GLSL Introduction

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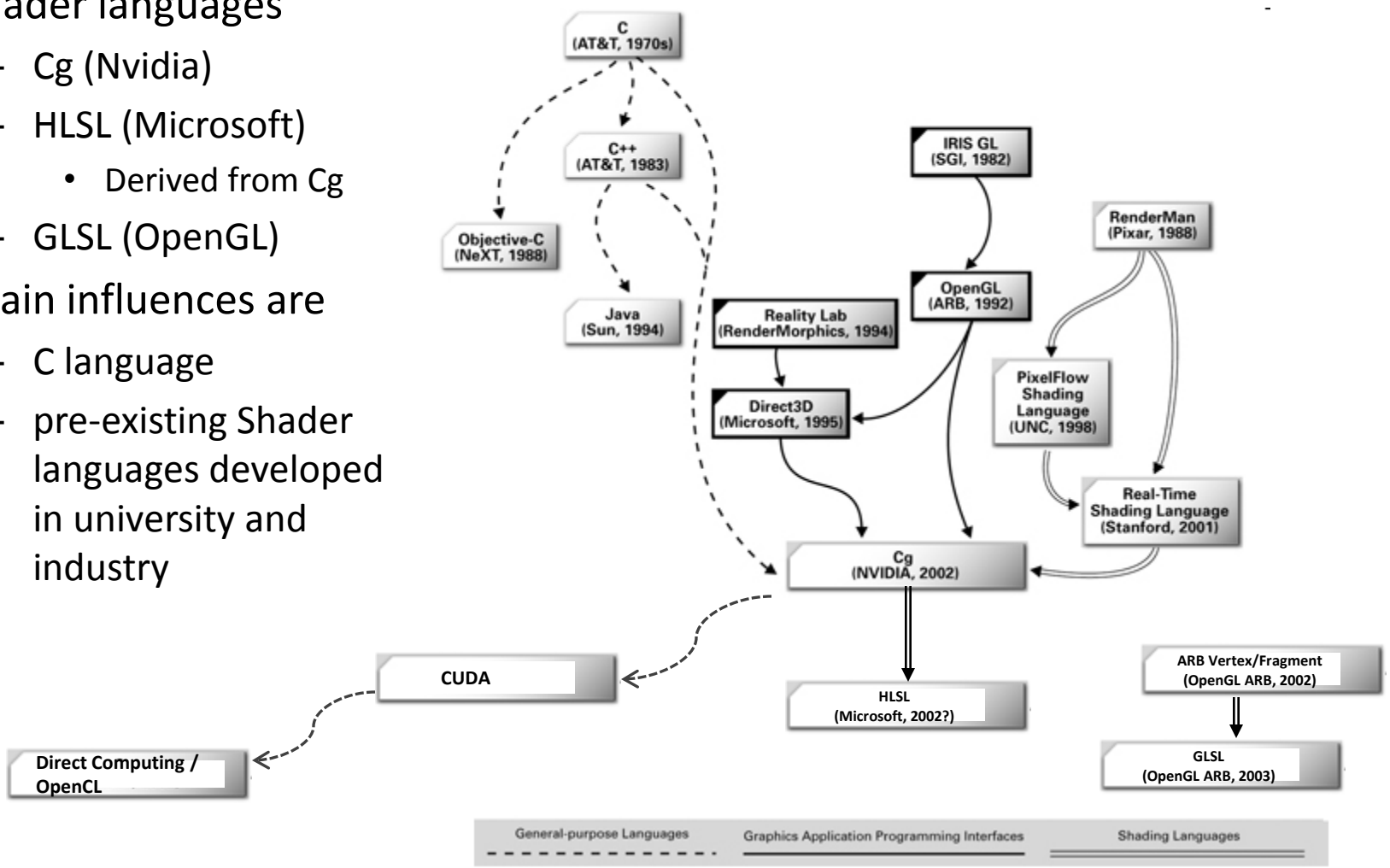
Thanks for materials from many other people

