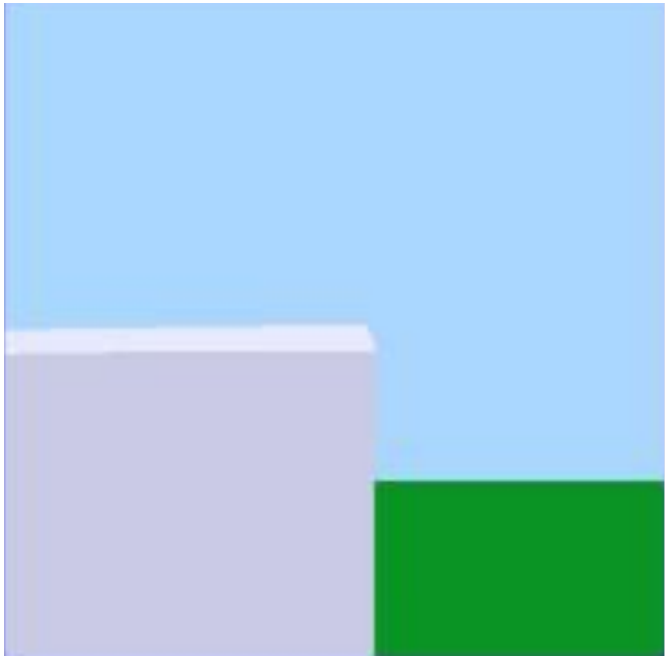
Texturing

What is Texturing?



Texture Mapping

- Definition: mapping a function onto a surface; function can be:
  - 1, 2, or 3D
  - sampled (image) or mathematical function

Mapped Parameters

- Surface color (Catmull 74)
- Specular reflection (Blinn and Newell 76)
- Normal vector perturbation (Blinn 78)
- Specularity (Blinn 78)
- Transparency (Gardner 85)
- Diffuse Reflection (Miller and Hoffman 84)
- Shadows, displacements, etc (Cook 84)
- Local coord system (Kajiya 85)

Map Indices

- Surface parameters
- Ray direction
  - Reflection/environment mapping
- Surface normal direction
  - Diffuse reflection mapping
  - Transparency/refraction mapping

Key Challenges

- Mapping function determination
- Resolution issues
- Texture design/capture

Mapping Functions

- Standard projecting functions
  - planar
  - cylindrical
  - spherical
- Mechanism
  - Two-stage mapping
  - Reverse projection
- Arbitrary

Two-stage Mapping

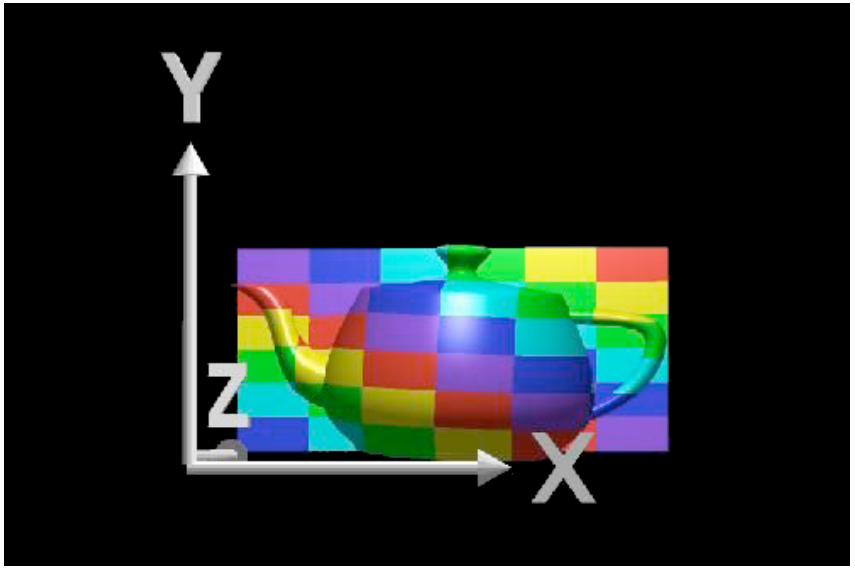
- S-mapping
  - map to simple 3D shape
  - intermediate surfs: plane, cylinder, cube, sphere
- O-mapping
  - map 3D texture onto surface
  - map entities: reflected view ray, surface normal, line through centroid, intermediate surface normal

