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

Specific details
Structured noise
Pattern w/ randomness
Section through volume
Bumps

2D Texture Mapping of Images

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

Specular
Color
Bump
2D Texture Mapping of Images

- Example of texture distortion

Texture Coordinates

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

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

Texture Coordinates - Drop z

\([x, y, z] \rightarrow [x, y] \rightarrow [u, v]\)

Image From: Rosalee Wolfe
Spherical Projection

\[ [x,y,z] \rightarrow [\rho, \phi, r] \rightarrow [\rho, \phi] \rightarrow [u,v] \]

Procedural Textures

- Generate texture based on some function
  - Well suited for “random” textures
  - Often modulate some noise function
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
  - \( \mathbf{b}(u,v) = [s,t,n](u,v) = \nabla i(u,v) \)
  - \( \nabla = \begin{bmatrix} \frac{\partial}{\partial u} & \frac{\partial}{\partial v} \end{bmatrix}^T \)

Gradient

Gradient of Grayscale Image
Storing Bumps as Image

Grayscale Image & Gradient

Bumps

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

Environmental 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

2D schematic
Environment Maps

\[
u = \frac{y + x}{2x}
\]

\[
v = \frac{z + x}{2x}
\]

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
Shadow Map Example

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