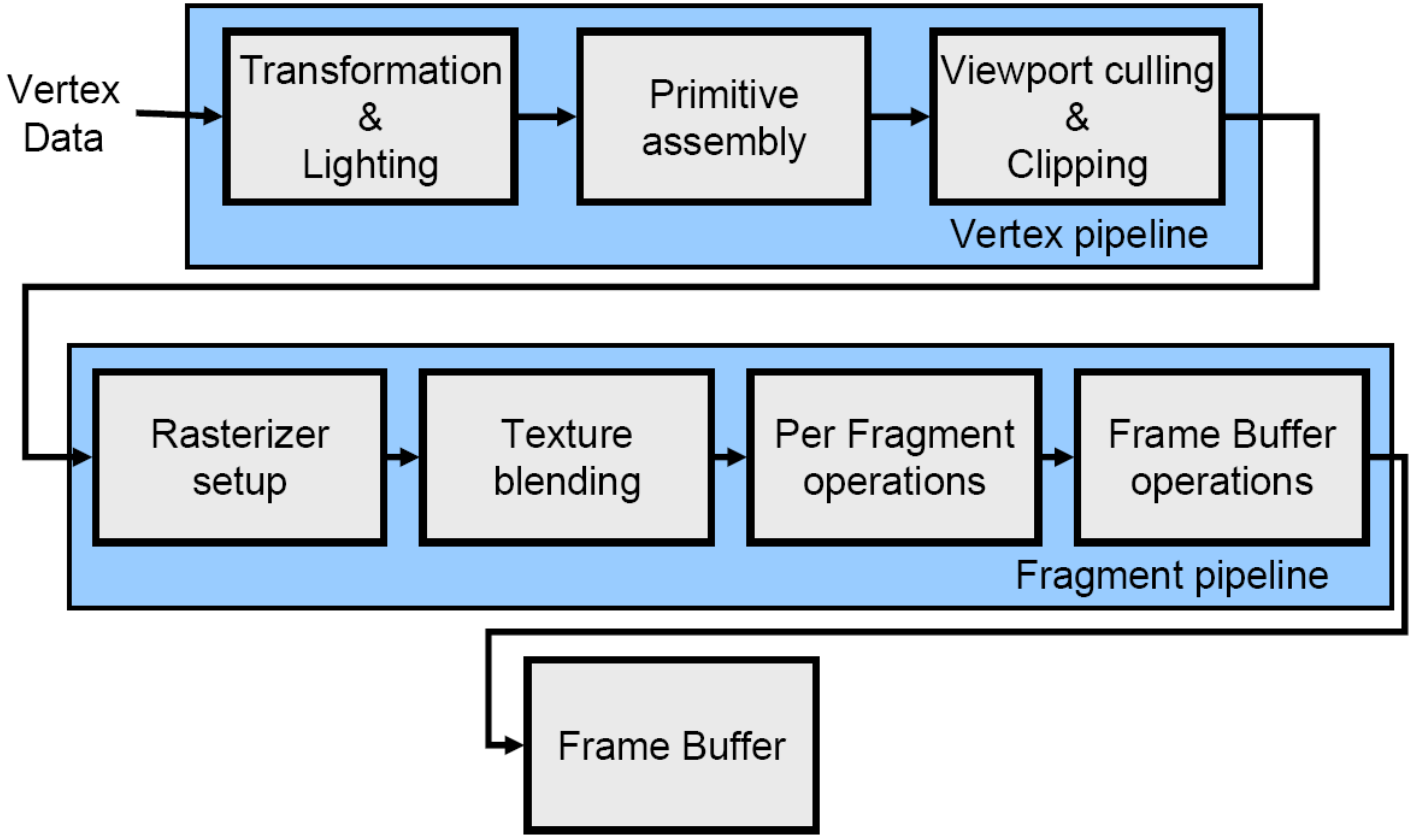
Shader Languages

- Currently 3 major shader languages
  - Cg (Nvidia)
  - HLSL (Microsoft)
    - Derived from Cg
  - GLSL (OpenGL)
- Main influences are
  - C language
  - pre-existing Shader languages developed in university and industry

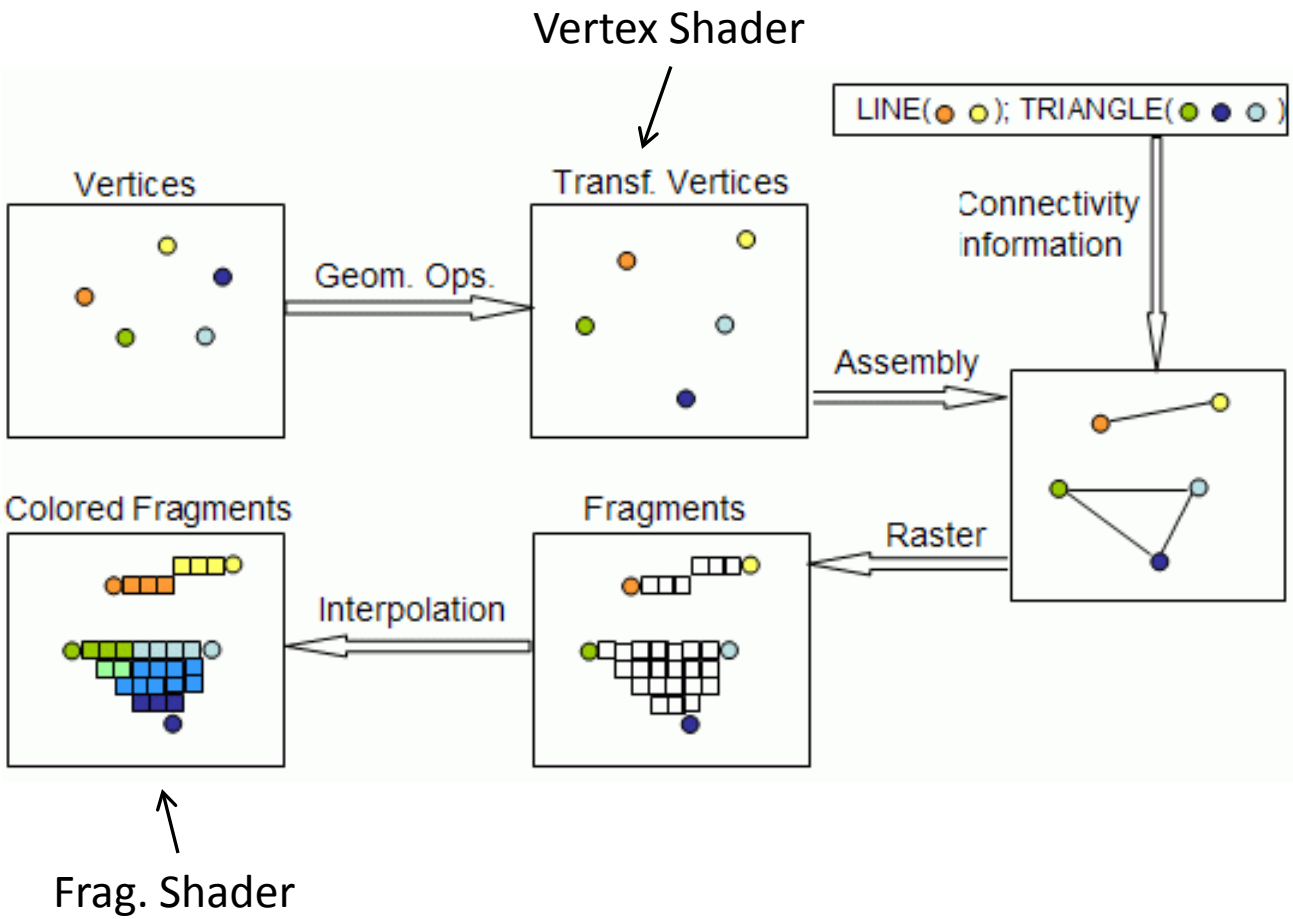
Source: http://http.developer.nvidia.com/CgTutorial/cg_tutorial_chapter01.html (Modified with information on HLSL and GLSL)



