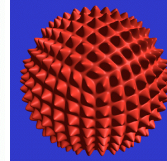
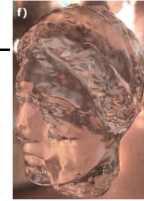


Procedural Modeling

Last Time?

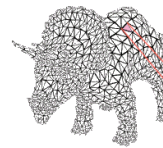
- Modern Graphics Hardware
- Cg Programming Language
- Gouraud Shading vs. Phong Normal Interpolation
- Bump, Displacement, & Environment Mapping



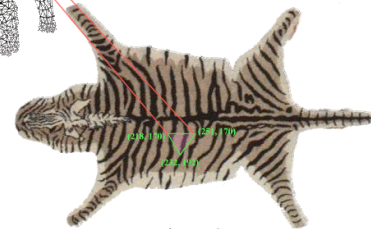
Today

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

Texture Mapping



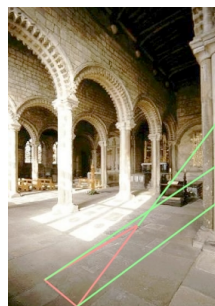
For each triangle in the model establish a corresponding region in the phototexture



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

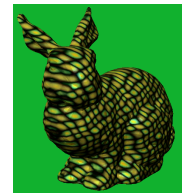


Can't do this!

You can get around this problem for planar surfaces if you specify 4 points...

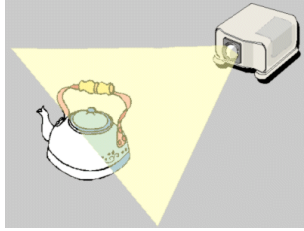
Common Texture Coordinate Mappings

- 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

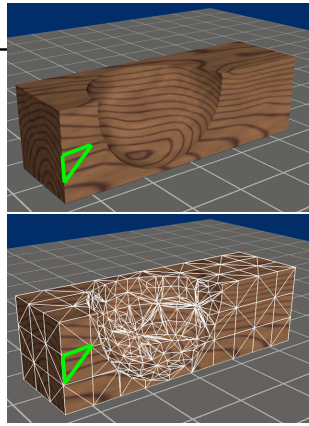
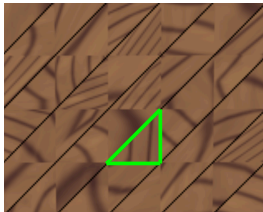
- Modeling from photographs
- Using input photos as textures



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

Texture Chart

- Pack triangles into a single image

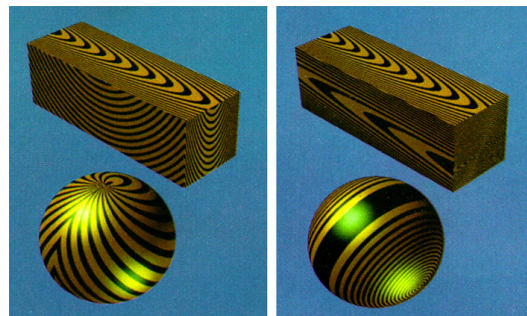


Questions?

Today

- 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

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

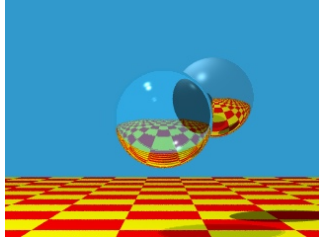
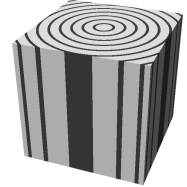
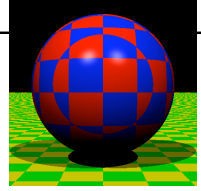


Image by Turner Whitted

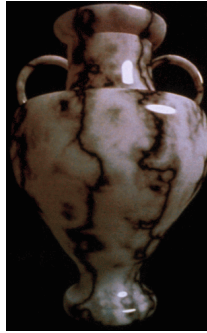
Procedural Textures

- 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



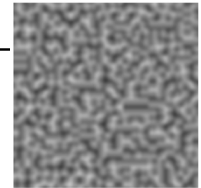
Readings for Today:

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



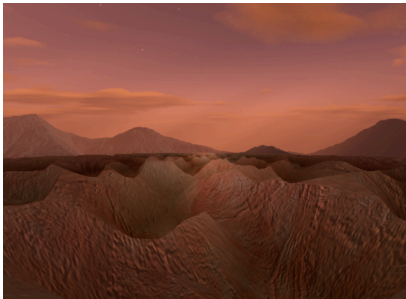
Perlin Noise

- 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.)

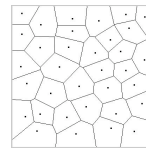


Reading for Today:

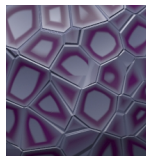
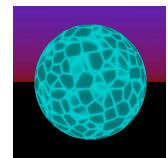
- “Parallel White Noise Generation on a GPU via Cryptographic Hash”, Tzeng & Wei, I3D 2008.



