Graphcut Textures: Image and Video Synthesis Using Graph Cuts

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Vivek Kwatra
Google Inc.

Arno Schödl
think-cell Software

Graphcut Textures:

Image and Video Synthesis Using Graph Cuts

Vivek Kwatra Arno Schodl Irfan Essa Greg Turk Aaron Bobick

GVU Center/College of Computing

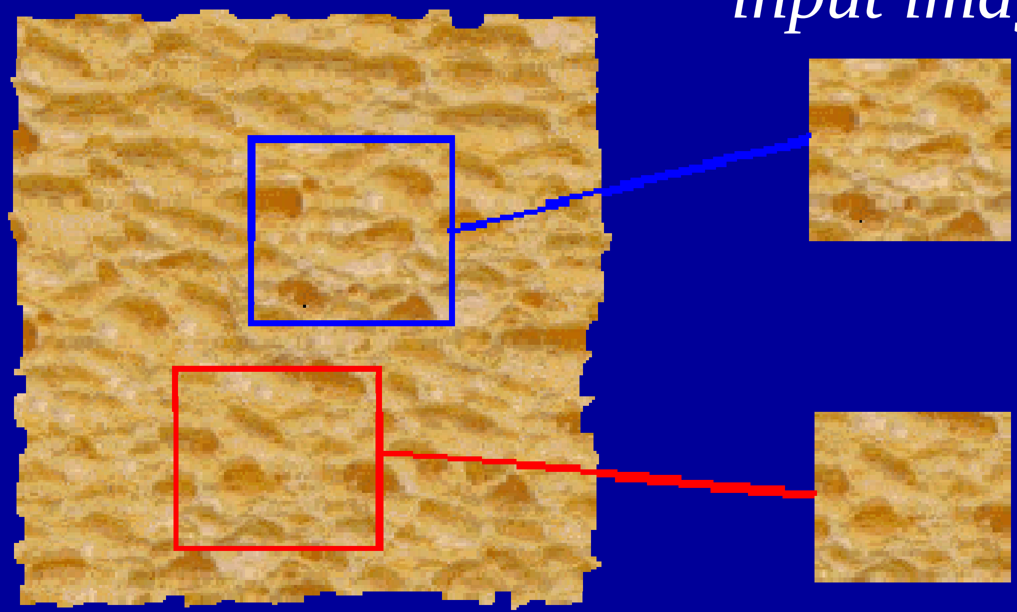
Georgia Institute of Technology

Overview

- The Goal of Texture Synthesis
- Related Work
- The Graph Cut Technique
- Patch Placement
- Image Synthesis Results
- Video Synthesis
- Conclusion

The Goal of Texture Synthesis

input image

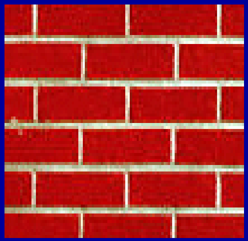


True (infinite) texture *Generated image*

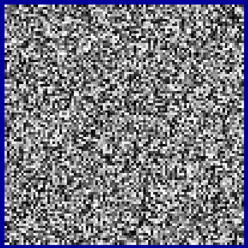
Given a finite sample of some texture, the goal is to synthesize other samples from that same texture

The Challenge

- Need to model the whole spectrum: from repeated to stochastic texture



repeated



stochastic

Both?

Related work

Texture synthesis techniques that generate an output texture from an example input can be roughly categorized into three classes.

- A fixed number of parameters within a compact parametric model to describe a variety of texture
  - [Heeger and Bergen 95]

- Non-parametric, use a collection of exemplars to model the texture
  - [DeBonet 97], [Efros and Leung 99], [Wei and Levoy 00]

