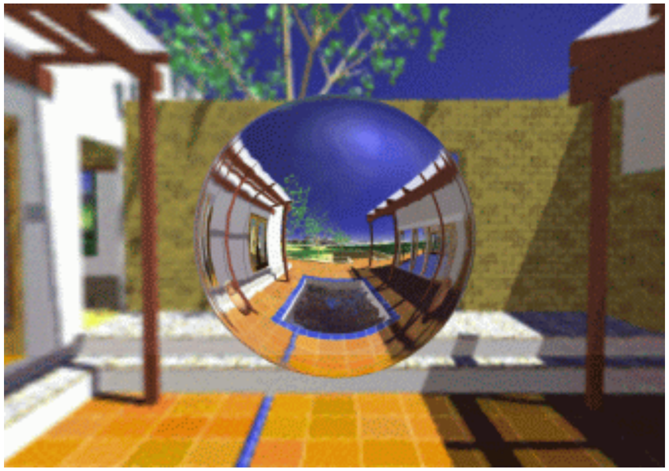
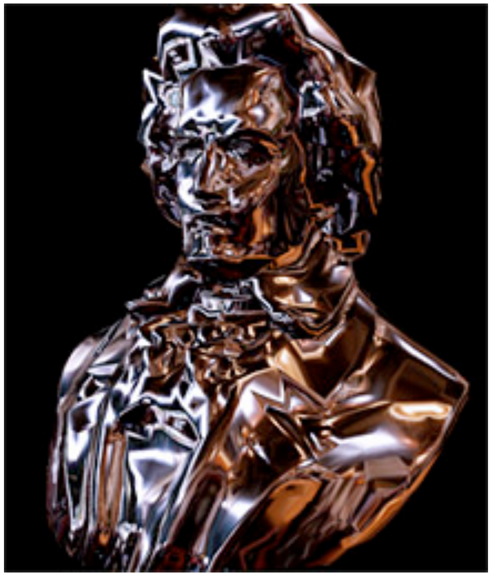
Environment Mapping

CSE 781





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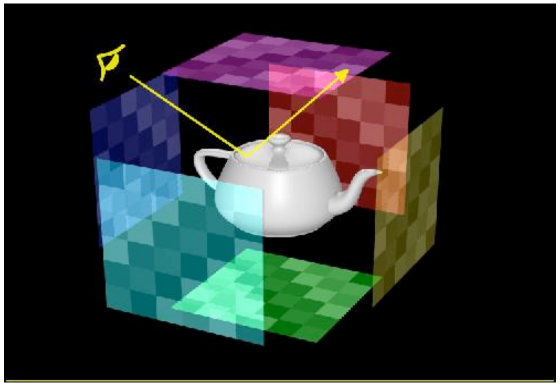
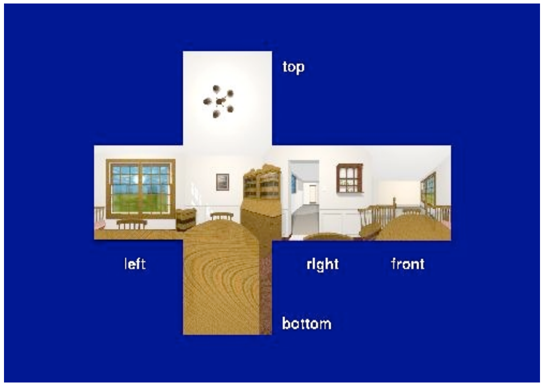
Environment Mapping

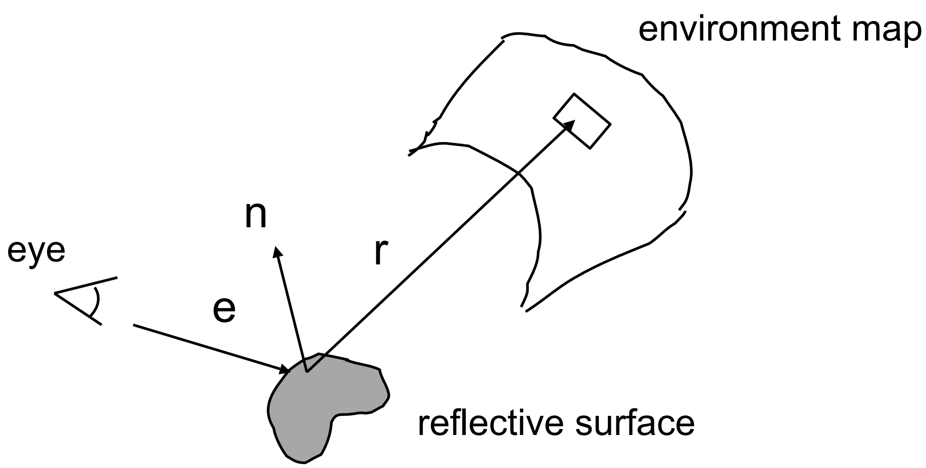
- Also called reflection mapping
- First proposed by Blinn and Newell 1976
- A cheap way to create reflections on curved surfaces – can be implemented using texture mapping supported by graphics hardware

