Texture Mapping

Adapted from slides by

Rich Riesenfeld

http://www.cs.utah.edu/classes/cs5600/

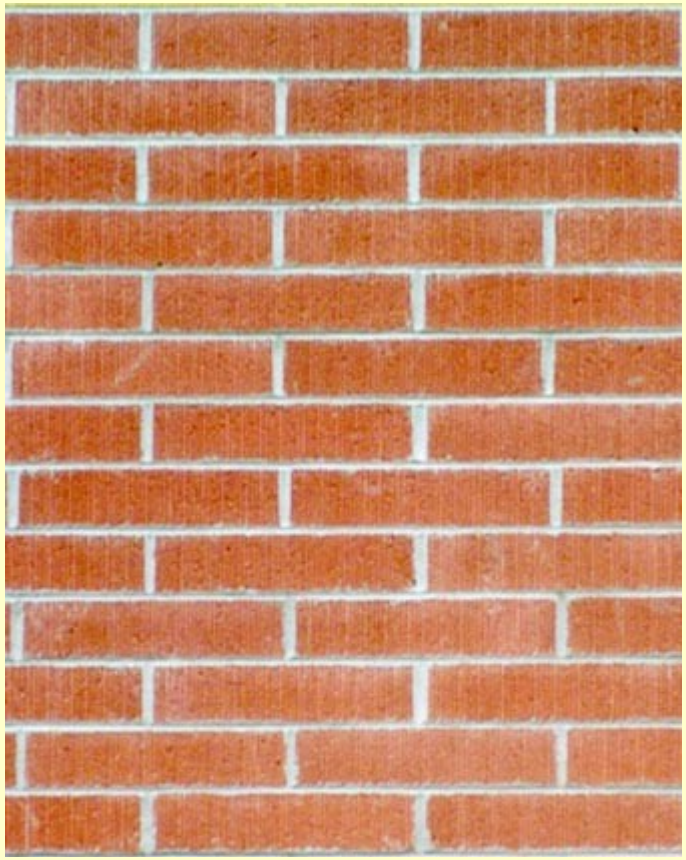
Texture Mapping

- Maps a pattern (texture) onto a surface
- *Texels* fill each pixel
- Texels selected from sample pattern (*texture map*)
- Pattern is often repeated

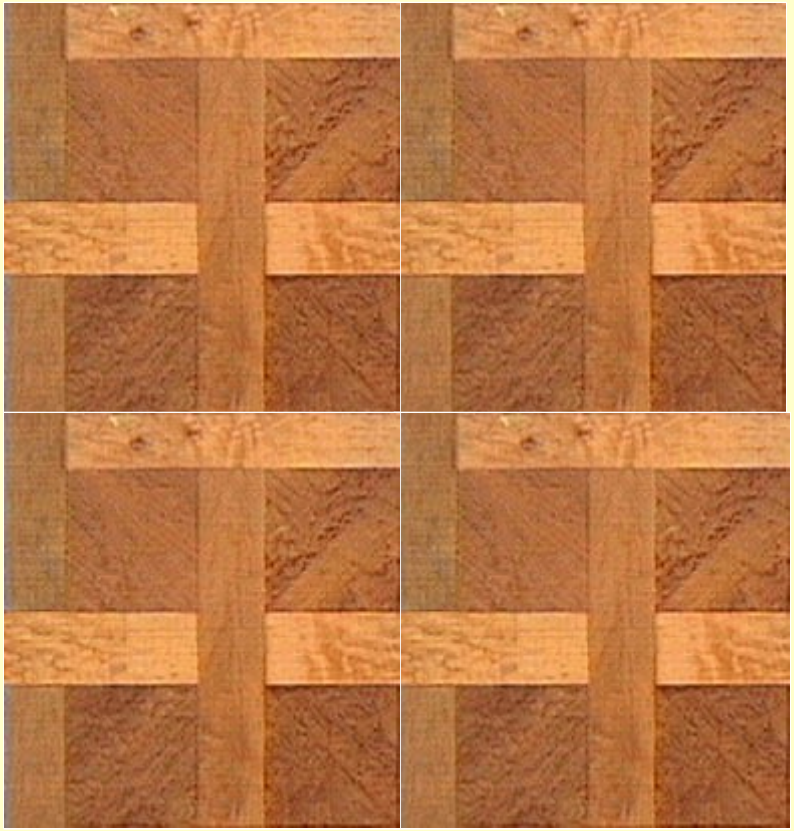
Texture Mapping Characteristics

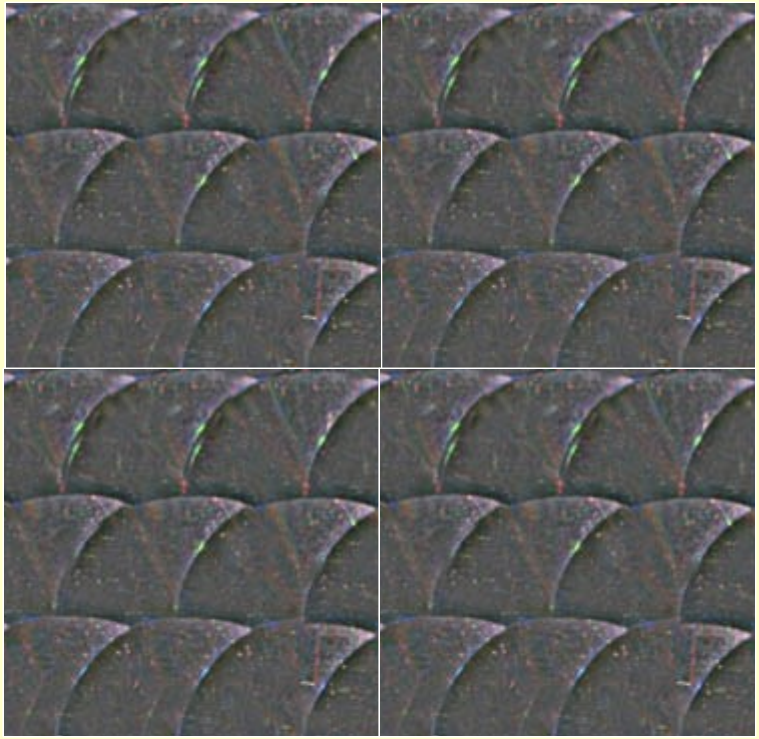
- Too much *detail* to model geometrically, like grass, etc
- Pattern is repeated (*periodic*)

