Texture Mapping

Adapted from slides by

Rich Riesenfeld

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

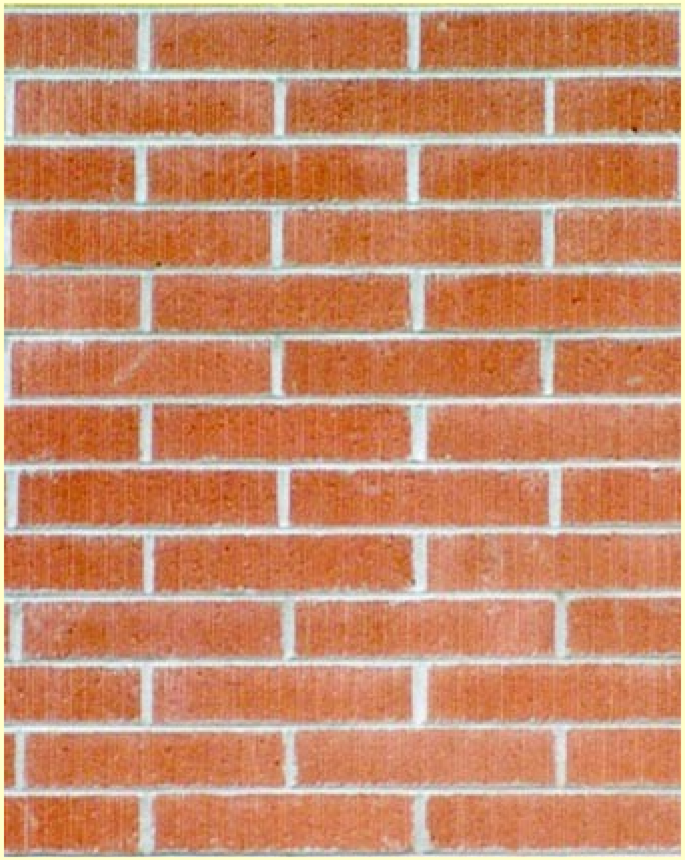
Texture Mapping

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

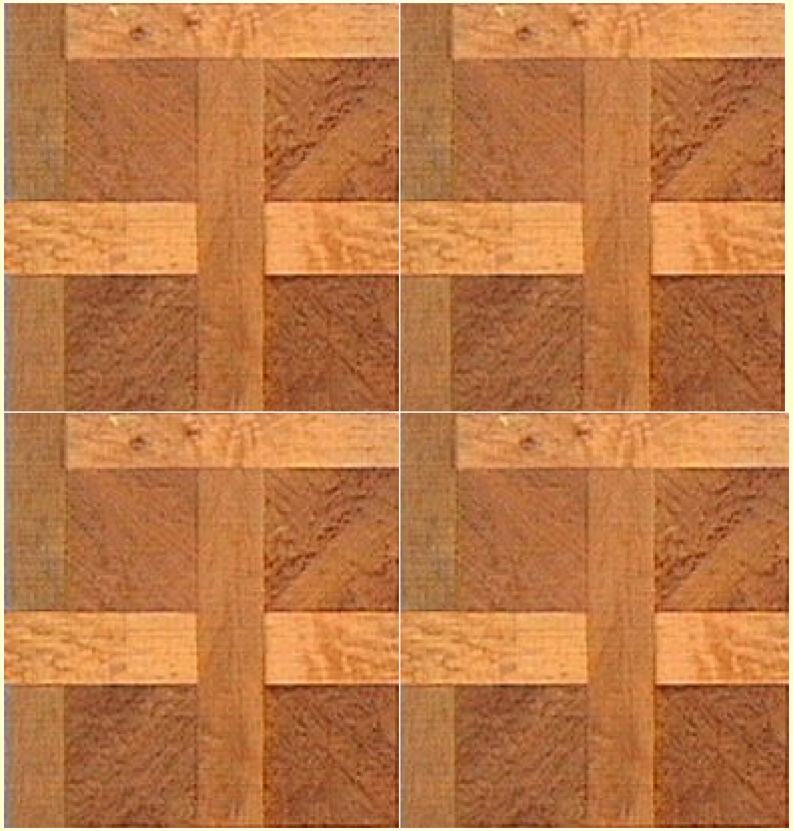
Texture Mapping Characteristics

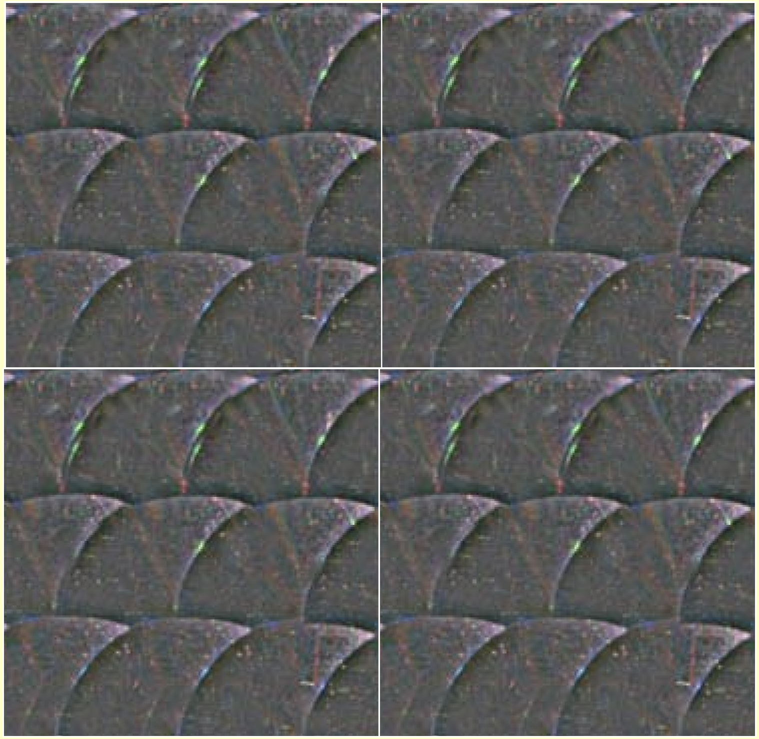
- Too much *detail* to model geometrically, like grass, etc
- Pattern is repeated (*periodic*)

