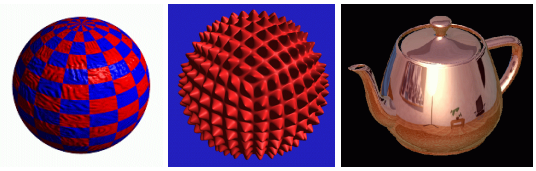
Procedural Modeling

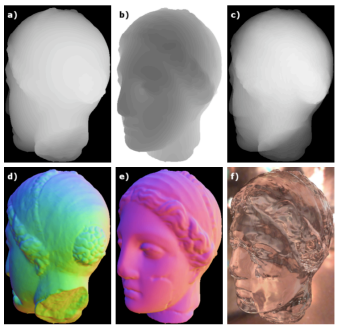
Last Time?

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



Reading for Last Time:

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



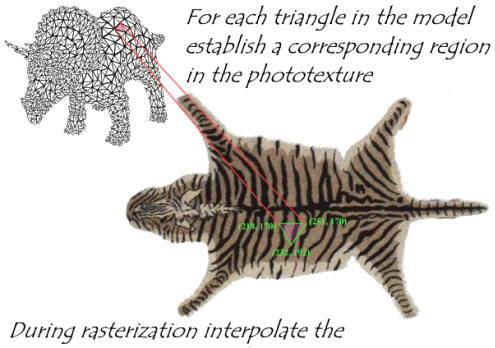
Final Project Progress Reports

- What do you plan to show for your progress report in 2 weeks?
- Each teammate should make a post 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

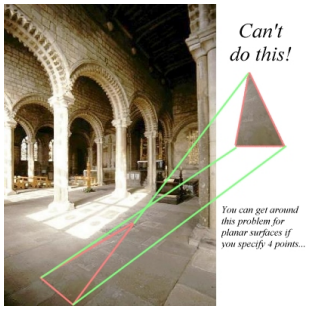


For each triangle in the model establish a corresponding region in the phototexture

During rasterization interpolate the coordinate indices into the texture map

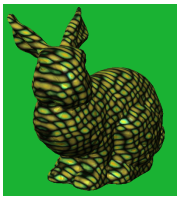
Texture Mapping Difficulties

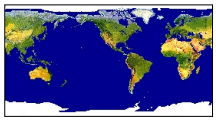
- Tedious to specify texture coordinates
- Acquiring textures is surprisingly difficult
  - Photographs have projective distortions
  - Variations in reflectance and illumination
  - Tiling problems



Common Texture Coordinate Mappings

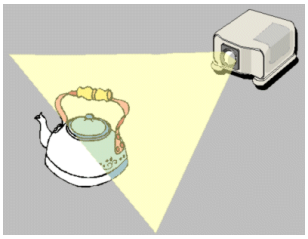
- Orthogonal
- Cylindrical
- Spherical
- Perspective Projection
- Texture Chart





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

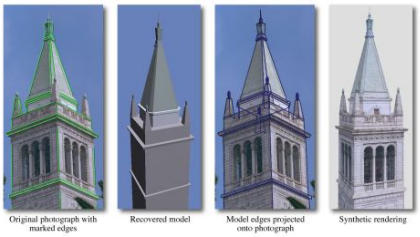
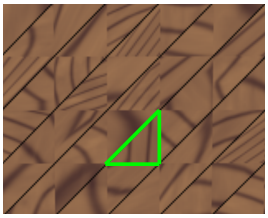
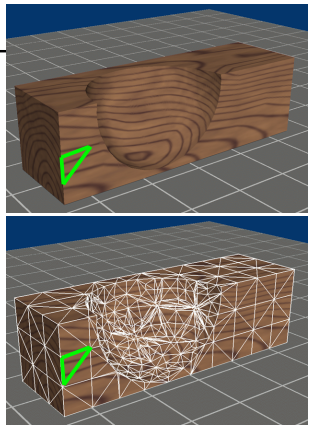


Figure from Debevec, Taylor & Malik
http://www.debevec.org/Research

Texture Chart

- Pack triangles into a single image





Questions?

Today

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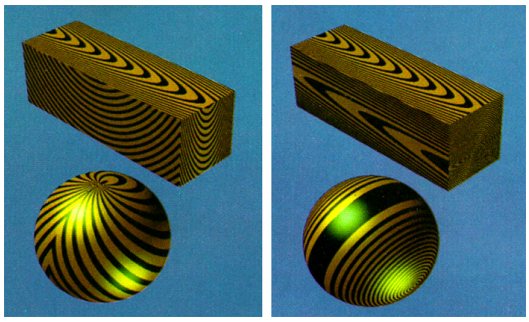
Texture Map vs. Solid Texture



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

Procedural Textures

f (x,y,z) → color

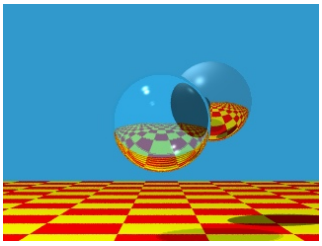
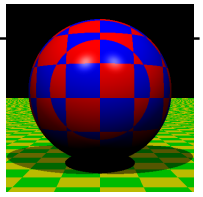
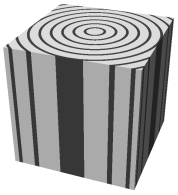


Image by Turner Whitted

Procedural Textures

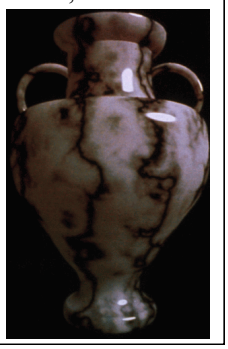


- Advantages:
  - easy to implement in ray tracer
  - more compact than texture maps (especially for solid textures)
  - infinite resolution
- Disadvantages
  - non-intuitive
  - difficult to match existing texture