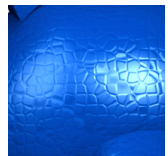
Cellular Textures



Voronoi diagram



“A Cellular Texture Basis Function”, Worley, SIGGRAPH 1996
www.worley.com



Questions?

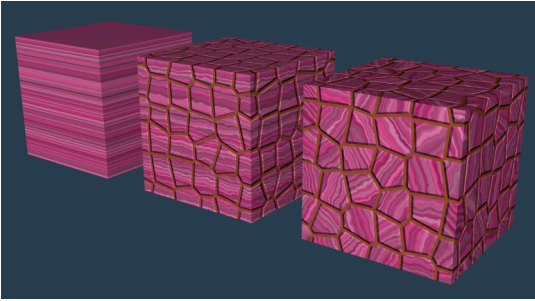
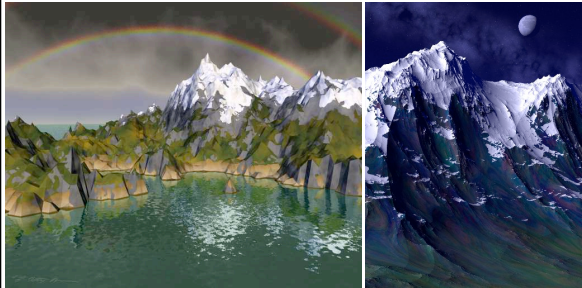


Image by Justin Legakis

Today

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

Procedural Displacement Mapping

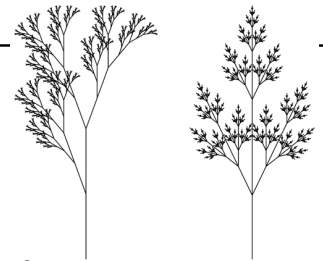


Ken Musgrave
www.kenmusgrave.com

L-Systems

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

generations:
 a
 b
 ba
 bab
 babba
 babbabab
 babbababbba
 babbababbababababab



d
 $n=7, \delta=20^\circ$
 X
 $X \rightarrow F [+X] F [-X] +X$
 $F \rightarrow FF$

e
 $n=7, \delta=25.7^\circ$
 X
 $X \rightarrow F [+X] [-X] FX$
 $F \rightarrow FF$

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

L-Systems

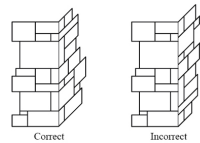


Animation of Plant Development
 Prusinkiewicz et al.,
 SIGGRAPH 1993

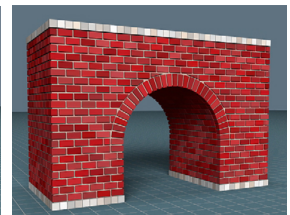
Prusinkiewicz & Lindenmayer,
The Algorithmic Beauty of Plants, 1990
<http://algorithmicbotany.org/>



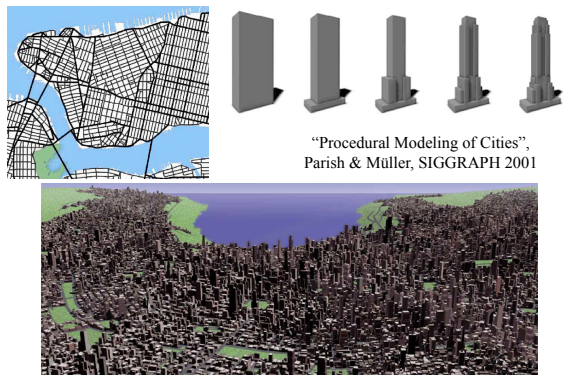
Cellular Texturing for Architecture



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



L-Systems for Cities



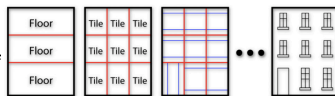
Procedural Modeling of Buildings



- "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?

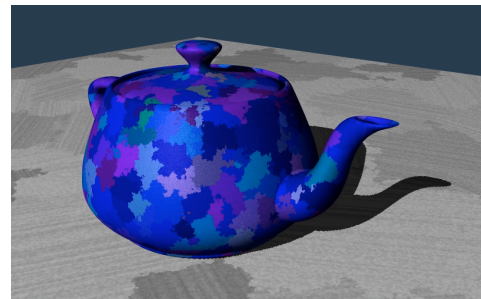


Image by Justin Legakis

Reading for Tuesday:

- "Towards Artistic Minimal Rendering", Rosin & Lai, NPAR 2010



Figure 1: Mona Lisa rendered in different styles. (a) line drawing, (b) image abstraction, (c)(d)(e): three styles of the proposed approach in this paper (single level, texture and pyramid).