Planar Mapping

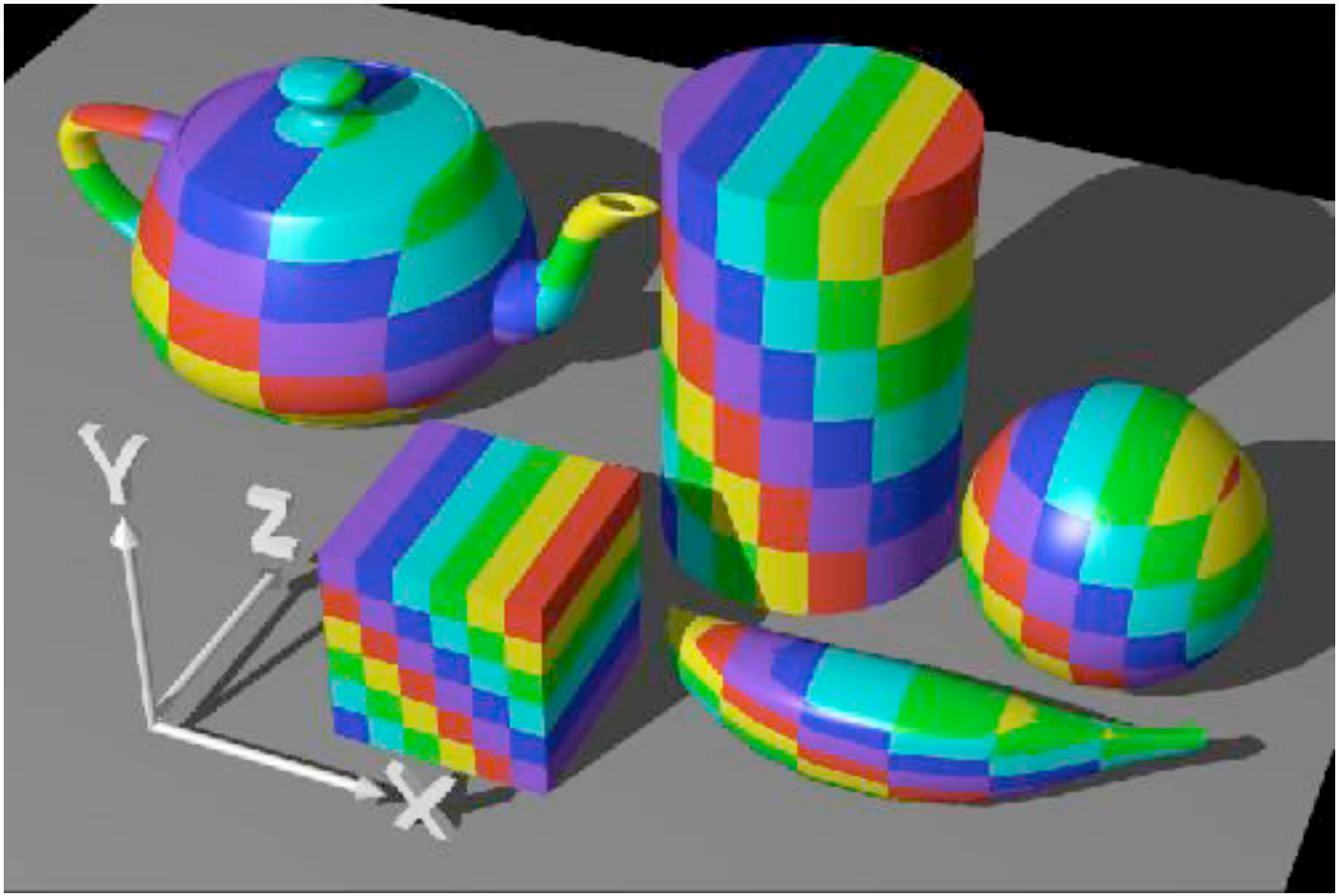
- For xy aligned plane

$$(u, v) = \left(\frac{x - x_1}{x_r - x_1}, \frac{y - y_1}{y_r - y_1} \right)$$

- Reverse projection



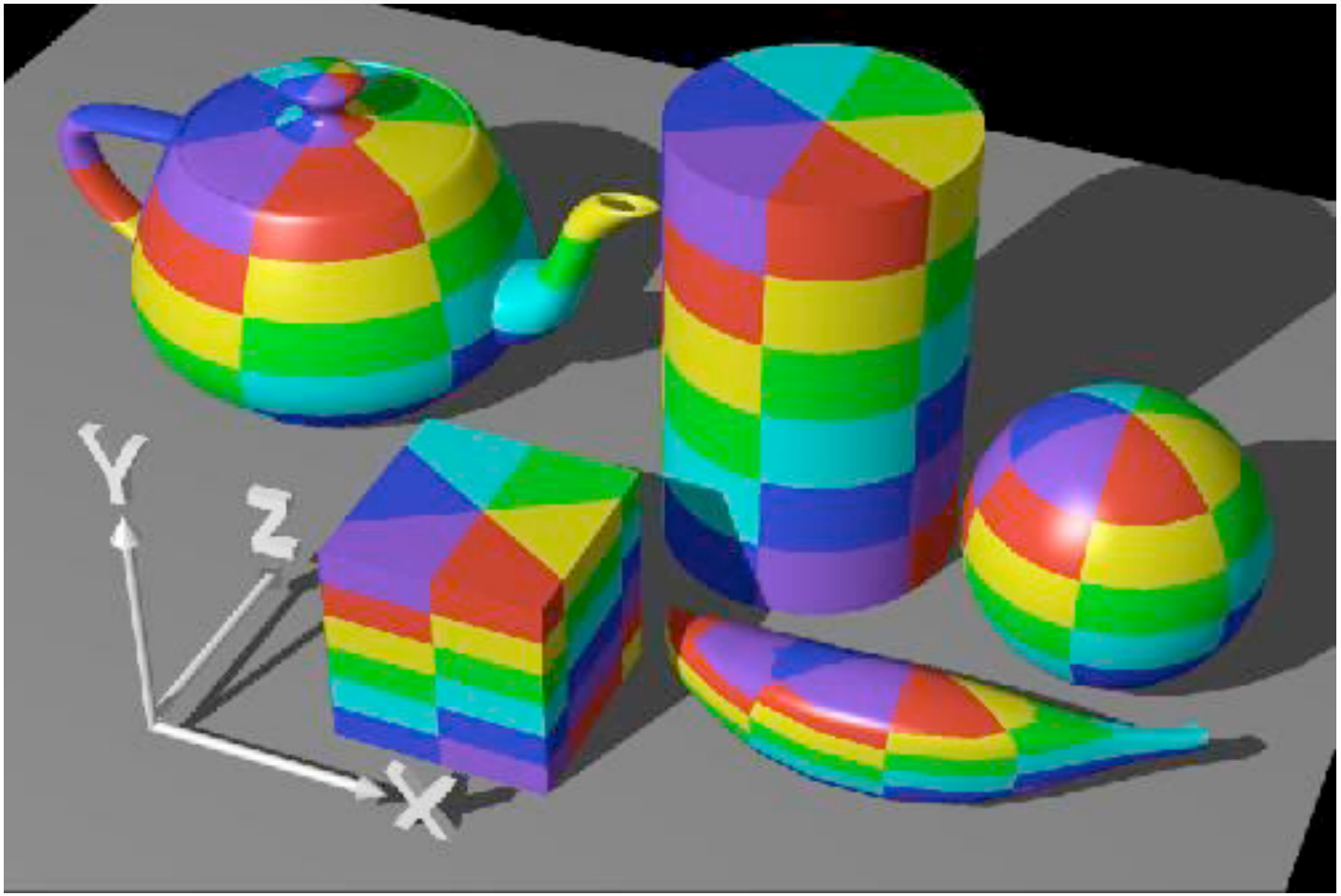
Planer Mapping



Cylindrical Mapping

- For cylinder with point
  - (r cos Θ, r sin Θ, h z)
- Texture coordinates
  - (u,v) =(Θ/2π, z)

