Procedural Modeling

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

Final Project Proposals

• Later today you will all get an email with feedback on your project proposal…
• Common feedback:
  – Test cases aren’t incremental/detailed enough
  – Project is possibly/definitely too big
  – Motivation could be strengthened
  – Use proper bibliographic citation
  – Individual projects that did not get pre-approval 😕
• In person/Email discussion with me and/or revised proposal suggested
### Final Project Progress Reports

- What do you plan to show for your progress reports in the next two weeks?

- Each teammate should make a post each week outlining their contributions thus far
  - Post image(s), e.g., bloopers
  - Post revised task list

### Today

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

For each triangle in the model establish a corresponding region in the phototexture

During rasterization interpolate the coordinate indices into the texture map

Texture Mapping Difficulties

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

Texture Chart

- Pack triangles into a single image
Questions?

Today

• Texture Mapping
• Common Texture Coordinate Mappings
• Solid Texture
• Procedural Textures
• Perlin Noise
• Procedural Modeling
• L-Systems
Texture Map vs. Solid Texture

“Solid Texturing of Complex Surfaces”,
Peachey, SIGGRAPH 1985

Procedural Textures

\[ f(x,y,z) \rightarrow \text{color} \]

Image by Turner Whitted
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

Readings for Tuesday:

  & “Improving Noise”, SIGGRAPH 2002
Perlin Noise

• Properties:
  – Looks “random”, but is deterministic (always returns the same answer for a specific coordinate)
  – Small memory footprint & fast to compute
  – 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.)

“Shade Trees”, Cook, SIGGRAPH 1984

Figure 1a. Shade tree for copper. Figure 1b. The mix node in a shade tree for wood.
Cellular Textures

www.worley.com

Questions?

Image by Justin Legakis
Today

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Procedural Displacement Mapping

Ken Musgrave
www.kenmusgrave.com
**L-Systems**

alphabet: {a, b}
initiator: a
production rules:
  a -> b
  b -> ba

generations:
  a
  b
  ba
  bab
  babba
  babbabab
  bababababab
  babbababababab

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Prusinkiewicz & Lindenmayer,
*The Algorithmic Beauty of Plants*, 1990
http://algorithmicbotany.org/

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**L-Systems**

*Animation of Plant Development*
Prusinkiewicz et al.,
SIGGRAPH 1993

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Prusinkiewicz & Lindenmayer,
*The Algorithmic Beauty of Plants*, 1990
http://algorithmicbotany.org/
Cellular Texturing for Architecture

“Feature-Based Cellular Texturing for Architectural Models”, Legakis, Dorsey, & Gortler, SIGGRAPH 2001

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
L-Systems for Cities

“Procedural Modeling of Cities”, Parish & Müller, SIGGRAPH 2001

Procedural Modeling of Buildings

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

Image-based Procedural Modeling of Facades

• Mueller, Zeng, Wonka, & Van Gool, SIGGRAPH 2007

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 tree?

Questions?

Image by Justin Legakis