Texture Mapping, Bump Mapping, OpenGL

CS116B

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Outline

• Surface Texture Mapping
• Texture Reduction Patterns
• Procedural Texturing Methods
• Bump Mapping
• Frame Mapping
• OpenGL
Surface Texture Mapping

**Texture Space** (s,t)  
- **Object Space** (u,v) parametrization of a surface (x(u,v), y(u,v), z(u,v))  
- **Image Space**: (x,y) Pixel Coordinates

- Typically, the texture space and the object space are rectangles so can map using the equations:
  \[ u(s,t) = a_u s + b_u t + c_u \]
  \[ v(s,t) = a_v s + b_v t + c_v. \]

- The object space to image space mapping depends on the surface we are parametrizing. For example, for a cylinder we might use \( x=r\cos u \), \( y=r\cos v \), \( z=v \).

- We can map either from texture space to image space (**texture scanning**) by composition or can map reverse direction (**pixel-order scanning**).
- The latter is useful to avoid pixel round off errors.
Volume Texturing

• Similar to surface texturing except now texture is 3D. So given by 3 coordinates (s,t,r).

• Might want to do for cut-away displays, scenes like inside a fish-tank, etc.
Texture Reduction Patterns

• As objects get far away, it doesn’t make sense to do lots of calculations to apply a texture to them.
• It also can cause distortion in how the texture looks.
• To avoid this we can create different textures of different levels of detail to use depending on the scale of the object.
• These texture reduction patterns are often called MIP maps (multum in parvo).
Procedural Texturing Methods

• Another technique for adding a texture pattern to an object is to use a procedural definition for the textures that are to be applied.

• That is have a little program that calculates something that looks like wood graining, marble, etc.
Bump Mapping

- Texture are not very effective when trying to model rough surfaces such as oranges, strawberries, or raisins.
- The problem is the light intensity given in a texture for such an object does not depend on the light in the scene. But these objects change a lot according to the lighting.
- **Bump mapping** is a technique to make realistic bumpy surfaces that can be used instead.
More Bump Mapping

• Let \( P(u,v) \) be a point on a surface.
• Then \( N = P_u \times P_v \) is the normal at \((u,v)\). Let \( n = N/|N| \).
• We can add a bump to the surface using an equation: \( P'(u,v) = P(u,v) + b(u,v)n \).
• Here \( b(u,v) \) is a bump function.
• Can show the perturbed normal is now approximately:
  \[ N' = N + b_v (P_u \times n) + b_u (P_v \times n) \]
• We now use this normal to do our lighting calculations.
Frame Mapping

- This is an extension to bump mapping.
- We not only perturb the surface normal, we also perturb the local coordinate system at the point.
- To do this we tweak the tangent vector $\mathbf{T}$ and calculate a binormal as $\mathbf{B} = \mathbf{T} \times \mathbf{N}$.
- This is useful in modeling anisotropic surfaces, such as wood grains, cross threading in clothing, and streaks on marbles.