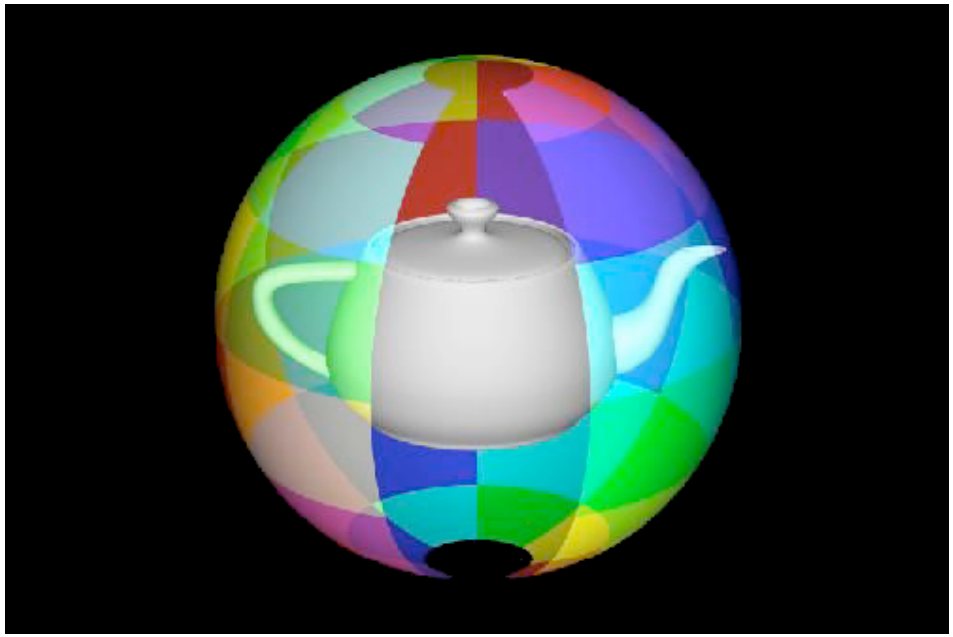
Cylindrical Mapping



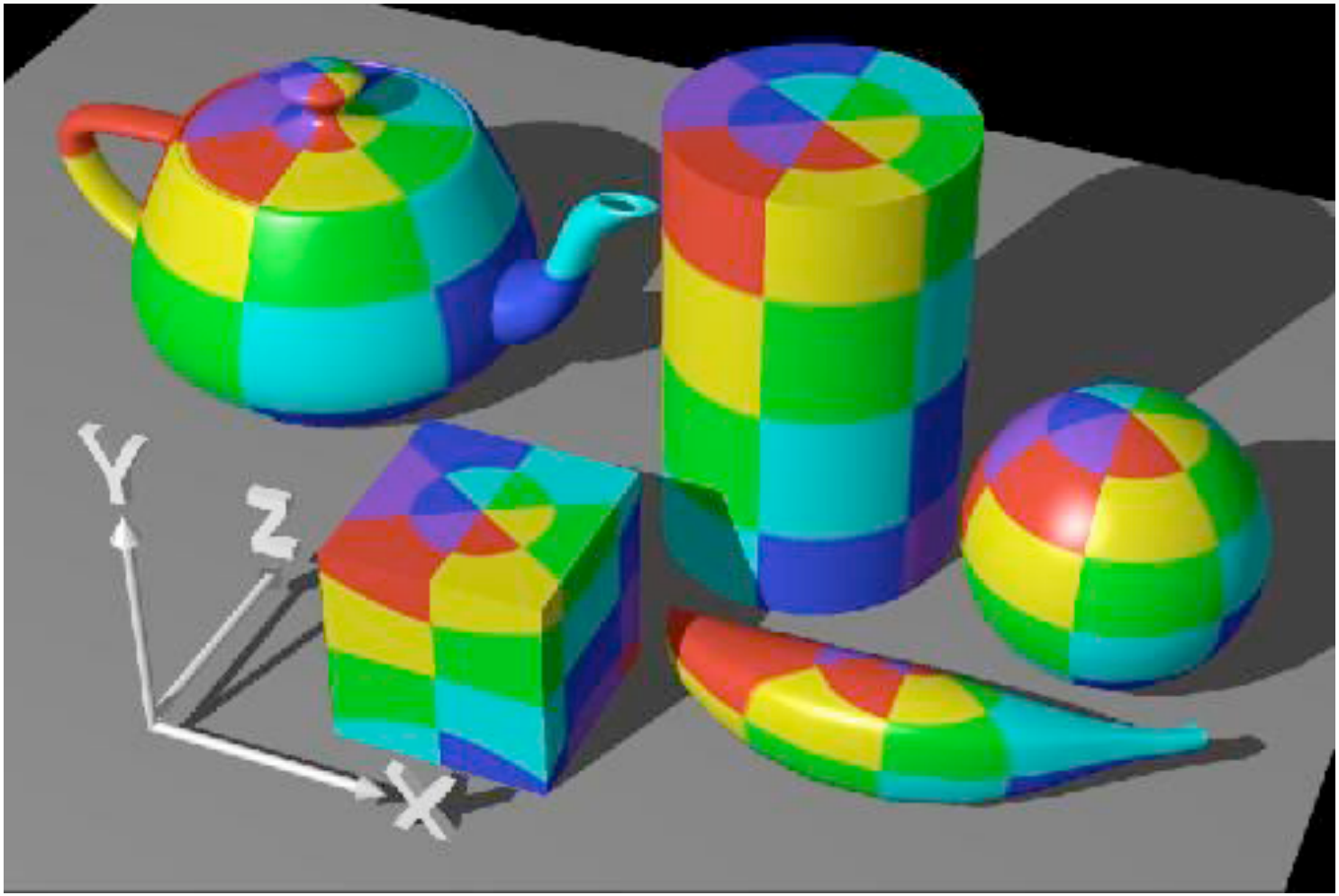
Spherical Mapping

- For sphere with point
  - (r cos Θ sin Φ, r sin Θ sin Φ, r cos Φ)
- Texture coordinates

