Texture Mapping
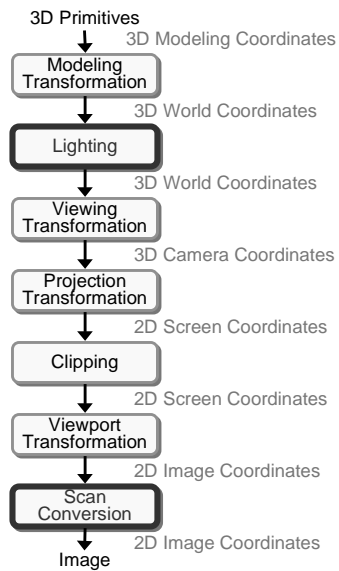
Thomas Funkhouser

Princeton University

C0S 426, Fall 2000

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

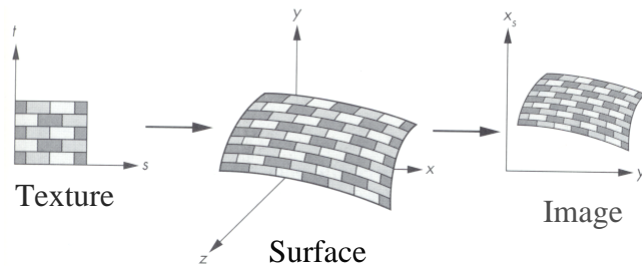Scan Conversion

↓ 2D Image Coordinates

Image

Texture mapping

Textures

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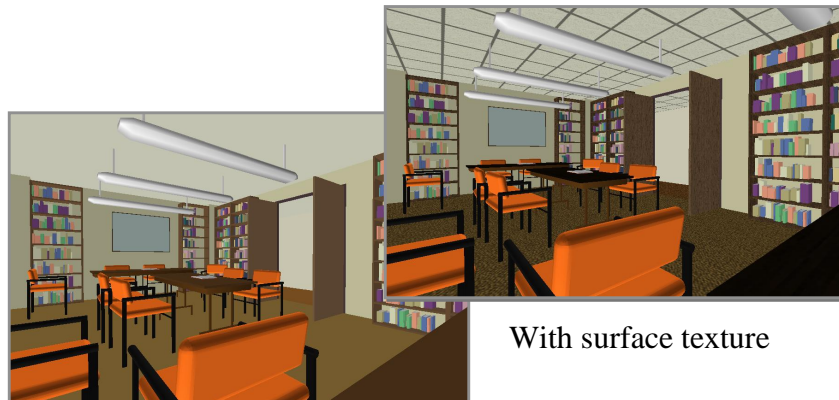
Texture

Surface

Image

Angel Figure 9.3

Surface Textures

- Add visual detail to surfaces of 3D objects

With surface texture
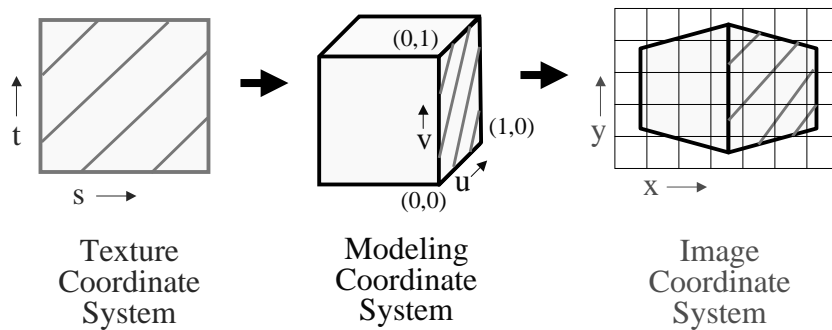
Polygonal model

Overview

- Texture mapping methods
  - Mapping
  - Filtering

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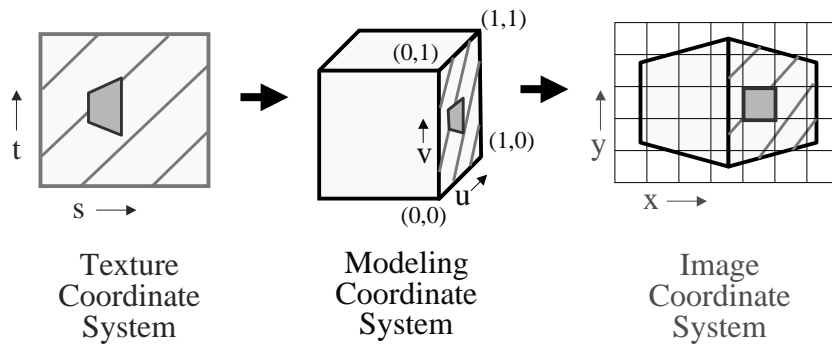 - Non-photorealistic rendering