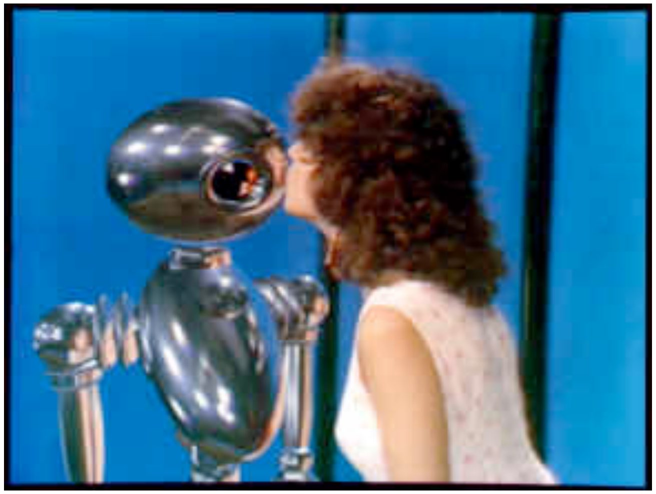




Basic Idea

- Assuming the environment is far away and the object does not reflect itself – the reflection at a point can be solely decided by the reflection vector



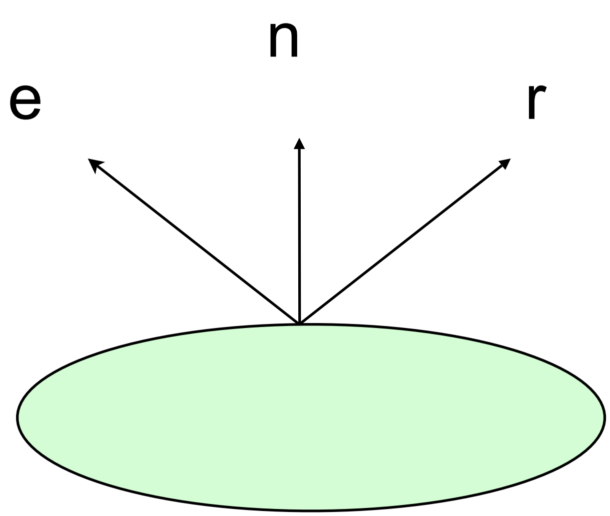


Basic Steps

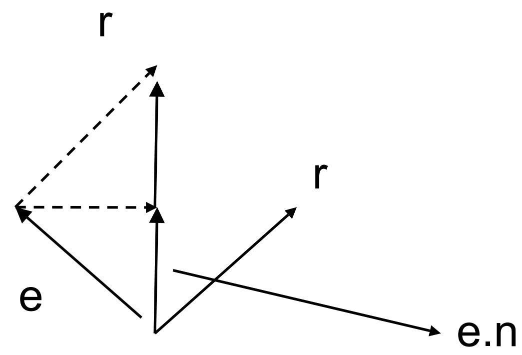
- Create a 2D environment map
- For each pixel on a reflective object, compute the normal
- Compute the reflection vector based on the eye position and surface normal
- Use the reflection vector to compute an index into the environment texture
- Use the corresponding texel to color the pixel