$$(u, v) = \left(\frac{\theta}{\pi/2}, \frac{\pi/2 - \phi}{\pi/4} \right)$$

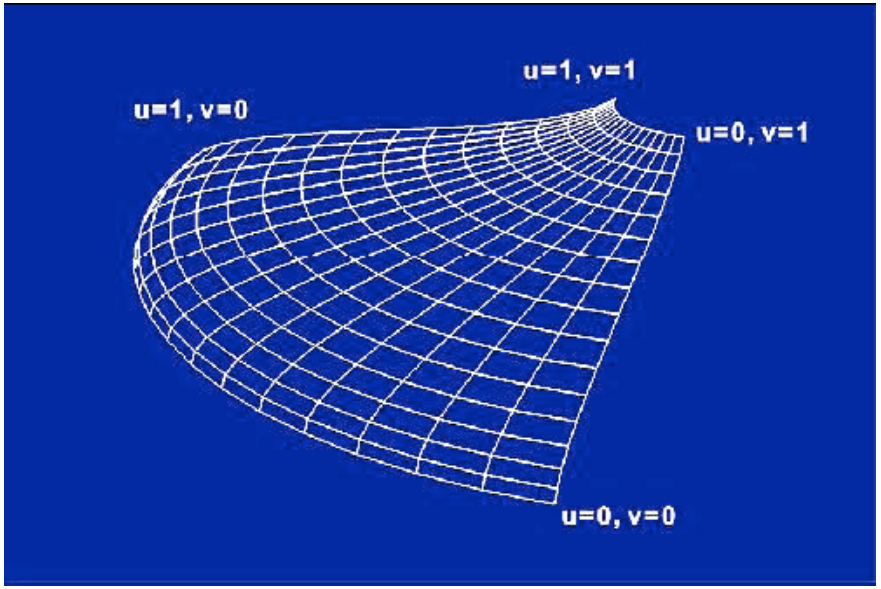


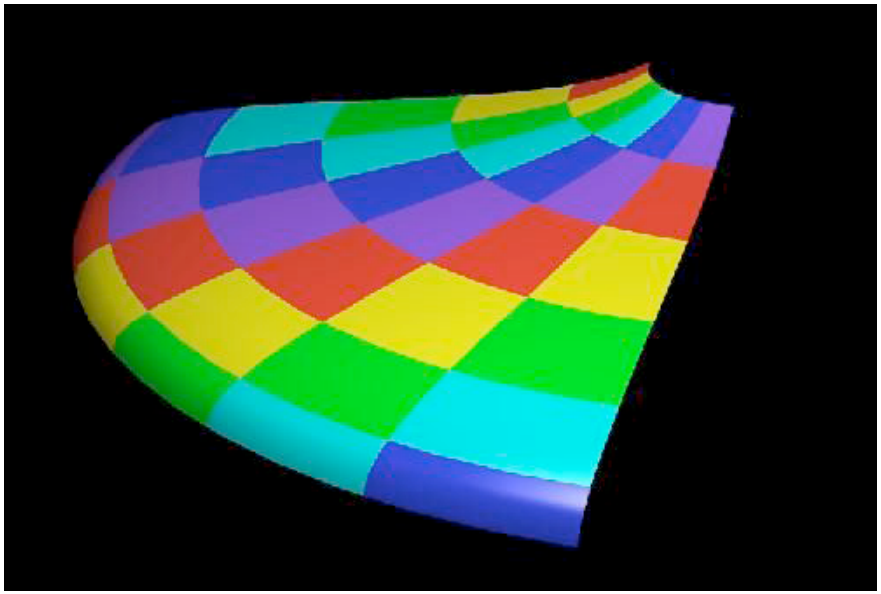
Spherical Mapping



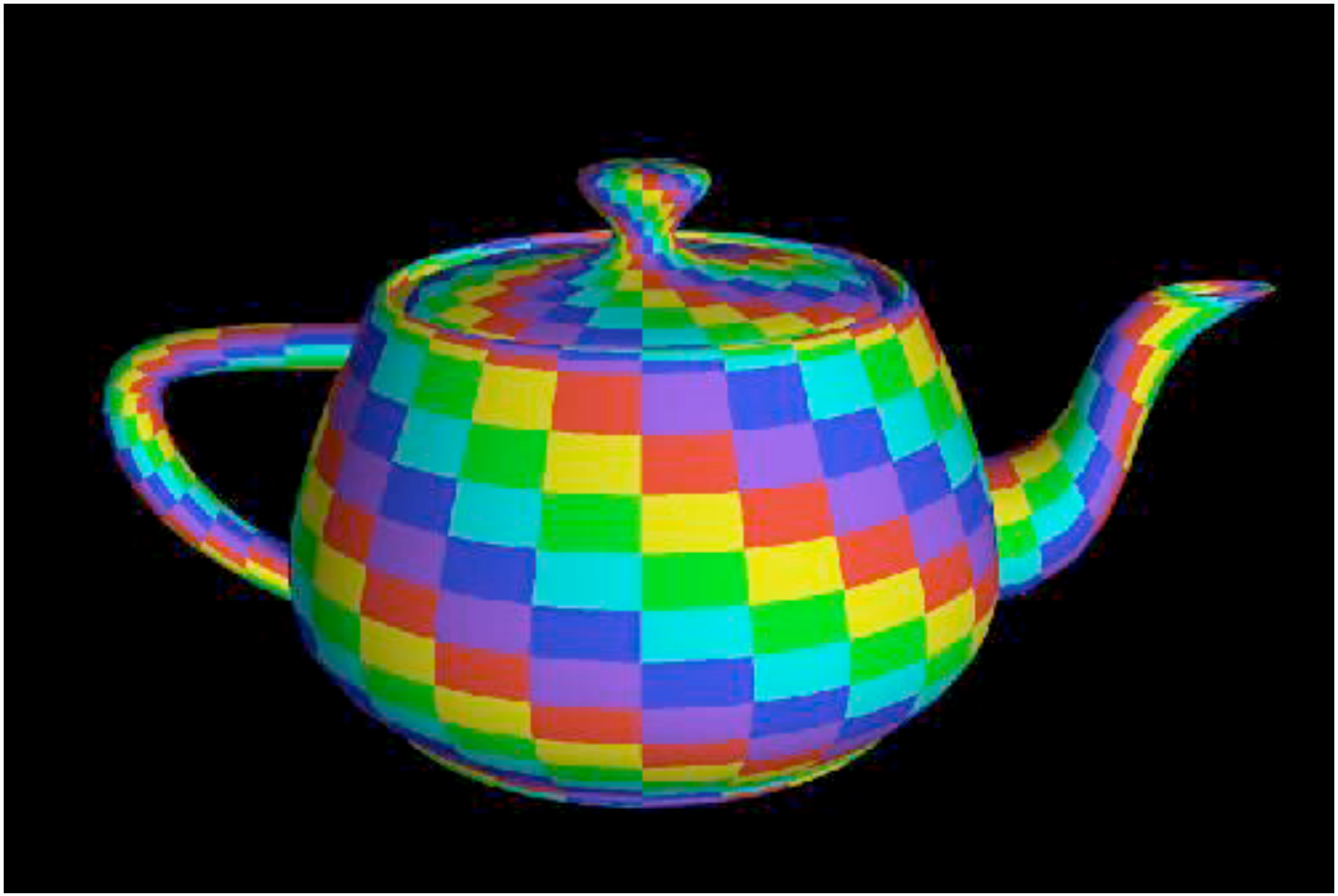
Mapping onto Parametric Patches

- Use scaled surface u,v parameters for texture u,v





Mapping onto Parametric Patches

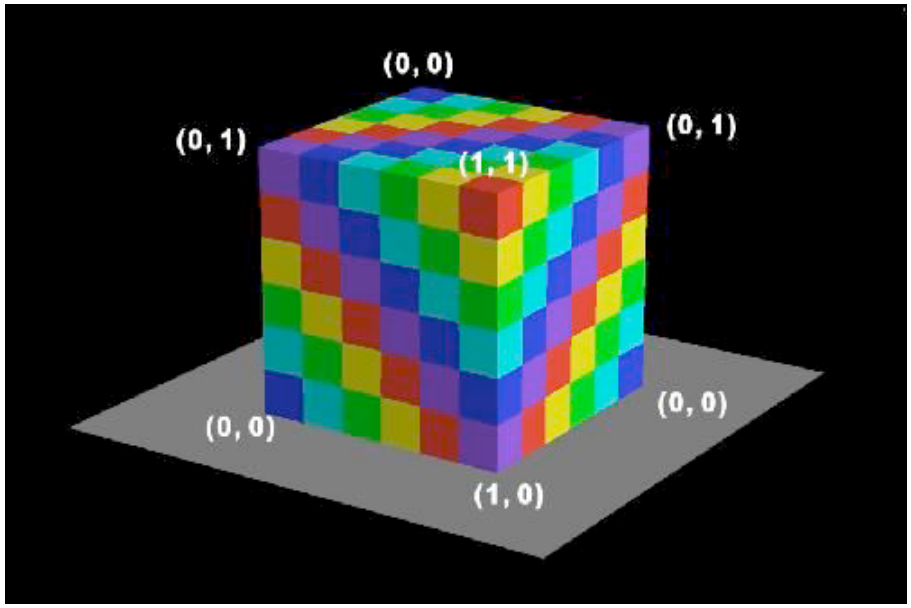


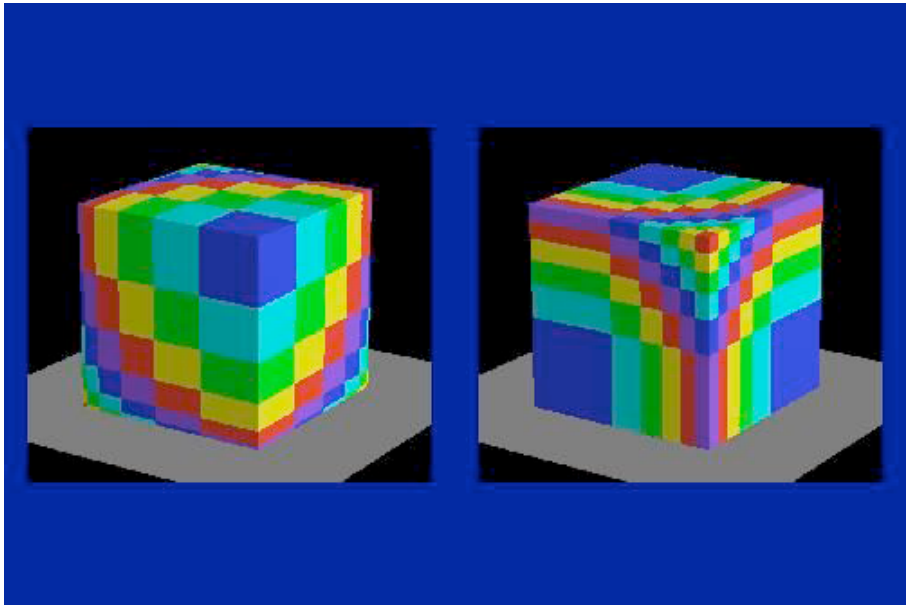
Mapping onto Polygons

- Like parametric surfaces, but use explicit vertex texture coordinates
- Screen-space Interpolation
  - Interpolate u,v
  - Nonlinearity and errors from lack of rotational invariance
  - Use small polygons to minimize artifacts
- Correct solution: per-pixel projection
  - Interpolate (u/w, v/w, 1/w); divide to get pixel (u,v)

