Texture Mapping

Objectives

- Introduce Mapping Methods
  - Texture Mapping
  - Environmental Mapping
  - Bump Mapping
- Consider basic strategies
  - Forward vs backward mapping
  - Point sampling vs area averaging

The Limits of Geometric Modeling

- Although graphics cards can render over 10 million polygons per second, that number is insufficient for many phenomena
  - Clouds
  - Grass
  - Terrain
  - Skin

Modeling an Orange

- Consider the problem of modeling an orange (the fruit)
- Start with an orange-colored sphere
  - Too simple
- Replace sphere with a more complex shape
  - Does not capture surface characteristics (small dimples)
  - Takes too many polygons to model all the dimples

Modeling an Orange (2)

- Take a picture of a real orange, scan it, and “paste” onto simple geometric model
  - This process is texture mapping
- Still might not be sufficient because resulting surface will be smooth
  - Need to change local shape
  - Bump mapping

Three Types of Mapping

- Texture Mapping
  - Uses images to fill inside of polygons
- Environmental (reflection mapping)
  - Uses a picture of the environment for texture maps
  - Allows simulation of highly specular surfaces
- Bump mapping
  - Emulates altering normal vectors during the rendering process

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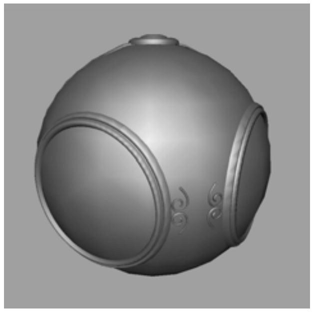
Texture Mapping



geometric model

texture mapped

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Environment Mapping

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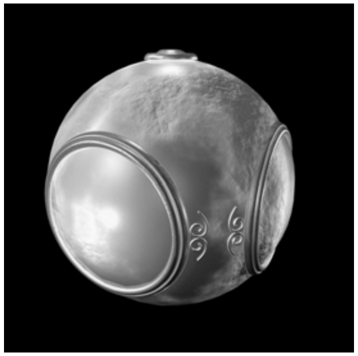
Bump Mapping



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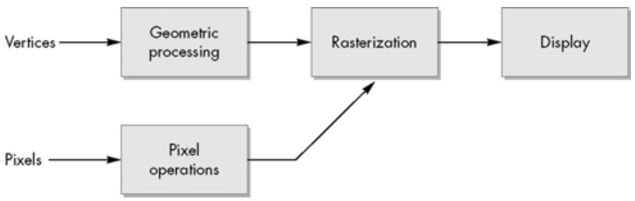
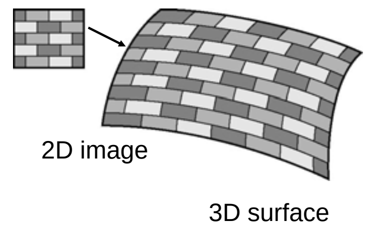
Where does mapping take place?

- Mapping techniques are implemented at the end of the rendering pipeline
  - Very efficient because few polygons pass down the geometric pipeline



Is it simple?

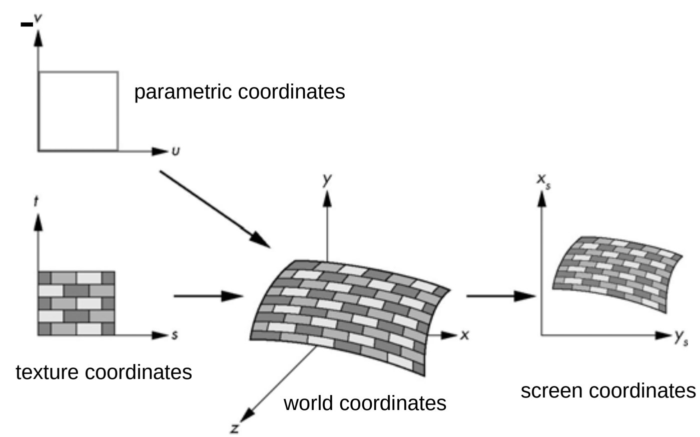
- Although the idea is simple---map an image to a surface---there are 3 or 4 coordinate systems involved



Coordinate Systems

- Parametric coordinates
  - May be used to model curved surfaces
- Texture coordinates
  - Used to identify points in the image to be mapped
- World Coordinates
  - Conceptually, where the mapping takes place
- Screen Coordinates
  - Where the final image is really produced

