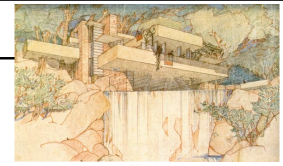
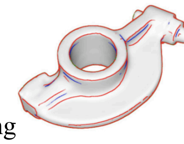
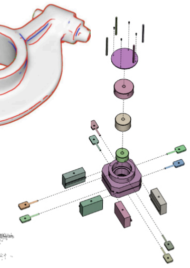
Texture Synthesis

Last Time?

- Non-Photorealistic Rendering
  - Line Drawing
  - Pen & Ink / Hatching
  - Technical Illustration
  - Painterly Rendering
- Architectural Rendering

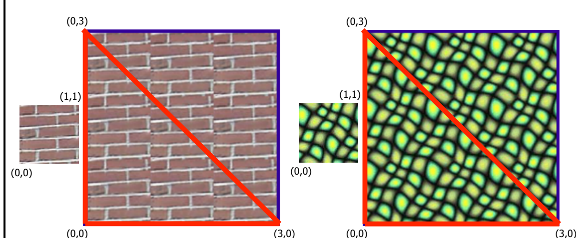




Today

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

Texture Tiling

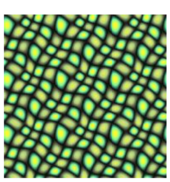
- Specify a texture coordinate (u,v) at each vertex
- Canonical texture coordinates (0,0) → (1,1)

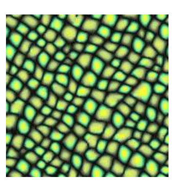


tiles with visible seams **seamless tiling (repeating)**

Texture Synthesis Challenge


input


tiled


synthesis

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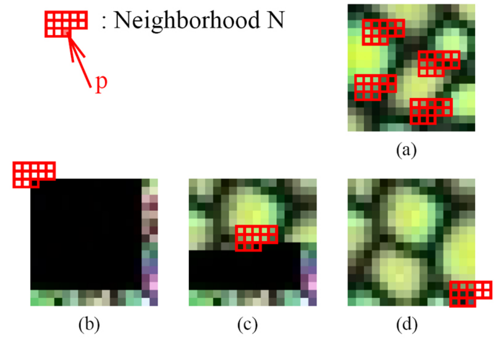
Markov Random Field

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

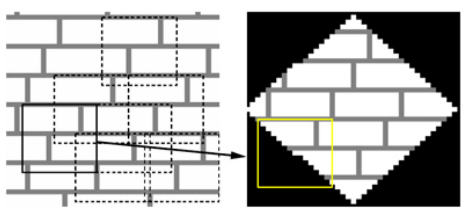
"I spent an interesting evening recently with a grain of salt."

Template

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



Alternate Synthesis Order



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

Neighborhood Size

Image from Efros & Leung

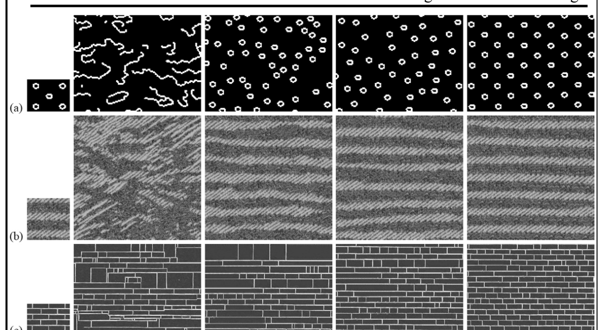
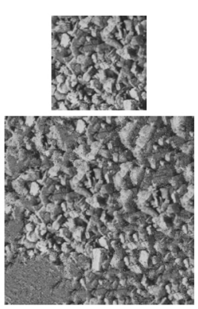


Figure 2. Results: given a sample image (left), the algorithm synthesized four new images with neighborhood windows of width 5, 11, 15, and 23 pixels respectively. Notice how perceptually intuitively the window size corresponds to the degree of randomness in the resulting textures. Input images are: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

Failure Examples



from Efros & Leung

from Wei & Levoy

Questions?

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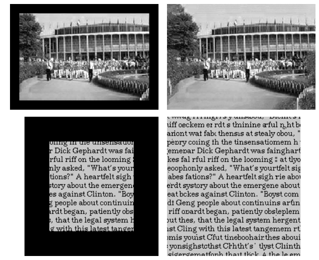
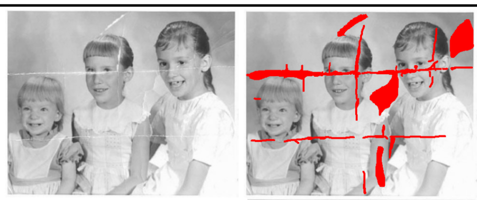
Constrained Texture Synthesis