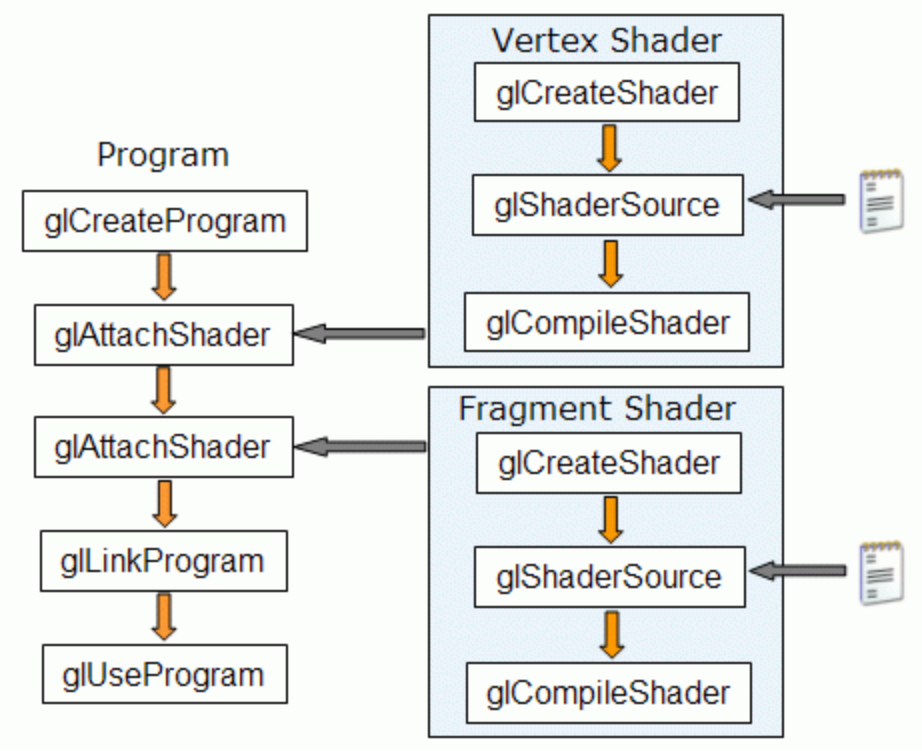
Data Flows


Vertex Data
Transformation & Lighting
Primitive assembly
Viewport culling & Clipping
Vertex pipeline
Rasterizer setup
Texture blending
Per Fragment operations
Frame Buffer operations
Fragment pipeline
Frame Buffer