Texture Maps

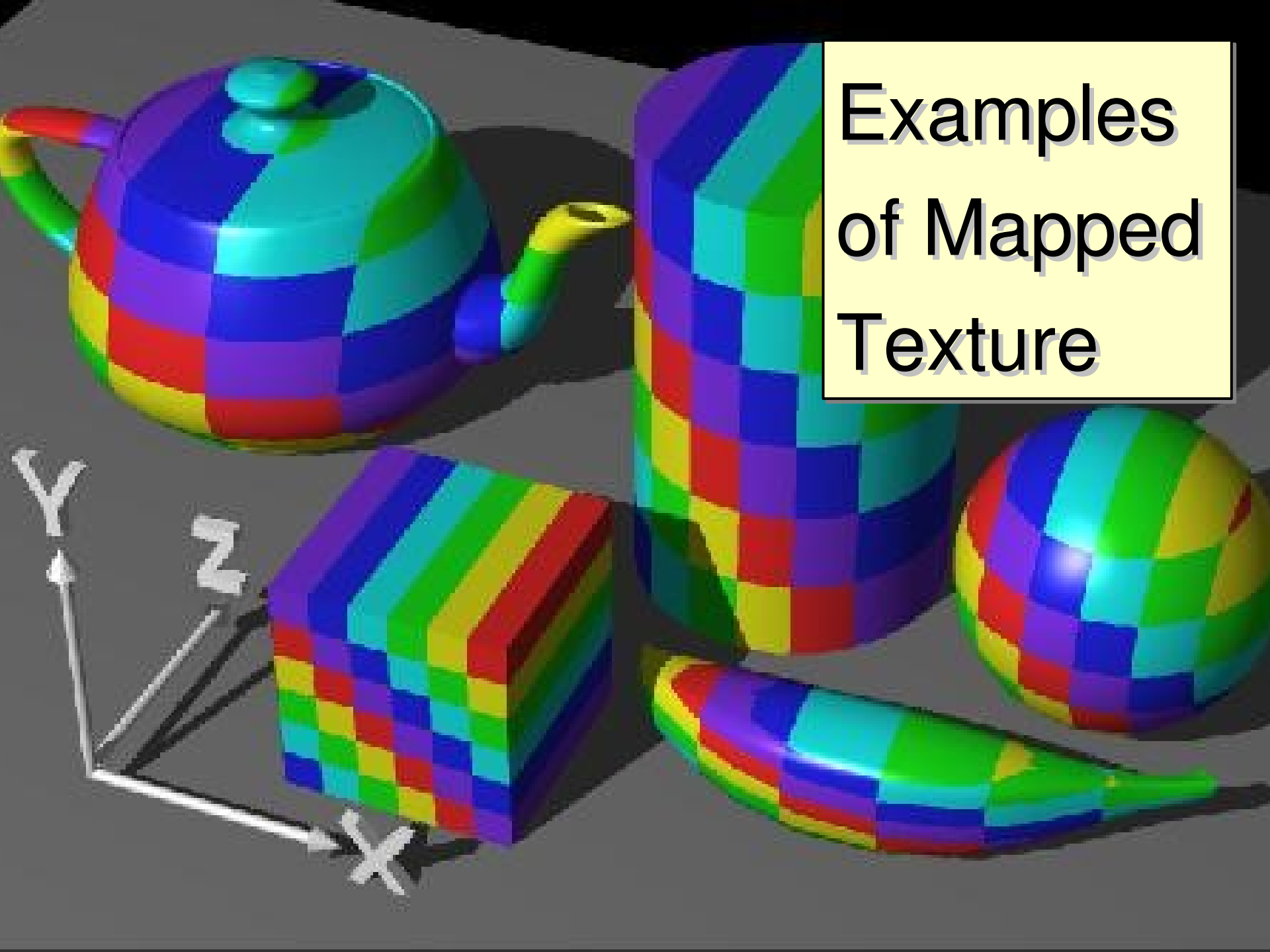


Tiling textures





Tiling textures


Examples
of Mapped
Texture
Y
Z
X

Basic Concept

(2D Texture maps)

- Relate a $2D$ image to a $3D$ model
- *Texture coordinates*
  - $2D$ coordinate (u,v) that corresponds to a location in the texture image
  - usually in range $[0,1]$

Elements of Texture Mapping

- Texture source function (1D, 2D or $3D$)
- Inverse map:

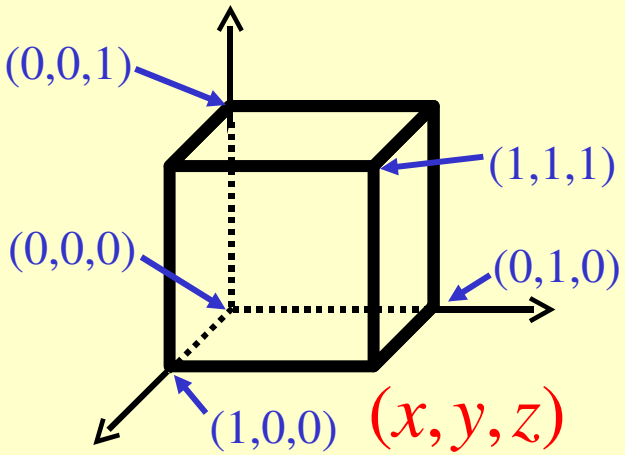
  $$\textit{texture location} \quad \textit{surface location}$$

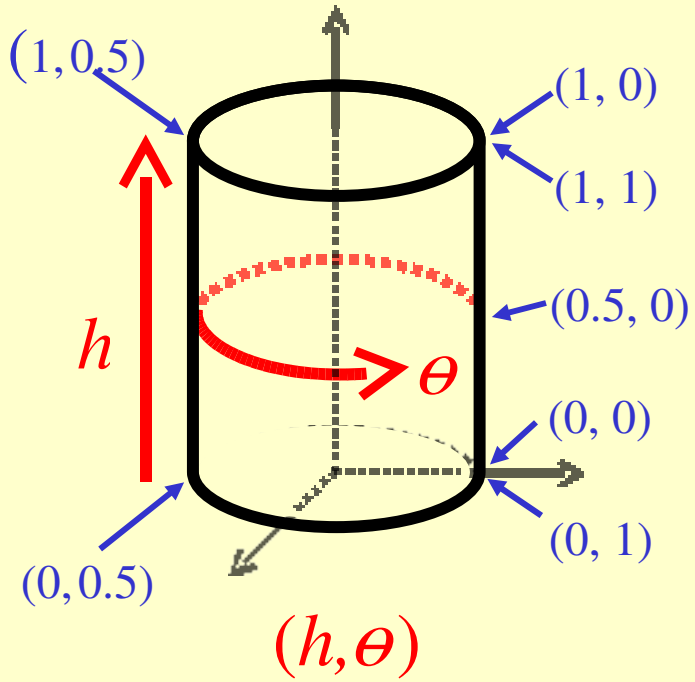
- Typical texture sources
  - Procedure
  - Tabular data (texture image)