Texture Maps

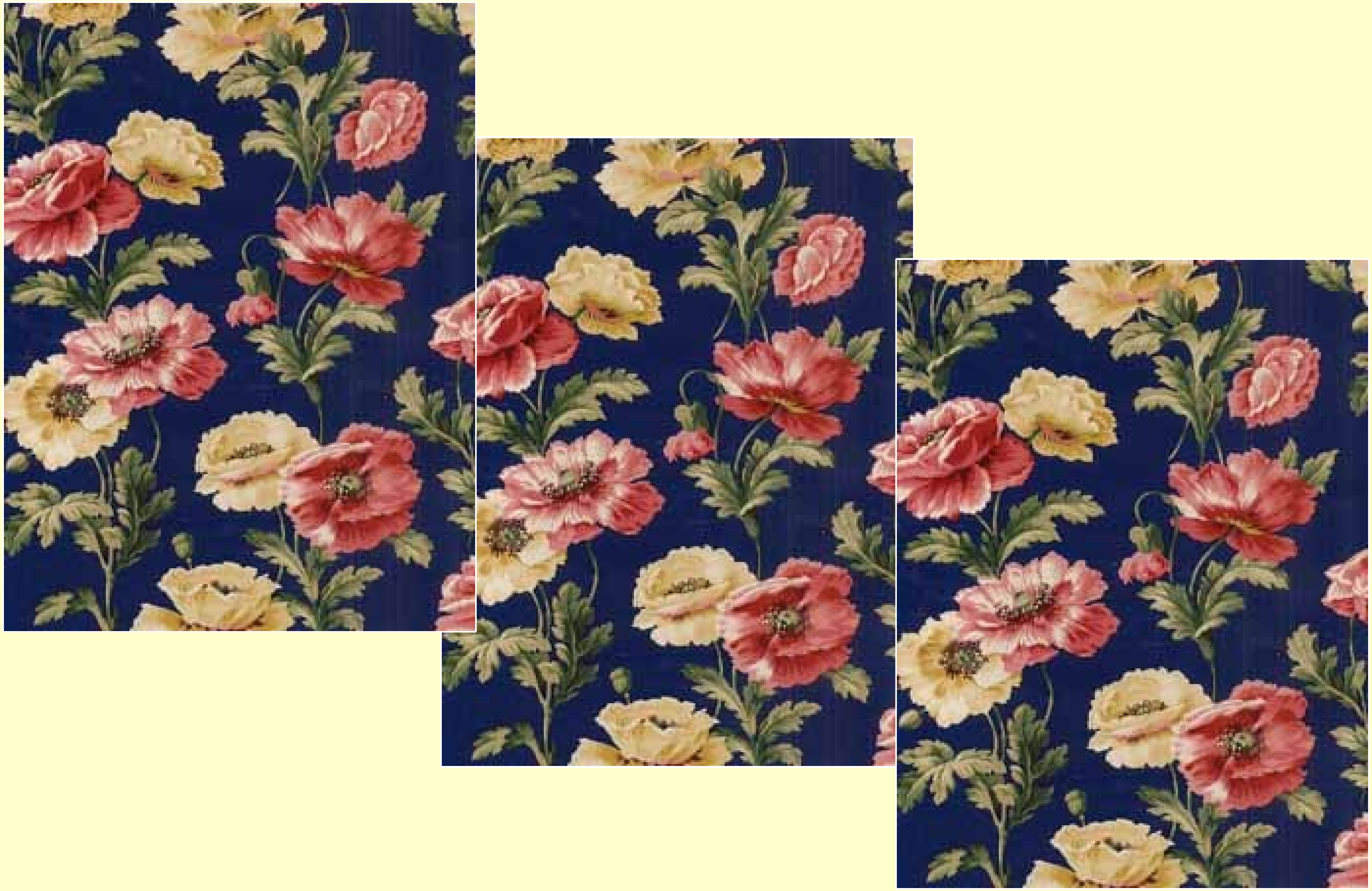


Tiling textures

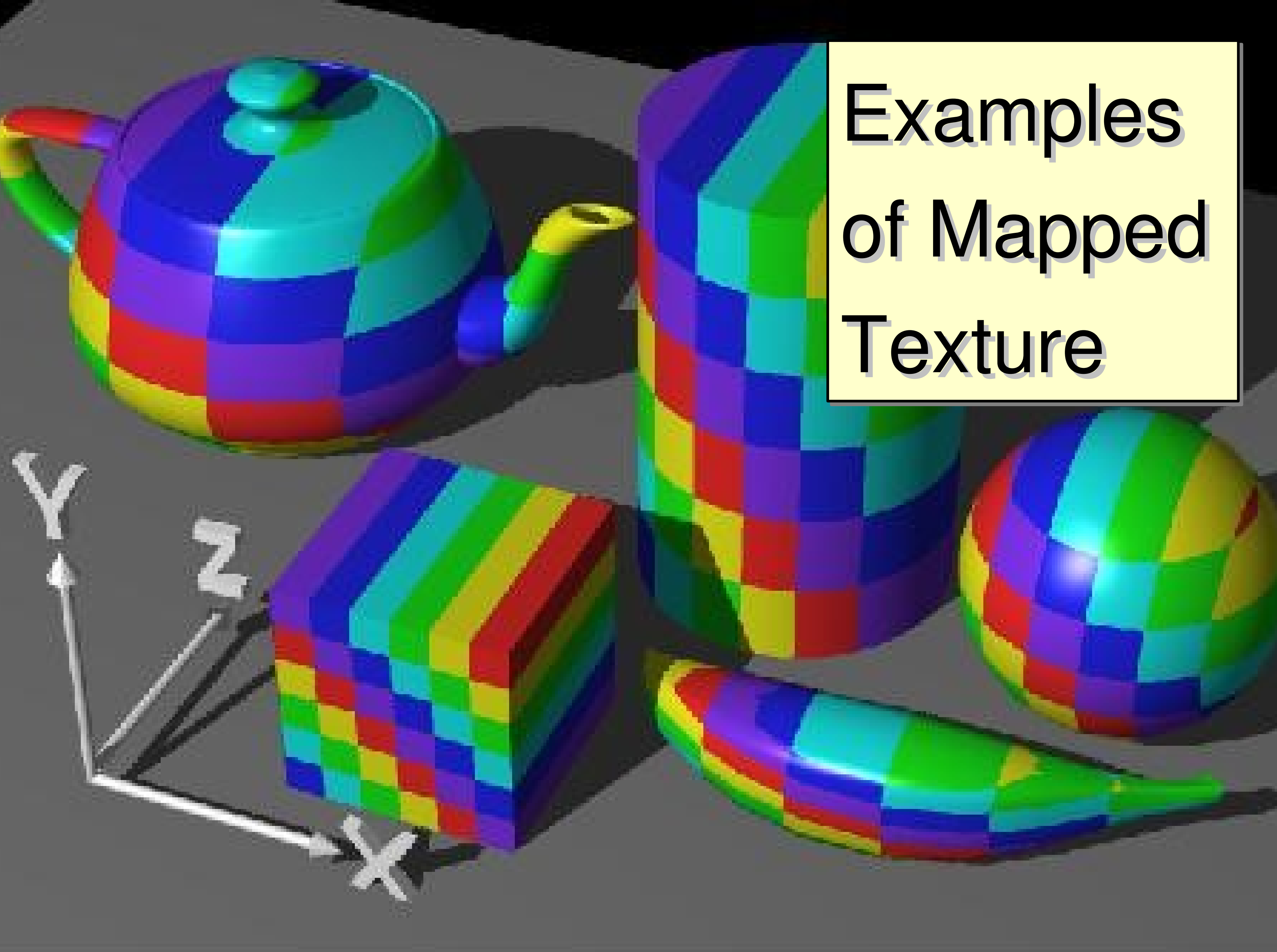




Tiling textures



Examples of Mapped Texture



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:

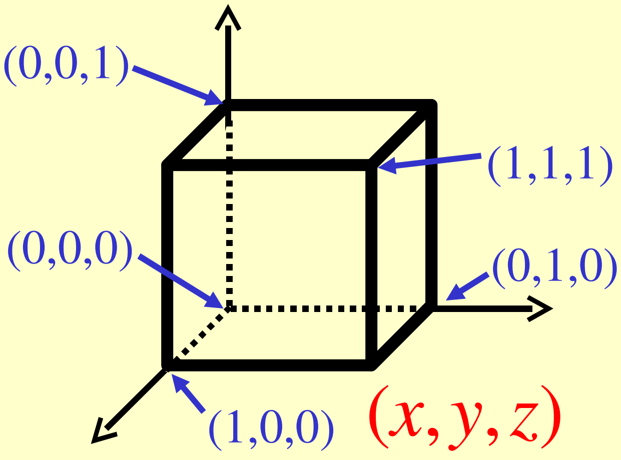
$$texture\ location \quad surface\ location$$

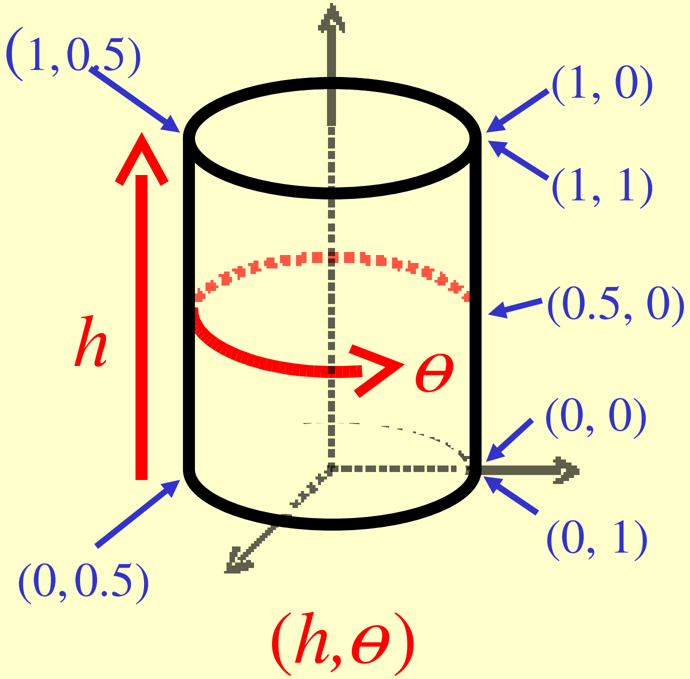
- Typical texture sources
  - Procedure
  - Tabular data (texture image)

