

# Texture Synthesis

## Last Time?

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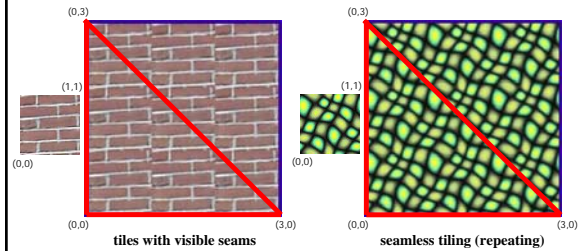
## Today

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

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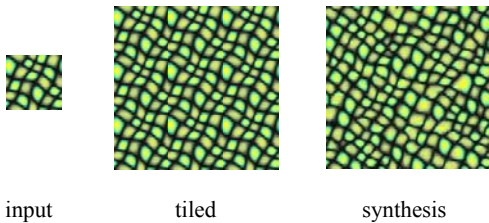
## Texture Tiling

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



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## Texture Synthesis Challenge



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## Questions?

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## Markov Random Field

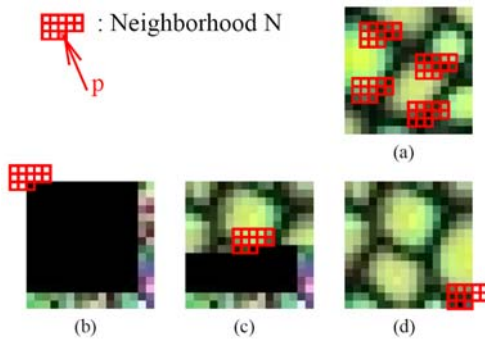
- English words and sentences can be modeled as a Markov Random Field:

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

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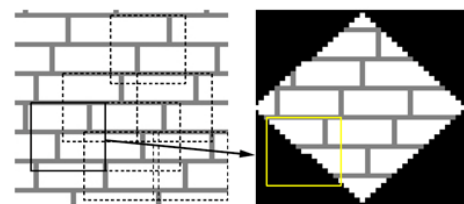
## Template

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



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## Alternate Synthesis Order



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

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## Neighborhood Size

Image from Efros & Leung

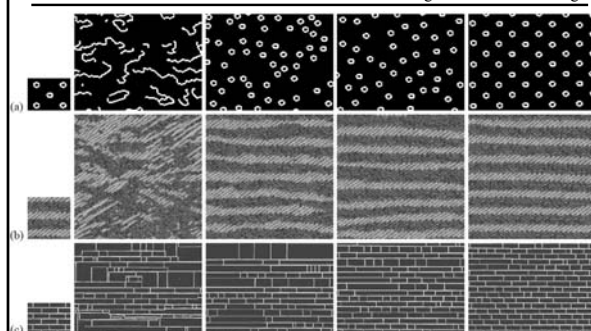
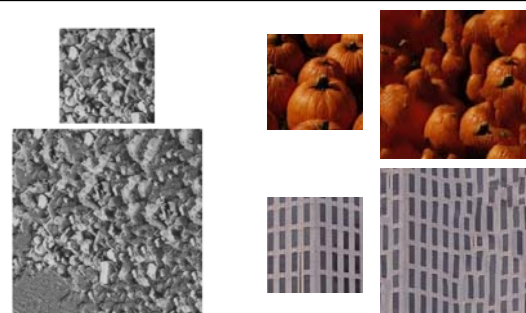


Figure 2. Results: given a sample image (left), the algorithm synthesized four new images with neighborhood windows of width 5, 11, 15, and 23 pixels respectively. Notice how perceptually intuitively the window size corresponds to the degree of randomness in the resulting textures. Input images are: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

## Failure Examples



from Efros & Leung

from Wei & Levoy

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## Questions?

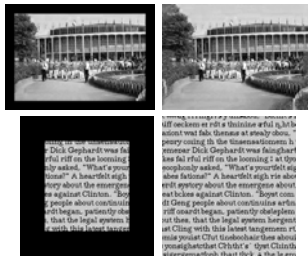
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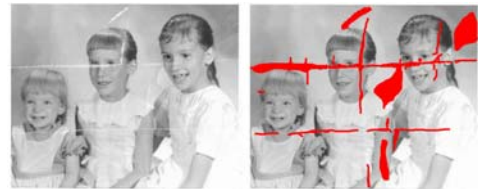
## Constrained Texture Synthesis



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

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## Image Inpainting

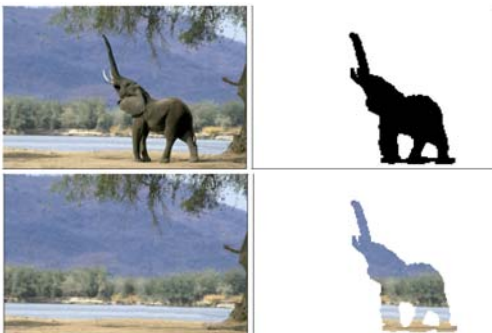


"Image Inpainting", Bertalmio,  
Sapiro, Caselles & Ballester,  
SIGGRAPH 2000



## Image Completion

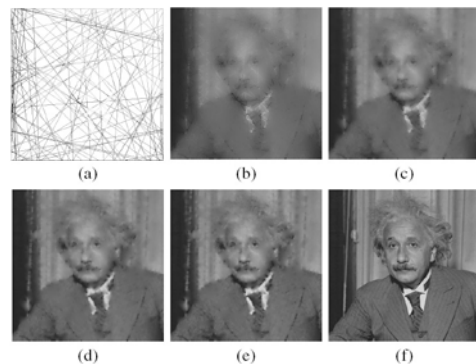
"Fragment-based image completion",  
Drori, Cohen-Or, Yeshurun,  
SIGGRAPH 2003