Finding the reflection vector

- r = 2 (n.e) n - e

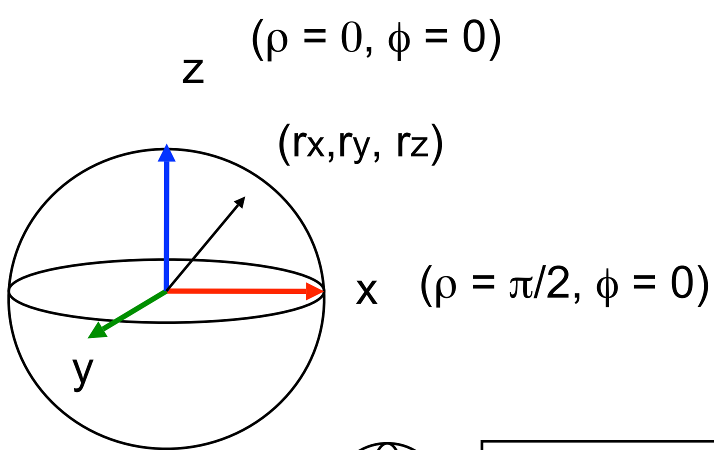


Assuming e and n are all normalized

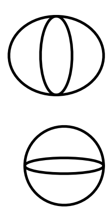


Blinn and Newell's

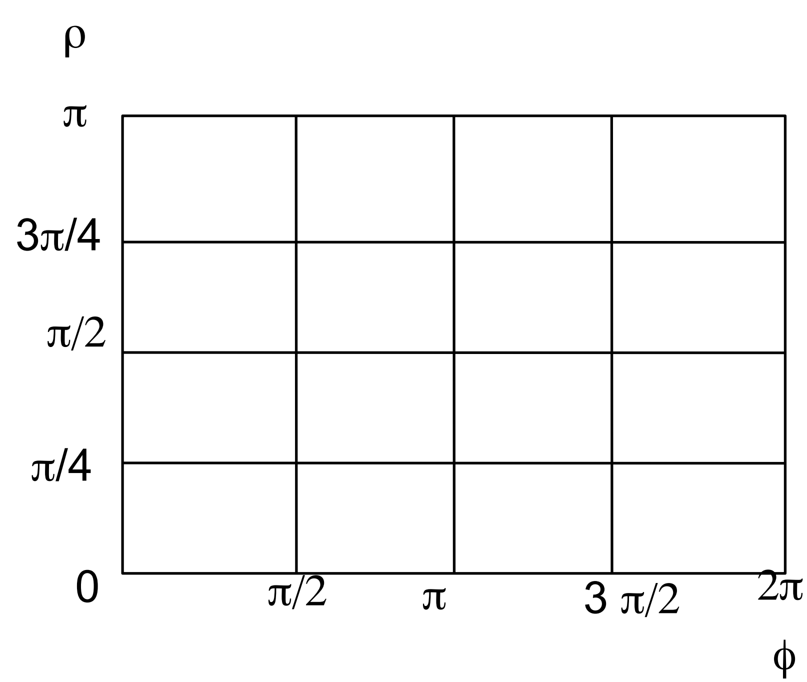
- Blinn and Newell's Method (the first EM algorithm)
- Convert the reflection vector into spherical coordinates (ρ,φ), which in turn will be normalized to [0,1] and used as (u,v) texture coordinates



ρ: latitude [0, π]
φ: longitude [0, 2π]