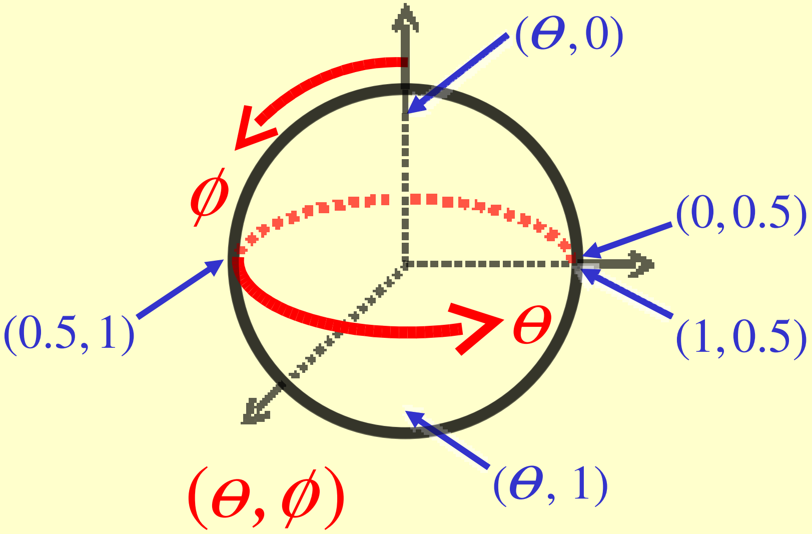
Texture Mapping Techniques

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

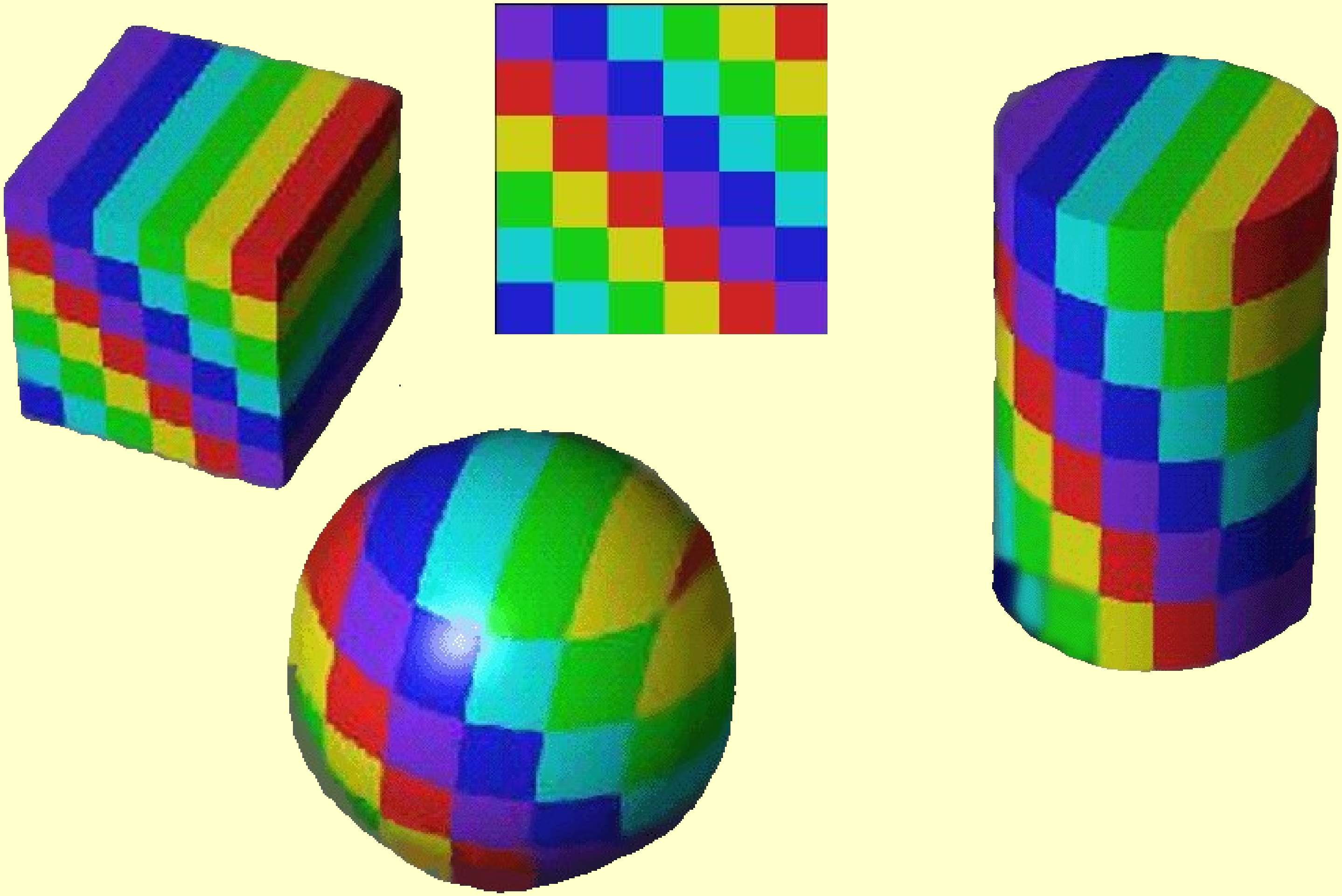
Need to Impose Parametrization



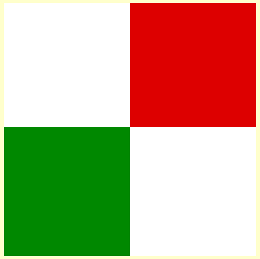


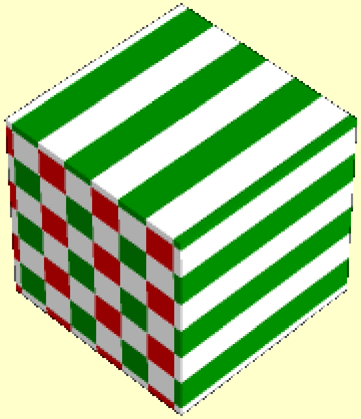


