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
Other uses of textures . . .

- Light maps
- Shadow maps
- Environment maps
- Bump maps
- Opacity maps
- Animation
Lookup reflectances in image

Image source: [1, 2]
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

preimage

pixel
Aliasing

Point sampling textures can lead to aliasing artifacts
Magnification and minification

texels applied to 3D polygon

grid of pixels on screen

Minification

Magnification
Aliasing artifacts

We apply filtering to reduce aliasing artifacts
A better but slower option is to use area averaging.
Use bilinear filtering

\[ P_0 \quad P_1 \quad P_2 \quad P_3 \]

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
Environment mapping

Use a texture for the distant environment to 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
Attribution