Mapping onto Polygons

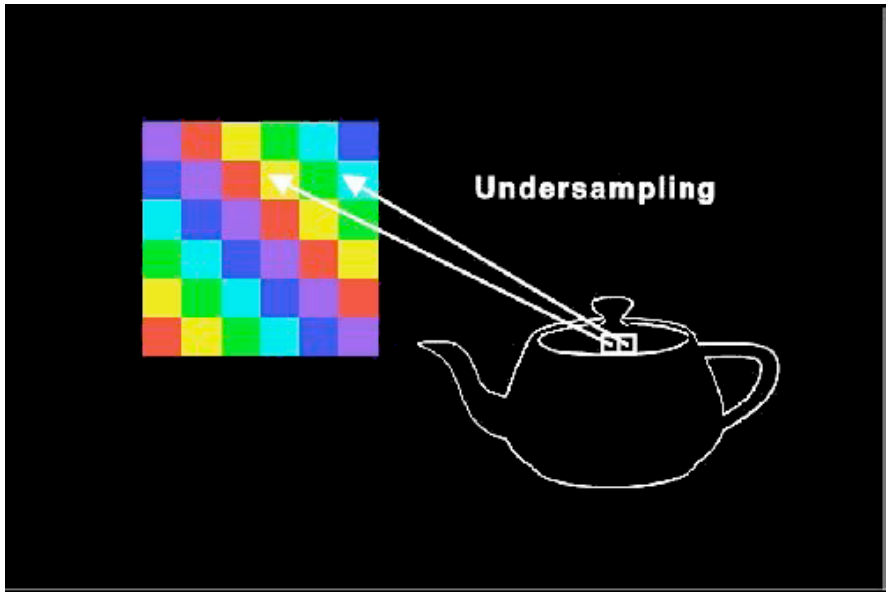
- Mapping need not be linear

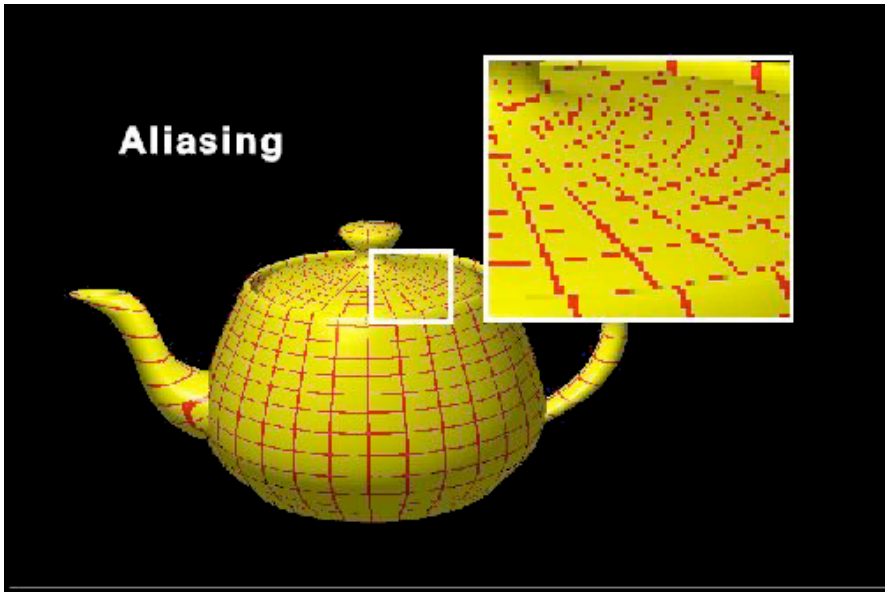




Texture Aliasing

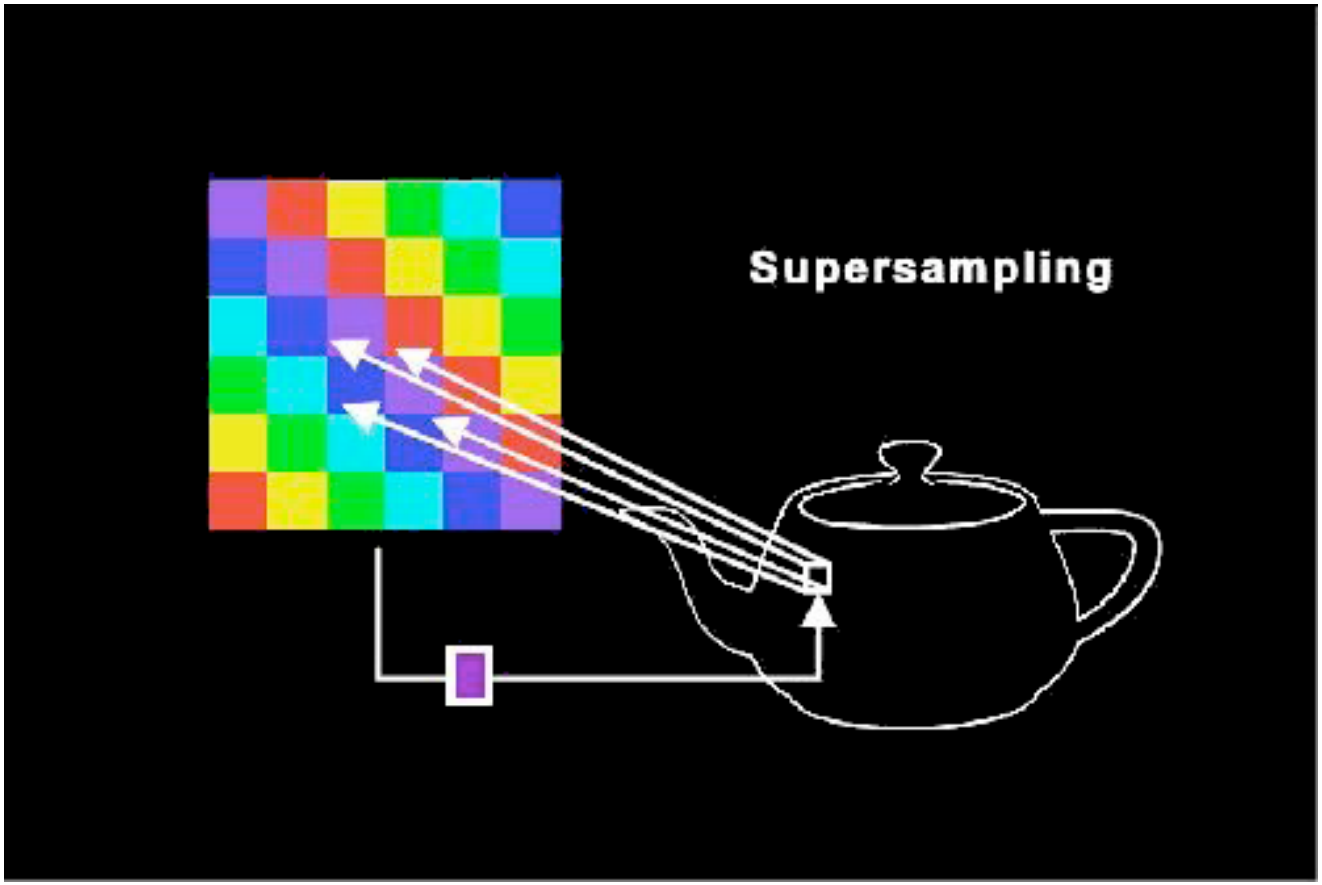
- Undersampling of texture map leads to texture aliasing
- Oversampling can show limited texture resolution





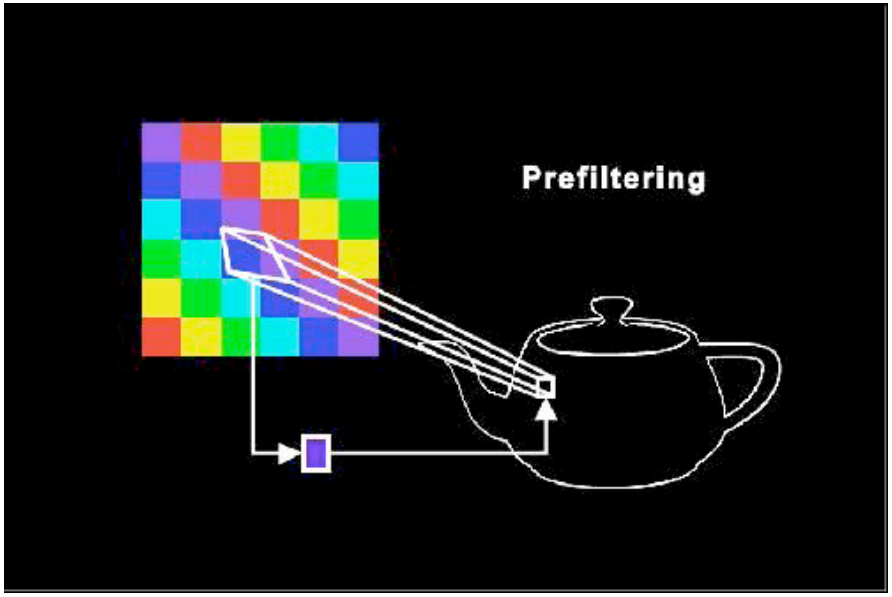
Supersampling

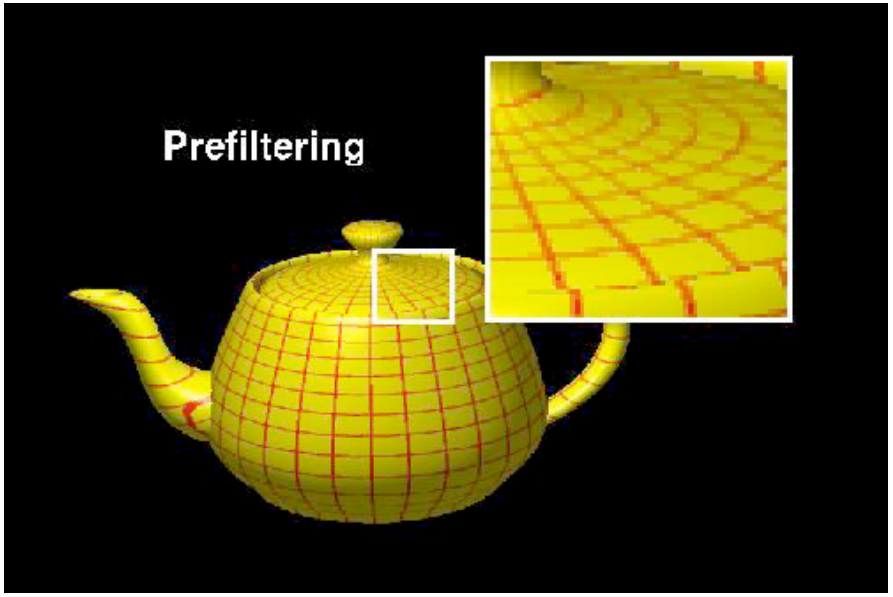
- Sample texture multiple times per pixel and reconstruct