Using a planar projection

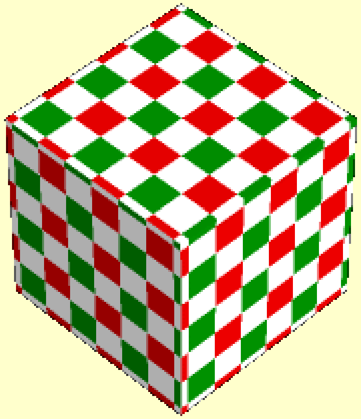


More Examples

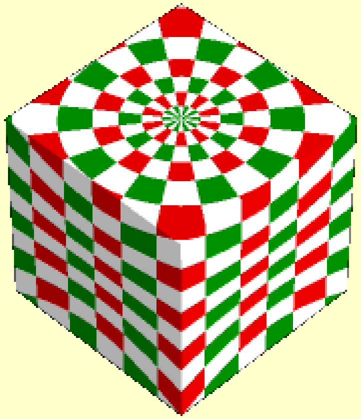




Planar



Cubic

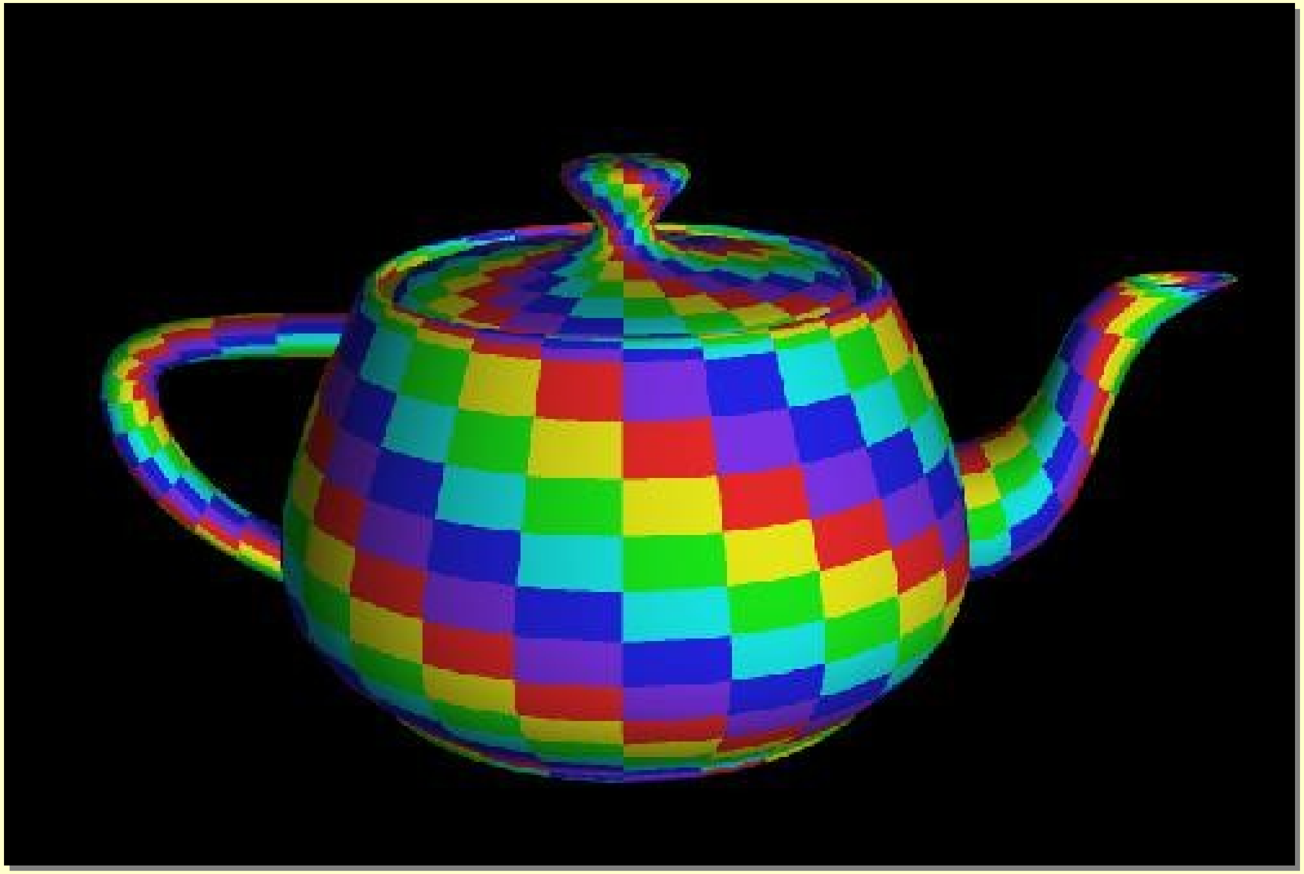


Cylindrical

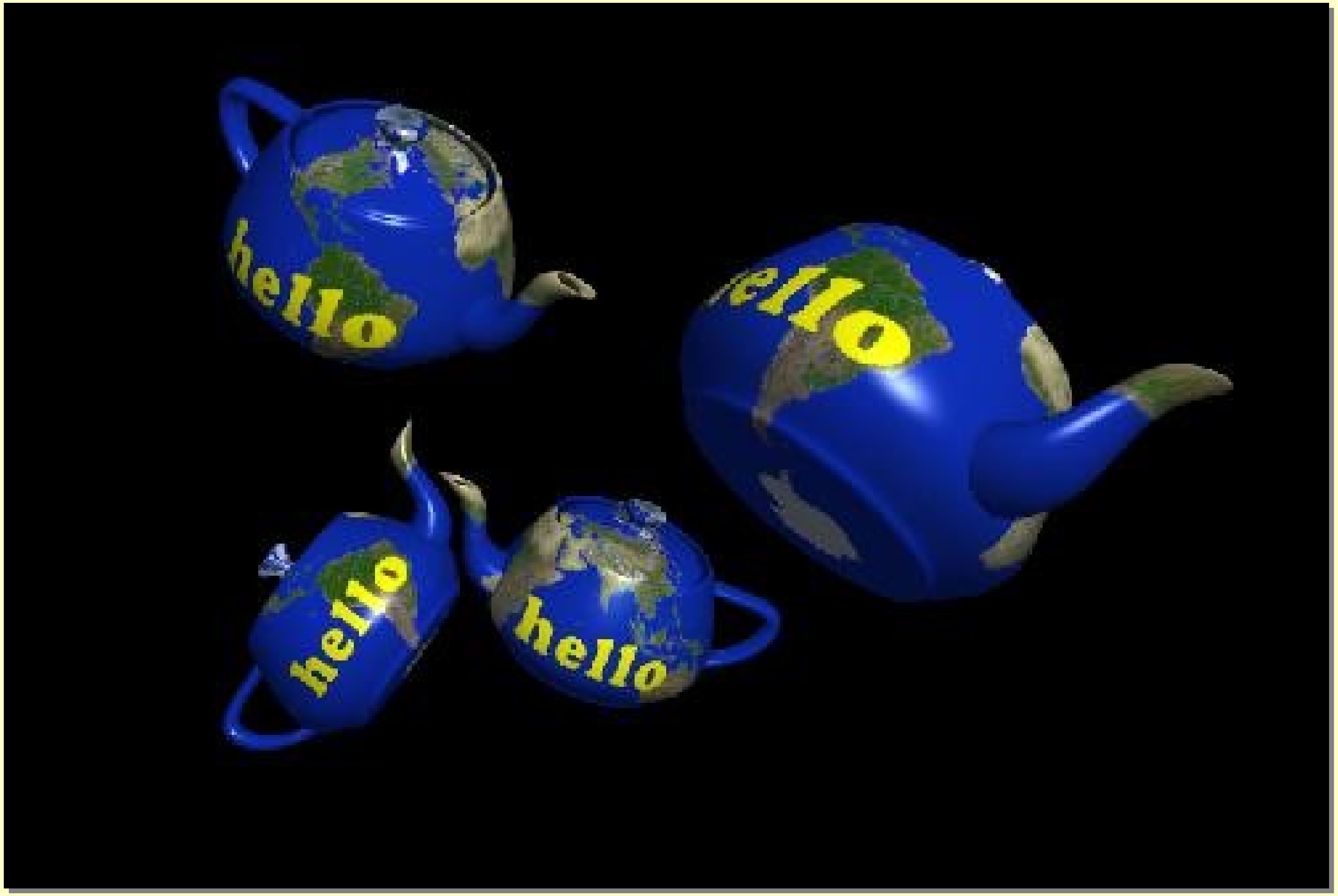
Texture Mapping, Paul Bourke (1987)