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

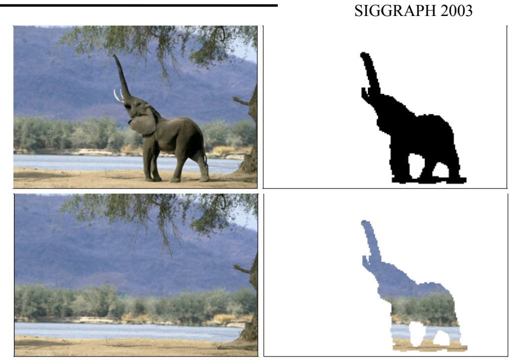
Image Inpainting



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

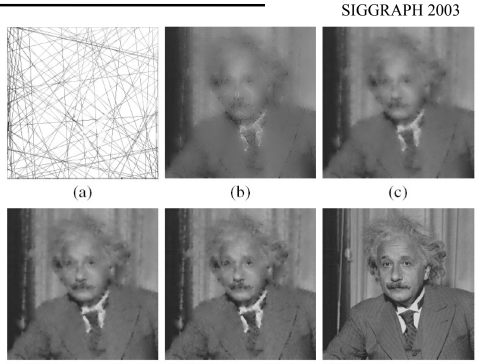
Reading for Today:

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



Reading for Today:

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



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

Reading for Today:

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

- Coarse to fine completion
- Confidence & traversal order
- Search for best match over different scales, rotations, & resolutions (texture frequency)
- Compositing fragments

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

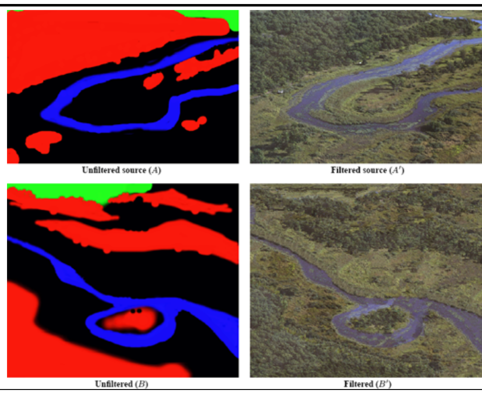


Image Quilting for Texture Synthesis and Transfer, Efros & Freeman, SIGGRAPH 2001

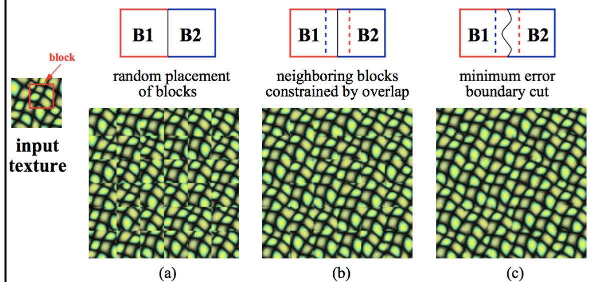
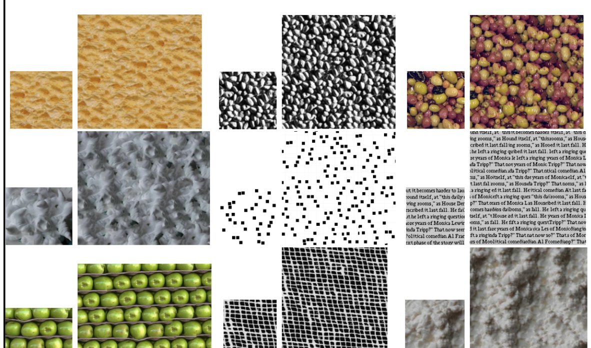
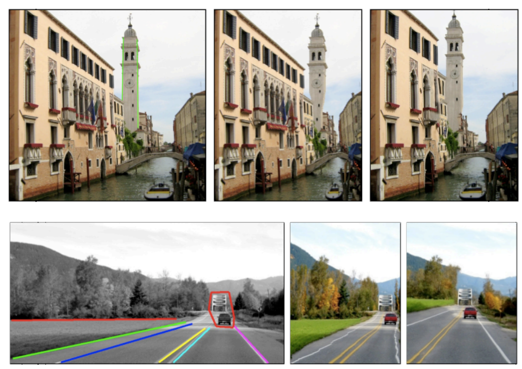


Image Quilting for Texture Synthesis and Transfer, Efros & Freeman, SIGGRAPH 2001



"PatchMatch: A Randomized Correspondence Algorithm for Structural Image Editing", Barnes, Shechtman, Finkelstein, & Goldman, SIGGRAPH 2009



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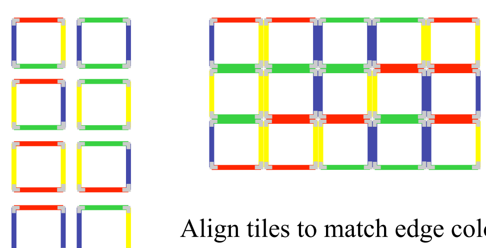
Wang Tiles

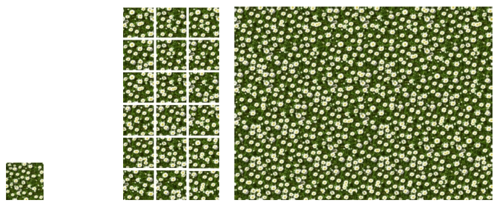


Align tiles to match edge color to create non-periodic tilings

"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

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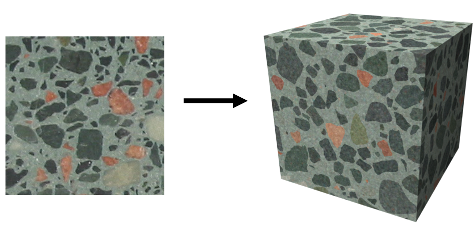
Objective

