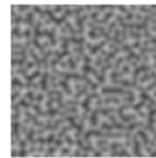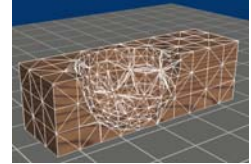# Texture Synthesis

Last Time?

- Texture Mapping
- Solid Texture
- Procedural Textures
  - Perlin Noise
- Procedural Modeling
  - L-Systems

Final Presentation Schedule

Tues. April 22	Fri. April 25	Tues. Apr 29
1. evaluations?	1. Steve W, Chris S. & JP	1. Jon, Justin, & Stephen
2. Ted & Sreekanth	2. Jhon & Danny	2. Dan B.
3. Chris Y & Igor	3. John & Zachary	3. Brett & Dan N.
4. Scott & Chris W.	4. Jixu	4. Ed & Stephen
5. Joseph		

Including setup & questions:
15 min (individual), 25 min (team of 2), 35 min (team of 3)

- Teams of 3:
  - Jean-Paul & Chris S. & Steve W., Jon B. & Justin & Stephen M.
- Teams of 2:
  - Jhon A. & Danny C., Sreekanth & Ted, Stephen K. & Ed, Brett & Daniel N., John S. & Zachary, Igor & Chris Y., Chris W. & Scott,
- Individuals:
  - Joseph, Dan B., Jixu

Readings for Today:

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
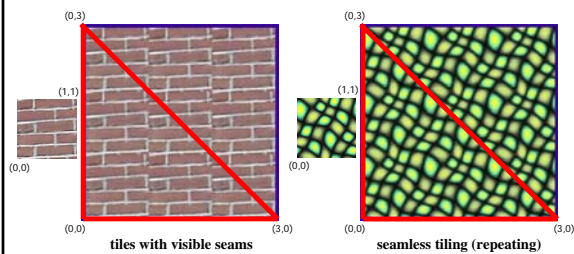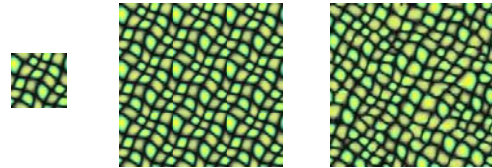
Today

- Texture Tiling
- Texture Synthesis Challenge
- Markov Model
- Constrained Texture Synthesis
- Image Completion
- Wang Tiles for Texture Synthesis
- Volumetric Texture Synthesis

Texture Tiling

- Specify a texture coordinate (u,v) at each vertex
- Canonical texture coordinates $(0,0) \rightarrow (1,1)$

tiles with visible seams — seamless tiling (repeating)

Texture Synthesis Challenge

input   tiled   synthesis

Today

- Texture Tiling
- Texture Synthesis Challenge
- Markov Model
- Constrained Texture Synthesis
- Image Completion
- Wang Tiles for Texture Synthesis
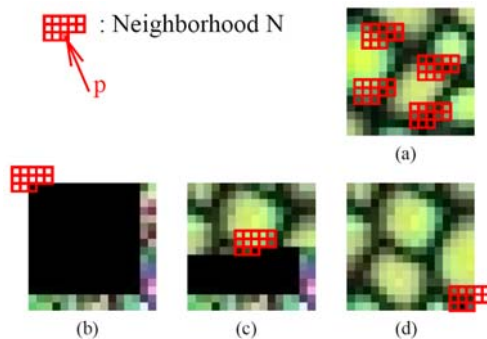- Volumetric Texture Synthesis

Markov Random Field

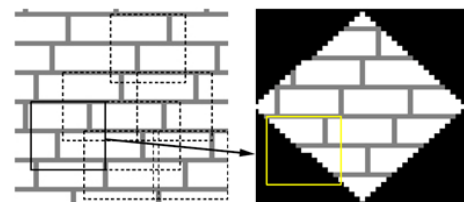- English words and sentences can be modeled as a Markov Random Field:

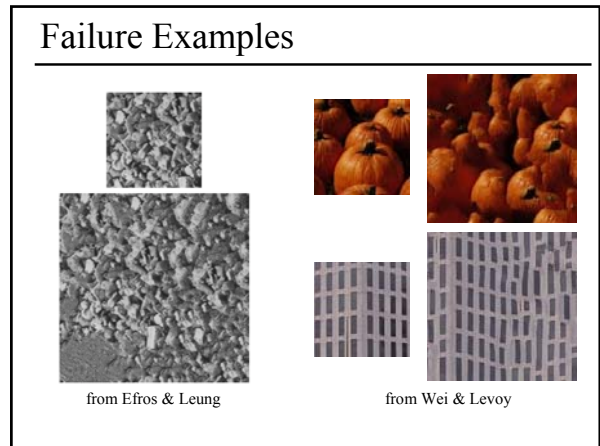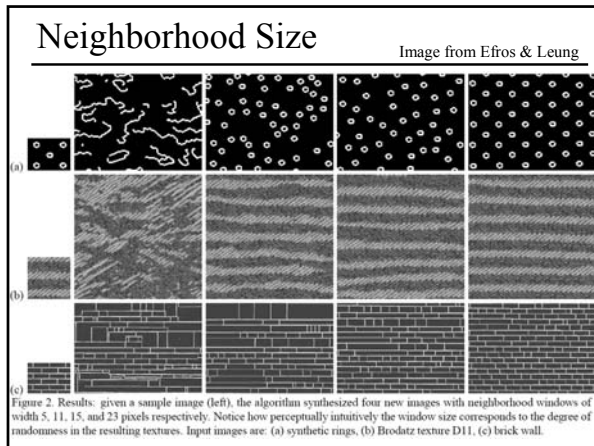*"I spent an interesting evening recently with a grain of salt."*

Template

"Fast Texture Synthesis using Tree-structured Vector Quantization", Wei & Levoy, SIGGRAPH 2000.

: Neighborhood N
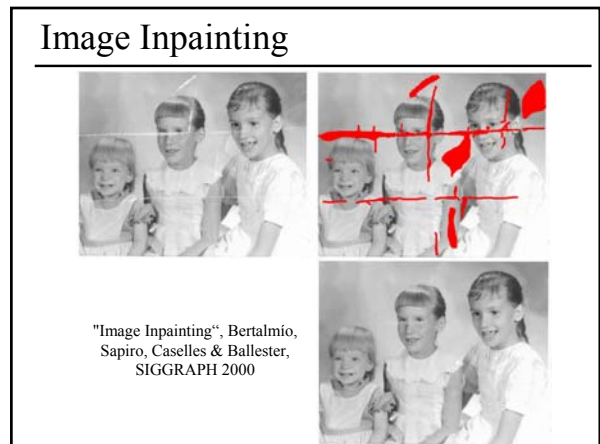
p

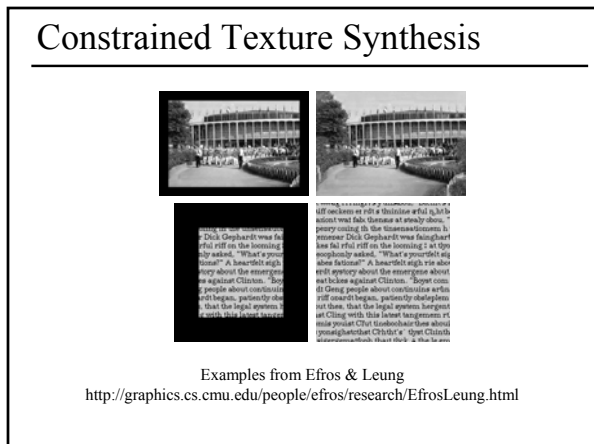(a)
(b)   (c)   (d)

Alternate Synthesis Order
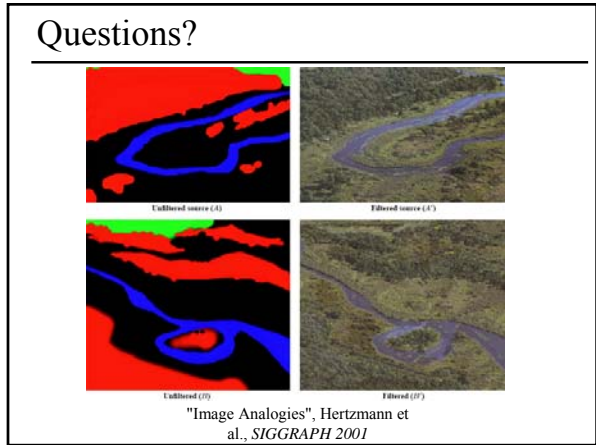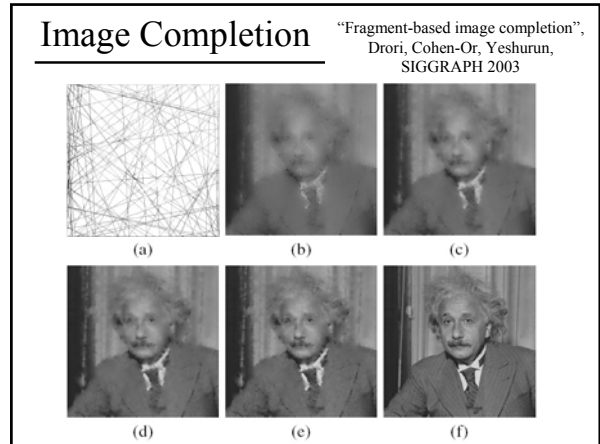