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

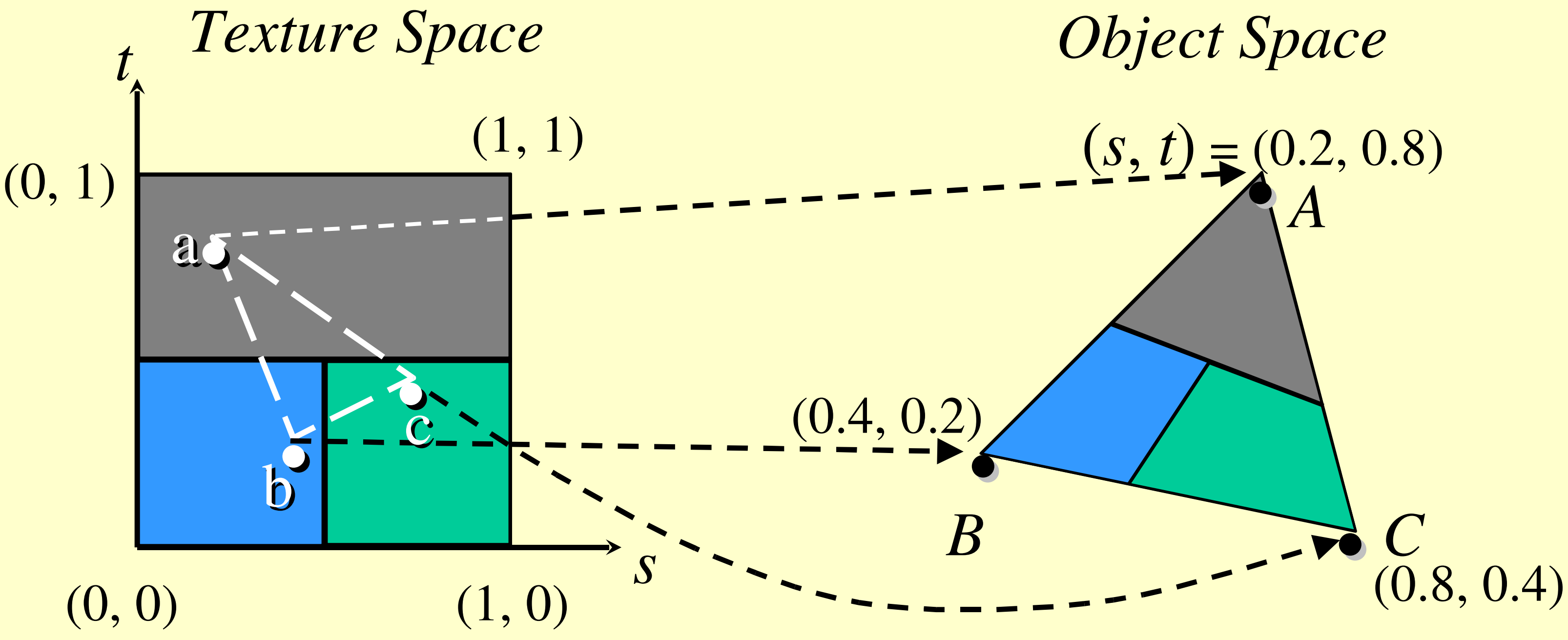
Mapping the $2D$ Texture to Surface

- 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

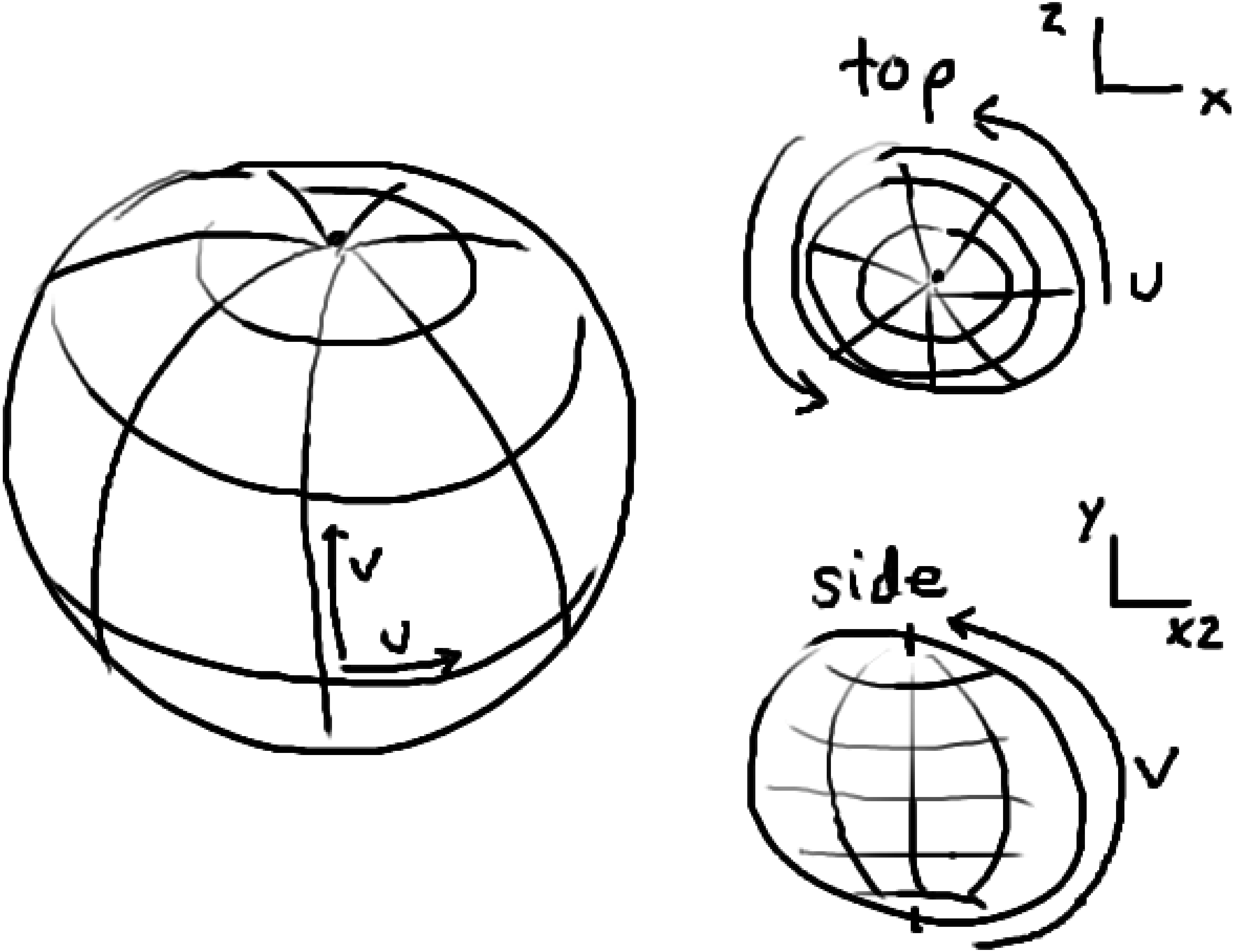
- Parametric surface:

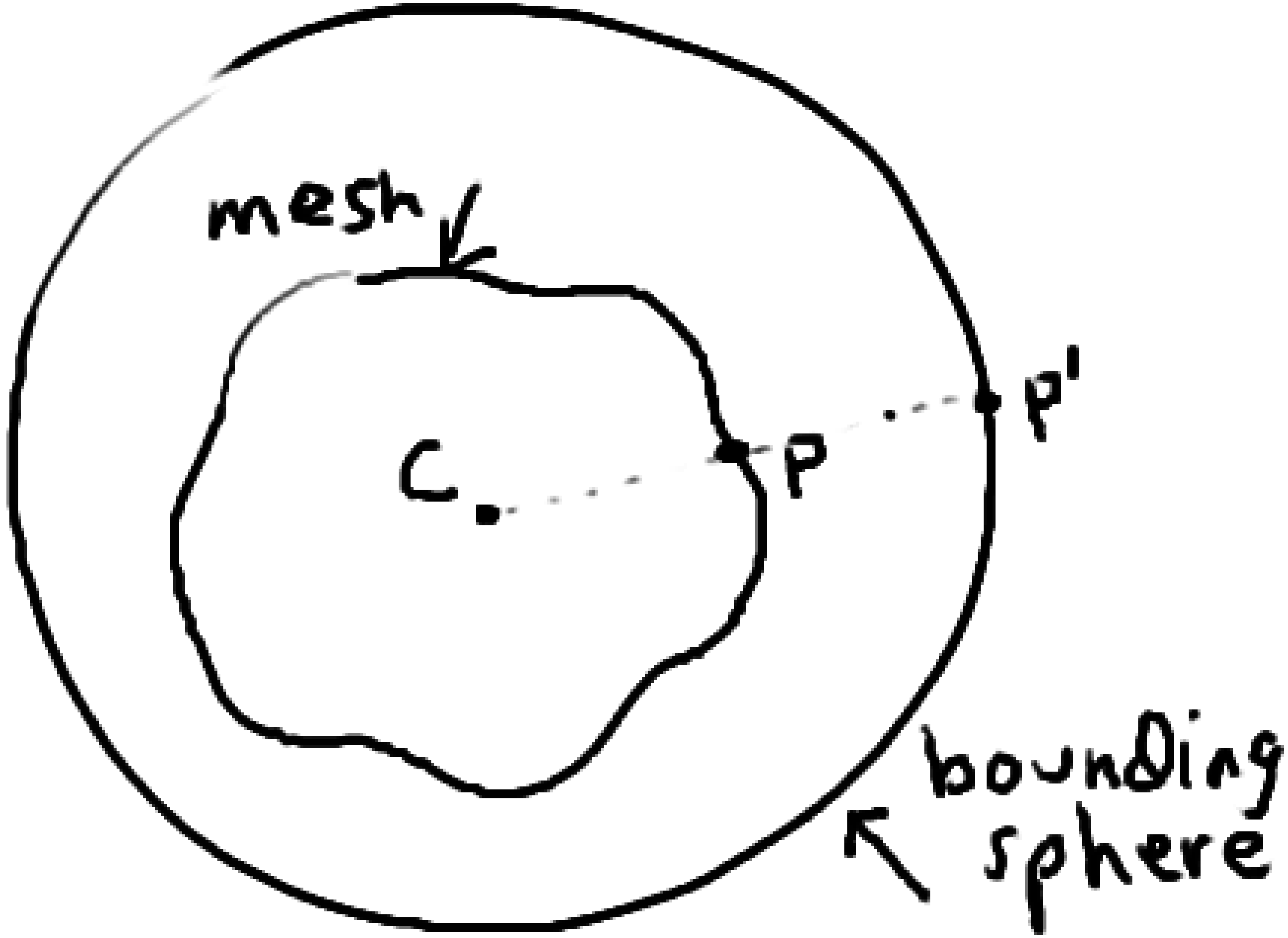
  $S(u,v) = (x(u,v), y(u,v), z(u,v))$

- Use (u,v) as texture coordinates

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


v
u
top
z
x
u
side
y
xz
v



c : center of mesh

p : point on mesh

p' : projection of p onto sphere

$p' = (p-c)/|p-c|$ (unit sphere)