Filtering

- Basic method (Catmull 78)
  - Project pixel polygon onto texture map
  - Average color over projected area



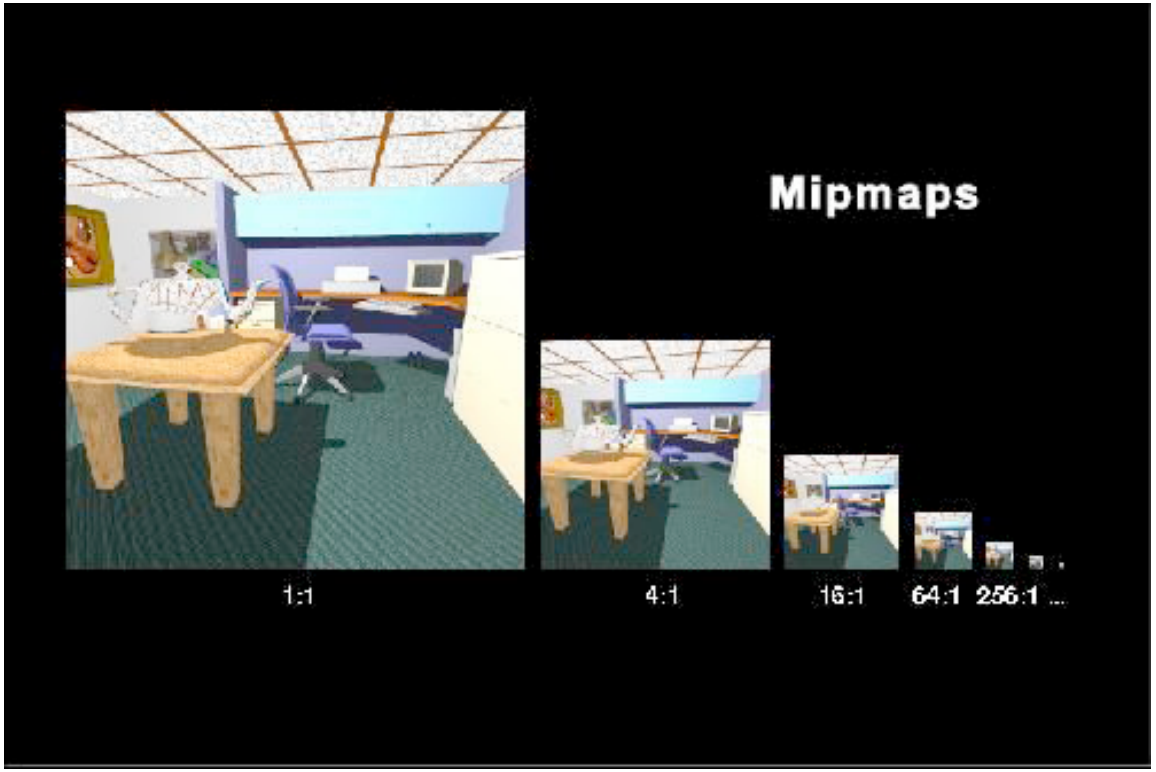


Filtering Types

- Direct Convolution
  - Average multiple samples from texture (usually selected in texture space)
- Prefiltering
  - Construct multi-resolution copies of texture
- Fourier filtering
  - Low pass filter texture in frequency space

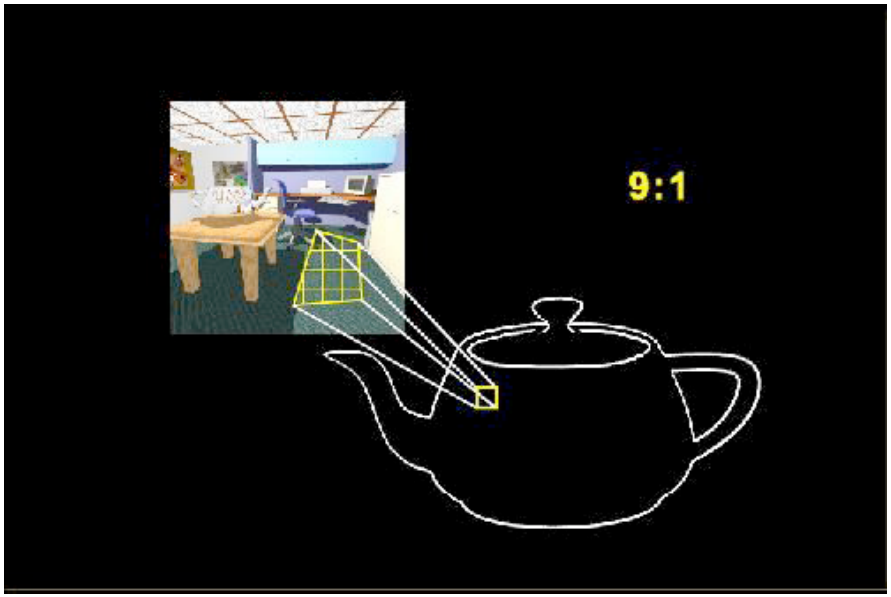
Mipmappng

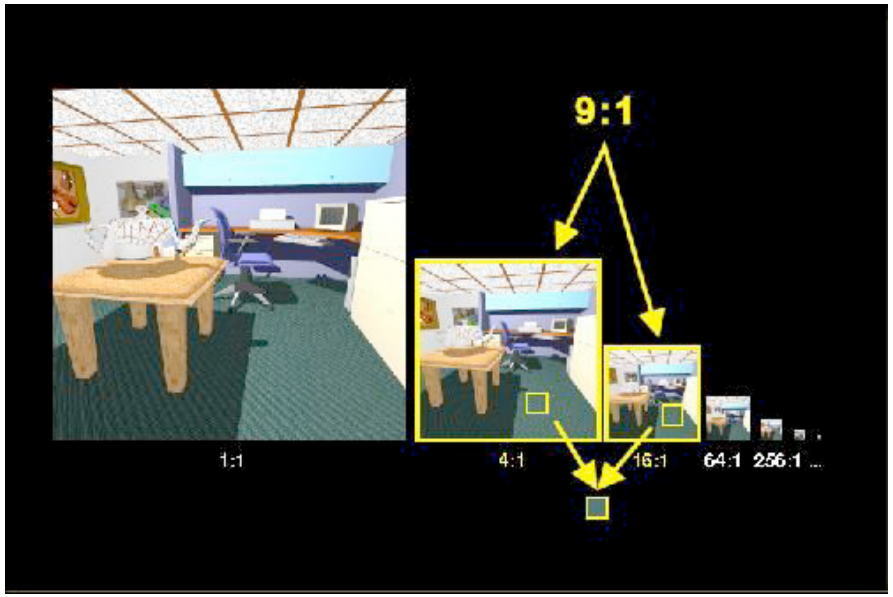
- Precalculate filtered maps at a range of resolutions (Williams 83)
- Higher memory requirements