Texture Mapping

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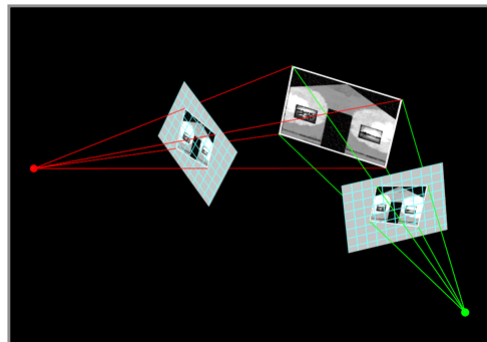 - Lookup texture values during scan conversion

Texture Coordinate System

Modeling 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 Coordinate System → Modeling Coordinate System → Image Coordinate System

Texture Mapping

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

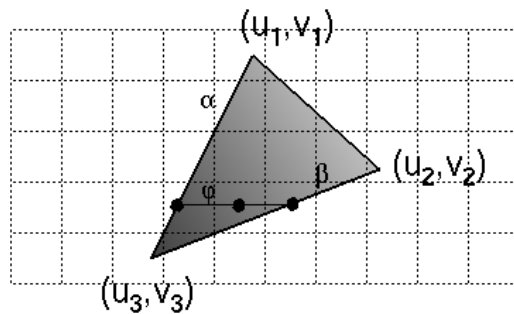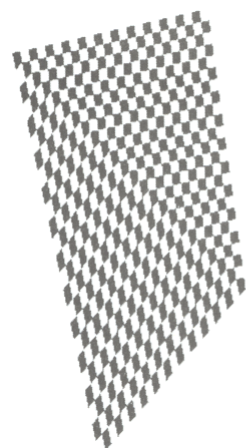Chris Buehler & Leonard McMillan, MIT
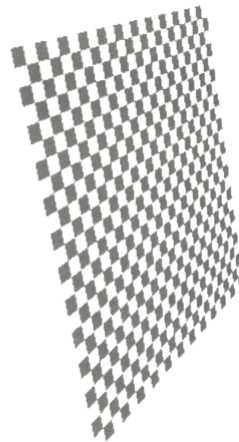
Texture Mapping

- 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
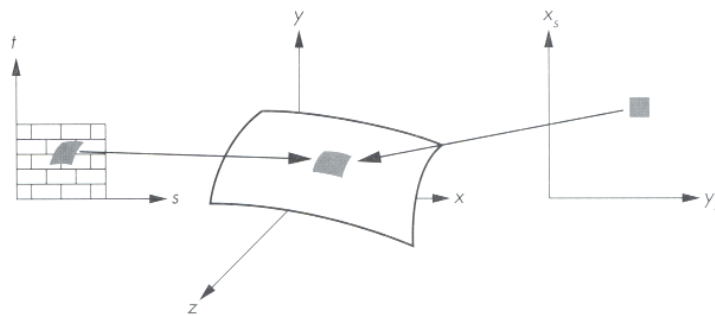
Hill Figure 8.42

Overview

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Texture Filtering

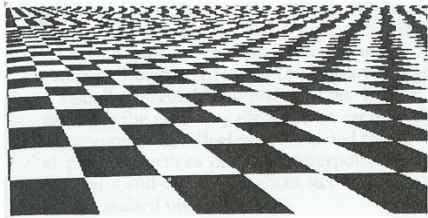- Must sample texture to determine color at each pixel in image
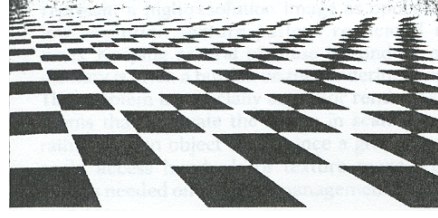