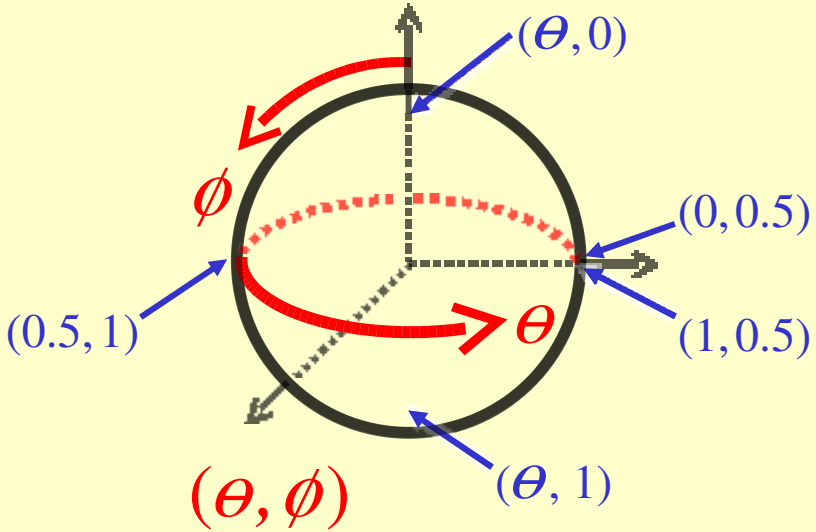
Texture Mapping Techniques

- $2D$ texture mapping: *paint* $2D$ pattern onto the surface
- *Environmental* (reflection) *mapping*
- *Bump mapping*: perturb surface normals to fool shading algorithms
- Procedural texture mapping

