CS4620/5620: Lecture 20

Texture Mapping

Announcements

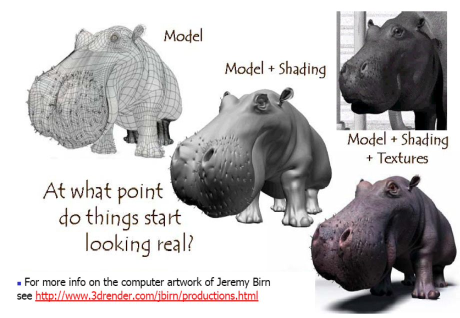
- Extra office hours

Texture mapping

- Objects have properties that vary across the surface

Texture Mapping

- Cannot model every single change using primitives
- Instead we make the shading parameters (and other properties) vary across the surface



Texture mapping

- Textures increase apparent visual complexity of geometry and material
  - Diffuse material properties
  - Specular properties
  - Normals
  - Positions
  - Lighting....
- Increases realism

Texture Mapping: applications

- Surprisingly simple idea but with big results
  - Again uses memory

Texture mapping

- Material properties are not the same everywhere on a surface
- Want a function that assigns a color (or some other material/geometry) to each point
  - the surface is a 2D domain
  - can represent using any image representation
  - raster texture images are very popular

A definition

Texture mapping: a technique of defining surface properties* in such a way that they vary as a function of position on the surface.

*= actually, surface, normal, geometry, lighting,...

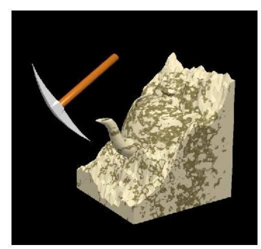
- This is very simple!
  - but it produces complex-looking effects

Examples

- Wood floor with smooth finish
  - diffuse color k_D varies with position (specular properties k_S, n are constant)
- Glazed pot with finger prints
  - specular exponent n varies with position (diffuse and specular colors k_D, k_S are constant)
- Adding dirt to painted surfaces
- Simulating stone, fabric, …
  - to approximate effects of small-scale geometry
    - they look flat but are a lot better than nothing

Mapping textures to surfaces

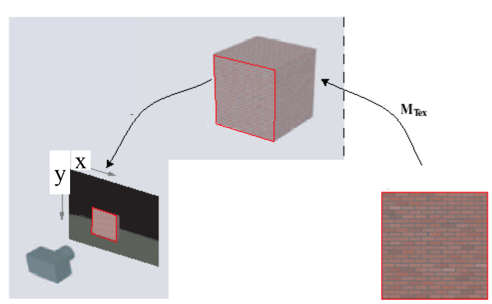
- Usually the texture is an image (function of *u*, v)
  - the big question of texture mapping: where on the surface does the image go?
  - obvious only for a flat rectangle the same shape as the image
  - otherwise more interesting
- Note that *3D textures* also exist
  - texture is a function of (*u*, *v*, *w*)
  - can just evaluate texture at 3D surface point
  - good for solid materials
  - often defined procedurally


[Wolfe / SG97 Slide set]

Aisde: Types of Textures

- 3D Textures
- 2D Textures
  - The most common
- Procedural texturing
  - Write a piece of code

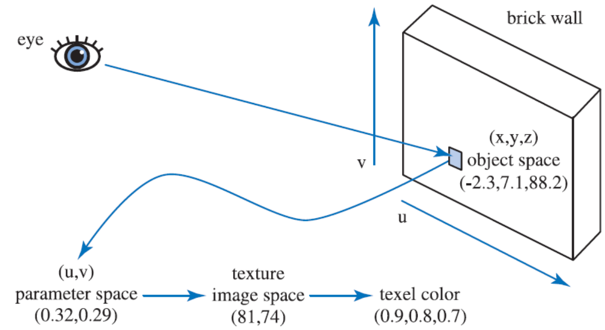
Texture mapping using images



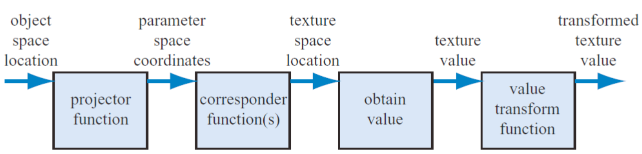
Texture Mapping using Images

- Most common form of texturing
- Map an image onto a surface
- Assume (u,v) coordinates in texture
- Mapping $M_{Tex}^{-1}(x,y,z) \rightarrow (u,v)$
  - –Between object space and texture space

How does it work?

