CS770/870 Spring 2017 OpenGL Textures

Notes originally created by Matt Plumlee

Also see: Angel 6e: ch 7.6

Preview

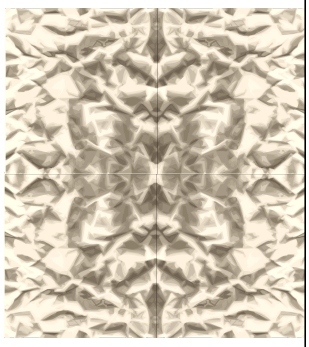
Opportunity: Polygon fill w/ pattern

Problem: How to specify, apply textures

OpenGL's solution

Opportunity

- With lighting
  - Start with material color, properties
  - Modify color according to lighting model
    - Normals
    - Light sources
    - View direction
- What if material isn'tsingle color?
  - Patterns: checkerboard, stripes, brick
  - Images: photos, renderings (reflections)

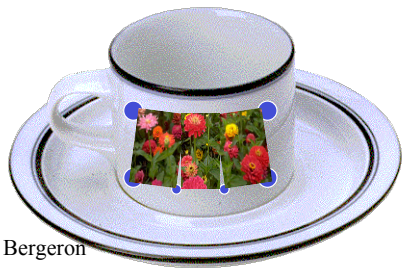


Problem

- Many ways to specify, apply texture
  - Is it from a file? Created in-program?
  - How many dimensions? 1D? 2D? 3D?
  - Is it monochrome? Multicolored?
  - Should it repeat? If so, how?
  - Should it respect lighting/shading?
  - Should it modify lighting?
  - Should it modify depth?
  - …

OpenGL's Solution

- Texture ID (int) → internal texture spec.
- Parameters set on that spec.
- Fill texture buffer with values (color, etc.)
- When time to draw with texture
  - "Bind" texture—one to use during fill
  - Map texture to geometry (tie points in texture to each vertex)



OpenGL Texture Initialization

At texture-creation time

- 1. Ask GL for a texture ID

```
glGenTextures( 1, txtureId ); // GLuint* txtureId
```

- 2. Bind the texture ID to proper type

```
glBindTexture( GL_TEXTURE_2D, txtureId );
```

- 3. Specify texture parameters

```
glTexParameteri( GL_TEXTURE_2D, GL_..., ... );
```

- 4. Specify data

```
glTexImage2D( GL_TEXTURE_2D, ... );
```
or
```
glGenerateMipmap( GL_TEXTURE_2D, ... );
```

- 5. Build texture coordinate buffer

```
2D version of coord buffer, normal buffer, etc
```


OpenGL Texture Usage

In order to draw…

- 6. "Bind" your texture of that type

```
glBindTexture( GL_TEXTURE_2D, textureID );
```

- 7. Load texture coord buffer

```
glBufferData( . . . );
```

- 8. Draw, unbind texture

```
glDrawArrays( . . . );
glBindTexture( GL_TEXTURE_2D, 0 );
```

Key glTexParameteri() Paramerters

Parameter	Values
GL_TEXTURE_MAG_FILTER magnification policy when texel covers many pixels	GL_NEAREST or GL_LINEAR
GL_TEXTURE_MIN_FILTER minification policy when pixel covers multiple texels	GL_NEAREST, GL_LINEAR, GL_NEAREST_MIPMAP_NEAREST, GL_NEAREST_MIPMAP_LINEAR, GL_LINEAR_MIPMAP_NEAREST, or GL_LINEAR_MIPMAP_LINEAR

Table 9-1 : Filtering Methods for Magnification and Minification, from http://www.glprogramming.com/red/chapter09.html

Key glTexParameteri() Paramerters

Parameter	Values
GL_TEXTURE_WRAP_S GL_TEXTURE_WRAP_T If texture space smaller than area	GL_CLAMP, GL_REPEAT
GL_TEXTURE_BORDER_COLOR	any four values in [0.0, 1.0]
GL_TEXTURE_PRIORITY	[0.0, 1.0] for the current texture object

Table 9-4 : glTexParameter() Parameters , from* http://www.glprogramming.com/red/chapter09.html

Code from Texture.java

```
int tex = glGenTextures();
glBindTexture( GL_TEXTURE_2D, tex );
glTexParameteri( GL_TEXTURE_2D,
                 GL_TEXTURE_MAG_FILTER,
                 GL_LINEAR );
glTexParameteri( GL_TEXTURE_2D,
                 GL_TEXTURE_MIN_FILTER,
                 GL_LINEAR );
glTexImage2D( GL_TEXTURE_2D, 0, GL_RGBA,
                 w.get(0), h.get(0), 0,
                 GL_RGB, GL_UNSIGNED_BYTE,
                 image );
```


Texture code from Shape3D.redraw()

```
// has a loadTexCoordBuffer method to
//    load the appropriate buffer if needed
// redraw code
if ( hasTexture )
     texture.bind(); // our Texture object
// Everything drawn will have this texture
glDrawArrays( GL_TRIANGLES, 0, nVertices );
if ( hasTexture )
     texture.unbind()
```

glGenerateMipmap

```
int tex = glGenTextures();
glBindTexture( GL_TEXTURE_2D, tex );
glTexImage2D( GL_TEXTURE_2D, 0, GL_RGBA,
                w.get(0), h.get(0), 0,
                GL_RGB, GL_UNSIGNED_BYTE,
              image );
glGenerateMipmap( GL_TEXTURE_2D );
glTexParameteri( GL_TEXTURE_2D,
                 GL_TEXTURE_MAG_FILTER,
                 GL_LINEAR );
glTexParameteri( GL_TEXTURE_2D,
                 GL_TEXTURE_MIN_FILTER,
                 GL_LINEAR_MIPMAP_LINEAR );
```


Lots To Explore with Textures

- Rendering to textures (requires pbuffers)
- 1D, 3D, and cube-mapping textures
- Blending multiple textures
- …leads toward vertex shaders

Resources

- Some OpenGL texture resources
  - *http://www.opengl-tutorial.org/beginners-tutorials*
    - *general approach is good, but based on C-only image tools*
  - *https://learnopengl.com*
    - *also seems informative but based on SOIL C-based image tools*
  - *https://www.khronos.org/opengl/wiki/Texture*
    - *more than you want to know right now*

Review

- Initializing a texture

```
glGenTextures(1, textureID);
glBindTexture(GL_TEXTURE_2D, textureID);
glTexParameteri(GL_TEXTURE_2D, GL_..., ...);
glTexImage2D(GL_TEXTURE_2D, ...);   or
glGenerateMipmap( id );
```

- Using a texture

```
glBindTexture(GL_TEXTURE_2D, textureID);
Need buffer for texture coordinate data
```