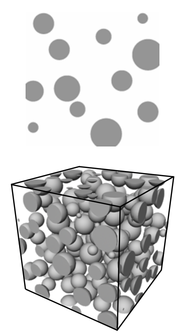
"Stereological Techniques for Solid Textures"
Jagnow, Dorsey, & Rushmeier, SIGGRAPH 2004

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)

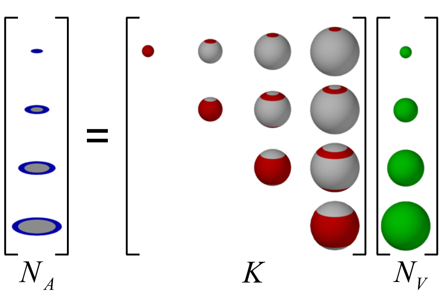
$\overline{H}$ = Mean caliper particle diameter

The fundamental relationship of stereology:

$$N_A = \overline{H} N_V$$

Slide from Rob Jagnow

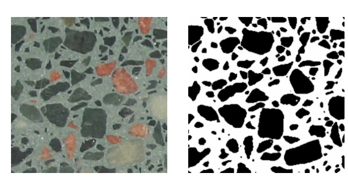
Recovering Sphere Distributions



Slide from Rob Jagnow

Profile Statistics

Segment input image to obtain profile densities N_A.



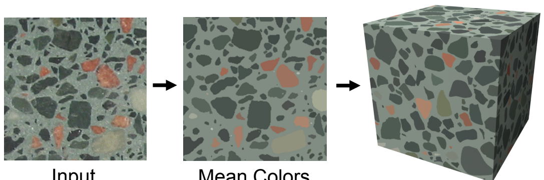
Input — Segmentation

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?

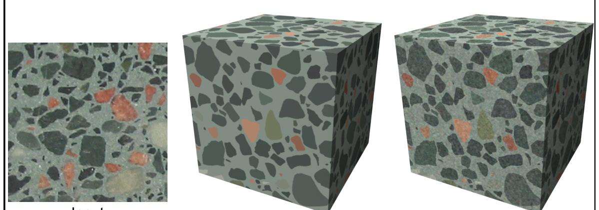
Input - Mean Colors = Residual

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

Synthesized Residual

Slide from Rob Jagnow

Putting It All Together

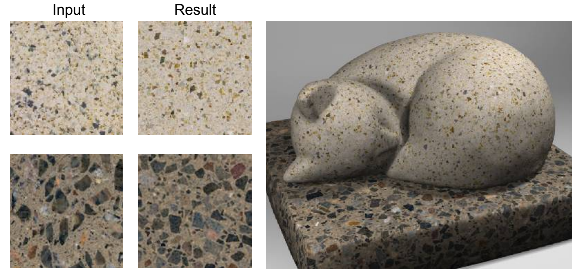


Input | Synthetic volume without noise | Synthetic volume with noise

Slide from Rob Jagnow

Results

Input | Result



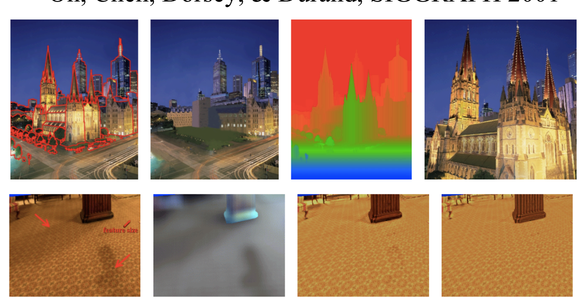
Slide from Rob Jagnow

Reading for Tuesday:

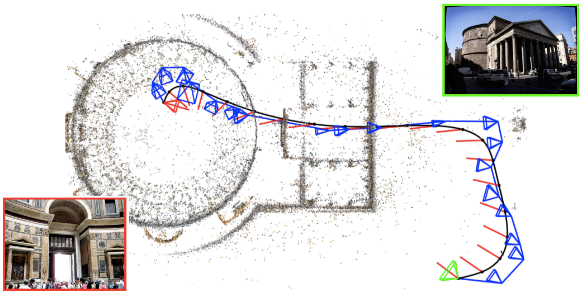
- "Environment Matting and Compositing"
  Zongker, Werner, Curless, & Salesin, SIGGRAPH 1999

Reading for Tuesday:

- Image-Based Modeling and Photo Editing
  Oh, Chen, Dorsey, & Durand, SIGGRAPH 2001



Reading for Tuesday:



Finding Paths through the World's Photos,
Snavely, Garg, Seitz, & Szeliski, SIGGRAPH 2008
Photo tourism: Exploring photo collections in 3D,
Snavely, Seitz, & Szeliski, SIGGRAPH 2006