Texture mapping (Woo et al., fig. 9-1)

Texture mapping allows you to take a simple polygon and give it the appearance of something much more complex.

- Due to Ed Catmull, PhD thesis, 1974
- Refined by Blinn & Newell, 1976

Texture mapping ensures that “all the right things” happen as a textured polygon is transformed and rendered.

Non-parametric texture mapping

With “non-parametric texture mapping”:

- Texture size and orientation are fixed
- They are unrelated to size and orientation of polygon
- Gives cookie-cutter effect

Reading

Required
- Angel, 8.6, 8.7, 8.9, 8.10

Recommended

Optional
- Woo, Neider, & Davis, Chapter 9
Parametric texture mapping

With “parametric texture mapping,” texture size and orientation are tied to the polygon.

Idea:
- Separate “texture space” and “screen space”
- Texture the polygon as before, but in texture space
- Deform (render) the textured polygon into screen space

A texture can modulate just about any parameter – diffuse color, specular color, specular exponent, …

Implementing texture mapping

A texture lives in its own abstract image coordinates parameterized by \((u, v)\) in the range ([0..1], [0..1]):

It can be wrapped around many different surfaces:

Computing \((u, v)\) texture coordinates in a ray tracer is fairly straightforward.

Note: if the surface moves/deforms, the texture goes with it.

Mapping to texture image coords

The texture is usually stored as an image. Thus, we need to convert from abstract texture coordinate:

\((u, v)\) in the range ([0..1], [0..1])

to texture image coordinates:

\((u_{\text{tex}}, v_{\text{tex}})\) in the range ([0..\(w_{\text{tex}}\)], [0..\(h_{\text{tex}}\)])

Q: What do you do when the texture sample you need lands between texture pixels?

Texture resampling

We need to resample the texture:

\(T(a, b) = T(i + \Delta_x, j + \Delta_y)\)

A common choice is **bilinear interpolation**:
Texture mapping and the z-buffer

Texture-mapping can also be handled in z-buffer algorithms.

Method:
- Scan conversion is done in screen space, as usual
- Each pixel is colored according to the texture
- Texture coordinates are found by Gouraud-style interpolation

Note: Mapping is more complicated if you want to do perspective right!

Solid textures

Q: What kinds of artifacts might you see from using a marble veneer instead of real marble?

One solution is to use solid textures:
- Use model-space coordinates to index into a 3D texture
- Like “carving” the object from the material

One difficulty of solid texturing is coming up with the textures.

Solid textures (cont’d)

Here’s an example for a vase cut from a solid marble texture:

Solid marble texture by Ken Perlin, (Foley, IV-21)

Displacement mapping

Textures can be used for more than just color.

In displacement mapping, a texture is used to perturb the surface geometry itself:

- These displacements “animate” with the surface

Q: Do you have to do hidden surface calculations on \( \tilde{Q} \)?
**Bump mapping**

In **bump mapping**, a texture is used to perturb the normal:

- Use the original, simpler geometry, \( Q(u) \), for hidden surfaces
- Use the normal from the displacement map for shading:

\[
\tilde{N} = \text{normal}[\tilde{Q}(u)]
\]

**Q:** What artifacts in the images would reveal that bump mapping is a fake?

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**Displacement vs. bump mapping**

- Input texture
- Rendered as displacement map over a rectangular surface

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**Environment mapping**

- In **environment mapping** (also known as **reflection mapping**), a texture is used to model an object's environment:
  - Rays are bounced off objects into environment
  - Color of the environment used to determine color of the illumination
  - Really, a simplified form of ray tracing
  - Environment mapping works well when there is just a single object – or in conjunction with ray tracing

Under simplifying assumptions, environment mapping can be implemented in hardware.

With a ray tracer, the concept is easily extended to handle refraction as well as reflection.

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**Displacement vs. bump mapping (cont'd)**

- Original rendering
- Rendering with bump map wrapped around a cylinder

*Image of gazing sphere (taken in a pub)*

*Environment-mapped rendering*
Combining texture maps

Using texture maps in combination gives even better effects, as *Young Sherlock Holmes* demonstrated …

Construction of the glass knight, (Foley, IV-24)

Combining texture maps (cont'd)

Summary

What to take home from this lecture:

1. The meaning of the boldfaced terms.

2. Familiarity with the various kinds of texture mapping, including their strengths and limitations.

Construction of the glass knight, (Foley, IV-24)