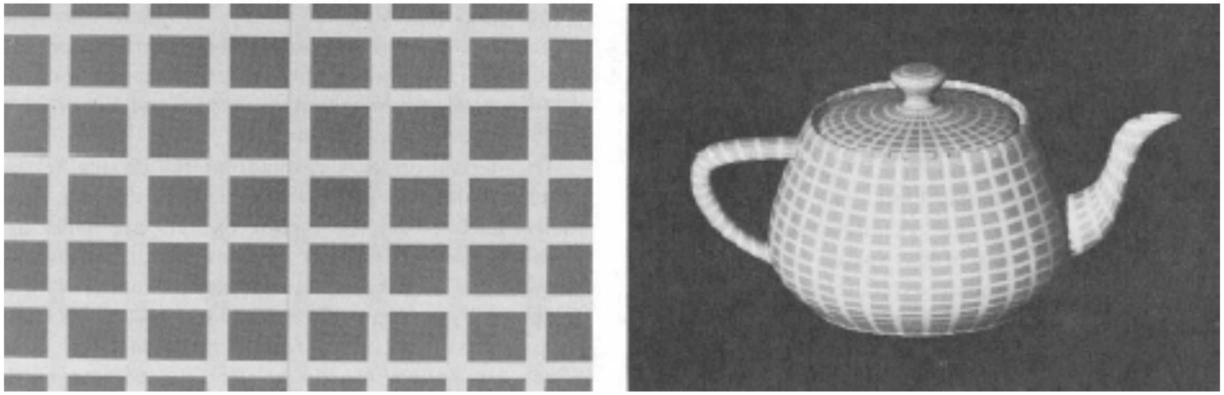


$\rho = \arccos(-rz)$
$\phi = \mathrm{atan2}(ry, rx)$



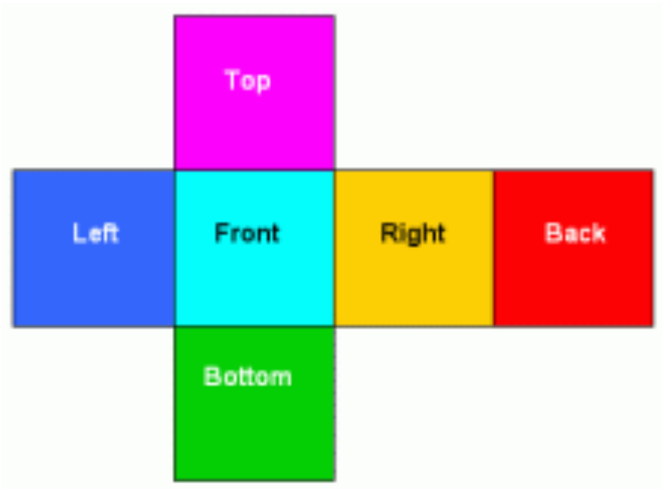
Issues

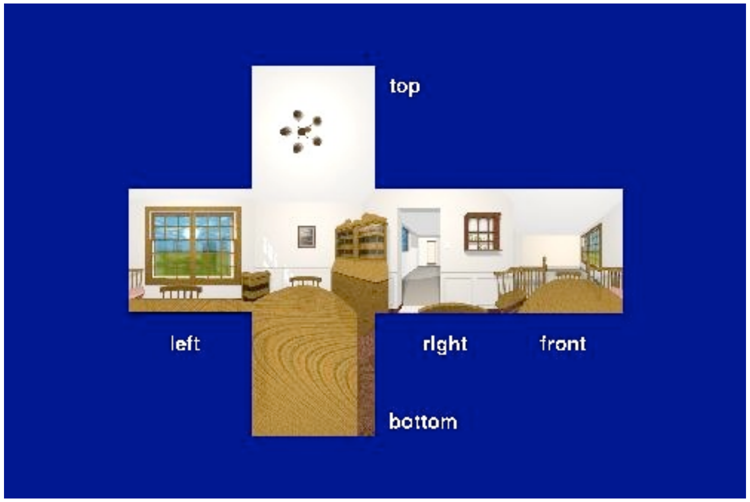
- Seams at $\phi = 0$ when the triangle vertices span over
- Distortion at the poles, and when the triangle vertices span over
- Not really been used much in practice



Cubic Environment Mapping

- Introduced by Nate Green 1986 (also known as environment cube map)
- Place the camera in the center of the environment and project it to 6 sides of a cube





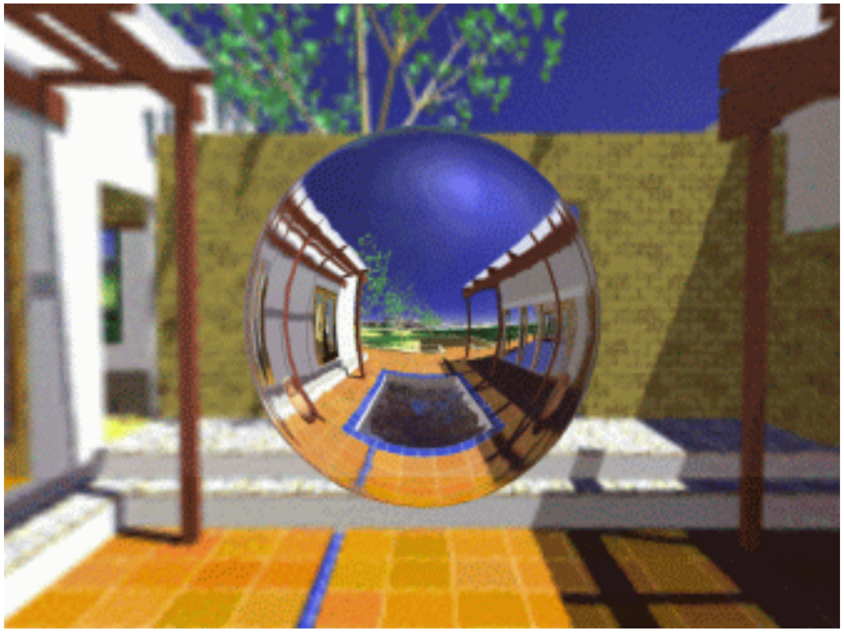
Cubic Environment Mapping (2)