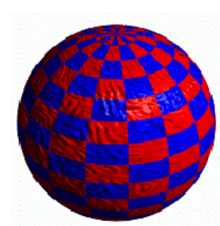


Texture Pipeline



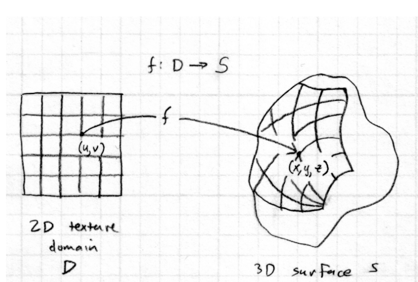
Projector Functions

- Planes, cylinders, spheres



Mapping textures to surfaces

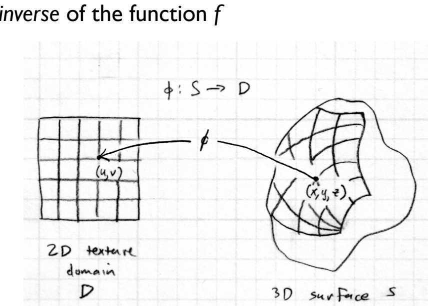
- "Putting the image on the surface"
  - –this means we need a function *f* that tells where each point on the image goes
  - –this looks a lot like a parametric surface function
  - –for parametric surfaces you get *f* for free



Projector functions

- Non-parametrically defined surfaces: more to do
  - –can't assign texture coordinates as we generate the surface
  - –need to have the *inverse* of the function *f*
- Texture coordinate fn.

  $\phi : S \rightarrow \mathbb{R}^2$
  - –for a vtx. at **p** get texture at $\phi(\mathbf{p})$



Example: texture mapping for diffuse color

- Define texture image as a function

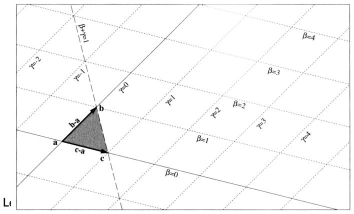
$$T : D \to C$$

  – where *C* is the set of colors for the diffuse component
- Diffuse color (for example) at point **p** is then

$$k_D(\mathbf{p}) = T(\phi(\mathbf{p}))$$

Examples of projector functions

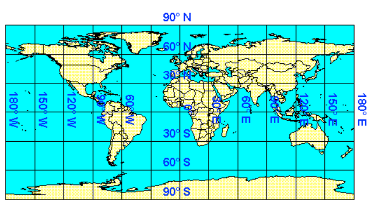
- A square/rectangle
  – image can be mapped directly, unchanged
- An arbitrary plane
  – simple affine transformation (rotate, scale, translate)
- A triangle



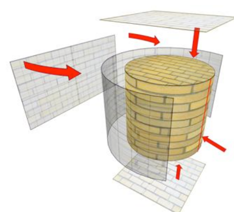
Examples of projector functions

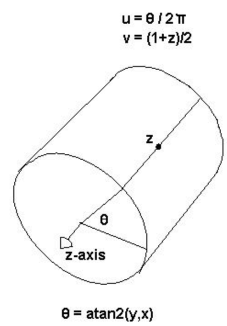
- For a sphere: latitude-longitude coordinates
  – ϕ maps point to its latitude and longitude

[map: Peter H. Dana]



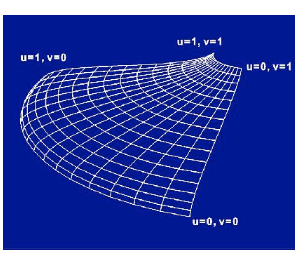
Cylinder

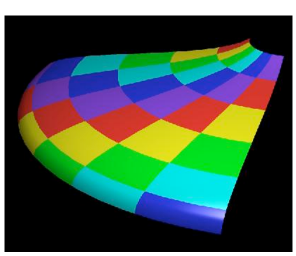




Examples of projector functions

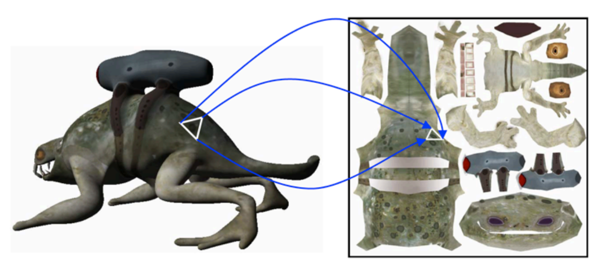
- A parametric surface (e.g. spline patch)
  – surface parameterization gives mapping function directly (well, the inverse of the projector function)





