Texture Mapping

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How do we simulate this?

- Store functions in memory buffers and map them onto surfaces
- Functions can be generated through simulation or acquisition from the real world
Enhanced realism
Not just bitmaps

one-dimensional

two-dimensional

three-dimensional

Shannonbowling, Shawn Hargreaves, Dong et al. 2008
Not really texture
UV mapping

- Associate texture coordinates \((u,v)\) with vertices
- Interpolate within polygons
- Use texture values to determine reflection coefficients
Perspective-correct interpolation essential

Rainwarrior (Wikimedia Commons), Paul Heckbert
Aliasing

unfiltered

filtered
Texture filtering
Minification and magnification

Minification:
- Texel mapped to a Pixel

Magnification:
- Pixel mapped to a Texel
Bilinear filtering

- Instead of rounding interpolated \((u,v)\) coordinates to integer values, blend the four adjacent texels. Weigh contributions based on distance.
- Aimed to address aliasing artifacts due to magnification
• Pre-filter the texture map at multiple resolutions, store the hierarchy
• “mip” stands for “multum in parvo”, meaning “much in little”
• Aimed to address aliasing artifacts due to minification
Mipmapping

- 1/3 increase in memory requirements
- Key simplification: approximate the pre-image of a pixel by a square

Williams, SIGGRAPH 1983
Mipmapping

$D = \max \left( \sqrt{\left( \frac{\partial u}{\partial x} \right)^2 + \left( \frac{\partial v}{\partial x} \right)^2}, \sqrt{\left( \frac{\partial u}{\partial y} \right)^2 + \left( \frac{\partial v}{\partial y} \right)^2} \right)$

$d = \log D$

- Hierarchy indexed by mipmap level $d$, which ranges from 0 to $\log(w)$
- Texture value produced by bilinear interpolation within two mipmap levels adjacent to $d$, then linear interpolation between the two values
- Partial derivatives determined by forward differencing

Williams, SIGGRAPH 1983
Mipmapping

No Mipmapping  With Mipmapping
Applications of Texture Mapping (Part 1)
Light maps

http://www.irrlicht3d.org
Opacity mapping
Specular mapping
Mirrors and portals

mirrors

portals
Slide or video projection

http://www.opengl.org/code; Segal et al., SIGGRAPH 1992