spherical projection, cont'd

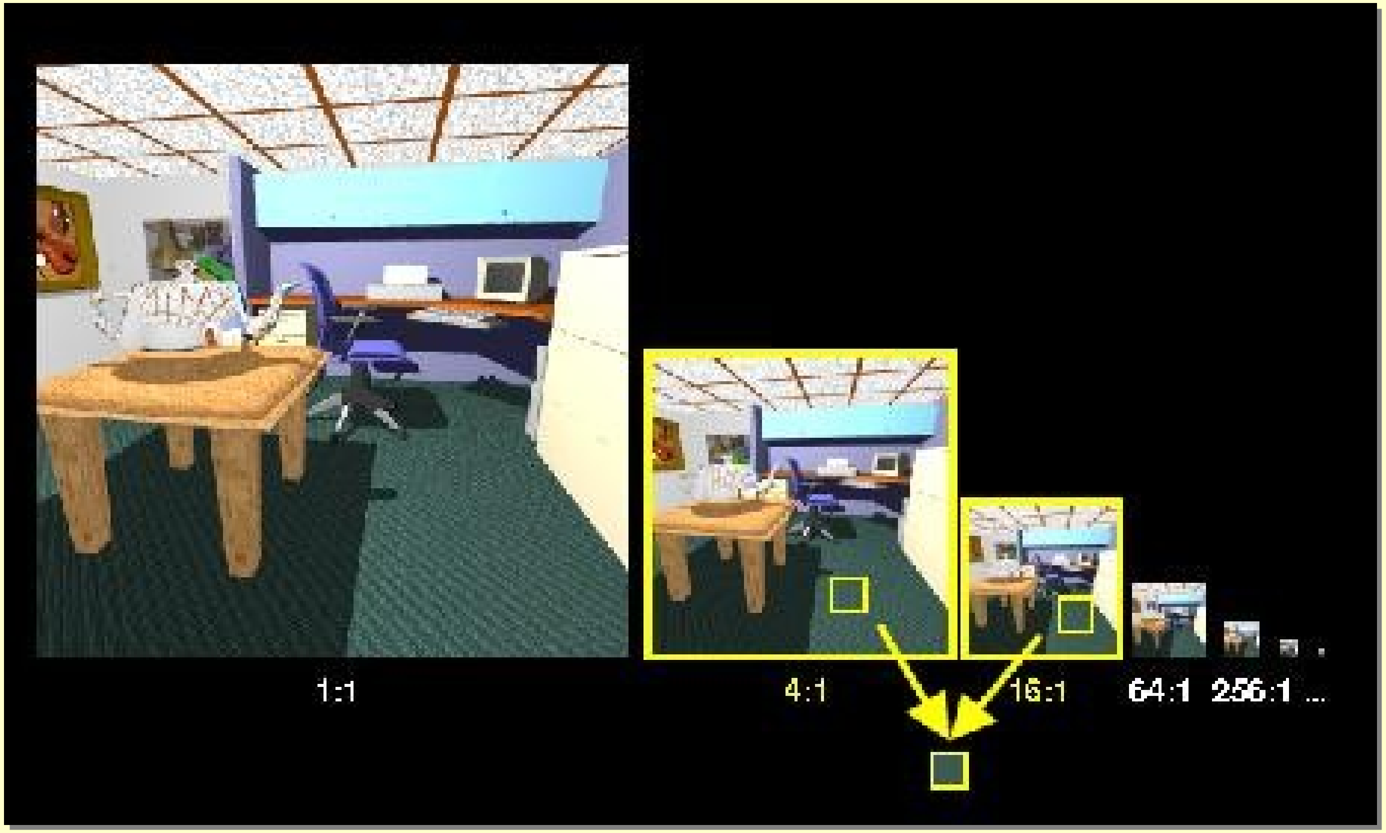
- starting with point p on the surface
- project to point p' on unit sphere:
  p' = (p - c)/|p – c|
- now use (x,y,z) coordinates of p' to compute (u,v) coordinates via the natural parameterization of the sphere

spherical projection, cont'd

- details of last step explained in project 2

MIP Mapping (*multum in parvo*)

“Many things in a small place”



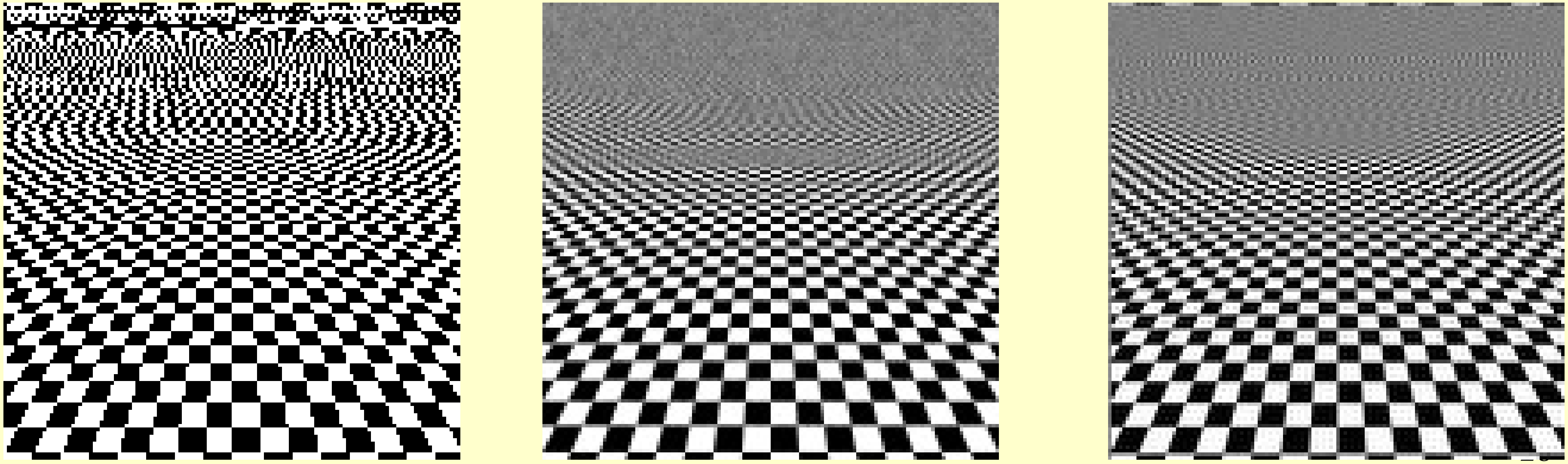
Mipmapped Textures

- Mipmapping:
  - prefiltered texture maps
  - decreasing resolutions
  - used to combat *aliasing*
- OpenGL supports mipmapping