Angel Figure 9.4

Texture Filtering

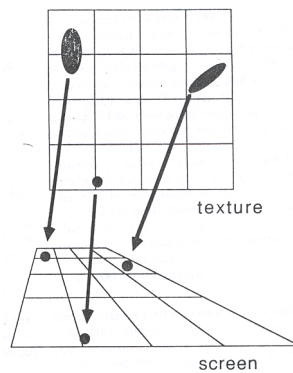- Aliasing is a problem

Point sampling

Area filtering

Angel Figure 9.5

Texture Filtering

- Ideally, use elliptically shaped convolution filters
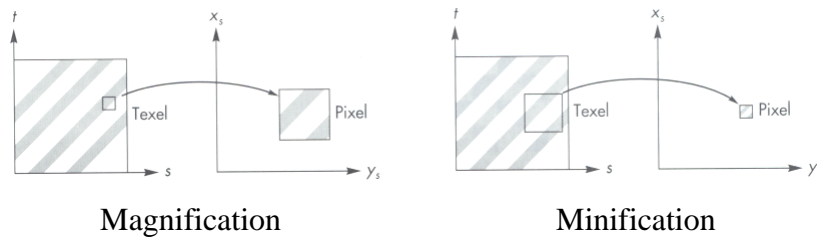

texture

screen

In practice, use rectangles

Texture Filtering

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

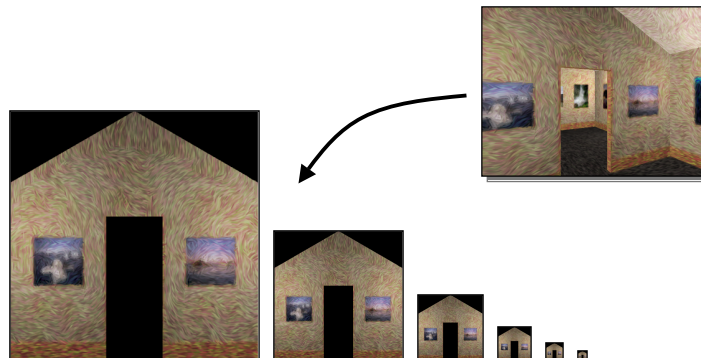Magnification   Minification

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)
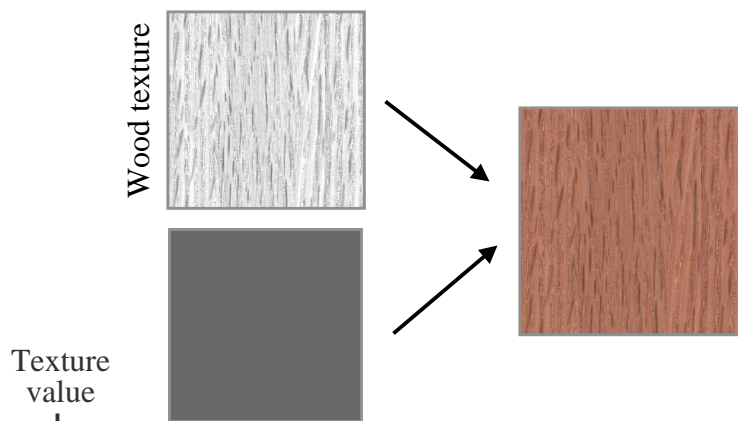   - Fast, easy for hardware

Overview

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Modulation textures

- Map texture values to scale factor

Wood texture

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
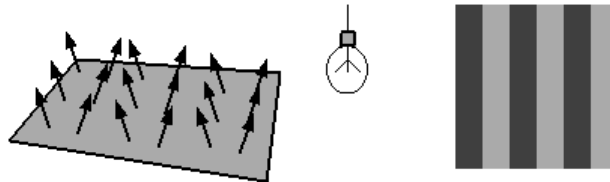 - K_A
  - K_D
  - K_S
  - K_T
  - n