"Texture Synthesis by Non-parametric Sampling", Efros & Leung, ICCV 1999

Neighborhood Size

Figure 2. Results: given a sample image (left), the algorithm synthesized four new images with neighborhood windows of width 5, 11, 15, and 23 pixels respectively. Notice how perceptually intuitively the window size corresponds to the degree of randomness in the resulting textures. Input images are: (a) synthetic rings, (b) Brodatz texture D11, (c) brick wall.

Failure Examples

from Efros & Leung   from Wei & Levoy

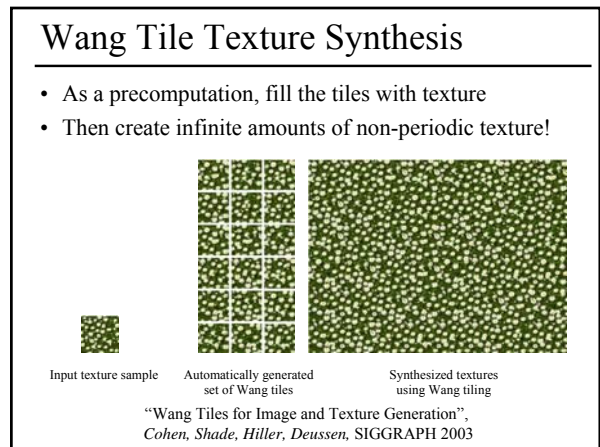## Questions?

Today

- Texture Tiling
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Constrained Texture Synthesis

Examples from Efros & Leung
http://graphics.cs.cmu.edu/people/efros/research/EfrosLeung.html

Image Inpainting

"Image Inpainting", Bertalmío,
Sapiro, Caselles & Ballester,
SIGGRAPH 2000

3

Image Completion

"Fragment-based image completion", Drori, Cohen-Or, Yeshurun, SIGGRAPH 2003

Image Completion

"Fragment-based image completion", Drori, Cohen-Or, Yeshurun, SIGGRAPH 2003

(a) (b) (c)
(d) (e) (f)

Questions?

Unfiltered source (A)   Filtered source (A')
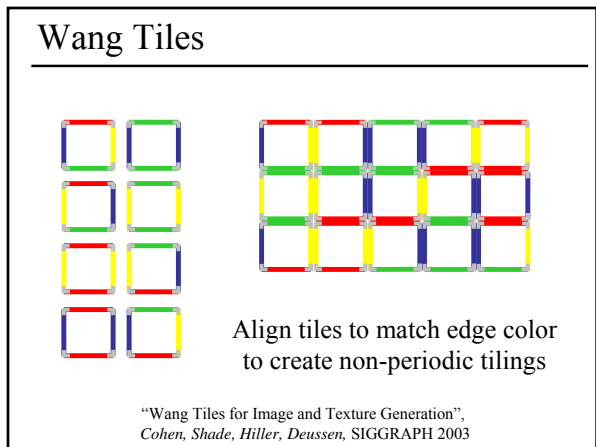Unfiltered (B)   Filtered (B')

"Image Analogies", Hertzmann et al., *SIGGRAPH 2001*

Today

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Wang Tiles

Align tiles to match edge color to create non-periodic tilings

"Wang Tiles for Image and Texture Generation", *Cohen, Shade, Hiller, Deussen,* SIGGRAPH 2003

Wang Tile Texture Synthesis

- As a precomputation, fill the tiles with texture
- Then create infinite amounts of non-periodic texture!

Input texture sample   Automatically generated set of Wang tiles   Synthesized textures using Wang tiling

"Wang Tiles for Image and Texture Generation", *Cohen, Shade, Hiller, Deussen,* SIGGRAPH 2003

Questions?