Aliasing

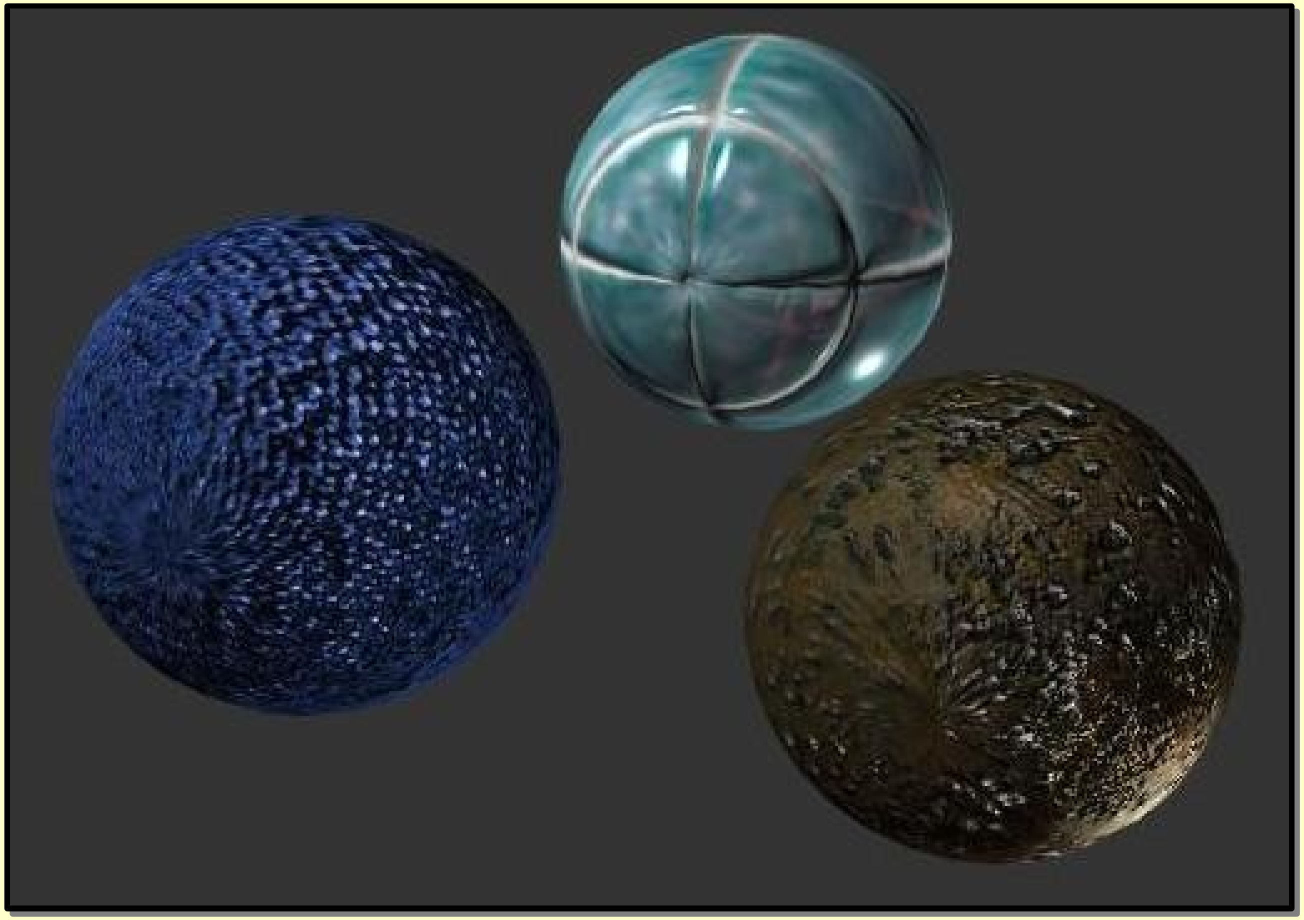
aliasing (left); antialiased (middle, right)

(from wikipedia)