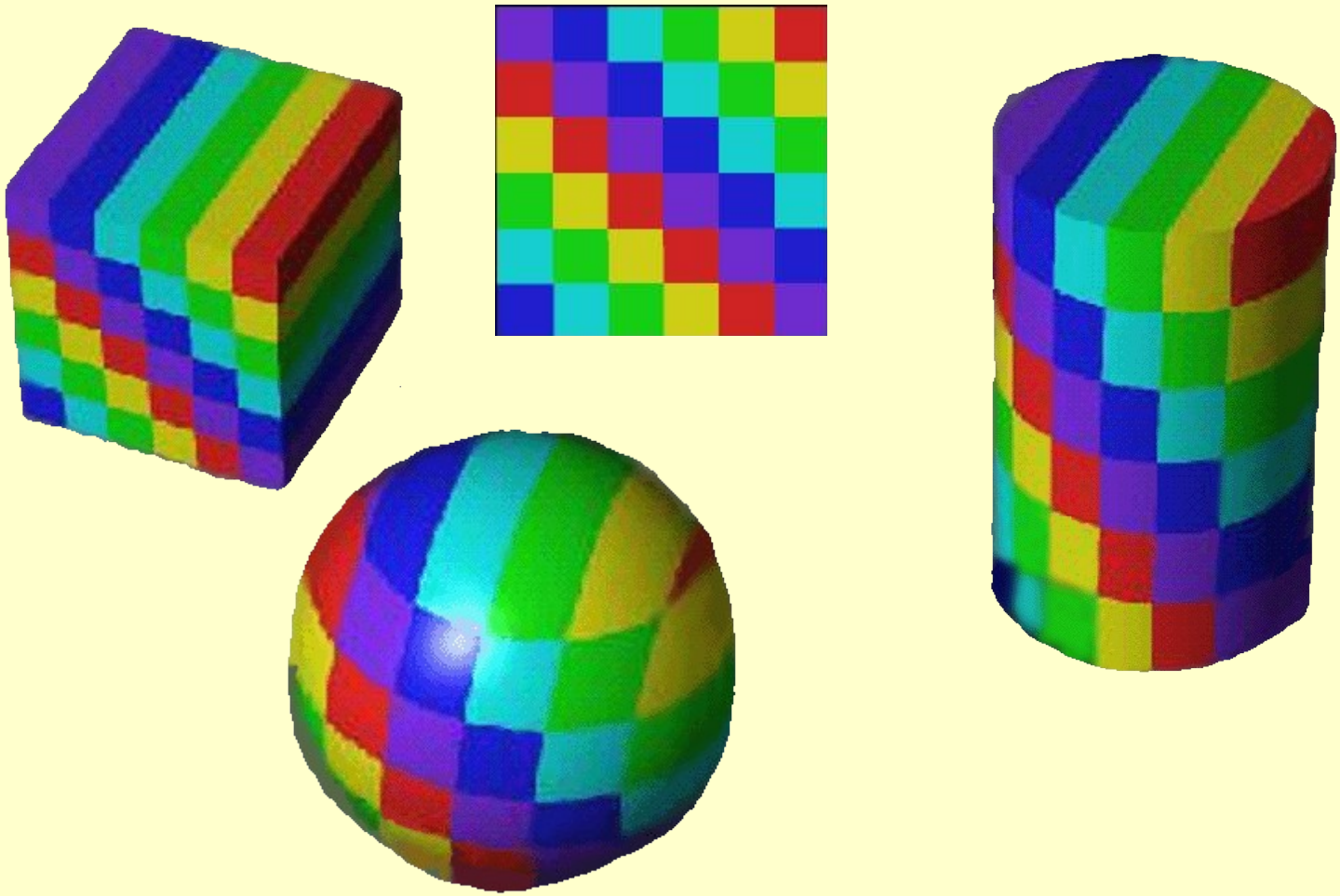
Need to Impose Parametrization



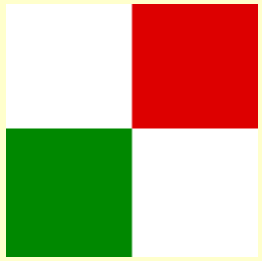


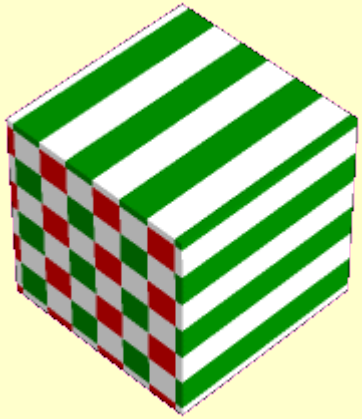


Define an *Invertible* Texture Map



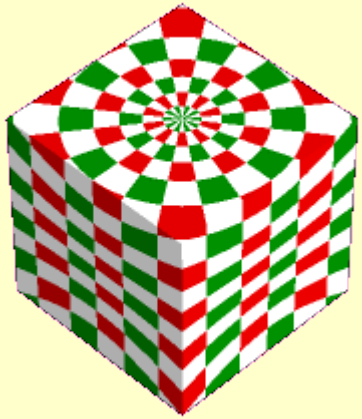
More Examples





Planar

Cubic

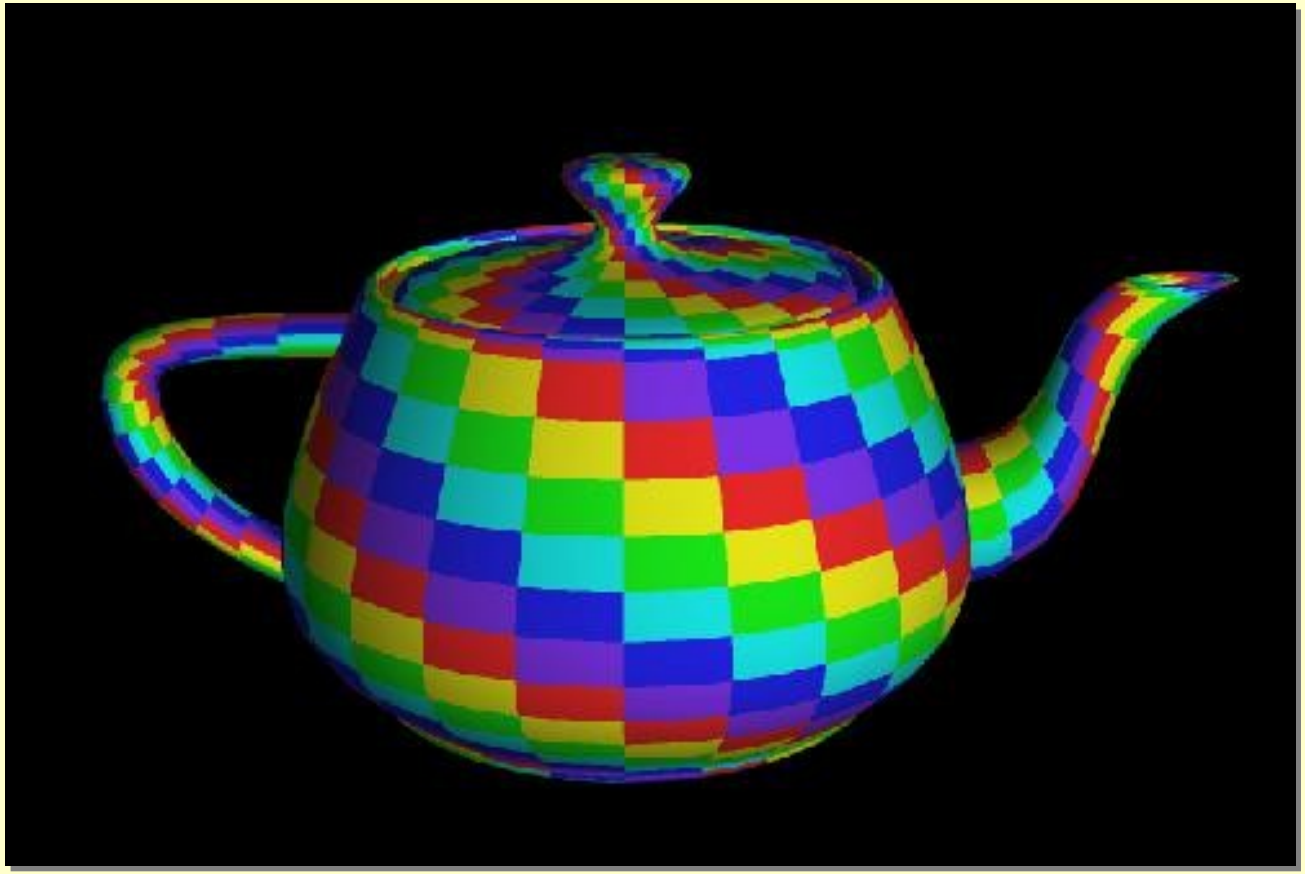


Cylindrical

Texture Mapping, Paul Bourke (1987)

http://astronomy.swin.edu.au/~pbourke/texture/texturemapping

Texture Mapped Teapot



Examples

Steps in Texture Mapping (OpenGL)

1. Create a texture object and specify a texture for that object
2. Indicate how the texture is to be applied to each pixel
3. Render the scene, supplying both texture and geometric coordinates