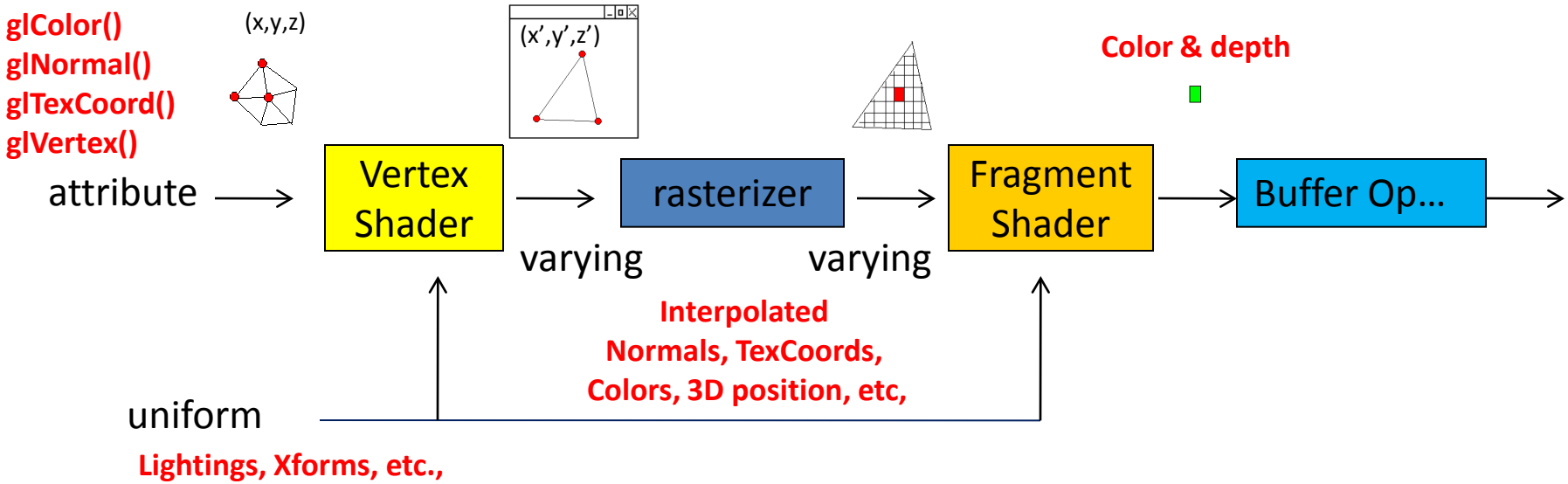
Fixed Functionality



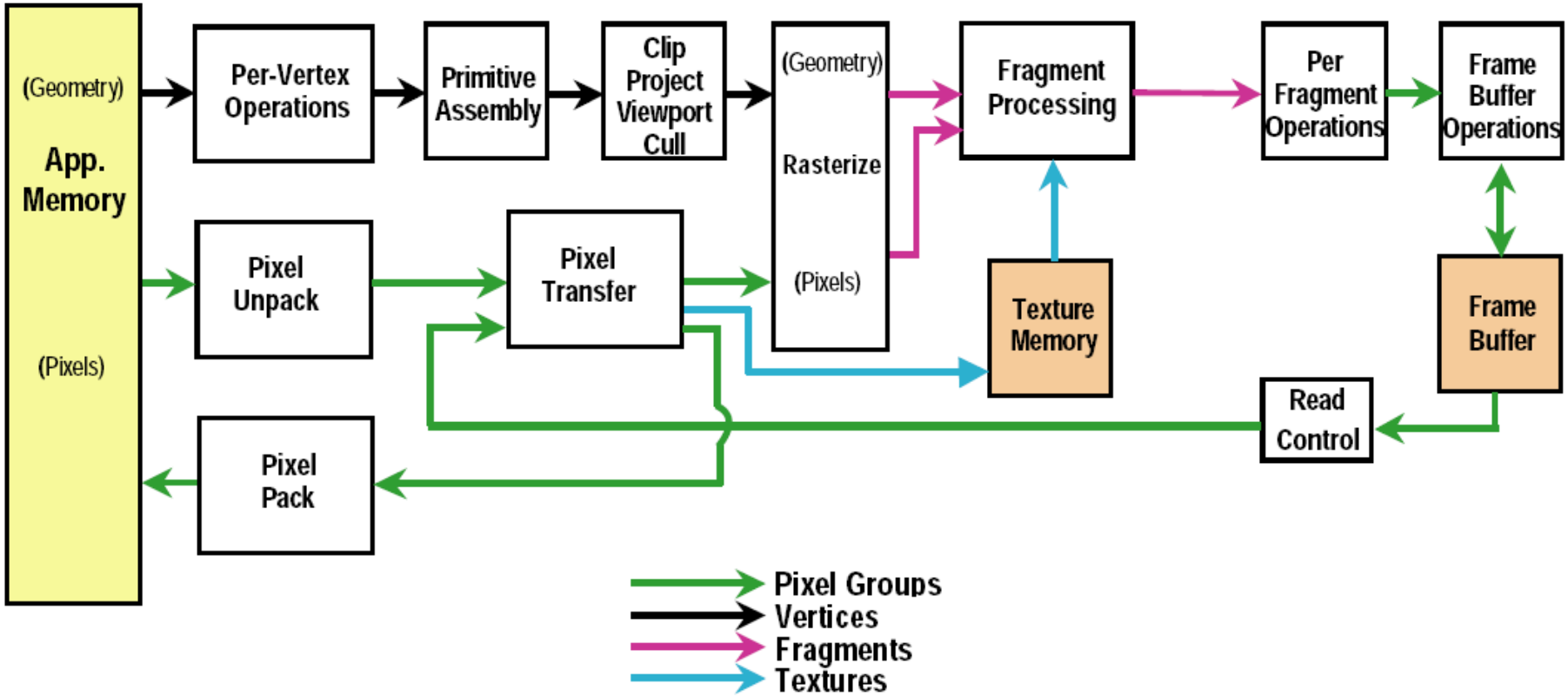
Shader Initialization



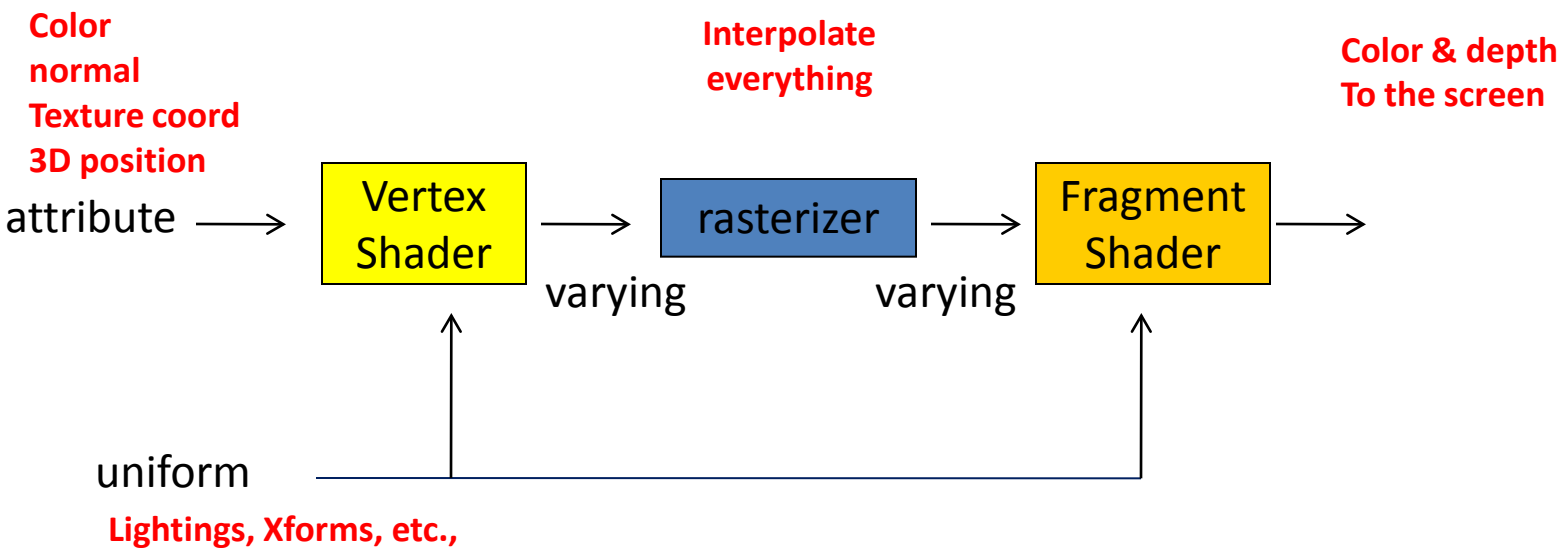
Qualifiers in pipeline



Really Complicated Pipeline

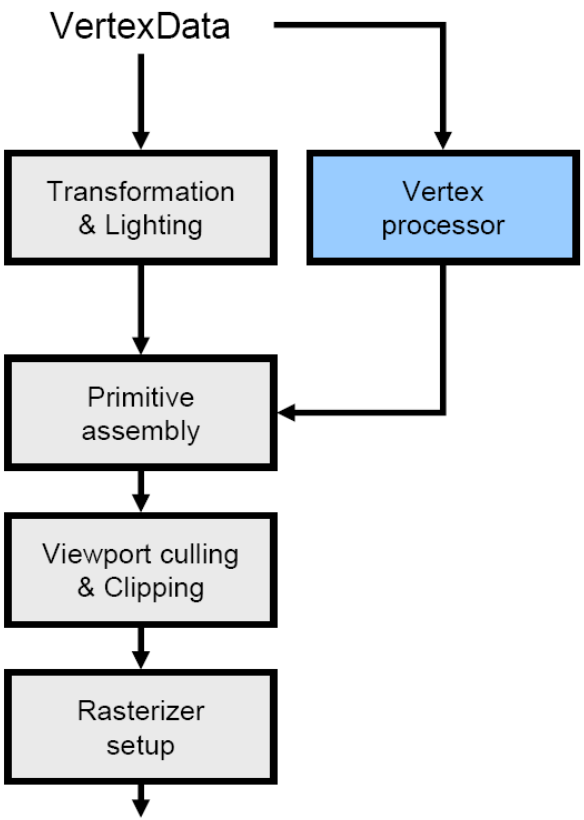


Simplified Data Flow

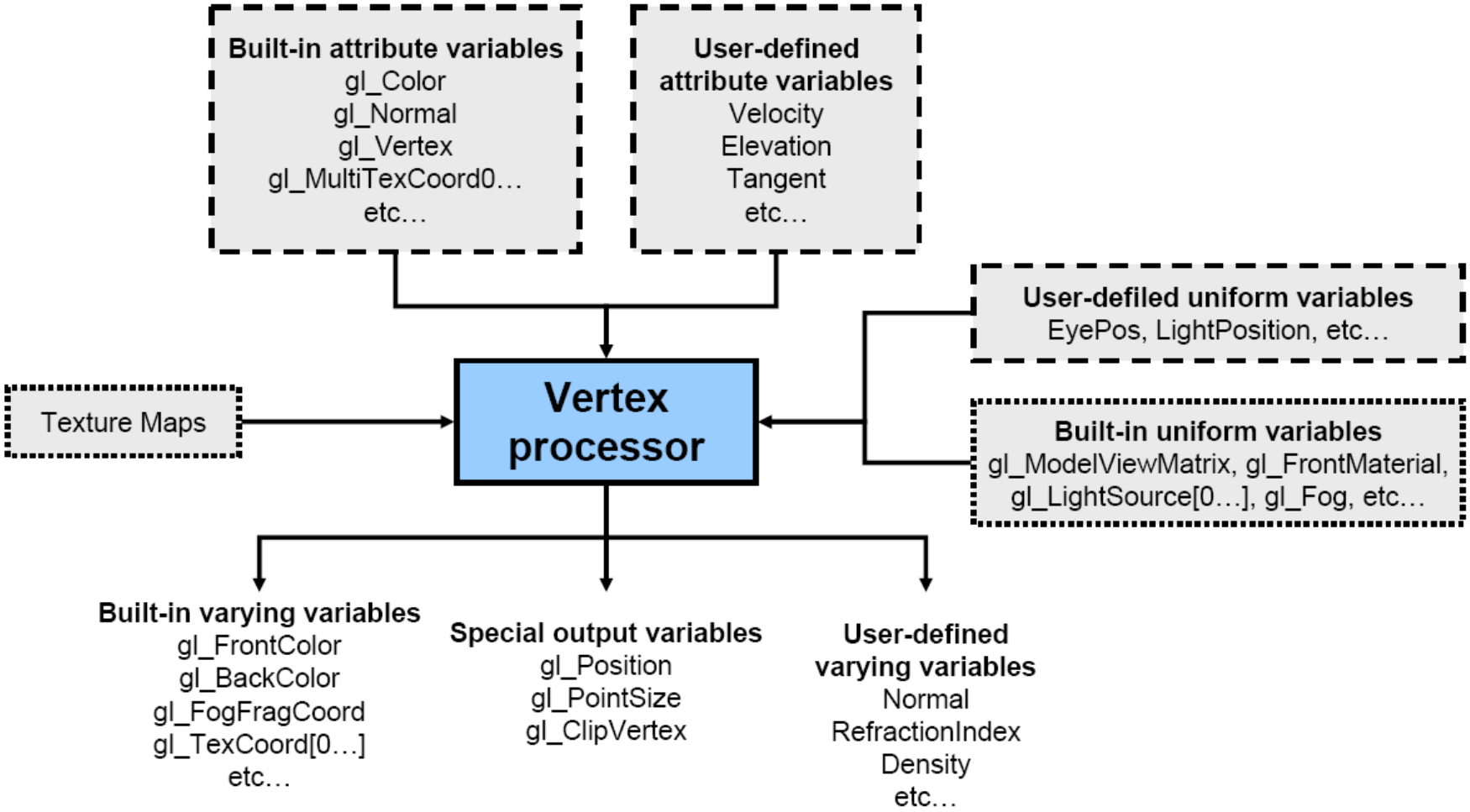


