**CS-184: Computer Graphics**

**Lecture #11: Texture and Other Maps**

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### 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
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 × 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

![Image of repeating texture](image1.png)

### Non-Color Textures

![Non-Color Textures](image2.png)
Bump Mapping

<table>
<thead>
<tr>
<th>No bump mapping</th>
<th>With bump mapping</th>
</tr>
</thead>
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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

\[ \mathbf{b}(u,v) = [s, t, n](u,v) = \nabla i(u,v) \]
\[ \mathbf{v} = \begin{bmatrix} \frac{\partial s}{\partial u} & \frac{\partial s}{\partial v} \\ \frac{\partial t}{\partial u} & \frac{\partial t}{\partial v} \\ \frac{\partial n}{\partial u} & \frac{\partial n}{\partial v} \end{bmatrix} \]
Bump Map Example

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

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

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
## 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

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### Shadow Buffer

From Stamminger and Drettakis

SIGGRAPH 2002

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### 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