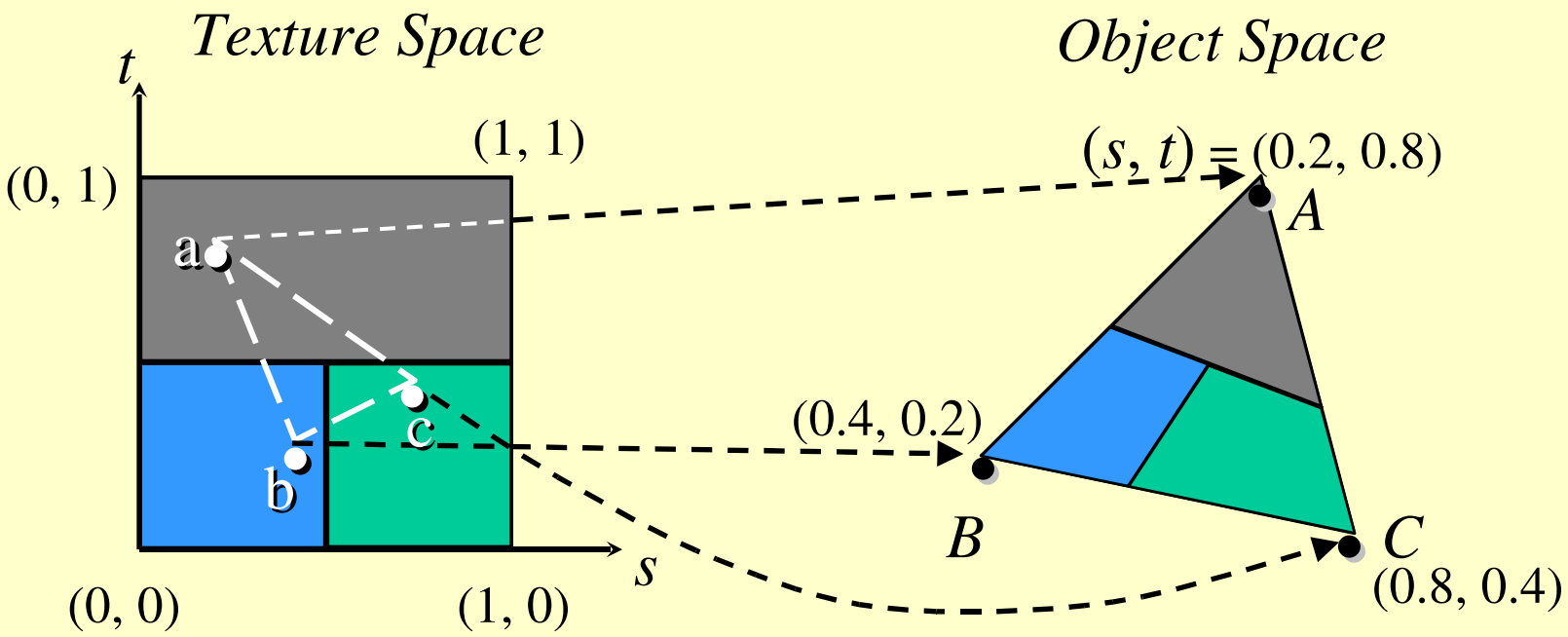
Mapping the $2D$ Texture to Surface

- The map: $2D$ texture(s,t) → $3D$ object(x,y,z)
- Mapping onto triangle is not difficult
- Mapping onto triangular mesh is more difficult (have to handle texture discontinuity)
- Mapping onto parametric surface is easier
- Alternative: use an intermediate parametric surface (cylinder, sphere)

Texture Mapping for Meshes

- Assign per-vertex texture coordinate
- During rasterization: interpolate texture coordinates at each pixel (similar to project 1)
- Lookup texture color via texture coordinate