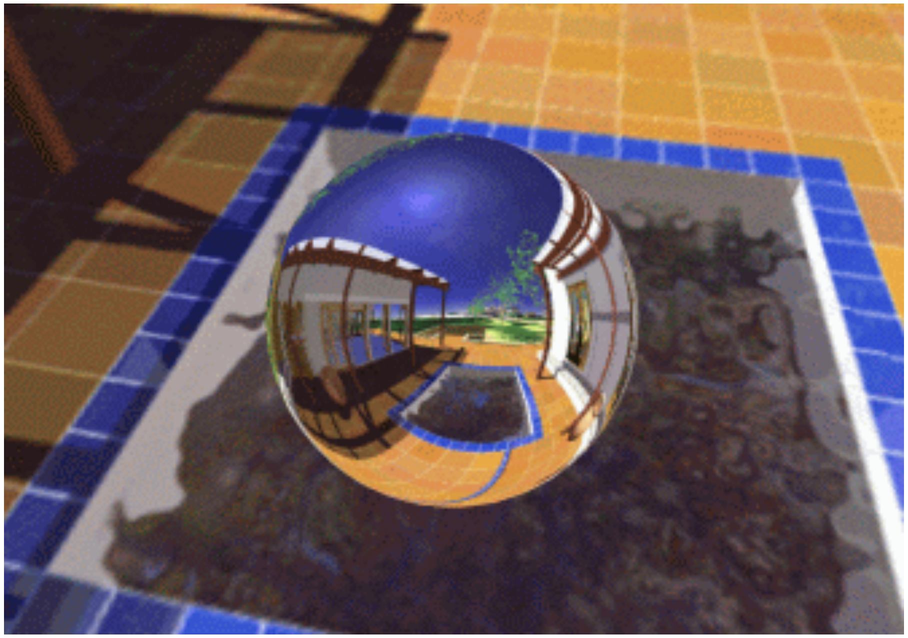
- Texture mapping process
  - Given the reflection vector (x,y,z), first find the major component and get the corresponding plane. (-3.2, 5.1, -8.4) -> -z plane
  - Then use the remaining two components to access the texture from that plane.
    - Normalize them to (0,1)

      (-3.2, 5.1) -> ((-3.2/8.4)/2+0.5, (5.1/8.4)/2+0.5)
    - Then perform the texture lookup
- No distortion or seam problems, although when two vertices of the same polygon pointing to different planes need to be taken care of.

Environment Cube Map

- Rendering Examples





Sphere Mapping

- The image texture is taken from a perfectly reflective sphere, which is viewed from the eye orthographically.
- Synthetic scene can be generated using ray tracing

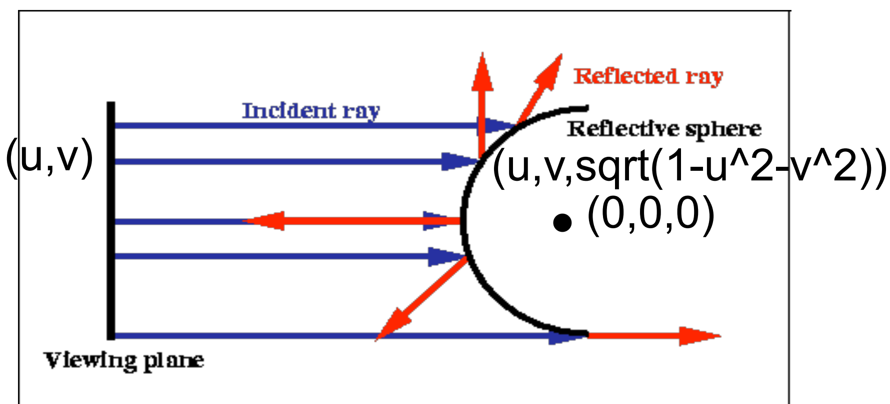


Figure 27. Creating a sphere map

Sphere Mapping (2)

- To access the sphere map texture
  - The surface normal (n) and eye (e) vectors need to be first transformed to the eye space
  - Then compute the reflection vector as usual

    $(r = (r_x, r_y, r_z) = e' - 2(n'.e')n')$
  - Now, compute the sphere normal in the local space n = $(r_x, r_y, r_z) + (0,0,1)$

    reflection vector   Directoin to the eye in local space
  - Normalize it and use x and y to access the sphere texture map: $u = rx / M + ½$; $v = ry / M + ½$;

    where $M = 2\ \mathrm{sqrt}(rx^2 + ry^2 + (rz+1)^2)$