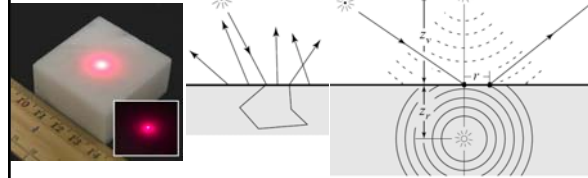
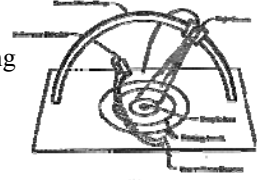


# Procedural Modeling

## Last Time?

- Measuring BRDFs
- 3D Digitizing & Scattering
- BSSRDFs
  - Monte Carlo Simulation
  - Dipole Approximation



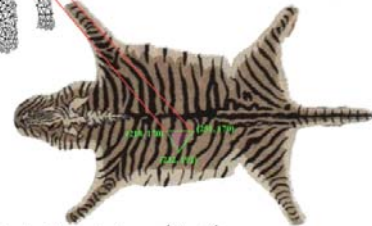
## Today

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

## Texture Mapping



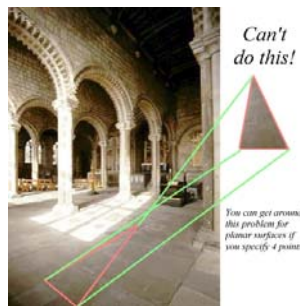
*For each triangle in the model establish a corresponding region in the phototexture*



*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



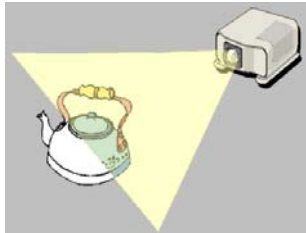
## Common Texture Coordinate Mappings

- 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

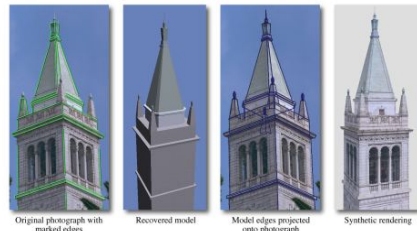
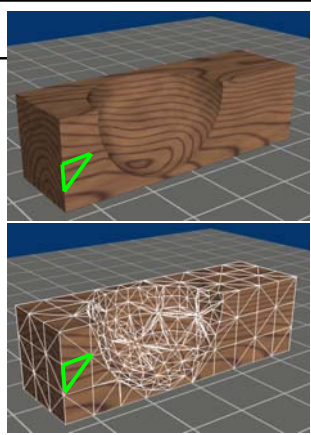


Figure from Debevec, Taylor & Malik  
<http://www.debevec.org/Research>

## Texture Chart

- Pack triangles into a single image

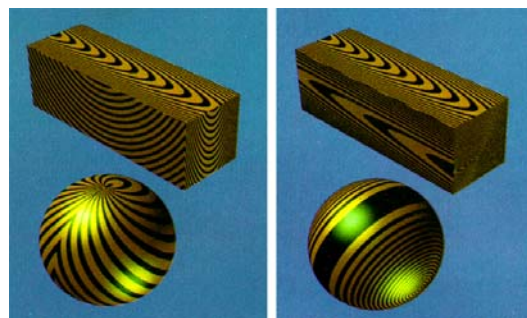


## Questions?

## Today

- 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

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

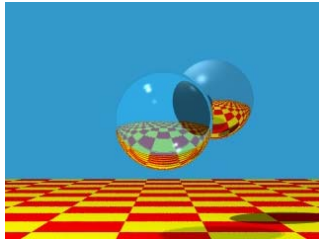
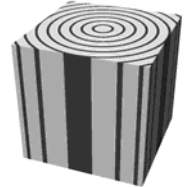
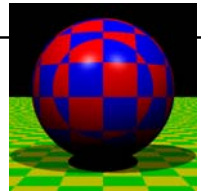


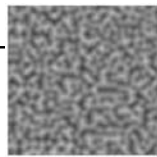
Image by Turner Whitted

## 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

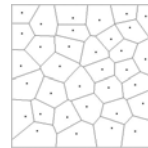


## Perlin Noise

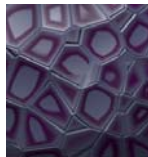
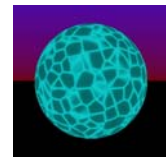


Ken Perlin,  
"An Image Synthesizer", SIGGRAPH 1985  
"Improving Noise", SIGGRAPH 2002

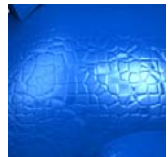
## Cellular Textures



Voronoi diagram



"A Cellular Texture Basis  
Function", Worley,  
SIGGRAPH 1996  
[www.worley.com](http://www.worley.com)



## Questions?

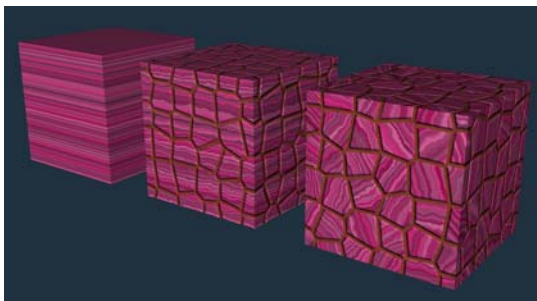


Image by Justin Legakis

## 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  
 babbababbabba  
 babbababbababbabab

**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/>

## L-Systems for Cities

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

## Cellular Texturing for Architecture

Correct

Incorrect

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

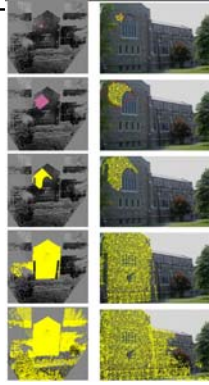
## Questions?

Image by Justin Legakis

## Readings for Today:

*Choose one:*

- "Estimating the Location of a Camera with Respect to a 3D Model", Yang, Becker, & Stewart, 3DIM 2007
- "Procedural Modeling of Buildings" Mueller, Wonka, Haegler, Ulmer & Van Gool, SIGGRAPH 2006



## Readings for Tuesday 4/15:

*Choose one:*

- "Face Transfer with Multilinear Models", Vlasic, Brand, Pfister, & Popovic, SIGGRAPH 2005



- "Real-time Collision Detection for Virtual Surgery" Lombardo, Cani, & Neyret, Computer Animation 1999