Mapping Texture



Mapping Texture onto Parametric Surface

- Point on the parametric surface

$$p : x = x(u,v), y = y(u,v), z = z(u,v)$$

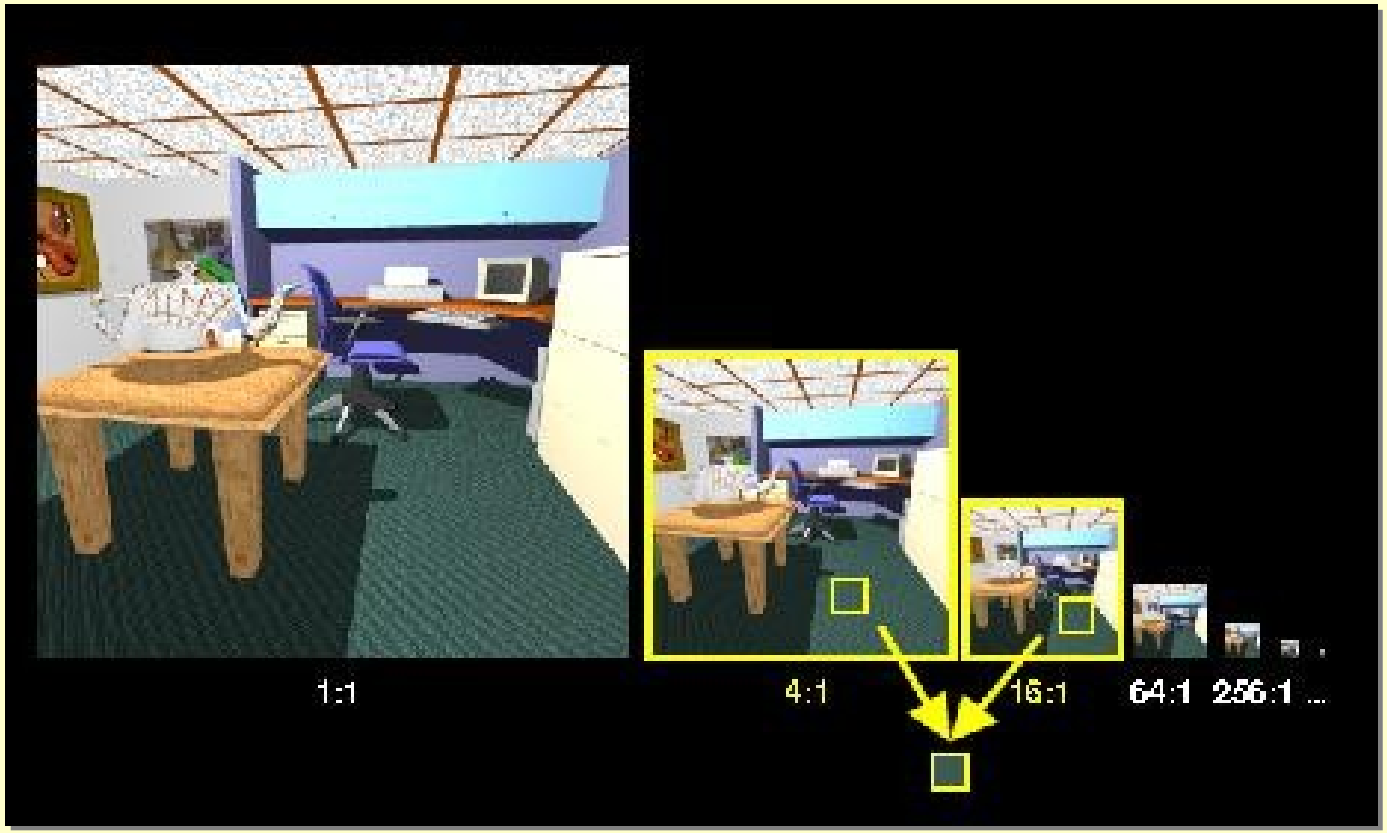
- Use (u,v) as texture coordinates

Mapping texture to a surface using an intermediate surface

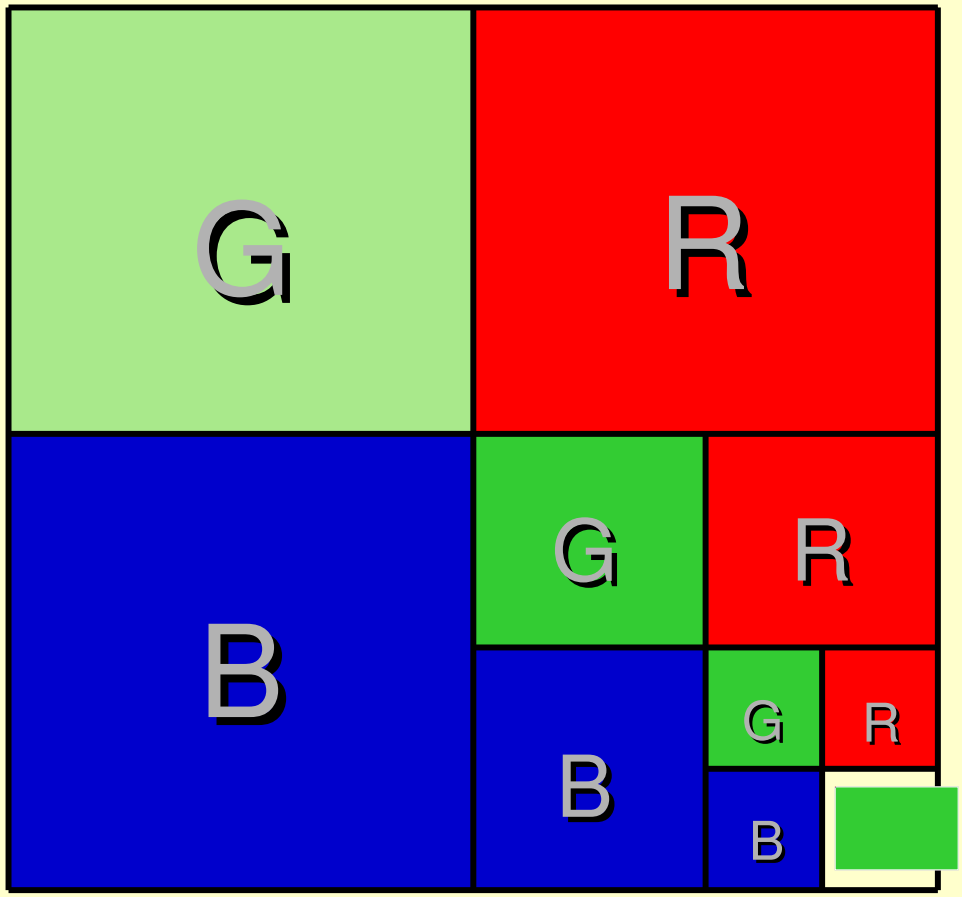
- Two-step mapping
  - Map the texture to a simple intermediate surface (sphere, cylinder, cube)
  - Map the intermediate surface (with the texture) onto the surface being rendered

MIP Mapping (*multum in parvo*)

"Many things in a small place"



MIP Mapping (LOD)



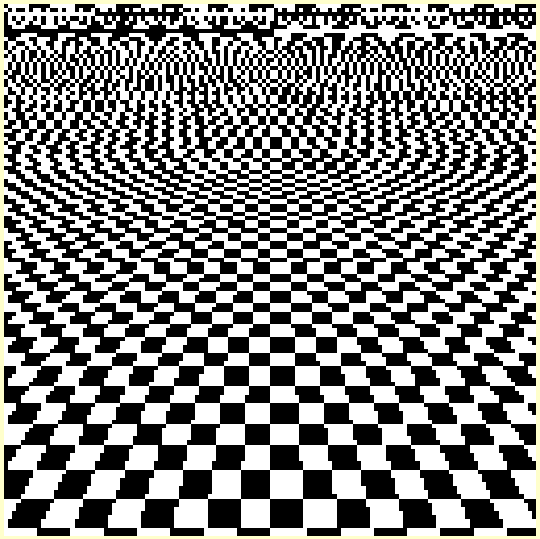
Mipmapped Textures

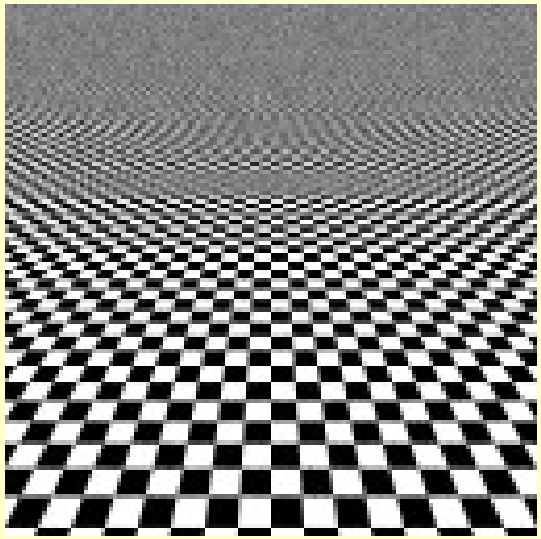
- Mipmap allows
  - prefiltered texture maps
  - decreasing resolutions
- Lessens interpolation errors for smaller objects
- OpenGL supports LOD

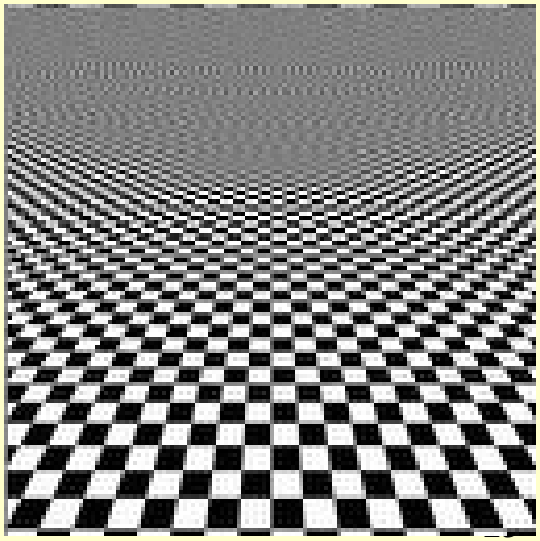
Aliasing

aliasing (left); antialiased (middle, right)

(from wikipedia)



