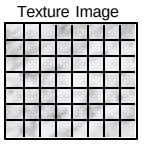
Texture Mapping

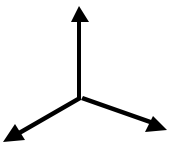
Lecture 10

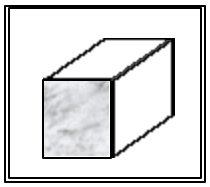
- Increase Object Detail
  - Paint
    - Decal
  - Material
    - Wood Grain
    - Marble
    - Non-Plastic
  - Geometry
    - Surface Normal
  - Surrounding Environment
    - Reflection
    - Transparency (Clouds)
- Increased Computation Time

Texture Mapping

Lecture 10







- Texture Space (s, t)
- Texels

- Object Space (u, v)
- Parametric Surface

- Rendered Image Space (i, j)
- Pixels

I. (s,t) —Map to Surface→ (u,v) —Project to Image→ (i,j)

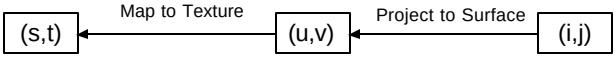
II. (s,t) ←Map to Texture— (u,v) ←Project to Surface— (i,j)

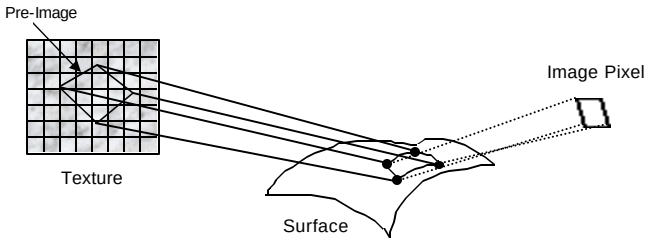
III. Two Pass Method

Texture Mapping

Lecture 10

II.





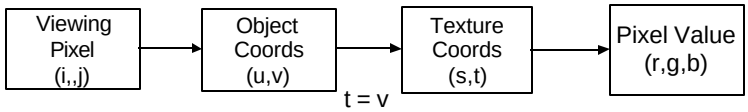
- Project 4 Pixel Corners Onto Parametric Surface(u,v)
- Transform Parametric Surface Values to Texel Space (s,t)
- Compute Weighted Sum of Texels in Bounding Quadrilateral
- Set Image Pixel Value

