Texture Mapping

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Limits of geometric modeling

Although modern GPUs can render millions of triangles/sec, that’s not enough sometimes...
Texture mapping for detail

This image contains 8 polygons!
Texture mapping comparison

no texture

with texture
Pixar - Toy Story
Other uses of textures...

- Light maps
- Shadow maps
- Environment maps
- Bump maps
- Opacity maps
- Animation
Lookup reflectance in image
Texture mapping in the pipeline

- Geometry and pixels have separate paths through pipeline
- Textures applied in fragment shader
  - End of pipeline
  - Efficient since relatively few polygons get past clipper
uv Mapping

2D texture is parameterized by \((u, v)\)

Assign polygon vertices texture coordinates

Interpolate within polygon
Texturing triangles

- Store \((u, v)\) at each vertex
- Interpolate inside triangles using barycentric coordinates
Texturing triangles

- Store \((u, v)\) at each vertex
- Interpolate inside triangles using barycentric coordinates

\[
\begin{align*}
\mathbf{p}(\beta, \gamma) &= \mathbf{p}_a + \beta(\mathbf{p}_b - \mathbf{p}_a) + \gamma(\mathbf{p}_c - \mathbf{p}_a) \\
u(\beta, \gamma) &= u_a + \beta(u_b - u_a) + \gamma(u_c - u_a) \\
v(\beta, \gamma) &= v_a + \beta(v_b - v_a) + \gamma(v_c - v_a)
\end{align*}
\]
Texture mapping
Point sampling

Map back to texture image and use the nearest texel
Aliasing

Point sampling textures can lead to aliasing artifacts
Magnification and minification

Minification

Magnification

texels applied to 3D polygon

grid of pixels on screen
We apply filtering to reduce aliasing artifacts
Area averaging

A better but slower option is to use *area averaging*.
Use bilinear filtering

mitigate magnification artifacts
Mipmapping

- Reduce minification artifacts
- Prefilter the texture to obtain reduced resolutions
- Requires $\frac{1}{3}$ more space
- Get a texture hierarchy indexed by level
point sampling
linear filtering

mipmapped point sampling
mipmapped linear filtering
Environment mapping
Use a texture for the distant environment simulate the effect of ray tracing more cheaply.
Sphere mapping

- Project objects in the environment onto sphere centered at eye
- Unwrap and store as texture
- Use reflection direction to look up texture value
Cube mapping

- Compute six projections, one for each wall
- Store as texture
- Use reflection direction to lookup texture value
Different environment maps

Blinn/Newell
latitude mapping
spherical mapping
cube mapping
Create the effect of a mirror with two-pass rendering

**First pass:** render the scene from the perspective of the mirror

**Second pass:** render from original pov; use the first image as a texture for the mirror
Bump mapping
bump mapping

geometric detail
Normal mapping

original mesh
4M triangles

simplified mesh
500 triangles

simplified mesh and normal mapping
500 triangles