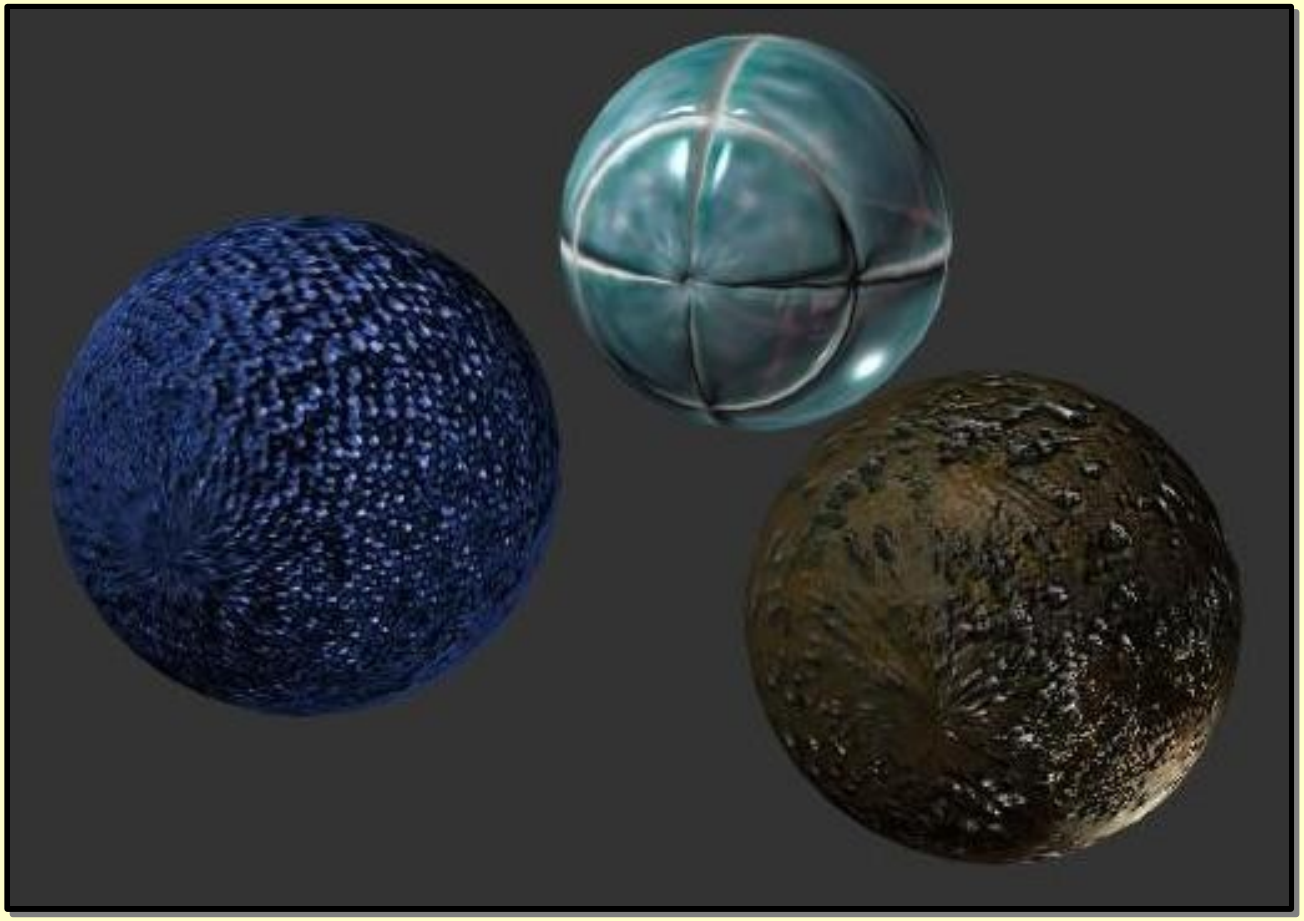




Bump Mapping

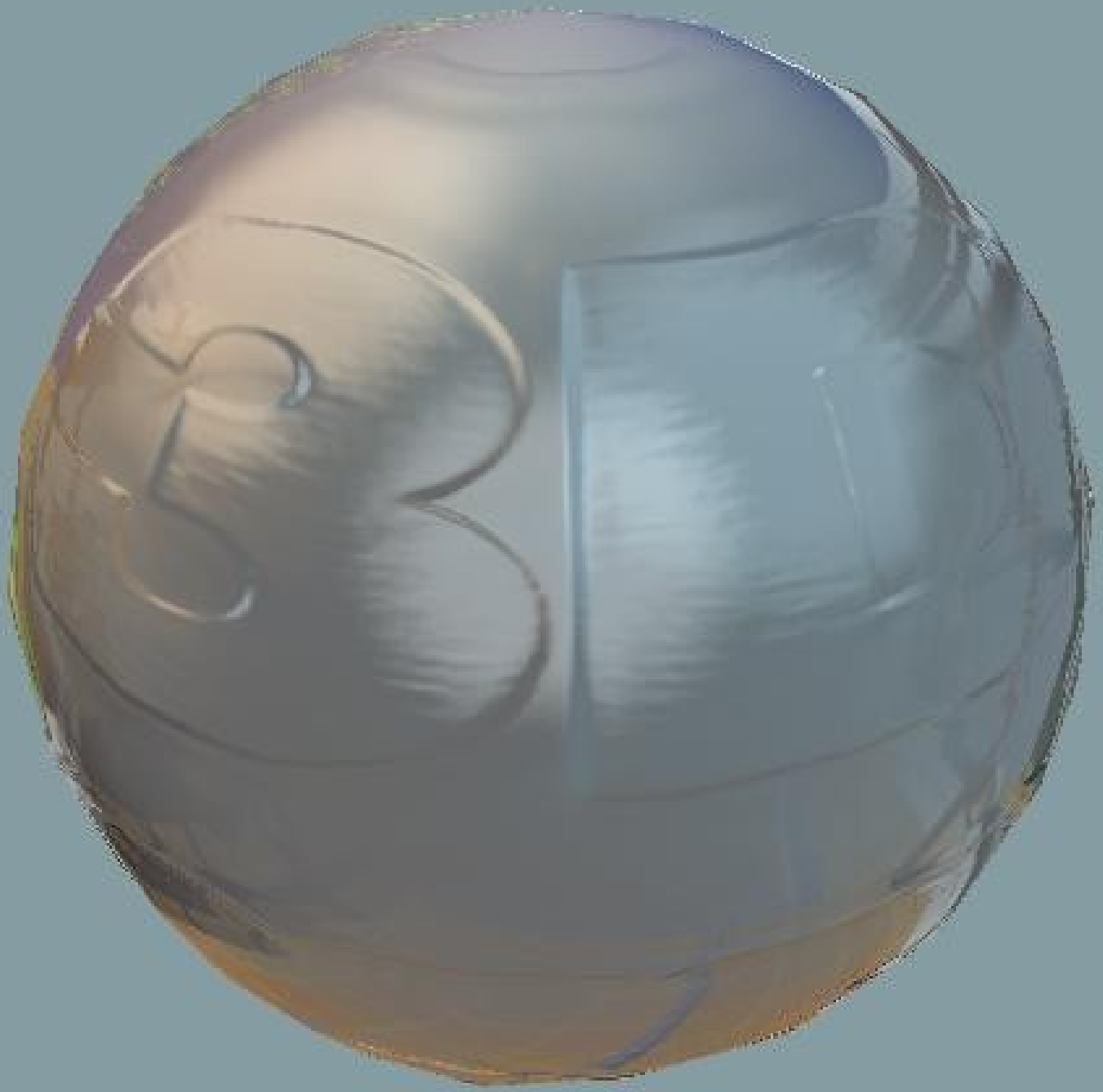
smooth

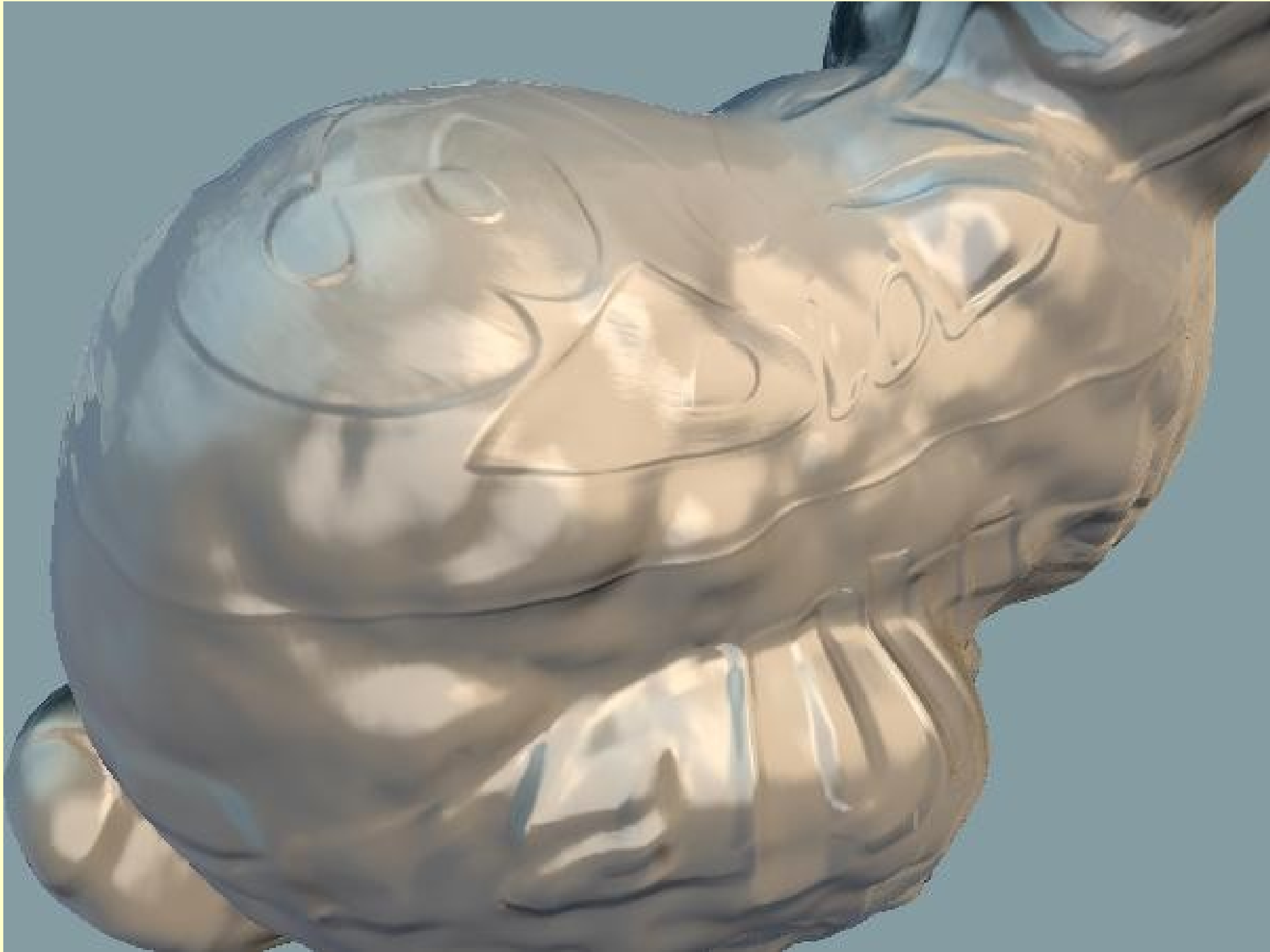
silhouettes



Bump mapping

- $2D$ texture map creates odd looking rough surfaces
- Bump mapping: use texture map to perturb surface normal
  - Use texture array to set a function which perturbs surface normals
  - Apply illumination model using perturbed normal





Painted Numbers, Plus *Motion Blur*, and more

