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)
3D Primitives
  → 3D Modeling Coordinates
     Modeling Transformations
     → 3D World Coordinates
     Lighting Transformations
     → 3D Camera Coordinates
     Projection Transformations
     → 2D Screen Coordinates
     Clipping
     → 2D Screen Coordinates
     Viewing Transformations
     → 2D Image Coordinates
     Scan Conversion
     → 2D Image Coordinates

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

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[Daren Horley]

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

[PiPoni2000]

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Texture Mapping

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

Modeling Coordinate System  ▶️  Texture Coordinate System  ▶️  Image 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 mapping is a 2D projective transformation
  - texture coordinate system: (t,s) to
  - image coordinate system (x,y)

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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

Angel Figure 9.5

Texture Filtering

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

Magnification  Minification

Angel Figure 9.14

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

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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

Illumination Mapping
Map texture values to surface material parameter

\[ I = I_e + K_a I_a + \sum (K_d(N \cdot L) + K_r(V \cdot R)^s) S_I + K_f I_f + K_f I_d \]

Bump Mapping
Texture values perturb surface normals

Bump Mapping
Texture values perturb surface normals

Environment Mapping
Texture values are reflected off surface patch

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

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