Vertex Shader

- Vertex Xform
- Normal Xform
- Text Coord
- Per-vertex lighting

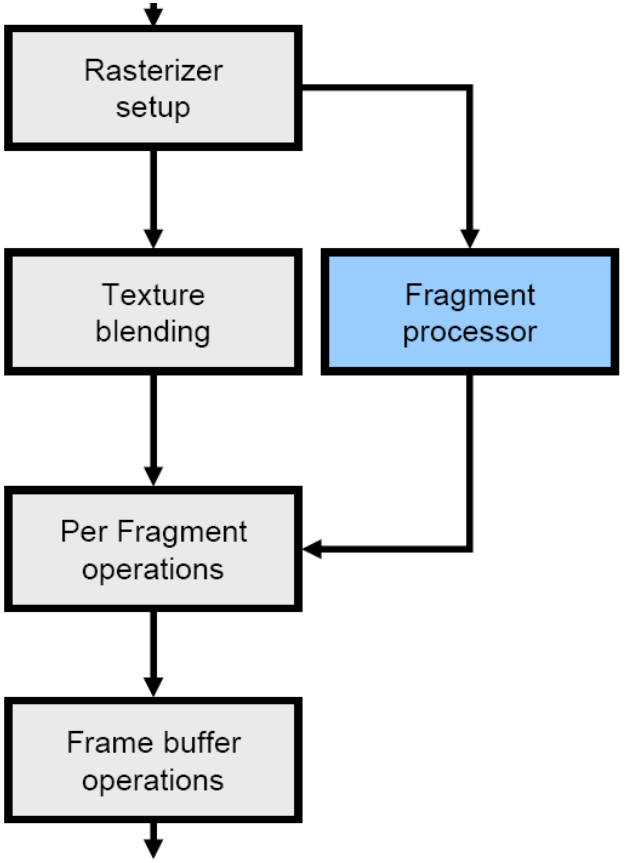


Vertex Shader

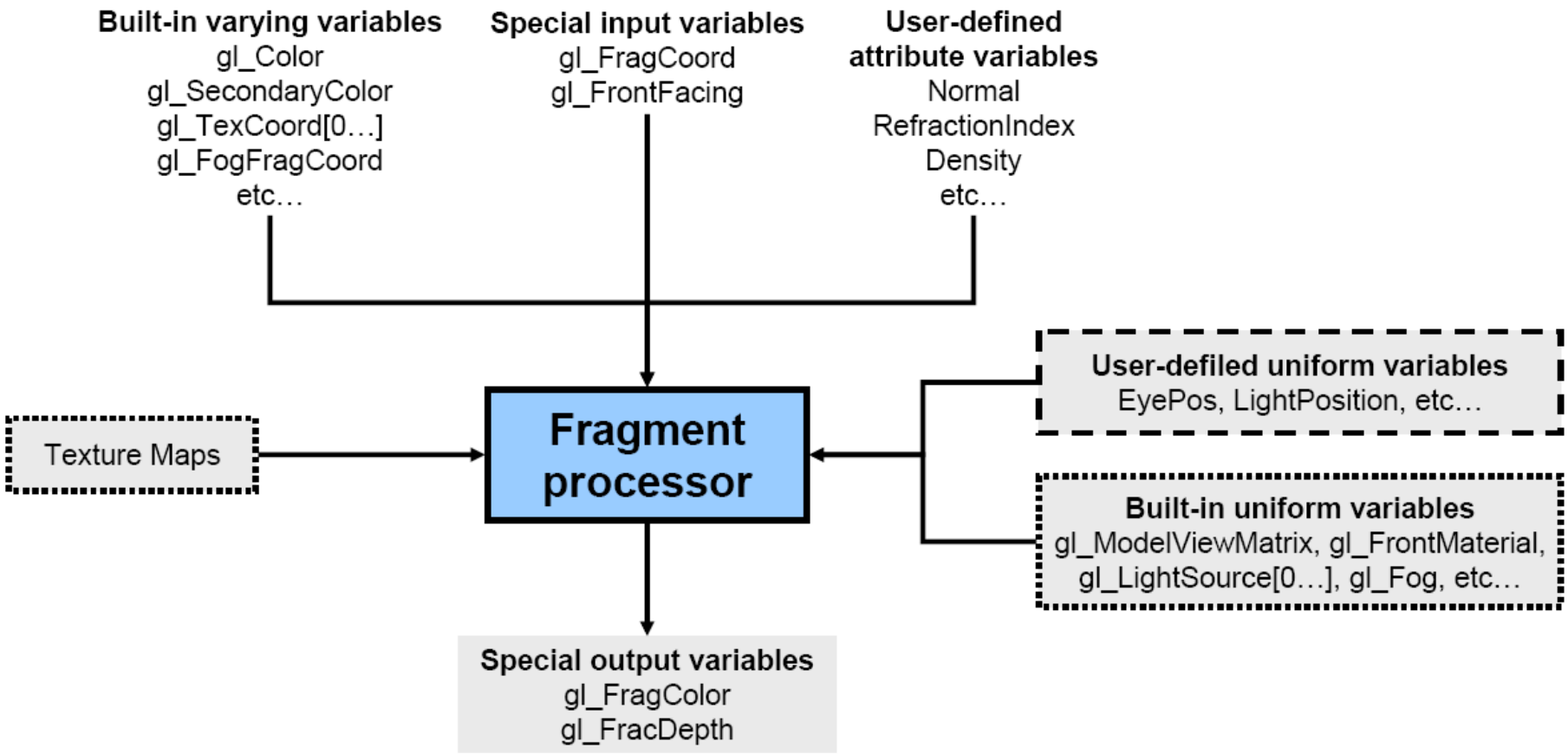


Fragment (pixel) Shader

- Interpolated
- Texture access
- Applications
  - Texture
  - Fog
  - Color sum



Fragment Shader



GLSL Language Definition

- Data Type Description
  - **int** Integer
  - **float** Floating-point
  - **bool** Boolean (*true* or *false*).
  - **vec2** Vector with two floats.
  - **vec3** Vector with three floats.
  - **vec4** Vector with four floats.
  - **mat2** 2x2 floating-point matrix.
  - **mat3** 3x3 floating-point matrix.
  - **mat4** 4x4 floating-point matrix.

