Texture Mapping

Courtesy of Adam Finkelstein Princeton University
Textures

- Describe color variation in interior of 3D polygon
  - When scan converting a polygon, vary pixel colors according to values fetched from a texture
3D Rendering Pipeline (for direct illumination)

3D Primitives

3D Modeling Coordinates

Modeling Transformation

3D World Coordinates

Lighting

3D World Coordinates

Viewing Transformation

3D Camera Coordinates

Projection Transformation

2D Screen Coordinates

Clipping

2D Screen Coordinates

Viewport Transformation

2D Image Coordinates

Scan Conversion

2D Image Coordinates

Image

Texture mapping
Surface Textures

- Add visual detail to surfaces of 3D objects
Surface Textures

- Add visual detail to surfaces of 3D objects
Overview

- Texture mapping methods
  - Parameterization
  - Mapping
  - Filtering

- Texture mapping applications
  - Modulation textures
  - Illumination mapping
  - Bump mapping
  - Environment mapping
  - Image-based rendering
  - Non-photorealistic rendering
Parameterization

- \textbf{Q}: How do we decide \textit{where} on the geometry each color from the image should go?
Option: Varieties of projections

[Paul Bourke]
Option: unfold the surface

[Piponi2000]
Option: make an atlas

charts       atlas       surface

[Sander2001]
Overview

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Texture Mapping

• Steps:
  ○ Define texture
  ○ Specify mapping from texture to surface
  ○ Lookup texture values during scan conversion
Texture Mapping

- When scan convert, map from …
  - image coordinate system (x,y) to
  - modeling coordinate system (u,v) to
  - texture image (t,s)
Texture Mapping

• Texture mapping is a 2D projective transformation
  - texture coordinate system: \((t,s)\) to
  - image coordinate system \((x,y)\)
Texture Mapping

- Scan conversion
  - Interpolate texture coordinates down/across scan lines
  - Distortion due to bilinear interpolation approximation
    » Cut polygons into smaller ones, or
    » Perspective divide at each pixel
Texture Mapping

Linear interpolation of texture coordinates

Correct interpolation with perspective divide

Hill Figure 8.42
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Texture Filtering

- Must sample texture to determine color at each pixel in image
Texture Filtering

- Aliasing is a problem

Point sampling

Area filtering

Angel Figure 9.5
Texture Filtering

• Ideally, use elliptically shaped convolution filters

In practice, use rectangles
Texture Filtering

• Size of filter depends on projective warp
  ◦ Can prefiltering images
    » Mip maps
    » Summed area tables
Mip Maps

- Keep textures prefiltered at multiple resolutions
  - For each pixel, linearly interpolate between two closest levels (e.g., trilinear filtering)
  - Fast, easy for hardware
Summed-area tables

- At each texel keep sum of all values down & right
  - To compute sum of all values within a rectangle, simply subtract two entries
  - Better ability to capture very oblique projections
  - But, cannot store values in a single byte
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Modulation textures

Map texture values to scale factor

\[ I = T(s,t)(I_E + K_A I_A + \sum_L (K_D (N \cdot L) + K_S (V \cdot R)^n) S_L I_L + K_T I_T + K_S I_S) \]
Illumination Mapping

Map texture values to surface material parameter

- $K_A$
- $K_D$
- $K_S$
- $K_T$
- $n$

$$K_T = T(s,t)$$

$$I = I_E + K_A I_A + \sum_L (K_D (N \cdot L) + K_S (V \cdot R)^n) S_L I_L + K_T I_T + K_S I_S$$
Bump Mapping

Texture values perturb surface normals
Bump Mapping
Environment Mapping

Texture values are reflected off surface patch

H&B Figure 14.93
Image-Based Rendering

Map photographic textures to provide details for coarsely detailed polygonal model
Solid textures

Texture values indexed by 3D location (x,y,z)

- Expensive storage, or
- Compute on the fly, e.g. Perlin noise →
Nonphotorealistic Rendering
Art-Maps
Summary

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