Today

- Texture Mapping
  - 2D
  - 3D
  - Procedural
- Bump and Displacement Maps
- Environment Maps
- Shadow Maps
Surface Detail

- Representing all detail in an image with polygons would be cumbersome
2D Texture Mapping of Images

- Use a 2D image and map it to the surface of an object

Example of texture distortion
Texture Coordinates

- Assign coordinates to each vertex
- Within each triangle use linear interpolation
- Correct for distortion!

MIP Map

- Pre-compute filtered versions of the texture
  - A given UV rate is some level of the texture
  - Tri-linear filtering UV × map level
**Procedural Textures**

- Generate texture based on some function
  - Well suited for “random” textures
  - Often modulate some noise function

**Assigning Texture Coordinates**

- Map a simple shape onto object by projection
  - Sphere, cylinder, plane, cube
- Assign by hand
- Use some optimization procedure
Repeating Textures

- Image Tiles allow repeating textures
  - Images must be manipulated to allow tiling
  - Often result in visible artifacts
    - There are methods to get around artifacts...

Repeating Textures

- Image Tiles allow repeating textures
  - Images must be manipulated to allow tiling
  - Often result in visible artifacts
    - Artifacts not an issue for artificial textures
Non-Color Textures

Bump Mapping

Images by Paul Baker
www.paulsprojects.net
Bump Mapping

• Add offset to normal
  • Offset is in texture coordinates S,T,N
  • Store normal offsets in RGB image components
  • Should use correctly orthonormal coordinate system

• Normal offsets from gradient of a grayscale image

\[ \mathbf{b}(u, v) = [s, t, n](u, v) = \nabla i(u, v) \]

\[ \nabla = \left[ \frac{\partial}{\partial u}, \frac{\partial}{\partial v} \right]^T \]

Bump Map Example

Catherine Bendebury and Jonathan Michaels
CS 184 Spring 2005
### Displacement Maps

- Actually move geometry based on texture map
  - Expensive and difficult to implement in many rendering systems
  - Note silhouette

<table>
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<th>Bump</th>
<th>Displacement</th>
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### Environment Maps

- Environment maps allow crude reflections
- Treat object as infinitesimal
  - Reflection only based on surface normal
- Errors hard to notice for non-flat objects
Environment Maps

(u,v) = (0,0)  
(x,y) = (-y, -z)

(u,v) = (1,1)  
(x,y) = (y, y)

right face
has $x > |y|, x > |z|$

\[ u = \frac{y + x}{2x} \]
\[ v = \frac{z + x}{2x} \]
Environment Maps

- Sphere based parameterization
  - Wide angle image or
  - Photo of a silver ball

Images by Paul Haeberli

Environment Maps

- Used in 1985 in movie Interface
- Effect by group from the New York Institute of Technology
Environment Maps

- Used in 1985 in movie *Interface*
- Effect by group from the New York Institute of Technology

Note errors
Shadow Maps

- Pre-render scene from perspective of light source
  - Only render Z-Buffer (the shadow buffer)
- Render scene from camera perspective
  - Compare with shadow buffer
  - If nearer light, if further shadow

From Stamminger and Drettakis
SIGGRAPH 2002

Note: These images don't really go together; see the paper...
## Deep Shadow Maps

- Some objects only partially occlude light
  - A single shadow value will not work
  - Similar to transparency in Z-Buffer

From Lokovic and Veach
SIGGRAPH 2000