Texture

CS 419
Slides by Ali Farhadi
What is a Texture?
Texture

- Easy to recognize, Hard to define

- Spatially repeating patterns

- It's all about the scale
Texture Spectrum
Texture Synthesis

Efros & Leung ICCV99
How to paint this pixel?

Input texture

Efros & Leung ICCV99
Ask Neighbors

- What is the conditional probability distribution of \( p \), given it’s neighbors?

Efros & Leung ICCV99
Don’t bother to model the distribution

It’s already there, in the image

Efros & Leung ICCV99
Efros & Leung Algorithm

Synthesizing a pixel

non-parametric sampling

Input image

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
Varying Window Size

Increasing window size

Efros & Leung ICCV99
The Order matters
Some Results
More Results
More Results

french canvas

rafia weave

Efros & Leung ICCV99
More Results

wood

granite

Efros & Leung ICCV99
Growing Regions
Hole Filling
Hole Filling

Efros & Leung ICCV99
Extrapolation

Efros & Leung ICCV99
Failure Cases

Growing garbage

Verbatim copying

Efros & Leung ICCV99
Pros and Cons

- Very simple
- Easy to implement
- Promising results

- Very sloooooooowwwwwwwww
- Idea:
  - Patches instead of pixels
Patch based

Observation
- neighbouring pixels are highly correlated

Idea:
- unit of synthesis = block

Synthesizing a block

Input image

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

\[
\text{overlap error} = 2
\]

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

Efros & Freeman SIGGRAPH01
Dynamic Programming

\[ e_{ij} = (B_{1ij}^{ov} - B_{2ij}^{ov})^2 \]

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

Efros & Freeman SIGGRAPH01
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

Efros & Freeman SIGGRAPH01
parmesan + rice =

Efros & Freeman SIGGRAPH01
Image Analogies

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

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

Hertzman, Jacobs, Oliver, Curless, and Salesin, SIGGRAPH01
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 ($B'$)

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Colorization

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

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

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

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

(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

Avidan, Shamir, SIGGRAPH07
Retargeting
Avidan, Shamir, SIGGRAPH07
Retargeting
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.

Barnes et.al. SIGGRAPH09
reshuffling

(a) input  (b) our reshuffling

Barnes et.al. SIGGRAPH09
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.

This section shows a sampling of the duplication of soldiers.

Original photograph