Texture Mapping
Textures Provide Details
Makes Graphics Pretty

• Details creates immersion
• Immersion creates fun
Basic Idea

Paint pictures on all of your polygons

- adds color data
- adds (fake) geometric and texture detail

One of the basic graphics techniques

- tons of hardware support
Texture Mapping

• Map between region of plane and arbitrary surface
• Ensure “right things” happen as textured polygon is rendered and transformed
Parametric Texture Mapping

- Texture size and orientation tied to polygon
- Texture can modulate diffuse color, specular color, specular exponent, etc
- Separation of texture space from screen space
  - UV coordinates of range [0…1]
Retrieving Texel Color

- Compute pixel \((u,v)\) using barycentric interpolation
- Look up texture pixel (texel)
- Copy color to pixel
- Apply shading
Understanding Texture Maps

• Parameterization related to:
  • Texture mapping
  • UV coordinates
  • UV unwrapping
• Usually means assigning U and V coordinates to every pixel
• Or U and V for every vertex, then interpolate
How to Parameterize?

Classic problem: How to parameterize the earth (sphere)?

Very practical, important problem in Middle Ages…
Latitude & Longitude

Distorts areas and angles
Planar Projection

Covers only half of the earth
Distorts areas and angles
Stereographic Projection

Distorts areas
Albers Projection

Preserves areas, distorts aspect ratio
Fuller Parameterization
No Free Lunch

Every parameterization of the earth either:

• distorts areas
• distorts distances
• distorts angles
Good Parameterizations

- Low area distortion
- Low angle distortion
- No obvious seams
- One piece

- How do we achieve this?
Planar Parameterization

Project surface onto plane
• quite useful in practice
• only partial coverage
• bad distortion when normals perpendicular
Planar Parameterization

In practice: combine multiple views
Cube Map/Skybox
Cube Map Textures

- 6 2D images arranged like faces of a cube
  - +X, -X, +Y, -Y, +Z, -Z
  - Index by unnormalized vector
Cube Map vs Skybox

- Cube maps map reflections to emulate reflective surface (e.g. environment mapping in local illumination)
- Skyboxes provide scene information where there is no geometry
- Same mathematical idea — just different use cases!
Storing Textures

• Texture sizes traditionally powers of 2
• Textures usually compressed on GPU
• Textures can be 3D
  • Huge memory hog!
Texture Atlas

Break up surface into easy pieces, parameterize separately
Texture Atlas

More and more automatic methods exist…

but artists traditionally hand-painted UV coords and UV “unwrapping” is still a tedious process
Texture Mapping Flaws

Texture mapping adds fake geometric details but still looks flat.

How do we fix this?
Normal Map

Key idea: modify **normals** of flat face

- **is** flat
- shaded as if it were bumpy
Normal Map

How to represent normals?

Encode as second texture (same size)
  • (r,g,b) encodes coordinates of normal (x, y, z)
Applying Normal Map
Bump Mapping

Older technique: give **offset height** only

- Less flexible than normal mapping
- Can be converted to normal maps
- Artists may use terms interchangeably
Displacement Map

Like normal map, but change normals and geometry

- Fully correct
- Slow
- Increasingly common in games due to hardware improvements
Parallax Map

Take into account shift in texture coordinates
Parallax Map Example

Texture Mapped

Normal Mapped

Parallax Mapped