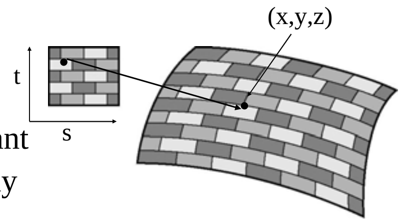
Texture Mapping



Mapping Functions

- Basic problem is how to find the maps
- Consider mapping from texture coordinates to a point on a surface
- Appear to need three functions

  x = x(s,t)
  y = y(s,t)
  z = z(s,t)



- But we really want to go the other way

Backward Mapping

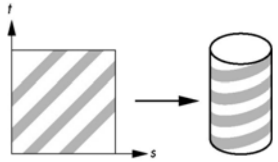
- We really want to go backwards
  - Given a pixel, we want to know to which point on an object it corresponds
  - Given a point on an object, we want to know to which point in the texture it corresponds
    - Need a map of the form

  s = s(x,y,z)
  t = t(x,y,z)

- Such functions are difficult to find in general

Two-part mapping

- One solution to the mapping problem is to first map the texture to a simple intermediate surface
- Example: map to cylinder



Cylindrical Mapping

parametric cylinder

$$x = r \cos 2\pi\, u$$
$$y = r \sin 2\pi u$$
$$z = v/h$$

maps rectangle in u,v space to cylinder of radius r and height h in world coordinates

$$s = u$$
$$t = v$$

maps from texture space

Spherical Map

We can use a parametric sphere

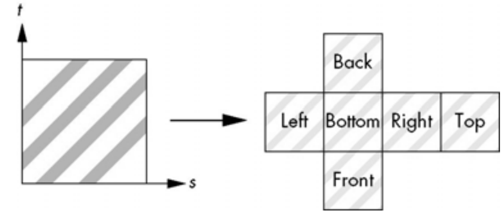
$x = r \cos 2\pi u$
$y = r \sin 2\pi u \cos 2\pi v$
$z = r \sin 2\pi u \sin 2\pi v$

in a similar manner to the cylinder
but have to decide where to put
the distortion
Ex: Mercator projection puts it at the poles

Spheres are used in environmental maps

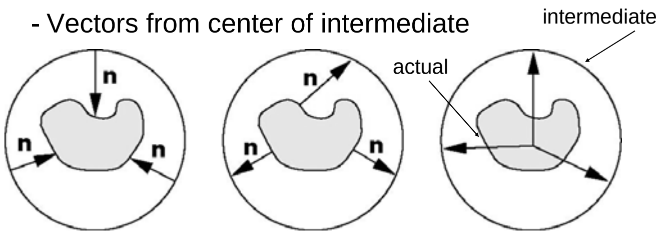
Box Mapping

- Easy to use with simple orthographic projection
- Also used in environmental maps



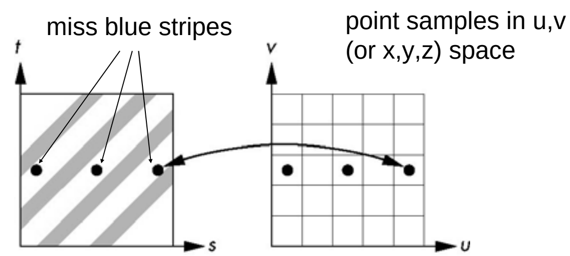
Second Mapping

- Map from intermediate object to actual object
- Three possible strategies
  - Normals from intermediate to actual
  - Normals from actual to intermediate
  - Vectors from center of intermediate



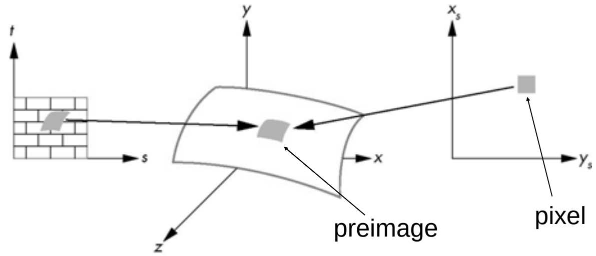
Aliasing

- Point sampling of the texture can lead to aliasing errors



Area Averaging

A better but slower option is to use *area averaging*



Note that *preimage* of pixel is curved