3

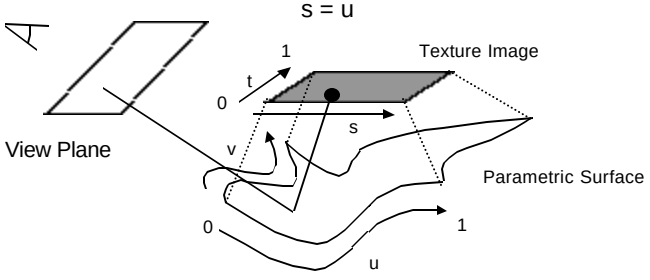
Texture Mapping

Lecture 10

- Shrinkwrapping Image Onto a Parametric Surface



t = v
s = u

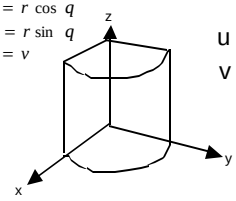


4

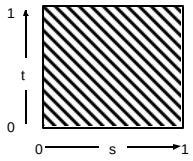
Texture Mapping

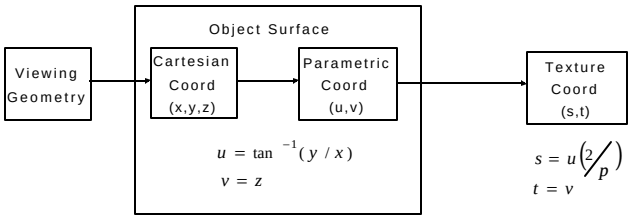
Lecture 10

$x = r \cos q$
$y = r \sin q$
$z = v$



$u = \theta \quad 0 \le q \le p/2$
$v = z \quad 0 \le z \le 1$



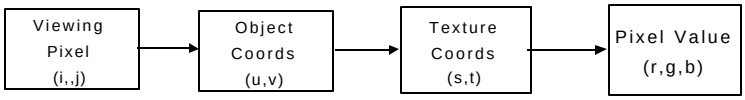


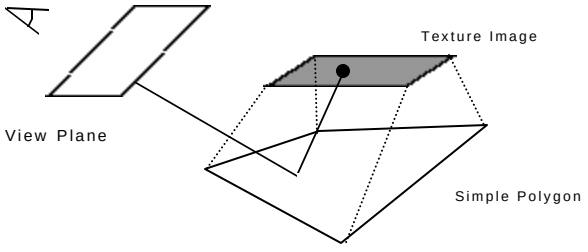
5

Texture Mapping

Lecture 10

• "Vacuum-Form" Image Onto a Polygonal Surface





• Assign Texture Coordinates to Polygon Verticies

6

Texture Mapping

Lecture 10

- Polygon Mesh Texture Mapping ?
- Two-Part Mapping
  - Map Texture onto an intermediate surface
    - Generally non-planar
    - Possesses an simple parametric definition
  - Map intermediate surface onto object
    - Correspondence between object point and texture point is a 3-D to 3-D transform
  - Handles “global” mapping of ploygon meshes
  - Texture may be distorted by double mapping

Two Pass Texture Mapping

Lecture 10

- Map from 2-D Texture Space to a *simple* 3-D intermediate surface
  - Cylinder
  - Sphere
  - Box
  - Plane

$$T(s,t) \rightarrow T'(x_i, y_i, z_i)$$ “S” mapping

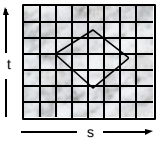
- Determine mapping from 3-D intermediate surface to 3-D object surface

$$T'(x_i, y_i, z_i) \rightarrow O(x, y, z)$$ “O” mapping

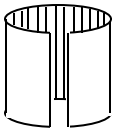
Two Pass Texture Mapping

Lecture 10

- "S" mapping



Texture
(s,t)



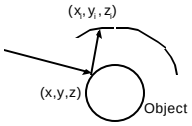
Surface
(θ,h)

$$s = \frac{r}{c}(q - q_0)$$

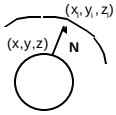
$$t = \frac{1}{d}(h - h_0)$$

c, d are scaling factors
θ_0, h_0 position the texture on the cylinder
r is the radius of the cylinder

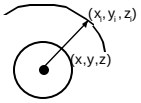
- "O" mapping



Reflected Ray



Object Normal



Object Centroid

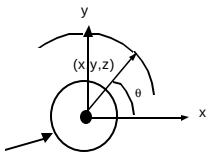
Two Pass Texture Mapping

Lecture 10

1. Map the four pixel corners to the surface of the object (x,y,z)

2. Apply the "O" mapping (θ, h)

$$q = \tan^{-1}(y / x)$$
$$h = z$$



Polygon Mesh Object

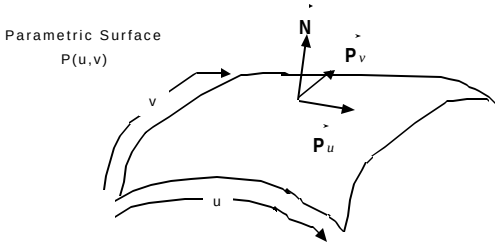
3. Apply "S" mapping to find texture point (s,t)

$$s = \frac{r}{c}(q - q_0) \qquad t = \frac{1}{d}(h - h_0)$$

Bump Mapping

Lecture 10

- Bump Mapping
  - Texture map image shadows won't change if scene lighting changes
  - Modify surface itself instead of surface color
  - Simulate wrinkled/rough surfaces [Blinn `78]



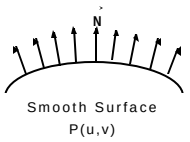
$$\vec{\mathbf{P}}_u = \frac{\partial}{\partial u}\vec{\mathbf{P}}(u,v)$$