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

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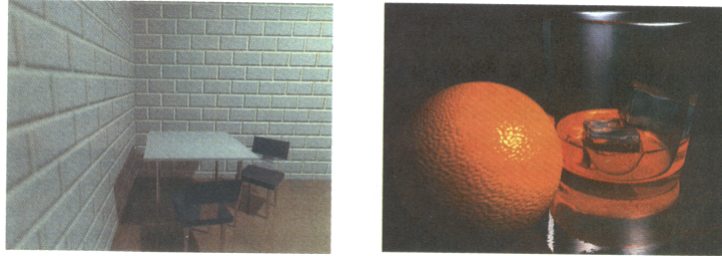
Bump Mapping

- Map texture values to perturbations of surface normals
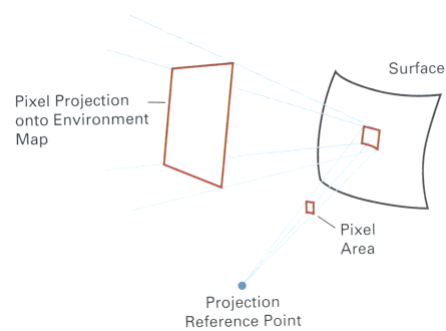
Bump Mapping

H&B Figure 14.100

Environment Mapping

- Map texture values to perturbations of surface normals
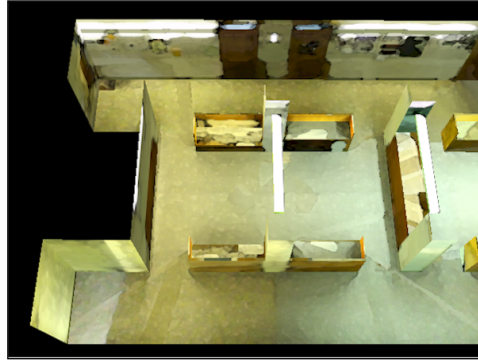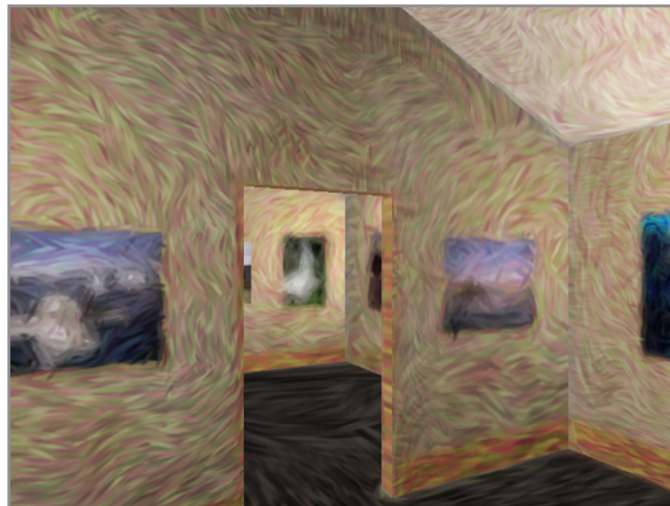

H&B Figure 14.93
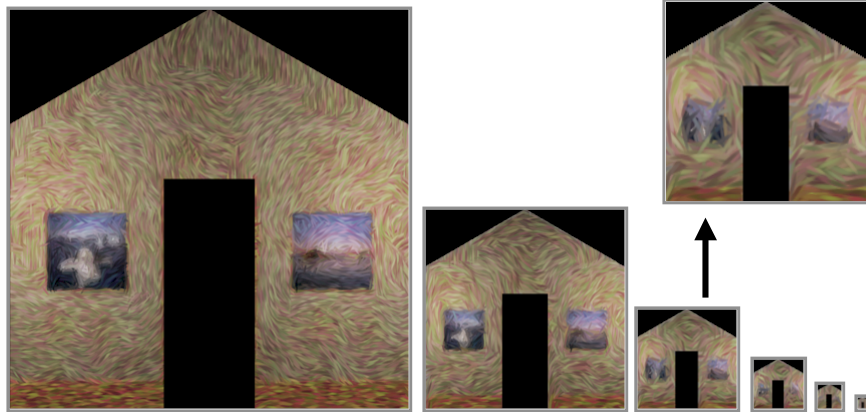
Image-Based Rendering

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

Nonphotorealistic Rendering

Art-Maps

Summary

- Texture mapping methods
  - Mapping
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  - Non-photorealistic rendering