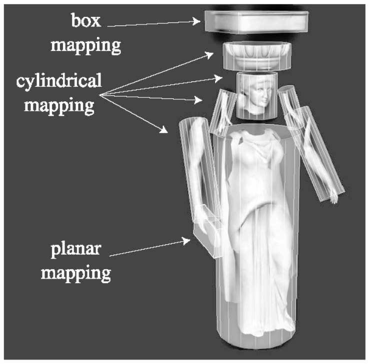
[Wolfe / SG97 Slide set]

Arbitrary Meshes

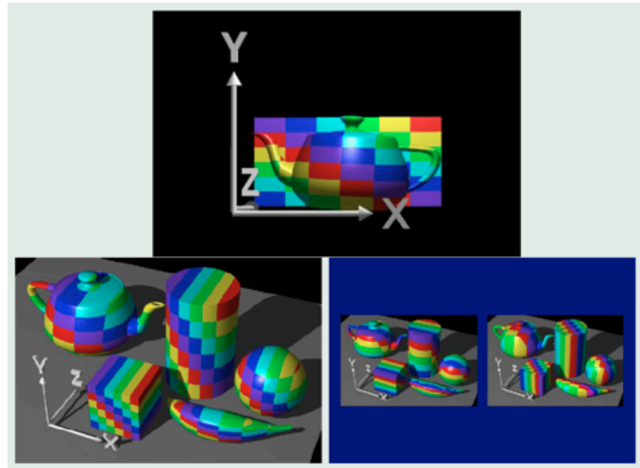


Projector Function: Arbitrary Surfaces

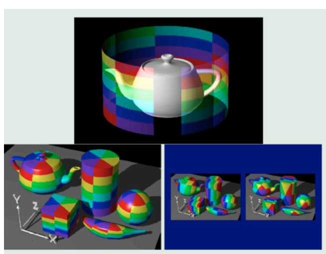
- Non-parametric surfaces: project to parametric surface



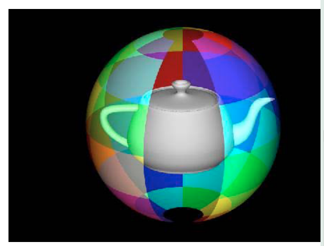
Images courtesy Tito Pagan

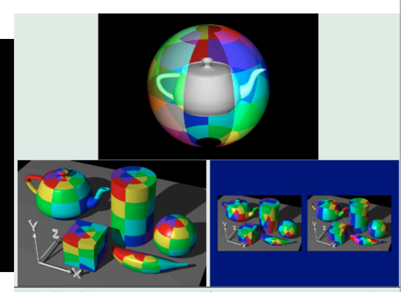


Cylindrical



Spherical

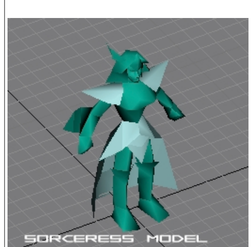


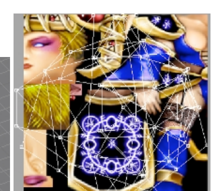


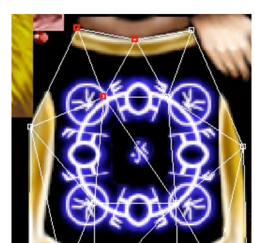
Projector Functions: User-Specified

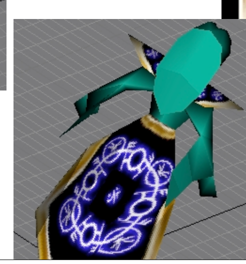
- Distortion in direction perpendicular to projection
- Approach
  - Unwrap mesh
    - Set of planar projections
    - Minimize the distortion
  - Smaller textures for each of the projections
  - Pack it into a larger texture

Projector Functions: User-Specified





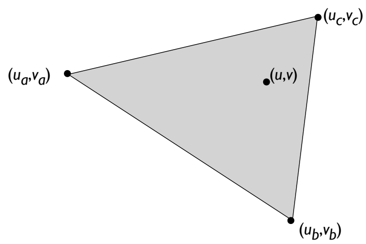




Warcraft III

Examples of projector functions

- Triangles
  - specify (u,v) for each vertex
  - define (u,v) for interior by linear interpolation



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Texture coordinates on meshes

- Texture coordinates become per-vertex data like vertex positions
  - can think of them as a second position: each vertex has a position in 3D space and in 2D texure space
- How to come up with vertex (u,v)s?
  - use any or all of the methods just discussed
    - in practice this is how you implement those for curved surfaces approximated with triangles
  - use some kind of optimization
    - try to choose vertex (u,v)s to result in a smooth, low distortion map

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