Advanced Shading Techniques

Reflection
- Planar reflectors
  - Stencil technique
  - Textured technique
- Curved reflectors
- Interreflections
- Refraction

Reflection

Unifying concepts
- Ray-tracing too expensive for any reasonably sized image
- Approximate appearance of reflected objects
- Build second version of scene that looks reflected to eye
  - For each vertex in scene,
  - Calculate virtual vertex in reflected scene
- Blend that second scene with the first somehow

Reflection

Mirror is XY plane at some z point?
Planar Reflections

Dinosaur is reflected by the planar floor. Easy hack, draw dino twice, second time has `glScalef(1,-1,1)` to reflect through the floor. But what if it’s not the XY plane?

Just like shadows.....

Planar Reflectors

Start with reflectors which lie in a plane
- Mathematically straightforward
- Reflection math is the same for all vertices
- Define reflection matrix from plane

Planar Reflectors

$\begin{bmatrix}
1-2N_x^2 & -2N_xN_y & -2N_xN_z & 2N_z N/N_z \\
-2N_yN_x & 1-2N_y^2 & -2N_yN_z & 2N_z N/N_y \\
-2N_zN_x & -2N_zN_y & 1-2N_z^2 & 2N_y N/N_z \\
0 & 0 & 0 & 1
\end{bmatrix}$

Reflection transformation matrix for $P$ and $N$ (i.e. it’s just a 4x4 matrix)

Planar Reflectors

Stencil buffer implementation
- Configure projection and viewing matrix, clear buffers
- Apply reflection transformation
- Draw scene normally (will be reflected) (skip mirror)
- Clear stencil to 0 and clear depth buffer
- Draw mirror polygon as stencil 1
- Clear color buffer everywhere stencil == 0
Planar Reflectors

Stencil buffer implementation, cont’d
- Remove reflection transformation
- Modulate reflected scene by mirror color & lighting
- Render remainder of scene normally (skip mirror)

Planar Reflectors

Projected texture implementation
- Configure projection and viewing matrix, clear buffers
- Apply reflection transformation
- Draw scene normally (will be reflected) (skip mirror)
- Copy framebuffer into texture
  - Can save just rectangular region around mirror

Planar Reflectors

Projected texture implementation, cont’d
- Clear buffers
- Remove reflection transformation
- Set up texture projection identical to camera projection
- Render mirror, modulating with color and lighting
- Render scene normally (skip mirror)
Planar Reflectors

One last technique
- If you scene has a background that fills window
- Draw reflected scene
- Clear depth
- Draw mirror modulated with reflection
- Draw background (will fill in areas around mirror)
- Draw unreflected scene

Planar Reflectors

Shiny marble, etc...
- Mirror can have color, texture, lighting, etc
- Stencil: Draw modulated by reflection in framebuffer
- Texture: Draw modulated with reflection texture
  - May need multipass or multitexture

Implementation issues
- Can cull to a frustum that bounds mirror polygon
- Need clipping plane in plane of mirror
  - Stuff transformed to front of mirror shouldn’t be rendered
  - Can also create skewed projection so near plane clips
- Magnification/minification special effect:
  - Hack for slight concavity/convexity
  - Translate reflected scene perpendicular to mirror

Implementation issues
- Texture implementation may be slow: fb copy to texture
- Stencil buffer implementation requires… stencil buffer?
- Could draw mirror into stencil up front, but:
  - Stencil enabled during entire reflected scene
  - Could just draw with clip planes if mirror = quad
Recursive Planar Mirrors

Basic idea of planar reflections can be applied recursively. Requires more stencil bits.