SIGGRAPH 97
Education Slide Set
Mapping Techniques

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Texture mapping
2D/3D

2D mapping

3D mapping
Sources: scanners, raytracers
Mapping one object pixel to a texture pixel
Object parameterization
Planar map shape
Planar map shape
Planar map shape
Cylindrical map shape
Cylindrical map shape
Cylindrical map shape
Spherical map shape
Spherical map shape
Spherical map shape
Cube map shape
Cube map shape
What do we get from the texture?

- Position
- Surface normal
- From centroid
- Reflection
Parametric patches
Parametric patches
Parametric patches
Parameterized cube
Non-linear mapping
Triangular meshes

• One texture coordinate per vertex
• Regular parameterization of the mesh
• Requirements:
  - Continuous
  - Small angular deformations
  - Small area deformations
  - Covers the entire mesh
  - In practice: at most two
Triangular mesh example
Singularities (poles)
Bump mapping
Examples
Bump mapping

• Input = normal map \((nx, ny, nz)\)

• Local frame:
  - \(z\) = geometric normal
  - \(x,y\) = tangent, bitangent

Follow the texture coordinates!
Bump mapping

- Example: note how blue (z) is dominant
Bump mapping

• Shading normal : local frame
• Light, eye: global frame
• Move everything to the same frame
• \([\text{TBN}]: \text{transformation matrix}\)
  - To inverse, or not to inverse?

• Note:
  - textures in \([0,1]^3\)
  - normals in \([-1,1]^3\)
Bump mapping
Displacement mapping
Displacement mapping: how?

• Not in the fragment shader
  - Except towards the inside?
  - Candidate for tessellation shader

• Easier with other rendering methods
  - ray-tracing
Relief textures

- displacement mapping extreme case
Relief textures

• How?
• Warp textures before mapping

• Or follow rays in a height field

• Polygons = convex hull
Environment mapping
Raytracing/Env. mapping
Raytracing/Env. mapping
Environment mapping

• Texture = distant light
• Parameterization: cube, sphere

• Incoming ray + reflection = outgoing ray
• Query texture in this direction
Environment mapping

Example environment map (spherical parameterization)
Environment mapping
Environment mapping

- Can also work with refracted rays
- Only one interface
  - huge approximation
Environment mapping
Aliasing
Under-sampling
Need pre-filtering
Multiple samples per pixel
Prefiltering
Aliasing

- Texture + distance = aliasing
  - Looks bad
  - Multi-sampling is not enough

- Color textures: can pre-filter

- Normal maps, height maps:
  - Pre-filtering doesn’t make sense
  - Open research problem
3d textures
3D parameterization
Examples: distance to a plane
Distance to a line
Color ramps, sinus...
Noise is useful
gradient noise
Simplex noise

• Same as gradient noise
• Use a simplex instead of a cube
• 3D: tetrahedron + gradient interpolation
• Underlying structure is invisible

http://en.wikipedia.org/wiki/Simplex_noise
Frequency

8

16

32
5 octaves together

Persistence = 0.5
5 octaves together

Persistence = 0.2
Noise

• Parameters:
  - Number of octaves
  - Amplitude of first octave
  - Persistence: ratio amplitude octaves
    • Geometric sequence
  - Lacunarity: ratio of octave periods
Noise

- Often compared to salt in cooking
- Only noise: not very good
- 3D textures without noise: a bit bland

- Combination textures 3D + noise
  - Really interesting
Procedural textures
Perturbations
Procedural textures + noise

- Not limited to color
- Normals, material parameters...
- Regular structure + a bit of noise
  - Wood, bricks, floor tiles...
- Filtering / anti-aliasing: harder, but necessary
Procedural textures for object definition
All together...