Texture Mapping

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.

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:

In graphics hardware, texture coordinates of triangle vertices are interpolated during rasterization.

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 $$[0, 1]$$ to texture image coordinates:

$$((u_{min}, v_{min}), (u_{max}, v_{max}))$$ in the range $$[0, w_{tex}], [0, h_{tex}]$$

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

Displacement mapping

Textures can be used for more than just color.

In displacement mapping, a texture is used to perturb the surface geometry itself. Here's the idea in 2D:

- These displacements "animate" with the surface
- In 3D, you would of course have $$(uvw)$$ parameters instead of just $$u$$

Q: Do you have to do hidden surface calculations on $$Q$$?

Texture resampling

We need to resample the texture:

A common choice is bilinear interpolation:

$$T(i, j) = T(i + \Delta_i, j) + \Delta_x T(i + \Delta_i, j + 1)$$

$$T(i + \Delta_i, j) = T(i, j) + \Delta_y T(i + 1, j)$$

$$T(i + \Delta_i, j + 1) = T(i, j) + \Delta_x T(i + 1, j) + \Delta_y \Delta_x T(i + 1, j + 1)$$

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:

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

Q: What artifacts in the images would reveal that bump mapping is a false?
Displacement vs. bump mapping

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.

Displacement vs. bump mapping (cont'd)

Original rendering

Rendering with bump map wrapped around a cylinder

Bump map and rendering by Wyvern Aldinger

Solid textures (cont'd)

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