Vector

- Vector is like a class
- You can use following to access
  - .r .g .b .a
  - .x .y .z .w
  - .s .t .p .q
- Example:

```
vec4 color;
color.rgb = vec3(1.0 , 1.0 , 0.0 );          color.a = 0.5
color = vec4(1.0 , 1.0 , 0.0 , 0.5);
color.xy = vec2(1.0 , 1.0);
color.zw =vec2(0.0 , 0.5);
```

GLSL Variable Qualifiers

- Qualifiers give a special meaning to the variable. In GLSL the following qualifiers are available:
  - **const** - the declaration is of a compile time constant
  - **uniform** – (used both in vertex/fragment shaders, read-only in both) global variables that may change per primitive (may not be set inside glBegin,/glEnd)
  - **varying** - used for interpolated data between a vertex shader and a fragment shader. Available for writing in the vertex shader, and read-only in a fragment shader.
  - **attribute** – (only used in vertex shaders, and read-only in shader) global variables that may change per vertex, that are passed from the OpenGL application to vertex shaders.

Vertex Shader Code Example

```
varying vec3 normal, lightDir, eyeDir;  //output

void main()
{
    // Calculate position for lighting
    vec3 vVertex = vec3(gl_ModelViewMatrix * gl_Vertex);

    normal = gl_NormalMatrix * gl_Normal;    //or use ModelViewInverseTranspose

    lightDir = vec3(gl_LightSource[0].position.xyz   -   vVertex);
    eyeDir  = -vVertex;

    // Calculate position for real projection(camera)
    gl_Position = projection_matrix * modelview_matrix * vec4(gl_Vertex, 1.0);
}
```

Fragment Shader Code Example

```
varying vec3 normal, lightDir, eyeDir;

void main (void)
{
	vec4 final_color = (gl_LightSource[0].ambient * gl_FrontMaterial.ambient);	//first ambient term

	vec3 N = normalize(normal);	//remember to normalize every direction vector
	vec3 L = normalize(lightDir);

	float lambertTerm = dot(N,L);	//cosine term in the diffuse component

	if(lambertTerm > 0.0)
	{
		final_color += gl_LightSource[0].diffuse * gl_FrontMaterial.diffuse * lambertTerm;

		//Finally specular term
		vec3 E = normalize(eyeDir);
		vec3 R = reflect(-L, N);
		float specular = pow( max(dot(R, E), 0.0), gl_FrontMaterial.shininess );
		final_color += gl_LightSource[0].specular * gl_FrontMaterial.specular * specular;
	}

	gl_FragColor = final_color;
}
```

