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
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!
MIP Map

- Pre-compute filtered versions of the texture
  - A given UV rate is some level of the texture
  - Tri-linear filtering UV $\times$ 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 tilling
  - 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 tilling
  - Often result in visible artifacts
    - Artifacts not an issue for artificial textures
Non-Color Textures
Bump Mapping

No bump mapping

With 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
  - \( \mathbf{b}(u, v) = [s, t, n](u, v) = \nabla i(u, v) \)
  - \( \nabla = \begin{bmatrix} \frac{\partial}{\partial u} & \frac{\partial}{\partial v} \end{bmatrix}^T \)
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

Bump

Displacement
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
Environment Maps

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

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

(right face)

has \( x > |y|, x > |z| \)

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

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

Shadow Buffer

From Stamminger and Drettakis
SIGGRAPH 2002

Image w/ Shadows

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