Texture Mapping

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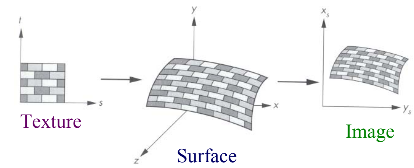
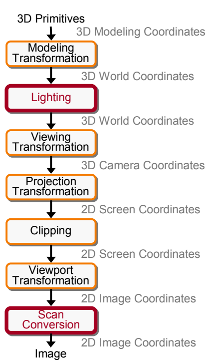
Textures

- Describe color variation in interior of 3D polygon
  - When scan converting a polygon, vary pixel colors according to values fetched from a texture



Angel Figure 9.3

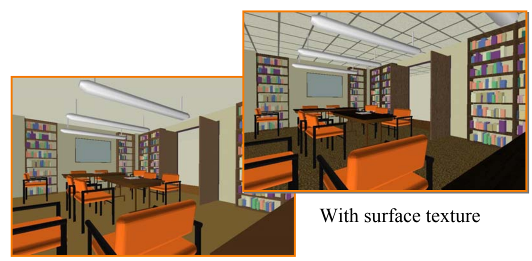
3D Rendering Pipeline (for direct illumination)



Texture mapping

Surface Textures

- Add visual detail to surfaces of 3D objects

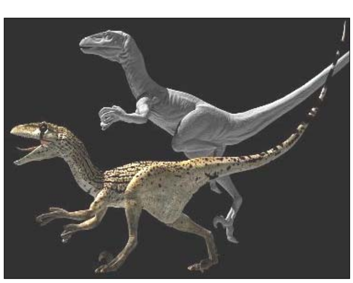


With surface texture

Polygonal model

Surface Textures

- Add visual detail to surfaces of 3D objects

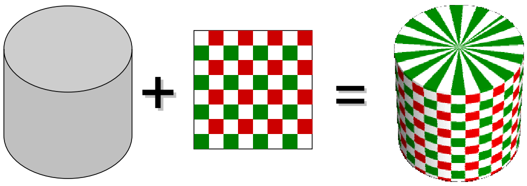


[Daren Horley]

Overview

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

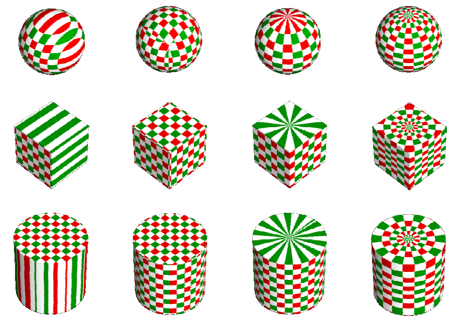
Parameterization



geometry image texture map

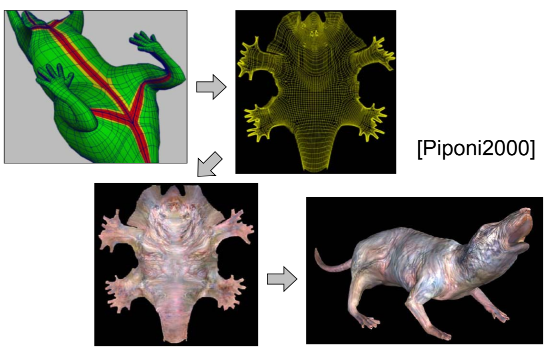
- Q: How do we decide *where* on the geometry each color from the image should go?

Option: Varieties of projections



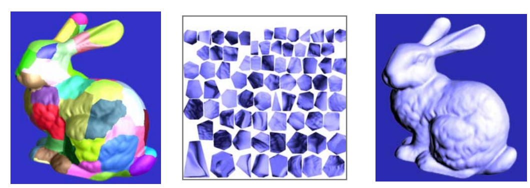
[Paul Bourke]

Option: unfold the surface



[Piponi2000]

Option: make an atlas



charts atlas surface

[Sander2001]

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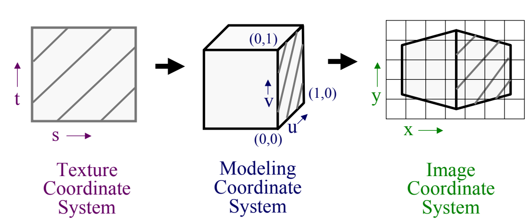
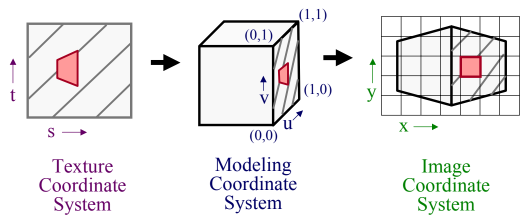
Texture Mapping

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



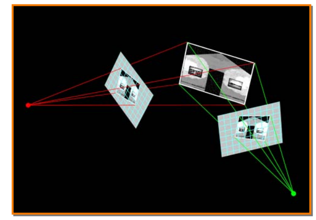
Texture Mapping

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



Texture Mapping

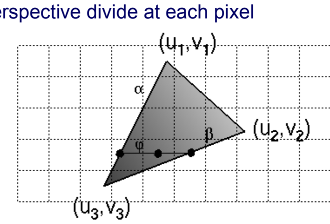
- Texture mapping is a 2D projective transformation
  - texture coordinate system: (t,s) to
  - image coordinate system (x,y)