Mipmapping Process

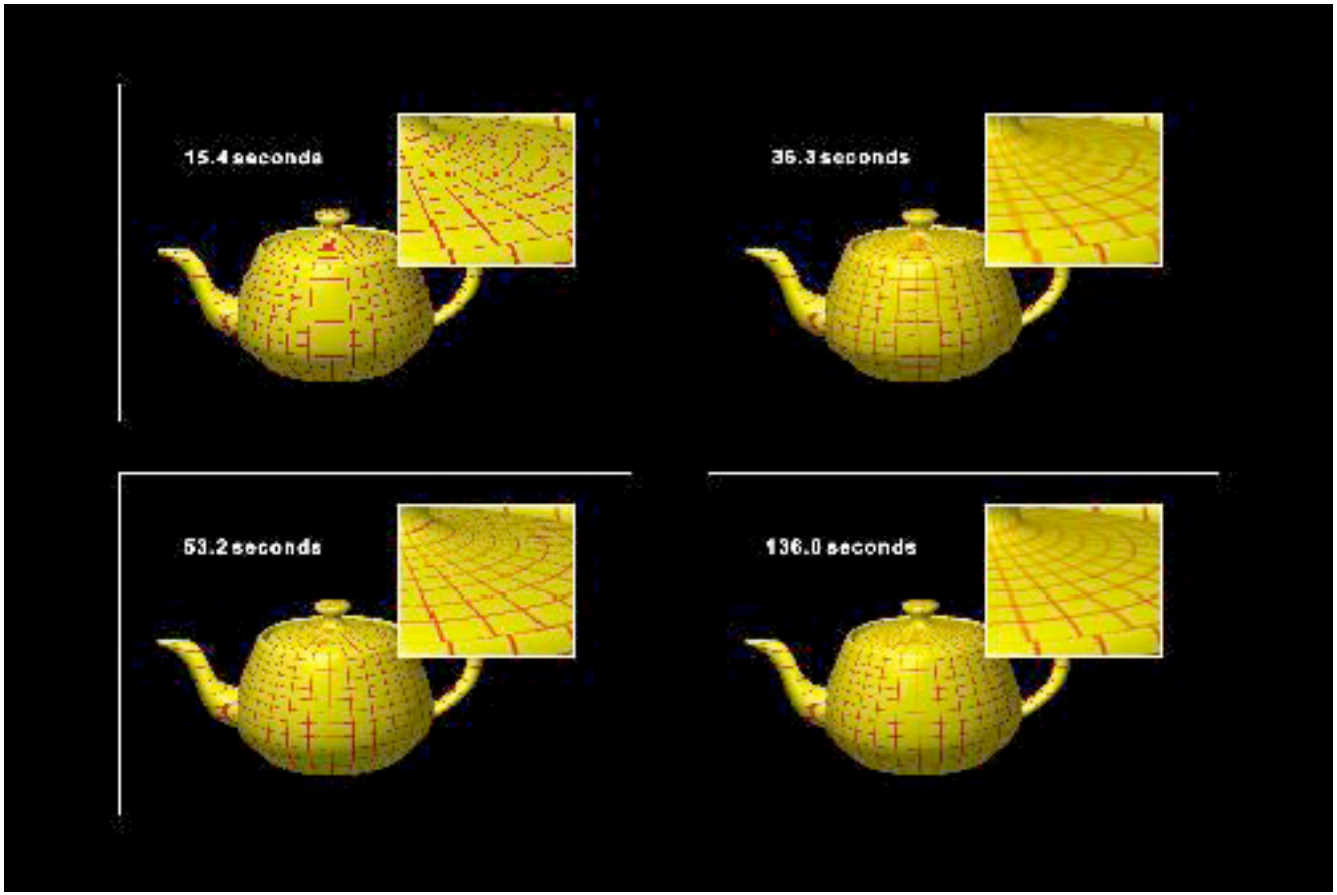
- Compute pixel area in mipmap
- Average from two closest maps





Comparison of Techniques

- Anti-aliasing: none, mipmapped, supersampled, supersampling and mipmapping



Bump Mapping

- Perturb surface normals to simulate shape variations




Bump Mapping

Bump vs. Displacement Mapping

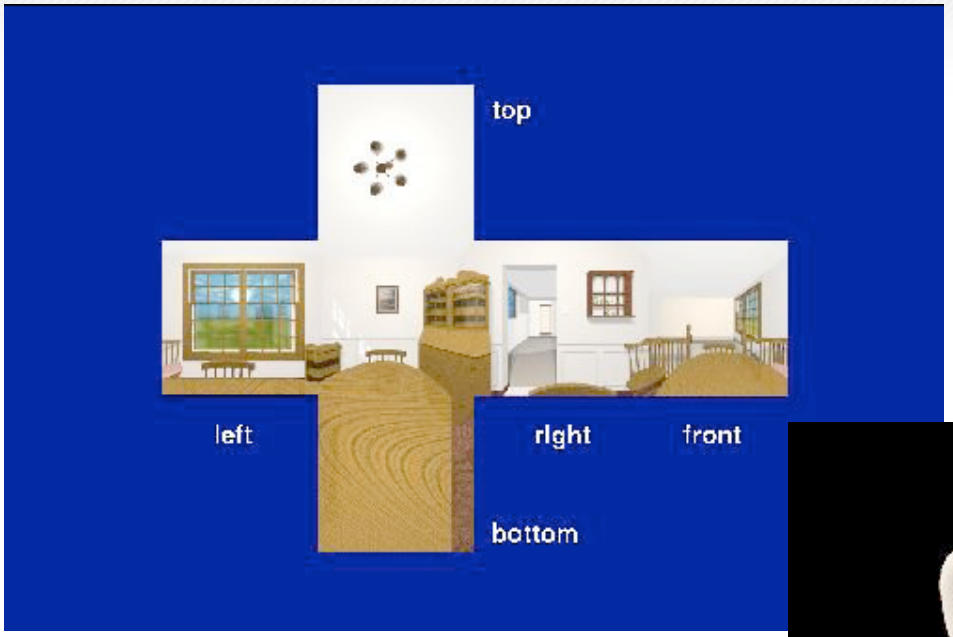
Bump Mapping

Displacement Mapping

Reflection Mapping

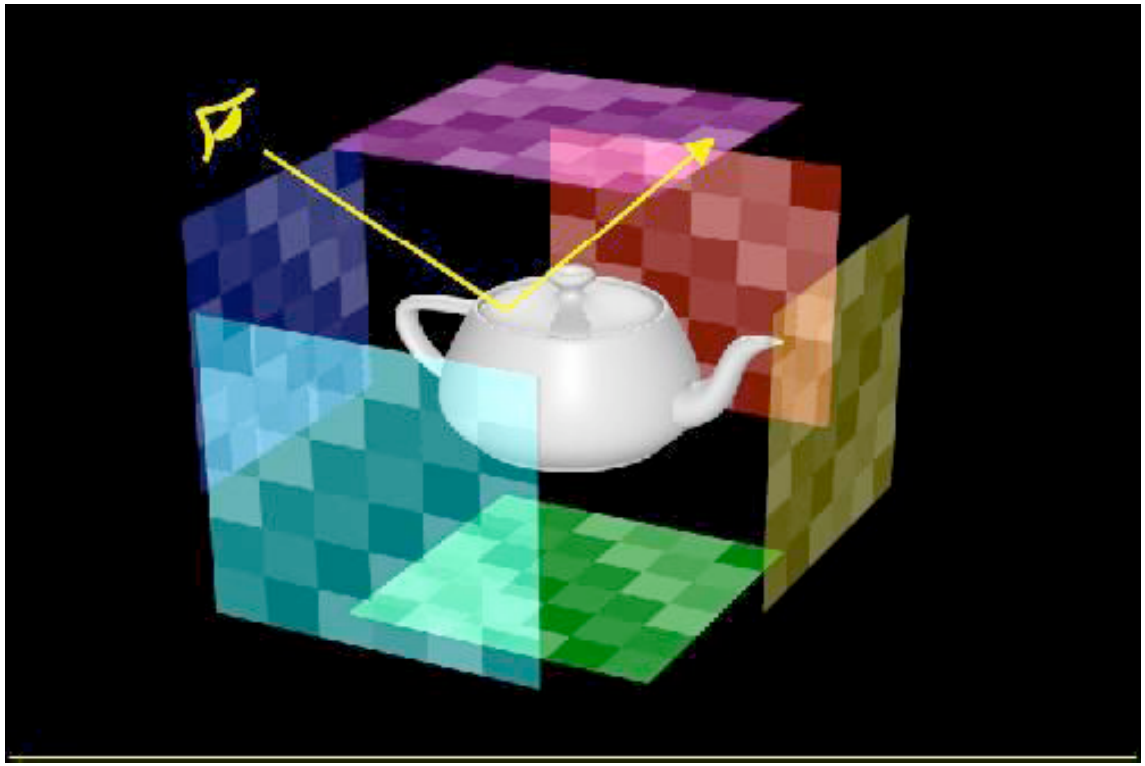
- Look up reflections on an object from a map simulating surrounding environment