Vertex vs. Fragment Shader

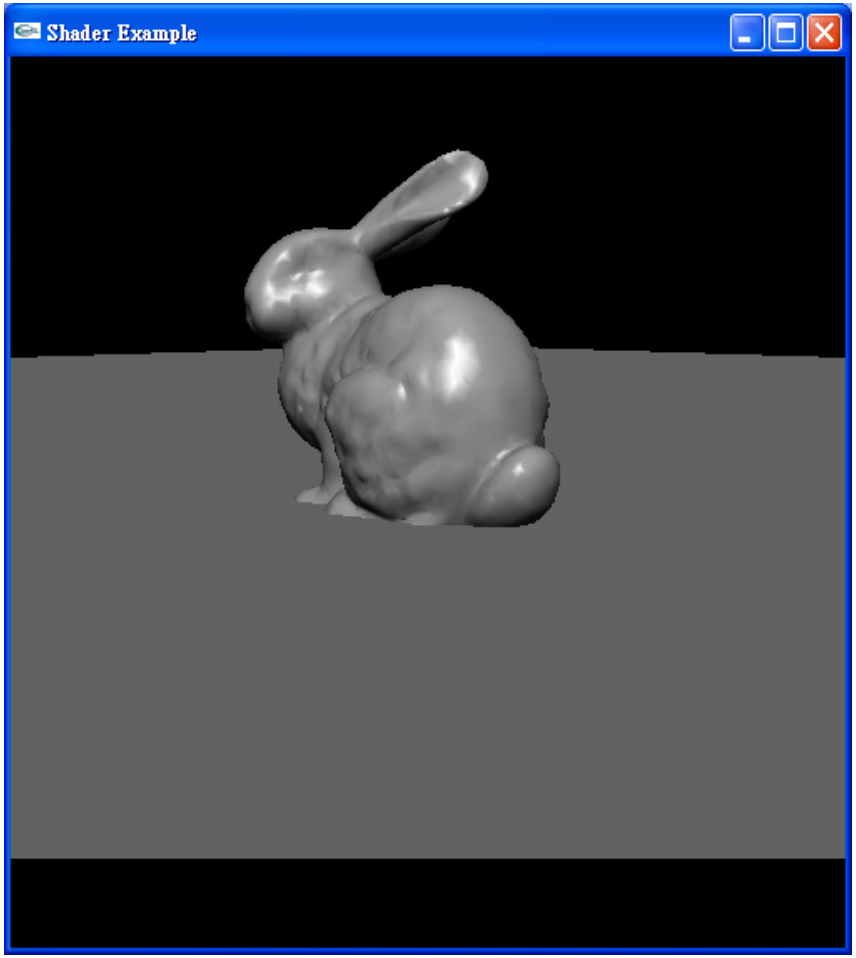
Smooth Shading

per vertex lighting

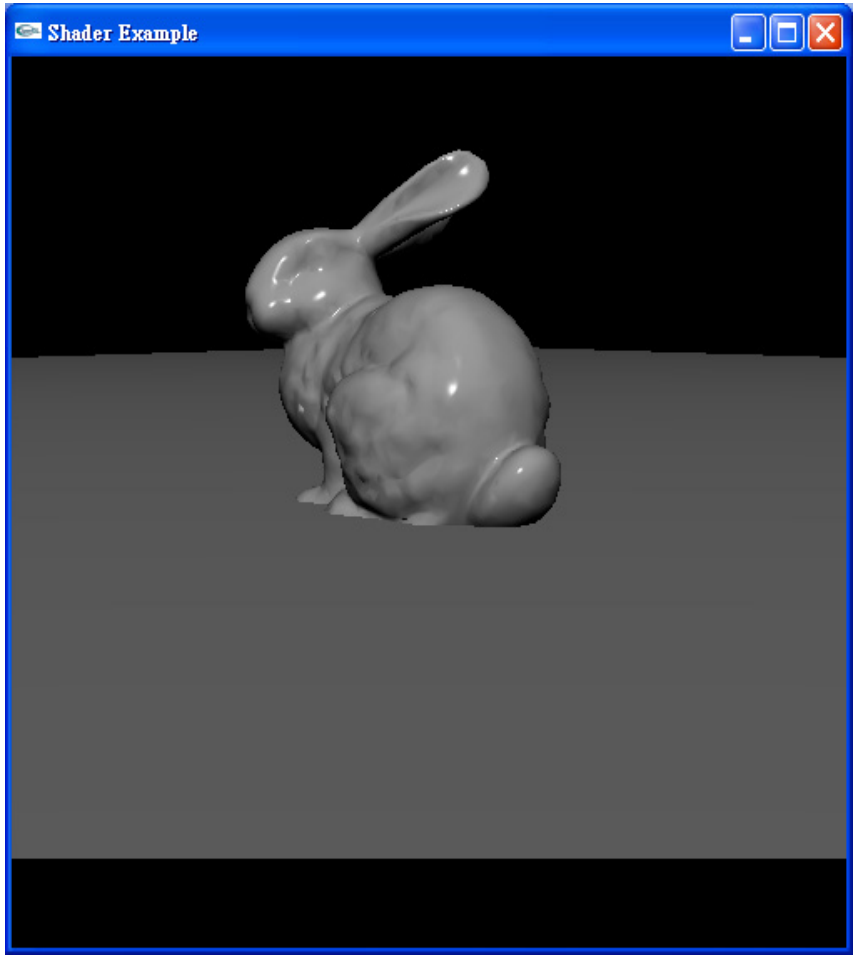
Phong Shading

per fragment lighting

Result



OpenGL Gouraud Shading



GLSL Phong Shading

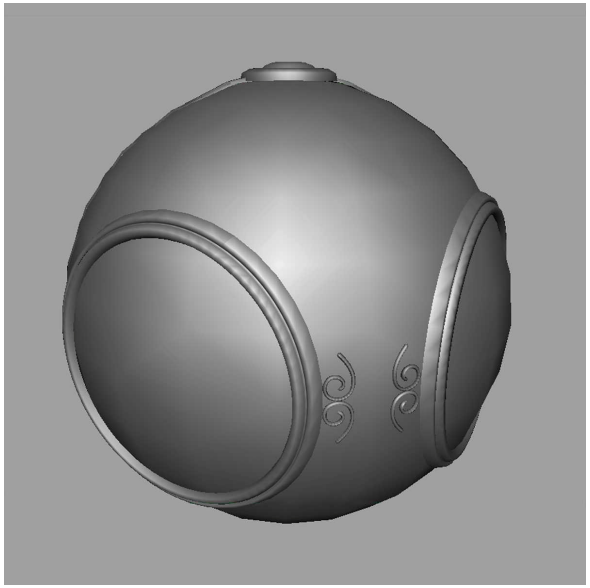
GLSL Statements

- Control Flow Statements: pretty much the same as in C.
- HIGHLY HARDWARE DEPENDENT!!

```
if (bool expression)
    ...
else
    ...

for (initialization; bool expression; loop expression)
    ...

while (bool expression)
    ...

do
    ...
while (bool expression)
```

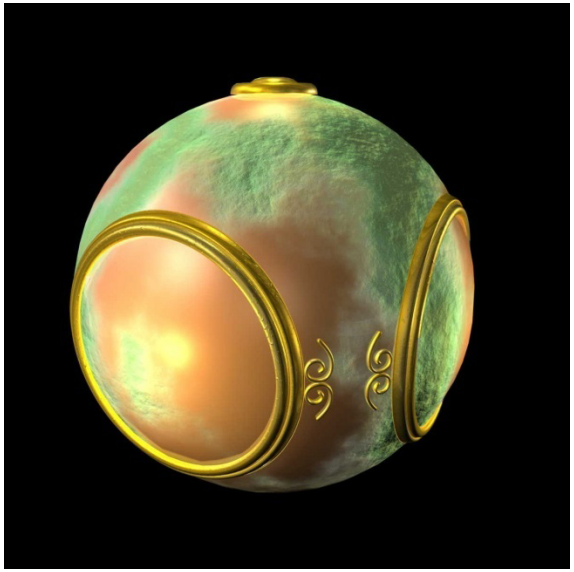
Note: only “if” are available on most current hardware

Fragment Shader Applications



smooth shading

environment mapping



bump mapping

Bump Mapping

- Perturb normal for each fragment
- Store perturbation as textures