GLSL II

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Objectives

- Coupling GLSL to Applications
- Example applications

Linking Shaders to OpenGL

- OpenGL Extensions
  - ARB_shader_objects
  - ARB_vertex_shader
  - ARB_fragment_shader
- OpenGL 2.0
  - Almost identical to using extensions
  - Avoids extension suffixes on function names

Program Object

- Container for shaders
  - Can contain multiple shaders
  - Other GLSL functions

```
GLuint myProgObj;
myProgObj = glCreateProgram();
 /* define shader objects here */
glUseProgram(myProgObj);
glLinkProgram(myProgObj);
```

Reading a Shader

- Shader are added to the program object and compiled
- Usual method of passing a shader is as a null-terminated string using the function **`glShaderSource`**
- If the shader is in a file, we can write a reader to convert the file to a string

Shader Reader

```
char* readShaderSource(const char* shaderFile)
{
   struct stat statBuf;
   FILE* fp = fopen(shaderFile, "r");
   char* buf;

   stat(shaderFile, &statBuf);
   buf = (char*) malloc(statBuf.st_size + 1 * sizeof(char));
   fread(buf, 1, statBuf.st_size, fp);
   buf[statBuf.st_size] = '\0';
   fclose(fp);
   return buf;
}
```

Adding a Vertex Shader

```
GLint vShader;
GLunit myVertexObj;
GLchar vShaderfile[] = "my_vertex_shader";
GLchar* vSource =
        readShaderSource(vShaderFile);
glShaderSource(myVertexObj,
          1, &vertexShaderFile, NULL);
myVertexObj =
          glCreateShader(GL_VERTEX_SHADER);
glCompileShader(myVertexObj);
glAttachObject(myProgObj, myVertexObj);
```


Vertex Attributes

- Vertex attributes are named in the shaders
- Linker forms a table
- Application can get index from table and tie it to an application variable
- Similar process for uniform variables

Vertex Attribute Example

```
GLint colorAttr;
colorAttr = glGetAttribLocation(myProgObj,
      "myColor");
/* myColor is name in shader */


GLfloat color[4];
glVertexAttrib4fv(colorAttrib, color);
/* color is variable in application */
```


Uniform Variable Example

```
GLint angleParam;
angleParam = glGetUniformLocation(myProgObj,
     "angle");
/* angle defined in shader */

/* my_angle set in application */
GLfloat my_angle;
my_angle = 5.0 /* or some other value */

glUniform1f(myProgObj, angleParam, my_angle);
```

Vertex Shader Applications

- Moving vertices
  - Morphing
  - Wave motion
  - Fractals
- Lighting
  - More realistic models
  - Cartoon shaders

Wave Motion Vertex Shader

```
uniform float time;
uniform float xs, zs;
void main()
{
float s;
s = 1.0 + 0.1*sin(xs*time)*sin(zs*time);
gl_Vertex.y = s*gl_Vertex.y;
gl_Position =
   gl_ModelViewProjectionMatrix*gl_Vertex;
}
```

Particle System

```
uniform vec3 init_vel;
uniform float g, m, t;
void main()
{
vec3 object_pos;
object_pos.x = gl_Vertex.x + vel.x*t;
object_pos.y = gl_Vertex.y + vel.y*t
       + g/(2.0*m)*t*t;
object_pos.z = gl_Vertex.z + vel.z*t;
gl_Position =
    gl_ModelViewProjectionMatrix*
      vec4(object_pos,1);
}
```


Modified Phong Vertex Shader I

```
void main(void)
/* modified Phong vertex shader (without distance term) */
{
   float f;
  /* compute normalized normal, light vector, view vector,
      half-angle vector in eye cordinates */
  vec3 norm = normalize(gl_NormalMatrix*gl_Normal);
  vec3 lightv = normalize(gl_LightSource[0].position
          -gl_ModelViewMatrix*gl_Vertex);
  vec3 viewv = -normalize(gl_ModelViewMatrix*gl_Vertex);
  vec3 halfv = normalize(lightv + norm);
  if(dot(lightv, norm) > 0.0) f = 1.0;
       else f = 0.0;
```

Modified Phong Vertex Shader II

```
/* compute diffuse, ambient, and specular contributions */

vec4 diffuse = max(0, dot(lightv, norm))*gl_FrontMaterial.diffuse
      *LightSource[0].diffuse;
vec4 ambient = gl_FrontMaterial.ambient*LightSource[0].ambient;
vec4 specular = f*gl_FrontMaterial.specular*
        gl_LightSource[0].specular)
       *pow(max(0, dot( norm, halfv)), gl_FrontMaterial.shininess);
 vec3 color = vec3(ambient + diffuse + specular)
 gl_FrontColor = vec4(color, 1);
 gl_Position = gl_ModelViewProjectionMatrix*gl_Vertex;
}
```


Pass Through Fragment Shader

```
/* pass-through fragment shader */
void main(void)
{
    gl_FragColor = gl_FrontColor;
}
```