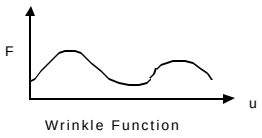
$$\vec{\mathbf{P}}_v = \frac{\partial}{\partial v}\vec{\mathbf{P}}(u,v)$$

$$\vec{\mathbf{N}} = \vec{\mathbf{P}}_u \times \vec{\mathbf{P}}_v$$

Bump Mapping

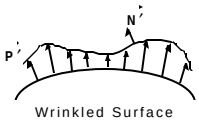
Lecture 10





$$\vec{\mathbf{P}}' = \vec{\mathbf{P}} + F(u,v)\hat{\mathbf{n}}$$

where F is the wrinkle function



$$\vec{\mathbf{N}}' = \vec{\mathbf{P}}'_u \times \vec{\mathbf{P}}'_v$$

Bump Mapping

Lecture 10

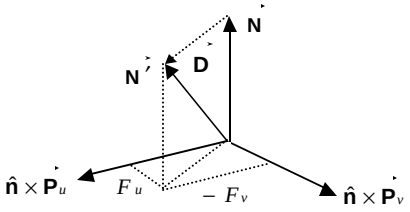
$$\mathbf{N}' = \mathbf{P}'_u \times \mathbf{P}'_v$$

$$\overrightarrow{\mathbf{P}'_u} = \frac{\partial}{\partial u}(\overrightarrow{\mathbf{P}} + F\hat{\mathbf{n}}) = \overrightarrow{\mathbf{P}_u} + F_u\hat{\mathbf{n}} + F\hat{\mathbf{n}}_u$$

$$\overrightarrow{\mathbf{P}'_v} = \frac{\partial}{\partial u}(\overrightarrow{\mathbf{P}} + F\hat{\mathbf{n}}) = \overrightarrow{\mathbf{P}_v} + F_v\hat{\mathbf{n}} + F\hat{\mathbf{n}}_v$$

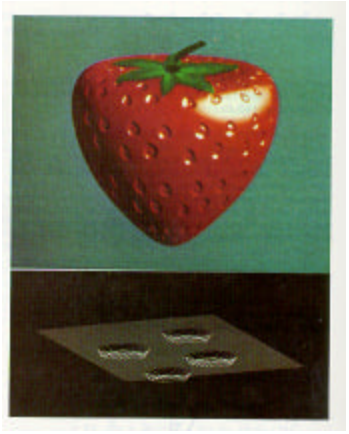
Let *F* be small, so that the last term can be neglected

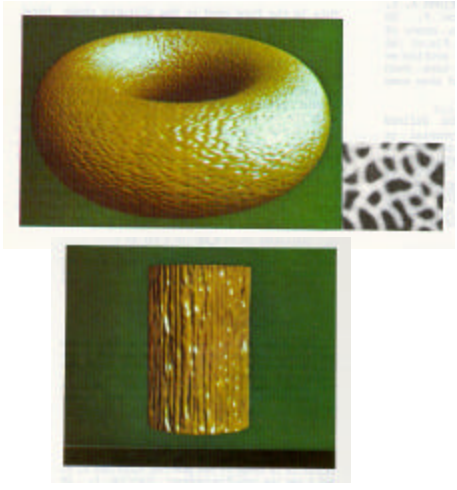
$$\mathbf{N}' = \mathbf{N} + \mathbf{D} = \mathbf{N} + \{F_u(\hat{\mathbf{n}} \times \mathbf{P}_v) - F_v(\hat{\mathbf{n}} \times \mathbf{P}_u)\}$$



Bump Mapping

Lecture 10





OpenGL Implementation

Lecture 10

- Texture Mapping in OpenGL
  - Create a Texture Object
    - Specify Texture for the Object
  - Define How the Texture is to be Applied
    - GL_DECAL, GL_REPLACE
  - Enable Texture Mapping
  - Draw the Scene
    - Supply Texture Coordinates
    - Supply Geometric Coordinates

- **Size of Textures Must be a Power of 2**
  - **Minimum Size : 64x64**

15

Advanced Texturing

Lecture 10

Mip Mapping

Environment Mapping

Procedural Textures

16

MIP Maps

Lecture 10

MIP Latin

"multim im parvo"

"Many thing is one place"

- Pre-filtered Offline
- Multi Levels of detail
- mip maps accessed through u,v,d
- gluBuild2DMipmaps gluBuild1DMipMaps

17

Environment Maps

Lecture 10

- Simulates specular reflected scene information
- Provides a virtual 1 ray ray-trace
- Only provide far field reflection correctly
- Can be mapped to a cube for easy access

18

Environment Maps

Lecture 10

19

Environment Maps

Lecture 10

20

Procedural Textures

Lecture 10

- Textures Based on functions not images
- Simulate the natural world through simplified Physics
- Noise Generators and Fractals
- 3-D Textures
- Not only colors but, materials, motion .....