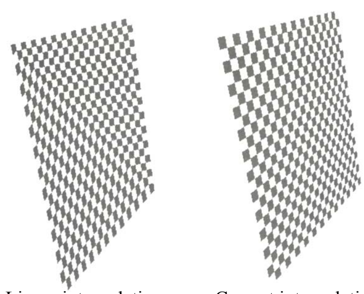
Allison Klein, Princeton

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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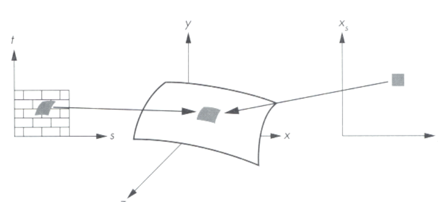
Texture Filtering

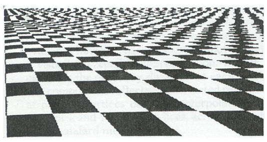
- Must sample texture to determine color at each pixel in image



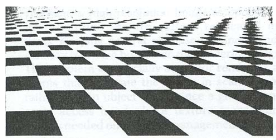
Angel Figure 9.4

Texture Filtering

- Aliasing is a problem



Point sampling

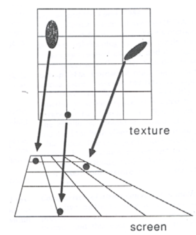


Area filtering

Angel Figure 9.5

Texture Filtering

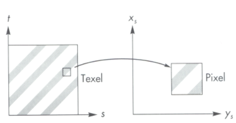
- Ideally, use elliptically shaped convolution filters



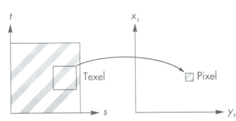
In practice, use rectangles

Texture Filtering

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



Magnification

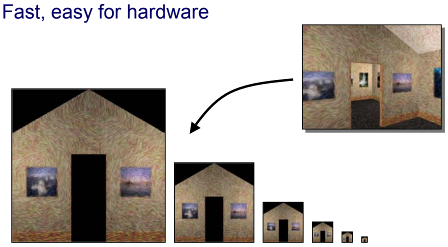


Minification

Angel Figure 9.14

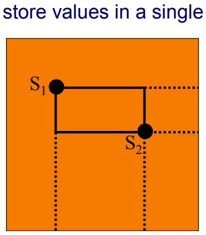
Mip Maps

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



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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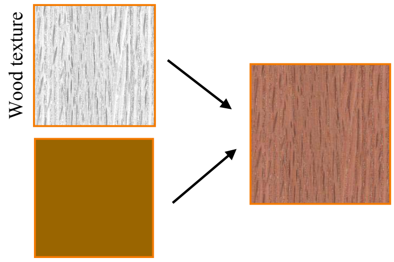
Modulation textures

Map texture values to scale factor



Texture value

$$I = T(s,t)(I_E + K_A I_A + \sum_L (K_D(N \bullet L) + K_S(V \bullet R)^n) S_L I_L + K_T I_T + K_S I_S)$$

Illumination Mapping

Map texture values to surface material parameter

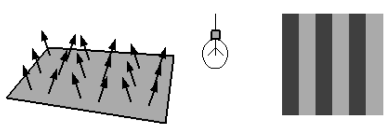
- K_A
- K_D
- K_S
- K_T
- n

$K_T = T(s,t)$

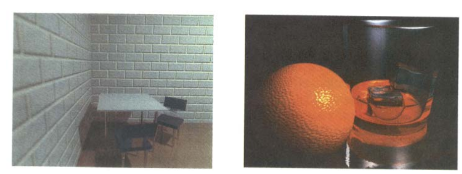
$$I = I_E + K_A I_A + \sum_L (K_D(N \bullet L) + K_S(V \bullet R)^n) S_L I_L + K_T I_T + K_S I_S$$

Bump Mapping

Texture values perturb surface normals



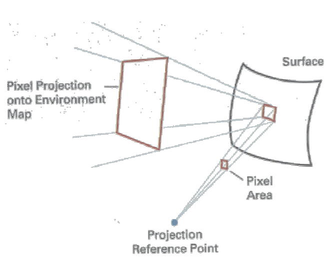
Bump Mapping



H&B Figure 14.100

Environment Mapping

Texture values are reflected off surface patch



H&B Figure 14.93

Image-Based Rendering

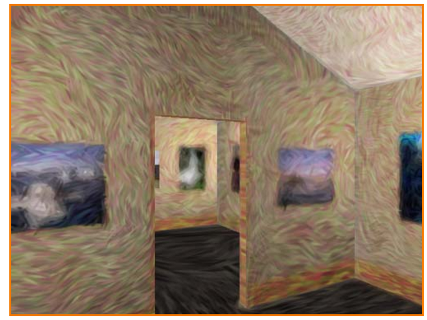
Map photographic textures to provide details for coarsely detailed polygonal model

Solid textures

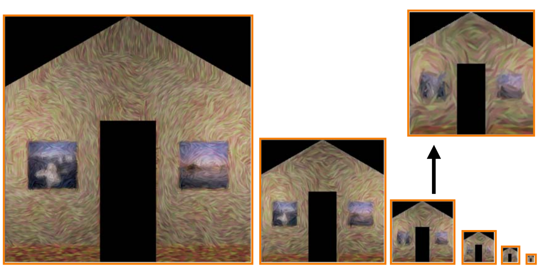
Texture values indexed by 3D location (x,y,z)

- Expensive storage, or
- Compute on the fly, e.g. Perlin noise →

Nonphotorealistic Rendering



Art-Maps



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