Example



Environment Mapping

- Surround scene with maps simulating surrounding detail



Ray Tracing vs. Environment Mapping

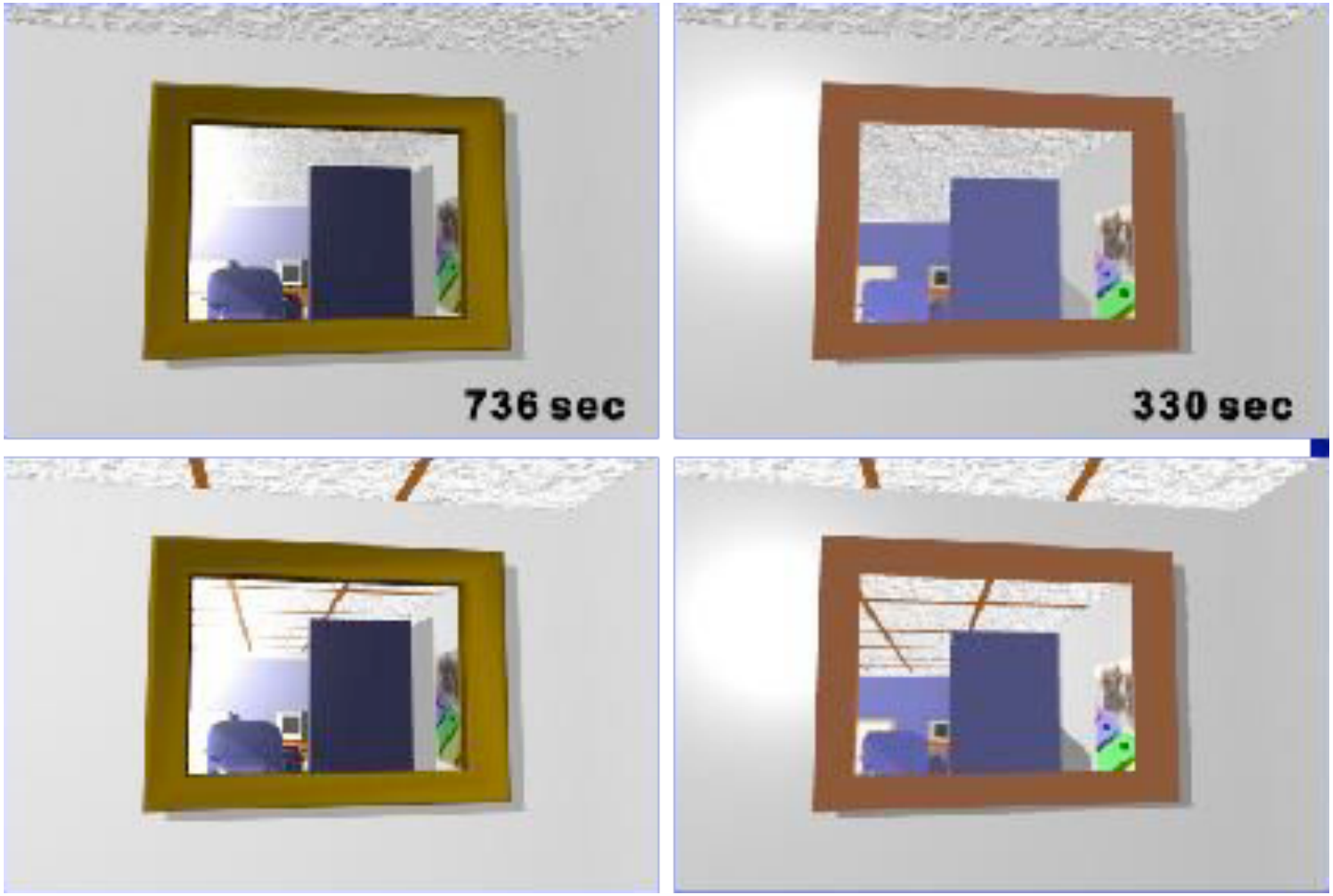
Ray Tracing

Environment Mapping

Ray Tracing vs. Environment Mapping

Ray Tracing

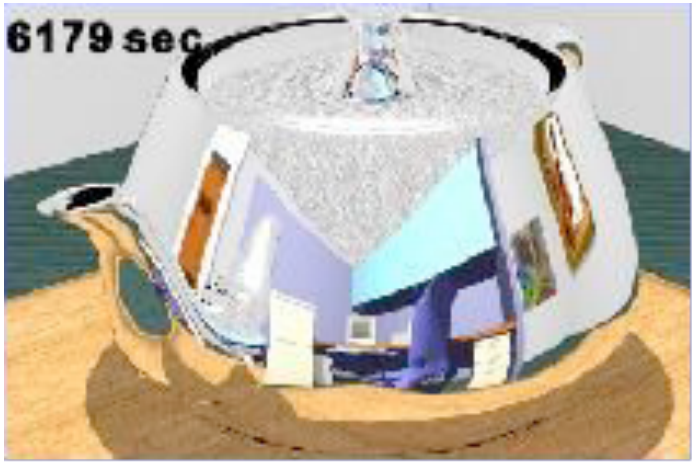
Environment Mapping

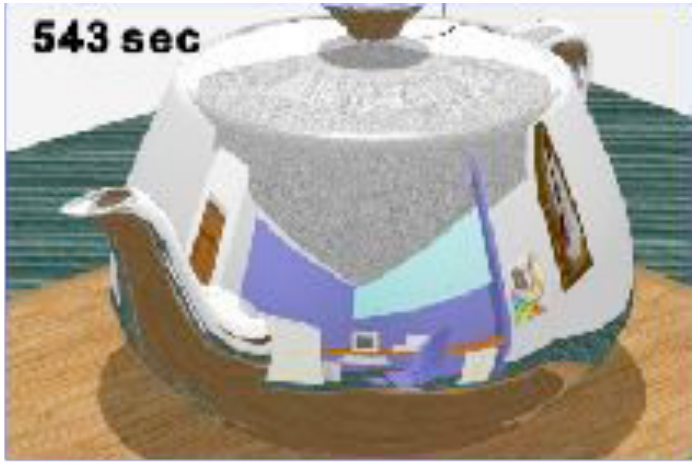


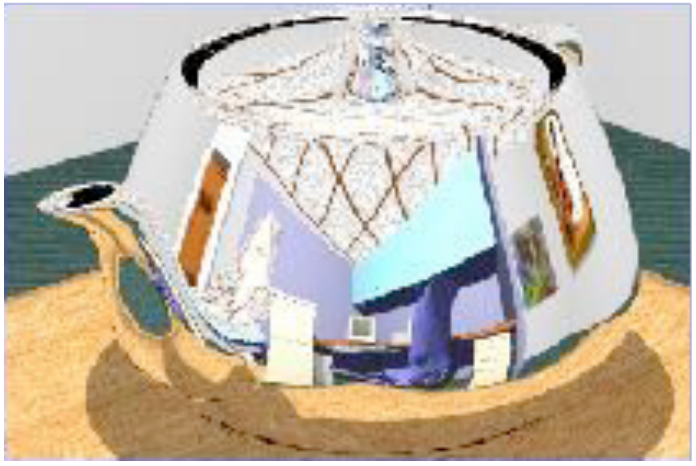
Ray Tracing vs. Environment Mapping

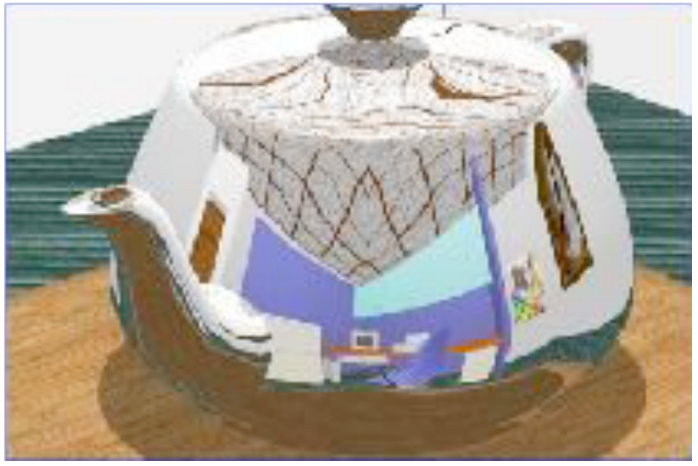
Ray Tracing

Environment Mapping









Refraction Mapping

- Perturb refraction rays through transparent surface by disruption of surface normal

Refraction Mapping