21

Procedural Textures

Lecture 10

Advantages

- Very compact when compared to images.
- No fixed resolution
- No fixed area
- Can be parameterized for general classes

Disadvantages

- Difficult to code and debug
- Not always predicable
- Can be slow
- Aliasing can be a problem

22

Procedural Textures

Lecture 10

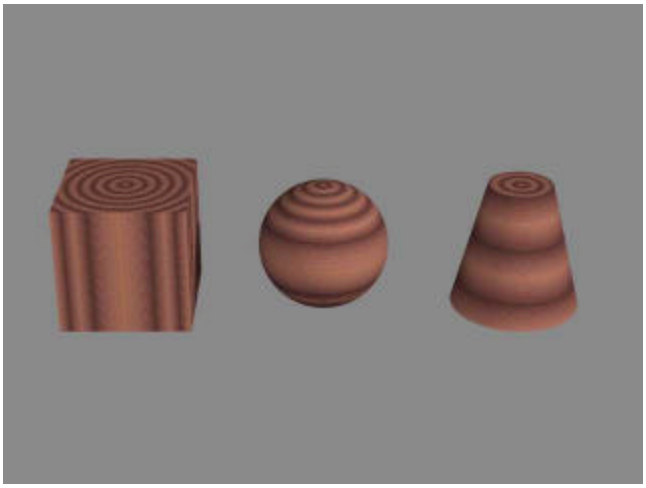
Wood Example

Simulate wood in 3-D
- Growth rings
- Color
- Position

23

Procedural Textures

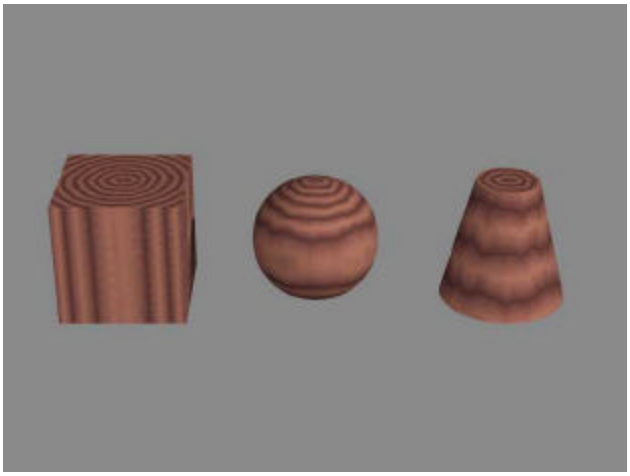
Lecture 10



24

Procedural Textures

Lecture 10



25

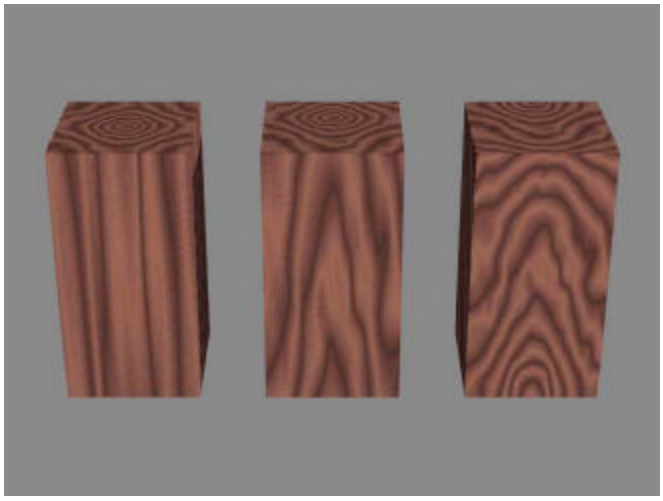
Procedural Textures

Lecture 10

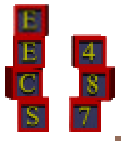
26

Procedural Textures

Lecture 10



27



Procedural Textures

Lecture 10

28

Procedural Textures

Lecture 10