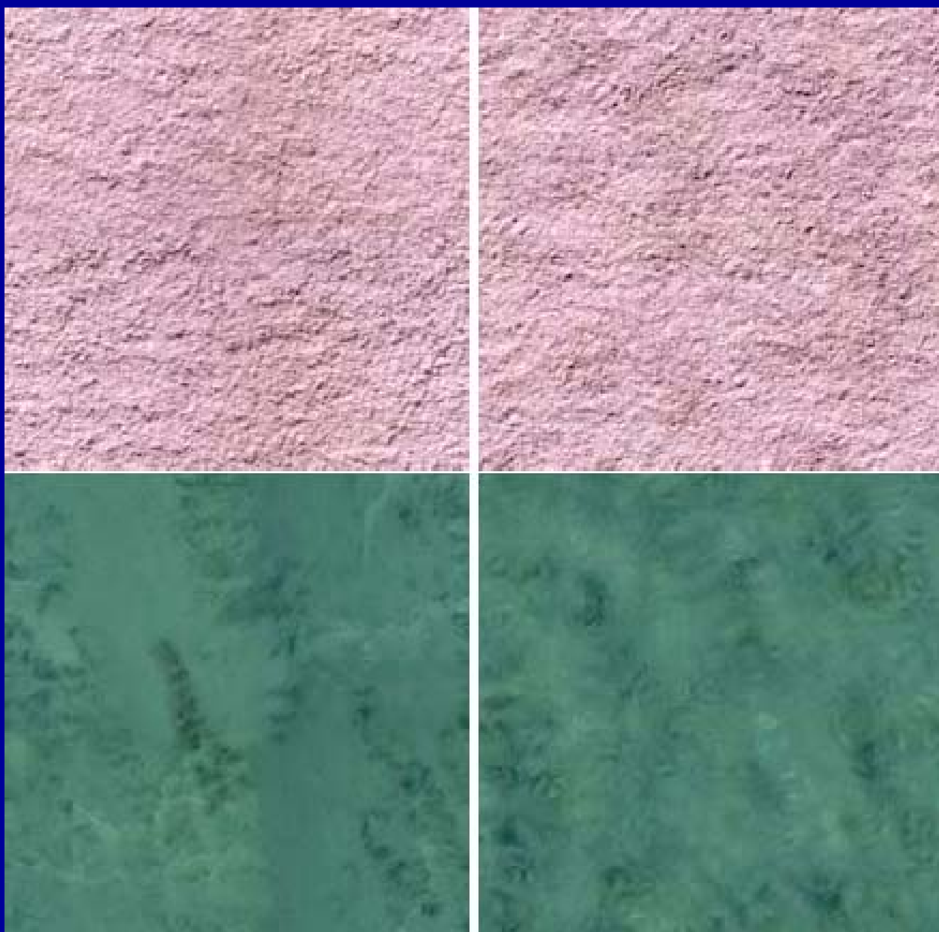
- Patch quilting
  - [Ashikmin 01], [Efros and Freeman 01]

Heeger Bergen 1995

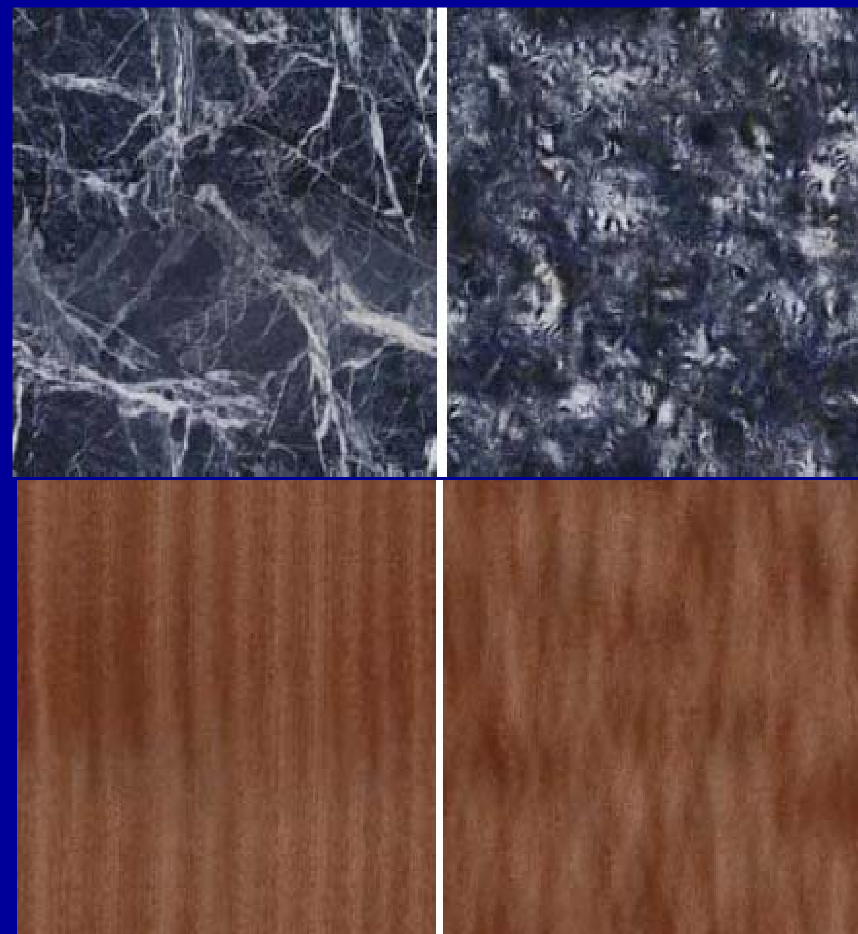
- Texture model:
  - Histograms of responses to various filters
- Avoiding copying:
  - Inherent in algorithm
- No user intervention required
- Captures stochastic textures well
- Does not capture structure
  - Lack of inter-scale constraints