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## Image Completion

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



## Questions?

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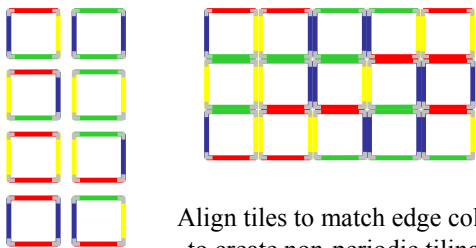
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## Wang Tiles

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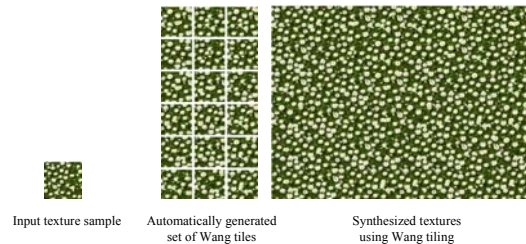
Align tiles to match edge color  
to create non-periodic tilings

“Wang Tiles for Image and Texture Generation”,  
Cohen, Shade, Hiller, Deussen, SIGGRAPH 2003

## Wang Tile Texture Synthesis

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



“Wang Tiles for Image and Texture Generation”,  
Cohen, Shade, Hiller, Deussen, SIGGRAPH 2003

## Questions?

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## Today

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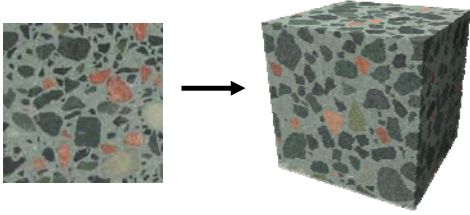
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## Objective

"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.



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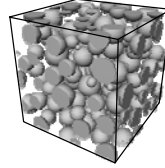
## Recovering Sphere Distributions



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

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

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

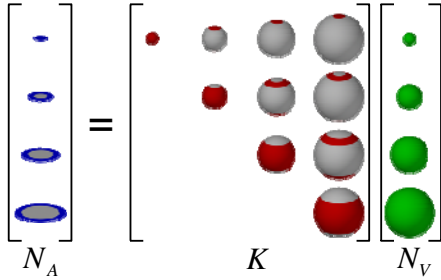


The fundamental relationship  
of stereology:

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

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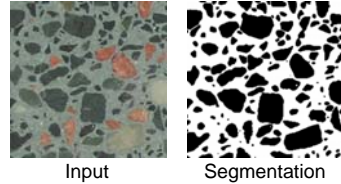
## Recovering Sphere Distributions



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## Profile Statistics

Segment input image to obtain profile densities  $N_A$ .



Input

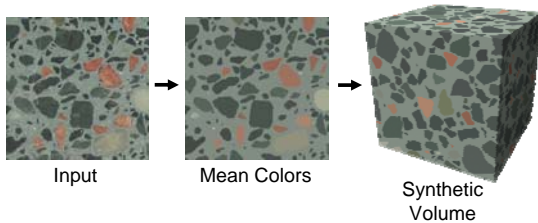
Segmentation

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

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## Recovering Color

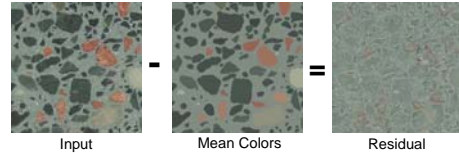
Select mean particle colors from  
segmented regions in the input image



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## 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

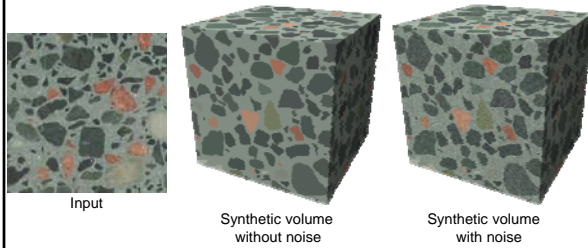


Synthesized Residual

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## Putting It All Together

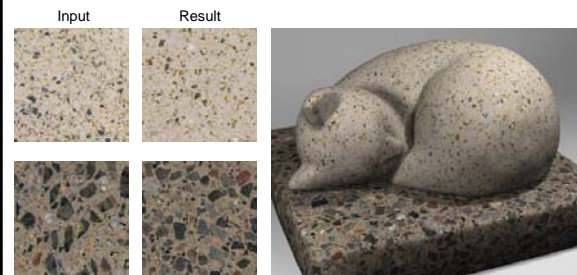
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## Results

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## Questions?

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