Graphcut Textures

Image and Video Synthesis Using Graph Cuts

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Topics

• What's the goal?
• Graph Cut
• Patch placement
• Extensions, Video
• Authors' conclusions
• My conclusions
Creating Textures

- Input is a small image
- Output is a large image
Idea behind

- Take a patch from the input
- Place the patch somewhere on the output such that no seams are visible
Idea behind

• Iterate over
  – Step 1: Patch matching & placement
  – Step 2: Graph cut
Graph Cut

- Cut two images, such that they can be seamless merged
- Minimize a cost function for cut and merge

\[ \text{blue} + \text{purple} = \text{merged} \]
Graph Cut

- A cut is more than a line

\[
\begin{array}{c}
\text{Image 1} + \text{Image 2} = \text{Result Image}
\end{array}
\]
Graph Cut

• Input
  – One graph
  – One costfunction

• Output
  – The cut with minimal costs
Graph Cut: Input

- Two images seen as graphs
Graph Cut: Input

- But only one graph required
- Use an “embracing” graph
Graph Cut: Input

- Costfunction

$$M(A, B, s, t) = |A(s) - B(s)| + |A(t) - B(t)|$$
Graph Cut - Input

\[ M(A, B, s, t) = |A(s) - B(s)| + |A(t) - B(t)| \]
Graph Cut - Output

- The minimal cut of the graph
Graph Cut - Output

• Merge the two images along the cut
• (Hopefully) no visible seams
Graph Cut: Example

- Two merged images
- No seams are visible
Graph Cut

- Algorithms are well known
- Many possible Costfunctions
- What about many images?
Many Images

- Merge first two images
- Merge resulting image with a third image...
Many Images

- Merge with a third image
- Result is very bad
- Don't throw away information!
Many Images

- Store old seam costs
Many Images

- Add the old seam costs to the new cut

\[ \text{cost} = \text{cost}_{\text{new}} + \text{cost}_{\text{old}} \]
Patch Placement

• Place input somewhere on the output
• Cut out a patch
• Random placement
• Entire patch matching
• Sub-patch matching
Random placement

- Place the input randomly on the output
- Graph cut decides, which part of the input will be seen

- The fastest approach
- Results are good for random textures
Entire patch matching

- Place the input such that it matches the output best
- Costfunction for Placement (SSD):

\[ C(t) = \frac{1}{|A_t|} \sum_{p \in A_t} |I(p) - O(p + t)|^2 \]

- Results are good for (semi-)structured textures

\( I \): Input  
\( O \): Output  
\( A \): Intersection \( I \cap O \)  
\( p \): Point  
\( t \): Translation
Sub patch matching

- Choose a small patch in the output
- Search a patch in the input that fits well
- Same Costfunction as “entire patch matching”

- Most general technique
- Good for videos
Results
Results

- Input, Output and Error
Results

• Not every image is a good input
Extensions

- Other cost functions
- Blending techniques to omit seams
- FFT for patch placing, dramatically fastens the algorithm
- Use not only translations, use rotations, mirroring and scaling.
Extensions

• Perspective by scaling the input
• Additional Constraints for scaling
Extensions

- Interactive Merging and Blending

1-2 hours of work
Video

- Can be used to generate infinite videos
- Just see a video as 3-dimensional graph with axis: x, y, t.
- Loop the video
Video Transition

- Search two good matching frames
- Make the cut through this two frames
- Cut is a plane
Random Temporal offset

- For small input
- No periodicity
- Requires continuous part in time
Spatio-Temporally Stationary Videos

- For videos with a one-directional movement (e.g., Smoke)
- Pixels moved in time and space
Temporal Constraints

- Moving pixels in time and place causes problems, continuity is lost
- First and last n frames fixed by input
- Last n frames removed when output created
Authors conclusions

- Algorithm is fast
- No restrictions for the shape
- Method for adding constraints
- Easily generalized
My conclusions

• Very flexible technique:
  – User interaction is possible
  – Different cost functions applicable
  – Different patch placing/matching algorithms available

• Good for random images
• Still problems with videos
The End