Texture Mapping

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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)

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

geometry + image = texture map

Q: How do we decide 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]

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Texture Mapping

• Steps:
  ⮝ Define texture
  ⮝ Specify mapping from texture to surface
  ⮝ Lookup texture values during scan conversion

Modeling Coordinate System

Image Coordinate System

Modeling Coordinate System

Texture Coordinate System
Texture Mapping

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

Texture Coordinate System  Modeling Coordinate System  Image Coordinate System

(x,y)  (u,v)  (t,s)

(0,0)  (1,0)  (0,1)  (1,1)

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

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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

- 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

Magnification  Minification

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

- Keep at each texel the 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

*Wood texture*

*Texture value*

**Illumination Mapping**

Map texture values to surface material parameter

- $K_a$
- $K_d$
- $K_s$
- $K_t$
- $n$

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

**Bump Mapping**

Map texture values to perturbations of surface normals

**Environment Mapping**

Map texture values to perturbations of surface normals

**Image-Based Rendering**

Map photographic textures to provide details for coarsely detailed polygonal model
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