Texture

CS 419

Slides by Ali Farhadi
What is a Texture?
<table>
<thead>
<tr>
<th>regular</th>
<th>near-regular</th>
<th>irregular</th>
<th>near-stochastic</th>
<th>stochastic</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="regular texture" /></td>
<td><img src="image2" alt="near-regular texture" /></td>
<td><img src="image3" alt="irregular texture" /></td>
<td><img src="image4" alt="near-stochastic texture" /></td>
<td><img src="image5" alt="stochastic texture" /></td>
</tr>
</tbody>
</table>
Texture scandals!!
Bush campaign digitally altered TV ad

President Bush’s campaign acknowledged Thursday that it had digitally altered a photo that appeared in a national cable television commercial. In the photo, a handful of soldiers were multiplied many times.
Two crucial algorithmic points

- Nearest neighbors
  - again and again and again

- Dynamic programming
  - likely new; we’ll use this again, too
Texture Synthesis

Efros & Leung ICCV99
How to paint this pixel?
Ask Neighbors

• What is the conditional probability distribution of $p$, given it’s neighbors?
Don’t bother to model the distribution
- It’s already there, in the image
Efros & Leung Algorithm

Efros & Leung ICCV99
Concerns

- Distance metric
- Neighborhood size
- Order to paint
Distance metric

- Normalized sum of squared distances
- Not all the neighbors worth the same
  - Gaussian mask
- Preserve the local structure
- Pick among reasonably similar neighborhoods
Neighborhood size

Efros & Leung ICCV99
Varying Window Size

Increasing window size

Efros & Leung ICCV99
The Order matters
Some Results
More Results

Efros & Leung ICCV99
More Results

french canvas

rafia weave

Efros & Leung ICCV99
Growing Regions
Hole Filling

Efros & Leung ICCV99
Failure Cases

Growing Garbage

Verbatim Copying

Efros & Leung ICCV99
Pros and Cons

• Very simple
• Easy to implement
• Promising results

• Very slooooonooooowwwwwwww
• Idea:
  • Patches instead of pixels
Patch based

- Observation
  - neighbouring pixels are highly correlated

- Idea:
  - unit of synthesis = block

Efros & Freeman SIGGRAPH01
Input texture

Random placement of blocks

Neighboring blocks constrained by overlap

Minimal error boundary cut

Efros & Freeman SIGGRAPH01
Minimal error boundary

overlapping blocks

vertical boundary

\[
\begin{align*}
&\text{overlap error} \\
&= 2
\end{align*}
\]

\[\text{min. error boundary}\]

Effros & Freeman SIGGRAPH 01
Dynamic Programming

\[ e_{ij} = (B1_{ij}^{ov} - B2_{ij}^{ov})^2 \]

\[ E_{i,j} = e_{i,j} + \min(E_{i-1, j-1}^{\cdot}, E_{i-1, j}^{\cdot}, E_{i-1, j+1}^{\cdot}) \]
Dynamic Programming

\[
e_{ij} = (B1_{ij}^{ov} - B2_{ij}^{ov})^2
\]

\[
E_{i,j} = e_{i,j} + \min(E_{i-1,j-1}, E_{i-1,j}, E_{i-1,j+1})
\]
Random placement of blocks

Neighboring blocks constrained by overlap

Minimal error boundary cut
More Results
More Results
Failures
Texture Transfer

- Take the texture from one object and paint it on another object

Decomposing shape and texture
- Very challenging
- Walk around
- Add some constraint to the search

Efros & Freeman SIGGRAPH01
Texture Transfer
parmesan + rice =

Efros & Freeman SIGGRAPH01
Image Analogies
Image Analogies
Image Analogies

Hertzman, Jacobs, Oliver, Curless, and Salesin, SIGGRAPH01
Image Analogies

Hertzman, Jacobs, Oliver, Curless, and Salesin, SIGGRAPH01
Training

Unfiltered source ($A$)  Filtered source ($A'$)
Hertzman, Jacobs, Oliver, Curless, and Salesin, SIGGRAPH01
Hertzman, Jacobs, Oliver, Curless, and Salesin, SIGGRAPH01
Learn to Blur

Unfiltered source ($A$)  Filtered source ($A'$)

Unfiltered target ($B$)  Filtered target ($B'$)

Hertzman, Jacobs, Oliver, Curless, and Salesin, SIGGRAPH01
Texture by Numbers

Unfiltered source ($A$)

Filtered source ($A'$)

Unfiltered ($B'$)

Filtered ($B'$)

Hertzman, Jacobs, Oliver, Curless, and Salesin, SIGGRAPH01
Colorization

Unfiltered source \((A)\)  
Filtered source \((A')\)  

Unfiltered target \((B)\)  
Filtered target \((B')\)

Hertzman, Jacobs, Oliver, Curless, and Salesin, SIGGRAPH01
Super-resolution

A

A'

Hertzman, Jacobs, Oliver, Curless, and Salesin, SIGGRAPH01
Super-resolution (result!)

Hertzman, Jacobs, Oliver, Curless, and Salesin, SIGGRAPH01
Training images

Hertzman, Jacobs, Oliver, Curless, and Salesin, SIGGRAPH01
Nearest Neighbor search

The core of most of the patch based methods
Very slow

Smarter neighborhood search

Barnes et.al. SIGGRAPH09
Applications

(a) original  (b) hole+constraints  (c) hole filled

(d) constraints  (e) constrained retarget  (f) reshuffle

Barnes et.al. SIGGRAPH09
Inpainting
Inpainting

(a) input  (b) hole and guides  (c) completion result

(d) input  (e) hole  (f) completion (close up)

(g) same input  (h) hole and guides  (i) guided (close up)
Retargeting
Retargeting

Avidan, Shamir, SIGGRAPH07
Retargeting

Barnes et.al, SIGGRAPH09
Retargeting

Barnes et.al. SIGGRAPH09
Local scale editing

(a) building marked by user
(b) scaled up, preserving texture
(c) bush marked by user
(d) scaled up, preserving texture.
reshuffling

(a) input  (b) our reshuffling

Barnes et.al. SIGGRAPH09