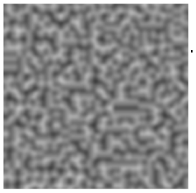


Readings for Today:

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

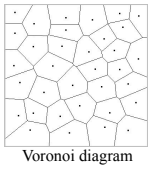


Perlin Noise

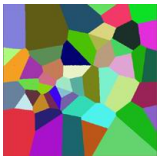


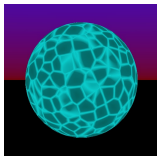
- Properties:
  - Looks "random", but is deterministic (always returns the same answer for a specific coordinate)
  - Small memory footprint & fast to compute
  - Known amplitude & frequency
  - Smooth interpolation when zoomed in
- Can be combined/layered:
  - Add multiple noise functions w/ different frequencies and amplitudes
  - Simple arithmetic operations (thresholding, sine waves, etc.)

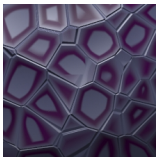
Cellular Textures



Voronoi diagram

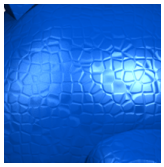






"A Cellular Texture Basis Function", Worley, SIGGRAPH 1996

www.worley.com



Questions?

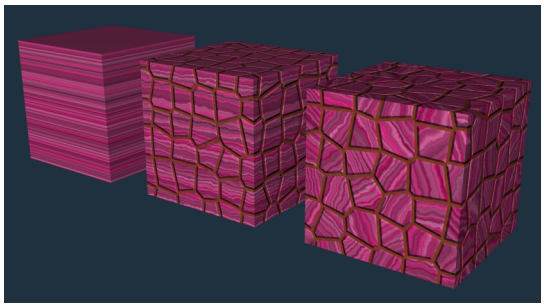


Image by Justin Legakis

Today

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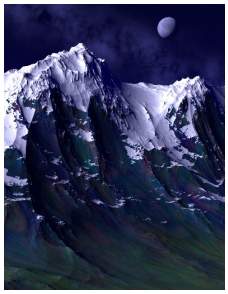
- L-Systems

Procedural Displacement Mapping



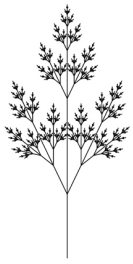
Ken Musgrave
www.kenmusgrave.com

L-Systems

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

generations:
a
b
ba
bab
babba
babbabab
babbababbabba
babbababbabbababbabab

d
n=7, δ=20°
X
X → F[+X]F[-X]+X
F → FF



e
n=7, δ=25.7°
X
X → F[+X][-X]FX
F → FF

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

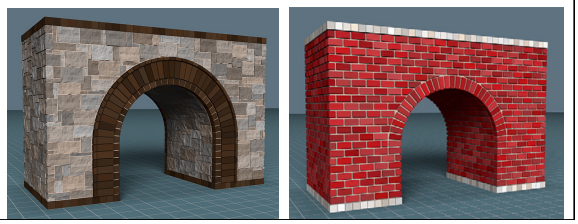
L-Systems

Animation of Plant Development
Prusinkiewicz et al.,
SIGGRAPH 1993

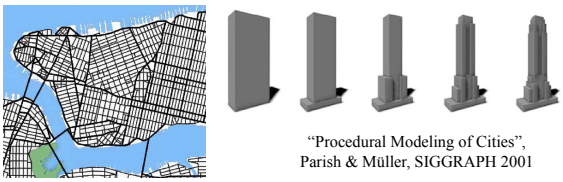
Prusinkiewicz & Lindenmayer,
The Algorithmic Beauty of Plants, 1990
http://algorithmicbotany.org/

Cellular Texturing for Architecture

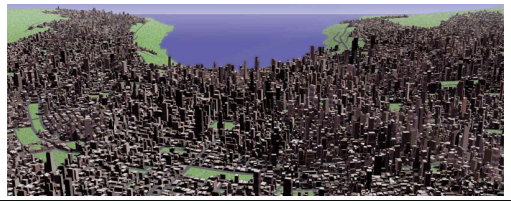
"Feature-Based Cellular Texturing for Architectural Models", Legakis, Dorsey, & Gortler, SIGGRAPH 2001



L-Systems for Cities



"Procedural Modeling of Cities", Parish & Müller, SIGGRAPH 2001

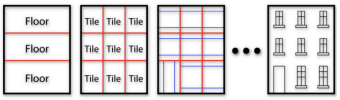


Procedural Modeling of Buildings

- "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



Input Photograph

Reconstructed 3D Geometry

Questions?

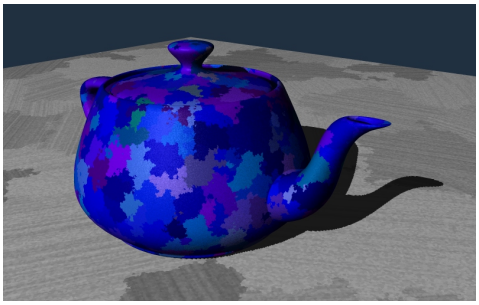


Image by Justin Legakis

Reading for Tuesday:

- "WYSIWYG NPR: Drawing Strokes Directly on 3D Models", Kalnins, Markosian, Meier, Kowalski, Lee, Davidson, Webb, Hughes, & Finkelstein, SIGGRAPH 2002