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)

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


Alternate Synthesis Order

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

Neighborhood Size

Image from Efros & Leung

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

Reading for Today:

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

Reading for Today:

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

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

Wang Tile Texture Synthesis

- 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

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

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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.

Recovering Sphere Distributions

\[ N_A = \text{Profile density (number of circles per unit area)} \]
\[ N_V = \text{Particle density (number of spheres per unit volume)} \]
\[ \bar{D} = \text{Mean caliper particle diameter} \]

The fundamental relationship of stereology:

\[ N_A = HN_V \]

Recovering Sphere Distributions

\[
\begin{bmatrix}
N_A \\
K \\
N_V
\end{bmatrix} = \begin{bmatrix}
\cdot \\
\cdot \\
\cdot
\end{bmatrix}
\]

Profile Statistics

Segment input image to obtain profile densities \( N_A \).

Bin profiles according to their area, \( \sqrt{A/A_{\text{max}}} \).
Recovering Color

Select mean particle colors from segmented regions in the input image

Input → Mean Colors → Synthetic Volume

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

Putting It All Together

Input → Synthetic volume without noise → Synthetic volume with noise

Results

Input → Result

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