, effects achieved, etc) and much faster

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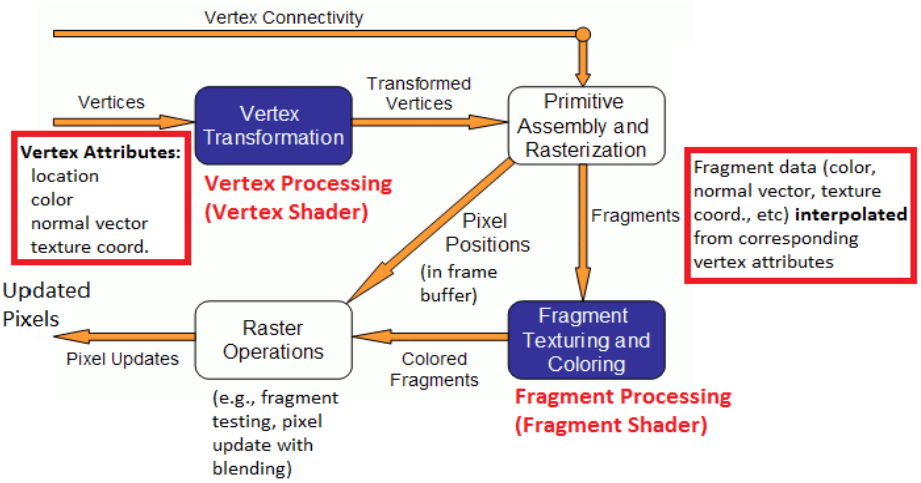
OpenGL Processing Pipeline



* Programmable shaders/GPU language support: assembly -> high-level (Cg -> GLSL)
* **OpenGL + GLSL = Shader-Based OpenGL**

OpenGL Commands to Set Up Shaders (inside an OpenGL Program)

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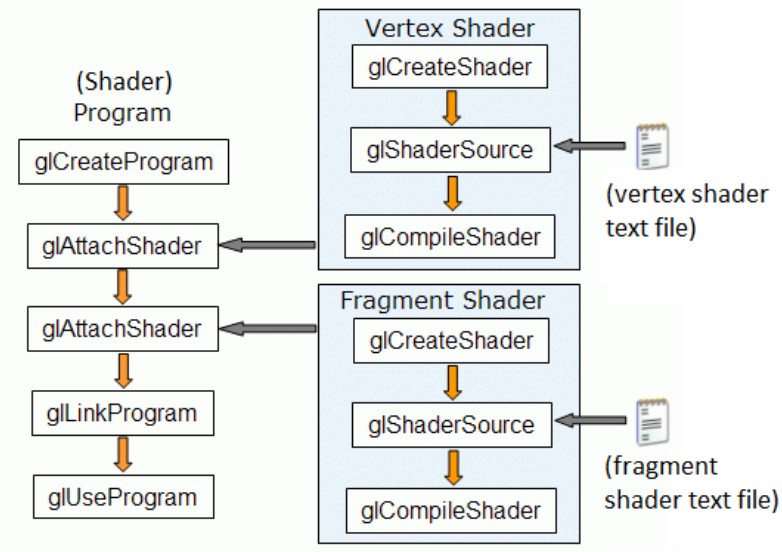

* Each shader is read & compiled & linked **at run time** of an OpenGL program.

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Introduction to GLSL

- Very similar to C, but functions can not make recursive calls (i.e., **no recursions**).
- Data types: int, float, etc. **New:** vec2, vec3, vec4, mat2, mat3, mat4 (e.g., mat4: 4 x 4 matrix, each element is a float).
- E.g., vec4 t;

t.x = t.r = t.s = t[0]
t.y = t.g = t.t = t[1]
t.z = t.b = t.p = t[2]
t.w = t.a = t.q = t[3]

Position: (x, y, z, w)
Color: (r, g, b, a)
Texture Coord.: (s, t, p, q)

Note: Texture coord. are (s, t, r, q) but r is already used in (r, g, b, a)
➔ Replace r with p, and thus (s, t, p, q).

- Each vertex/fragment shader must have one main( ) function.
- Vertex (frag.) shader is excecuted for each vertex (frag.).
- Shader min output: vertex: **gl_Position**; frag.: **color** of current frag.

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GLSL: Variable Types

1. **Attribute Variables:** Global, read-only, in vertex shader.
   * For vertex attributes. Only used in vertex shader.
   * Declared as "in" in vertex shader (e.g., in vec4 vPosition;).
   * Variable values are **set up/retrieved** from **vertex buffer obj.** (see Handout sample code for more details).

2. **Uniform Variables:** Global, read-only, used in both shaders.
   * For quantities/items whose values **stay the same across different vertices/fragments** (e.g.,
   uniform mat4 model-view;
   uniform float time;).
   (See Handout sample code for more details).

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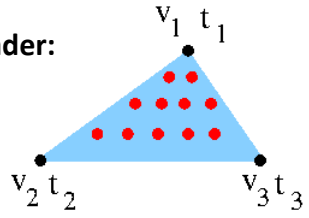
GLSL: Variable Types (cont.)

3. **Varying Variables:**
   * To communicate between vertex & fragment shaders.
   * Declared as "out" (output/writing) in vertex shader, and declared as "in" (input, read-only) in fragment shader, with the same variable name.

E.g. In vertex shader:	**In fragment shader:**
out float t;	in float t;



* Assign value in vertex shader, and then **interpolate** from vertices to obtain the value at each fragment as the **input** to the fragment shader for that fragment.