Vertex Shader for per Fragment Lighting

```
/* vertex shader for per-fragment Phong shading */
varying vec3 normale;
varying vec4 positione;
void main()
{
  normale = gl_NormalMatrixMatrix*gl_Normal;
  positione = gl_ModelViewMatrix*gl_Vertex;
  gl_Position = gl_ModelViewProjectionMatrix*gl_Vertex;
}
```


Fragment Shader for Modified Phong Lighting I

```
varying vec3 normale;
varying vec4 positione;
void main()
{
vec3 norm = normalize(normale);
vec3 lightv = normalize(gl_LightSource[0].position-positione.xyz);
vec3 viewv = normalize(positione);
vec3 halfv = normalize(lightv + viewv);
vec4 diffuse = max(0, dot(lightv, viewv))
  *gl_FrontMaterial.diffuse*gl_LightSource[0].diffuse;
vec4 ambient = gl_FrontMaterial.ambient*gl_LightSource[0].ambient;
```

Fragment Shader for Modified Phong Lighting II

```
int f;
if(dot(lightv, viewv)> 0.0) f =1.0);
else f = 0.0;
vec3 specular = f*pow(max(0, dot(norm, halfv),
        gl_FrontMaterial.shininess)
       *gl_FrontMaterial.specular*gl_LightSource[0].specular);
vec3 color = vec3(ambient + diffuse + specular);
gl_FragColor = vec4(color, 1.0);
}
```


Vertex vs Fragment Shader

per vertex lighting

per fragment lighting

Samplers

- Provides access to a texture object
- Defined for 1, 2, and 3 dimensional textures and for cube maps
- In shader:

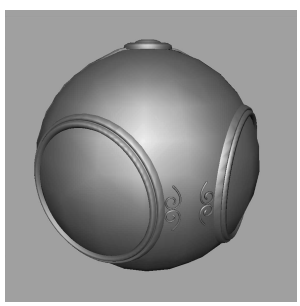
```
uniform sampler2D myTexture;
Vec2 texcoord;
Vec4 texcolor = texture2D(mytexture, texcoord);
```

- In application:

```
texMapLocation =
 glGetUniformLocation(myProg,"myTexture");
glUniform1i(texMapLocation, 0);
/* assigns to texture unit 0 */
```

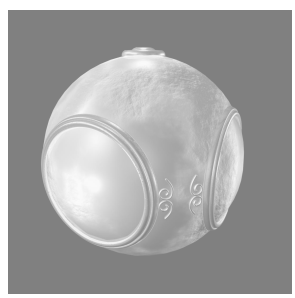

Fragment Shader Applications

Texture mapping



smooth shading

environment mapping



bump mapping

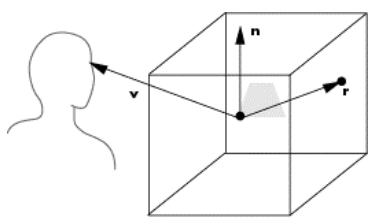
Cube Maps

- We can form a cube map texture by defining six 2D texture maps that correspond to the sides of a box
- Supported by OpenGL
- Also supported in GLSL through cubemap sampler

  vec4 texColor = textureCube(mycube, texcoord);
- Texture coordinates must be 3D

Environment Map

Use reflection vector to locate texture in cube map



Environment Maps with Shaders

- Environment map usually computed in world coordinates which can differ from object coordinates because of modeling matrix
  - May have to keep track of modeling matrix and pass it shader as a uniform variable
- Can also use reflection map or refraction map (for example to simulate water)

Environment Map Vertex Shader

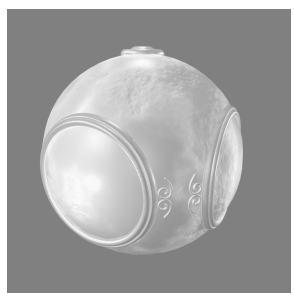
```
uniform mat4 modelMat;
uniform mat3 invModelMat;
uniform vec4 eyew;
void main(void)
{
  vec4 positionw = modelMat*gl_Vertex;
  vec3 normw = normalize(gl_Normal*invModelMat.xyz);
  vec3 lightw = normalize(eyew.xyz-positionw.xyz);
  eyew = reflect(normw, eyew);
  gl_Position = gl_ModelViewProjectionMatrix*gl_Vertex;
}
```

Environment Map Fragment Shader

```
/* fragment shader for reflection map */
varying vec3 reflectw;
uniform samplerCube MyMap;
void main(void)
{
   gl_FragColor = textureCube(myMap, reflectw);
}
```


Bump Mapping

- Perturb normal for each fragment
- Store perturbation as textures



Normalization Maps

- Cube maps can be viewed as lookup tables 1-4 dimensional variables
- Vector from origin is pointer into table
- Example: store normalized value of vector in the map
  - Same for all points on that vector
  - Use “normalization map” instead of normalization function
  - Lookup replaces sqrt, mults and adds