



Texture Mapping

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Objectives

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

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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

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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

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Modeling an Orange (2)

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

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Three Types of Mapping

- Texture Mapping
 - Uses images to fill inside of polygons
- Environment (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

- Texture mapping: adding surface detail by mapping texture patterns to the surface
- Developed by Catmull (1974), Blinn and Newell (1976), and others

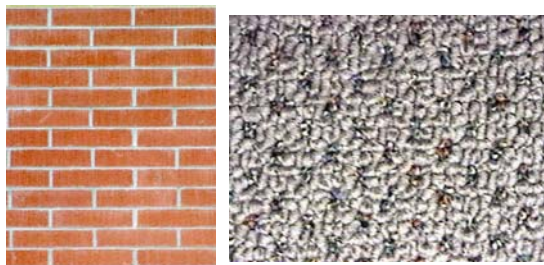


Texture Mapping

- Maps a pattern (texture) onto a surface
- *Texels* fill each pixel
- Texels selected from sample pattern (*texture map*)
- Pattern is repeated



Texture Maps



Texture Maps

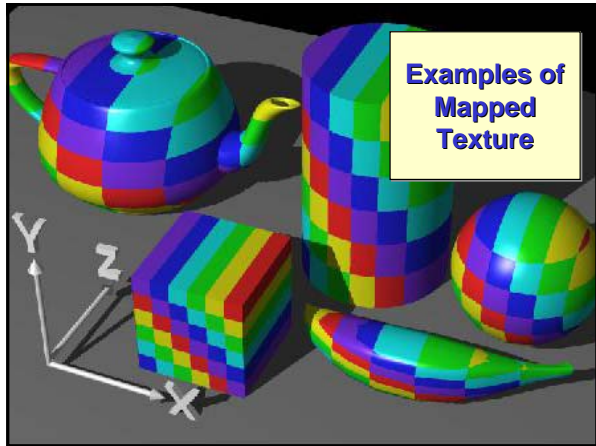


Wallpaper, Analogue Texture Map



Flooring, Tiling, etc





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Examples

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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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Bump Mapping

Look at smooth silhouettes

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Displacement Mapping

Look at silhouette

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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 make it past the clipper

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Is it simple?

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

2D image

3D surface

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Coordinate Systems

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

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Texture Mapping

parametric coordinates

texture coordinates

world coordinates

window coordinates

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Mapping Functions

- Basic problem is how to find the maps
- Consider mapping from texture coordinates to a point 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

(x,y,z)

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Spherical Map

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Box Mapping

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

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Two-part mapping

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

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Second Mapping

- Map from intermediate object to actual object
 - Normals from intermediate to actual
 - Normals from actual to intermediate
 - Vectors from center of intermediate

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More Examples

Planar Cubic Cylindrical

Texture Mapping, Paul Bourke (1987)
<http://astronomy.swin.edu.au/~pbourke/texture/textremapping>

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Aliasing

- Point sampling of the texture can lead to aliasing errors

miss blue stripes point samples in u,v (or x,y,z) space

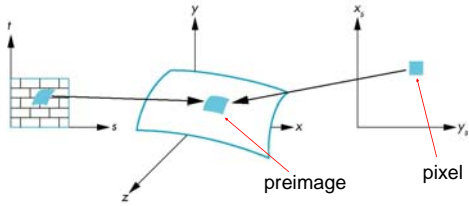
point samples in texture space

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Area Averaging

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



Note that *preimage* of pixel is curved