Procedural Modeling

Reading for Today

• "An Image Synthesizer", Perlin, SIGGRAPH 1985 & "Improving Noise", Perlin, SIGGRAPH 2002





Last Time?

- Modern Graphics Hardware
- Cg Programming Language
- Gouraud Shading vs. Phong Normal Interpolation
- Bump, Displacement, & Environment Mapping



Reading for Today

 Chris Wyman, "An Approximate Image-Space Approach for Interactive Refraction", SIGGRAPH 2005



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Today

- Texture Mapping
- Common Texture Coordinate Mappings
- Solid Texture
- Procedural Textures
- Perlin Noise
- Procedural Modeling
- L-Systems

Texture Mapping Difficulties

- Tedious to specify texture coordinates
- Acquiring textures is surprisingly difficult
 - Photographs have projective distortions
 - Variations in reflectance and illumination
 - Tiling problems



Texture Mapping



Common Texture Coordinate Mappings

- Orthogonal
- Cylindrical
- Spherical
- Perspective Projection
- Texture Chart





Projective Textures

- Use the texture like a slide projector
- No need to specify texture coordinates explicitly



Projective Texture Example

- Modeling from photographs
- Using input photos as textures







Model edges projected onto photograph

Figure from Debevec, Taylor & Malik http://www.debevec.org/Research





Questions?		

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Procedural Textures $f(x,y,z) \rightarrow color$

Texture Map vs. Solid Texture



"Solid Texturing of Complex Surfaces", Peachey, SIGGRAPH 1985

Procedural Textures

- Advantages:
 - easy to implement in ray tracer
 - more compact than texture maps (especially for solid textures)
 - infinite resolution
- Disadvantages
 - non-intuitive
 - difficult to match existing texture



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• Ken Perlin, "An Image Synthesizer", SIGGRAPH 1985 & "Improving Noise", SIGGRAPH 2002





Perlin Noise

• Properties:

 Looks "random", but is deterministic (always returns the same answer for a specific coordinate)



- Known amplitude & frequency
- Smooth interpolation when zoomed in
- Can be combined/layered:
 - Add multiple noise functions w/ different frequencies and amplitudes
 - Simple arithmetic operations (thresholding, sine waves, etc.)





• Note: The black & grey edges are perpendicular bisectors





Voronoi Diagram/Cells/Regions

- How to re-district the Netherlands into provinces so that everyone reports to the closest capital
- Cell edges are the perpendicular bisectors of nearby points
- 2D or 3D
- Supports efficient
 Nearest Neighbor queries
 http://ccc.inaoep.mx/~rodrigo/robotica/Trigui.pdf





Questions?



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Ken Musgrave www.kenmusgrave.com







"Synthetic Topiary", Prusinkiewicz, James, and Mech, SIGGRAPH 1994



Procedural Modeling Advantages

- Small representation
- Generate detail as needed ("infinite"? resolution)
- Great for natural mathematical patterns and manmade engineering and design
- Trivial to make many duplicate objects with small variations



Applications

- Entertainment Gaming
- Education Studying botanical variation
- Archeological reconstruction
- Realism for Training
- Predicting the future (how will things grow over time)
- Urban planning (preparing for traffic)
- Accommodate for that growth/change

Procedural Modeling of Buildings



• "Procedural Modeling of Buildings", Mueller, Wonka, Haegler, Ulmer & Van Gool, SIGGRAPH 2006

Image-based Procedural Modeling of Facades • Mueller, Zeng, Wonka, & Van Gool. SIGGRAPH 2007 Floor Flo

Input Photograph

Reconstructed 3D Geometry

Questions about Procedural Modeling

- Number of rules necessary?
- Cost in human designer time of creating procedural model?
- Re-useability of procedural model?
- Validation
- Can you build a procedural model that produces a specific target?
 - From a photo of a specific rare wood grain, can you create a procedural model that creates texture that looks like it came from a different location of the same/similar tree?

Questions?



Image by Justin Legakis