Today

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- Markov Model
- Constrained Texture Synthesis
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Objective

"Stereological Techniques for Solid Textures"
Jagnow, Dorsey, & Rushmeier, SIGGRAPH 2004

Given a 2D slice through an aggregate material, create a 3D volume with a comparable appearance.
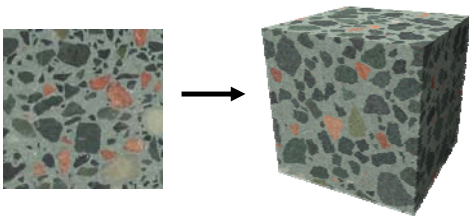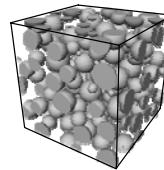
Slide from Rob Jagnow

Recovering Sphere Distributions

N_A = Profile density (number of circles per unit area)

N_V = Particle density (number of spheres per unit volume)

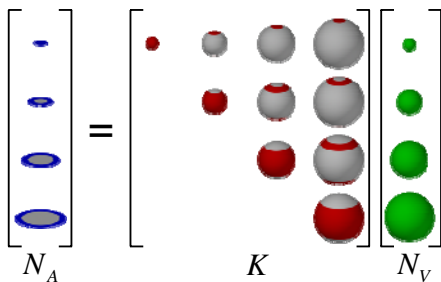$\overline{H}$ = Mean caliper particle diameter

The fundamental relationship of stereology:
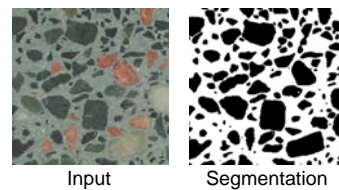
$$N_A = \overline{H} N_V$$

Slide from Rob Jagnow

Recovering Sphere Distributions

$N_A \quad\quad K \quad\quad N_V$

Slide from Rob Jagnow

Profile Statistics

Segment input image to obtain profile densities N_A.
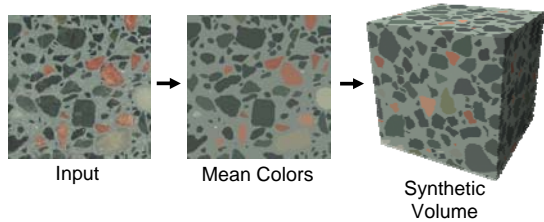
Input   Segmentation

Bin profiles according to their area, $\sqrt{A / A_{max}}$
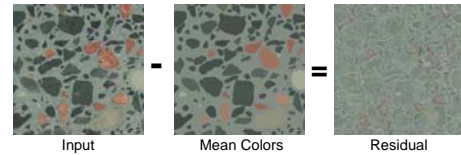
Slide from Rob Jagnow

Recovering Color

Select mean particle colors from segmented regions in the input image

Input → Mean Colors → Synthetic Volume

Slide from Rob Jagnow

Recovering Noise

How can we replicate the noisy appearance of the input?
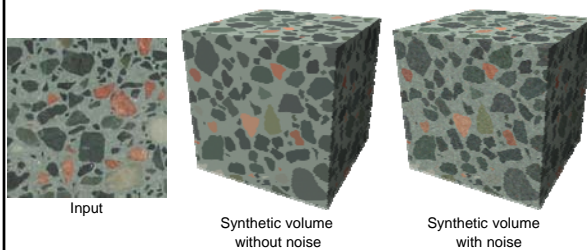

Input - Mean Colors = Residual

The noise residual is less structured and responds well to Heeger & Bergen's method

Synthesized Residual

Slide from Rob Jagnow

Putting It All Together

Input

Synthetic volume without noise

Synthetic volume with noise

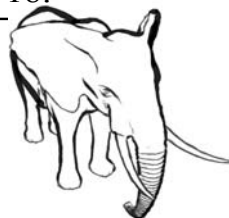Slide from Rob Jagnow

Results

Input   Result
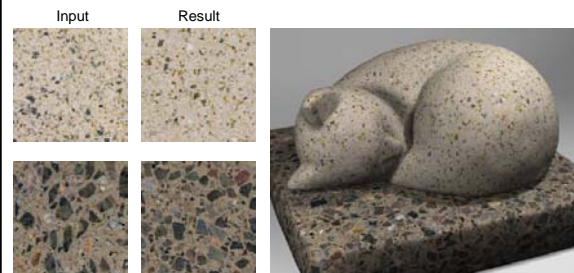
Slide from Rob Jagnow

Readings for Friday 4/18:

Choose one:

- "Isophote Distance: A Shading Approach to Artistic Stroke Thickness", Goodwin, Vollick, & Hertzmann, NPAR 2007

- "Soft Shadow Volumes for Ray Tracing", Laine, Aila, Assarsson, Lehtinen, & Akenine-Moller, SIGGRAPH 2005