TEXTURE MAPPING

Overview
- Basic texture mapping
- Variations
- Advanced techniques

Let start with a simple problem ...

We want to “glue” the image onto the triangle.

How should the texture be placed?

this is the input to our algorithm

Texture coordinates
Our algorithm answers this question: “What color is point \( p \) on the texture mapped triangle?”

1. Find the texture coordinates for \( p \).
2. Find the color of the texture at the texture coordinates for \( p \).

Use barycentric coordinates to find \( p' \)

1. Find the texture coordinates for \( p \).
2. Find the color of the texture at the texture coordinates for \( p \).

Resample to find texture color

1. Find the texture coordinates for \( p \).
2. Find the color of the texture at the texture coordinates for \( p \).

Basic Texturing in OpenGL

- Create the texture object
- Describe how texture should be applied
- Enable texturing
- Render scene supplying texture coordinates

Basic Texturing in OpenGL (cont.)

Create the texture object

```c
void glTexImage2D( GLenum target, GLint level, GLint internalFormat, GLsizei width, GLsizei height, GLint border, GLenum format, GLenum type, const GLvoid *pixels );
```

Example:

```c
glTexImage2D( GL_TEXTURE_2D, 0, GL_RGBA, 128, 128, 0, GL_RGBA, GL_UNSIGNED_BYTE, myTextureData );
```

Basic Texturing in OpenGL (cont.)

Specify how texture should be applied

```c
void glTexEnvi( GLenum target, GLenum pname, GLint param );
void glTexEnvf( GLenum target, GLenum pname, GLfloat param );
void glTexEnviv( GLenum target, GLenum pname, GLint* param );
void glTexEnvfv( GLenum target, GLenum pname, GLfloat* param );
```

Example:

```c
void glTexEnvf( GL_TEXTURE_ENV, GL_TEXTURE_ENV_MODE, GL_REPLACE );
```

Basic Texturing in OpenGL (cont.)

Enable and render

No Mapping

```c
glBegin( GL_TRIANGLES);

void glTexEnvi( GL_TEXTURE_ENV , GL_TEXTURE_ENV_MODE, GL_REPLACE );
```

Mapping

```c
glEnable(GL_TEXTURE_2D);

void glTexEnvi( GL_TEXTURE_ENV , GL_TEXTURE_ENV_MODE, GL_REPLACE );
```

Examples:

```c
glEnable( GL_TEXTURE_20 );
glBindTexture(myTexture);
glBegin( GL_TRIANGLES );
glTexEnvf( GL_TEXTURE_ENV , GL_TEXTURE_ENV_MODE, GL_REPLACE );
glTexCoord2f( 1, 1 );
glTexCoord2f( 1, 0 );
glTexCoord2f( 0, 0 );
glEnd();
glDisable( GL_TEXTURE_20 );
```

Variations

- Repeat, Mirror, Clamp, Border
- Decal, Replace, Modulate

Minification
Minification (cont.)

Mipmapping
Downsample the image ahead of time
Sample from different versions as appropriate

Texture
Texture

Transparency & Translucency

Alpha Testing
Simple boolean test:
- Transparent
- Not Transparent


Transparency & Translucency (cont.)

Blending
Normally:
`glTexImage2D( GL_SRC_ALPHA, GL_ONE_MINUS_SRC_ALPHA );`

Different options:
`GL_ONE_MINUS_SRC_ALPHA`
`GL_ONE_MINUS_DST_ALPHA`
`GL_SRC_ALPHA_SATURATE`
`GL_SRC_ALPHA`
`GL_DST_ALPHA`
`GL_ZERO`
`GL_ONE`
`GL_SRC_COLOR`
`GL_DST_COLOR`
`GL_ONE_MINUS_SRC_COLOR`
`GL_ONE_MINUS_DST_COLOR`


Bump & Normal Mapping

Goal: More accurately simulate additional model detail. (Replace polygons)

Regular Model

Normal-Mapped Model

Bump & Normal Mapping (cont.)

Bump-Mapping
Use a heightmap to represent deviations from the planar polygon surface

Bump & Normal Mapping (cont.)

Normal-Mapping
Use a 3-channel texture to store the actual per-texel normal vectors
Gloss & Light Mapping

Goal: More accurately simulate complex lighting effects

Gloss-Mapping

Light-Mapping (Half-Life 2: Episode)

Gloss-Mapping (cont.)

Use a greyscale image to store specular properties ("shininess")

Gloss & Light Mapping (cont.)

Light-Mapping

Pre-calculate complex lighting models and "bake" them into textures

Environment Mapping

Goal: Making things even more shiny

Misc. techniques

Billboarding

Procedural Techniques

Goal: Get the computer to do the hard work of making the textures.

Particle Systems
Procedural Techniques (cont.)

**Simple Noise**
Just random numbers.

**Perlin Noise**
Still random numbers, but more clever.

Procedural Techniques (cont.)

**Cellular Texturing**
Voronoi Diagrams etc.

**Reaction-Diffusion**
Partial differential equations

Finning (cont.)

Finning

When texturing just isn't enough.

And now for some billboardig