Okino Computer Graphics
www.okino.com/slidshow/poolball.htm

'1984' Pool Balls

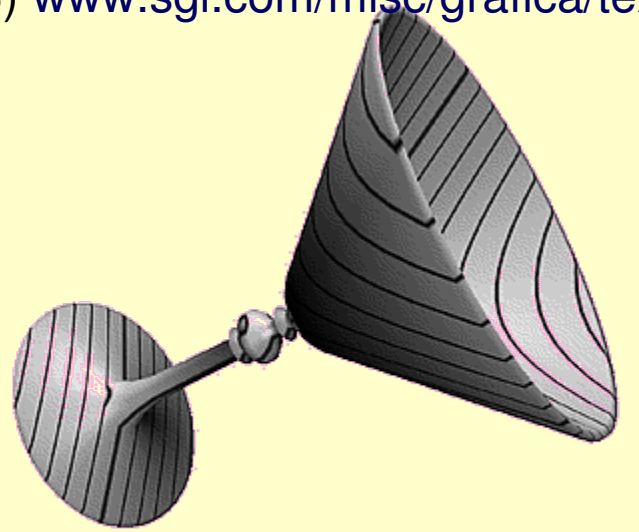
Okino Computer Graphics
www.okino.com/slidshow/bowling2.htm

More Examples

Texture Mapping as a Fundamental Drawing Primitive

Paul Haeberli and Mark Segal

(1993) www.sgi.com/misc/grafica/texmap/



Contours indicate equidistance from reference plane

Environment Mapping

Projective Texture Mapping