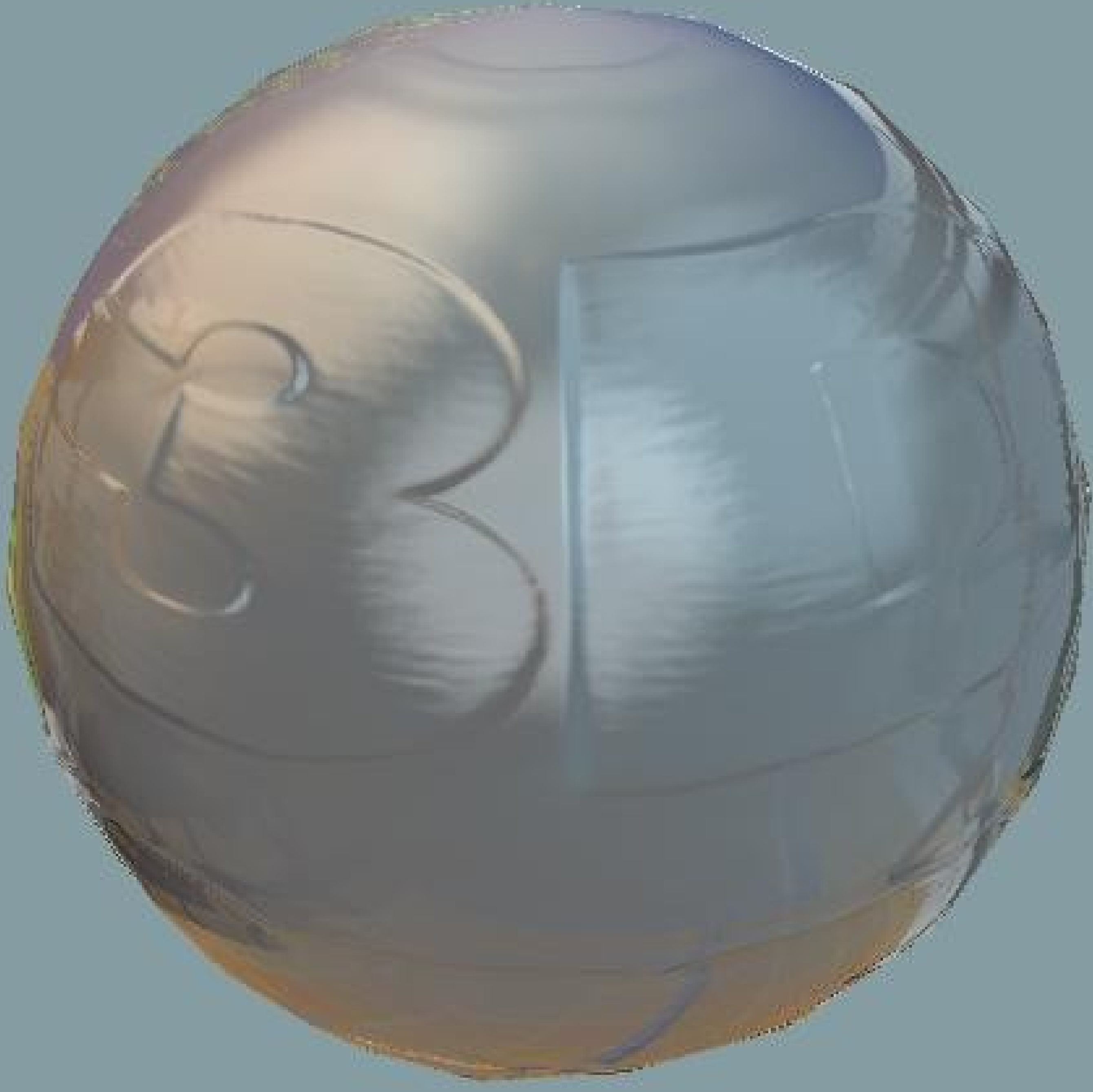
Bump Mapping

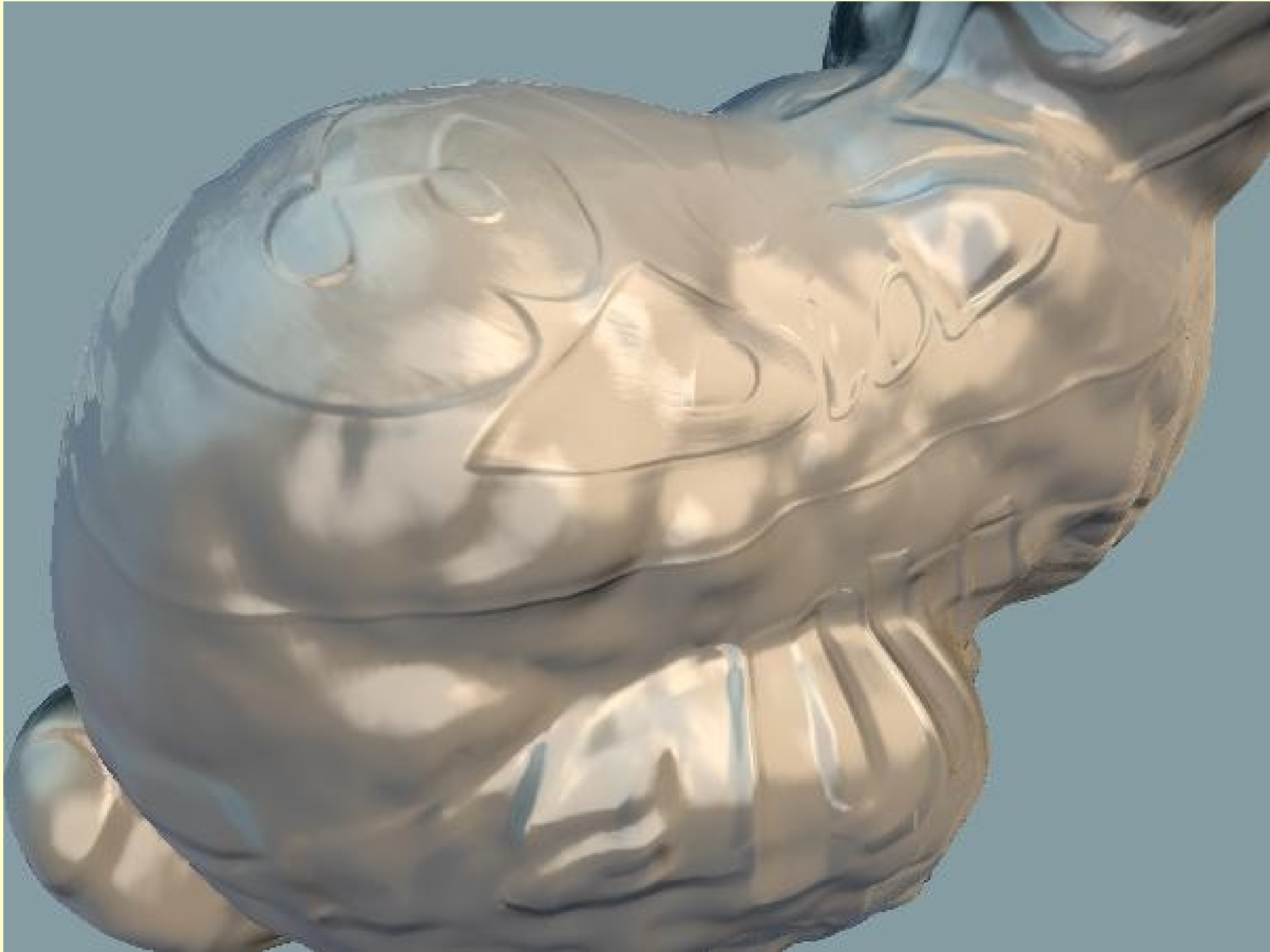
smooth silhouettes

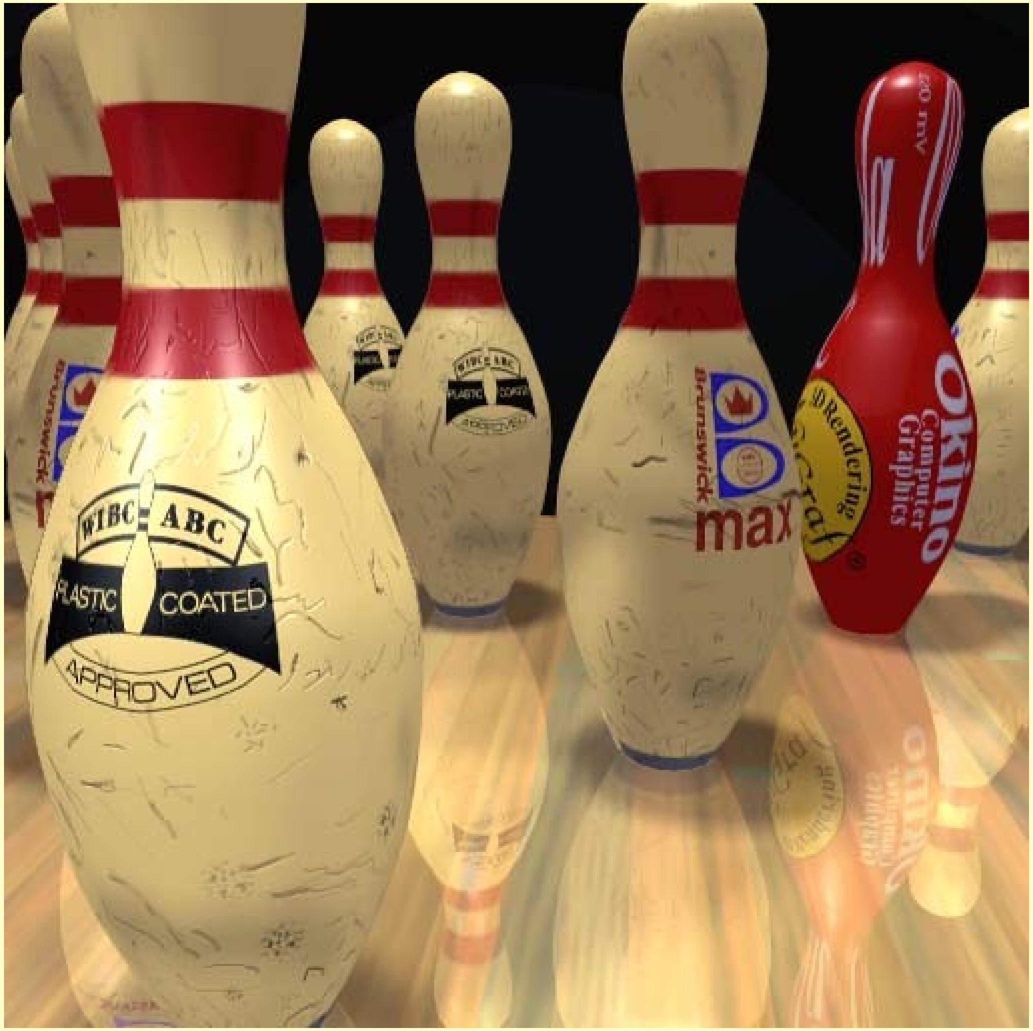


Bump mapping

- *2D* texture maps don't interact w/ lighting
- Bump mapping: use texture map to define *perturbed* surface normals
- Compute lighting using perturbed normals


3D





Okino Computer Graphics

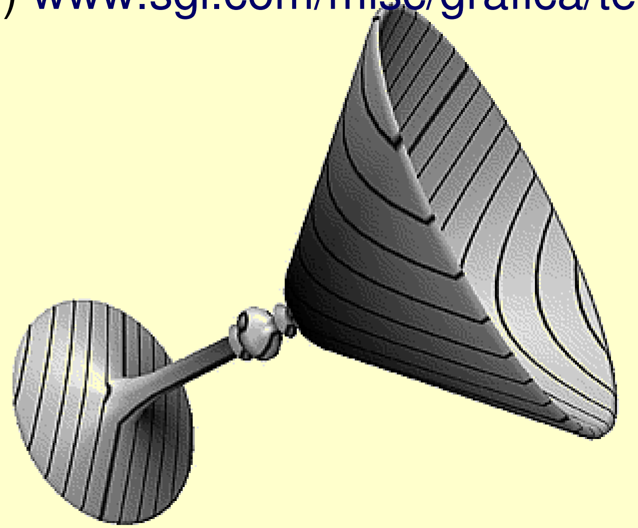
www.okino.com/slidshow/bowling2.htm

More Examples

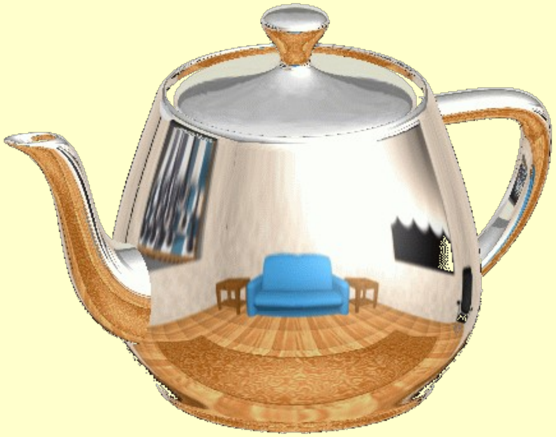
Texture Mapping as a Fundamental Drawing Primitive

Paul Haeberli and Mark Segal

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



Contours indicate equidistance from reference plane



Environment Mapping

Projective Texture Mapping