Results

Successes



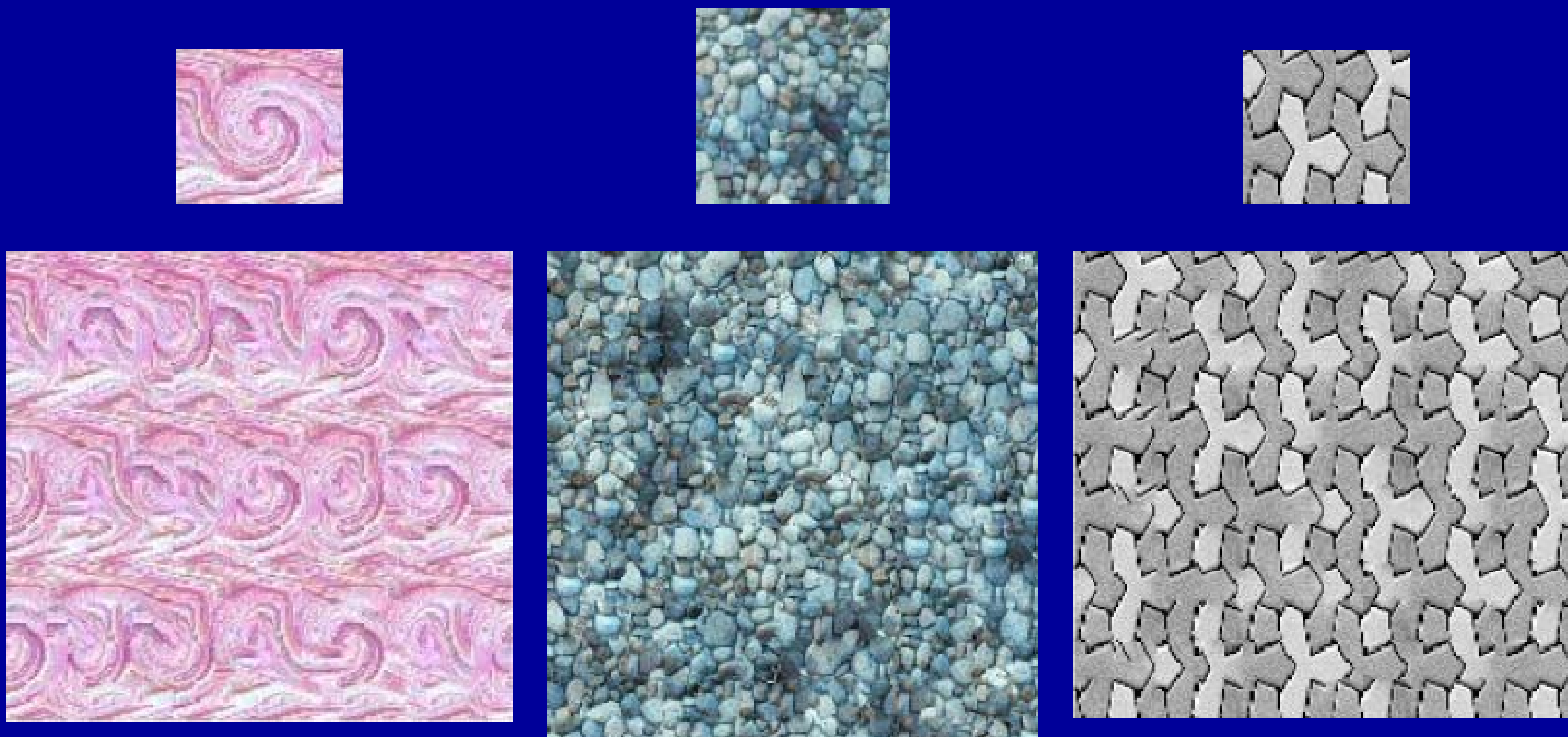
Failures



De Bonet 1997

- Texture model:
  - Feature vector containing multiscale responses to various filters
- Avoiding copying:
  - Random choice of pixels with ‘close’ feature vectors, but copying still frequent on small scale
- Individual per-filter thresholds are cumbersome
- Feature vectors used in later synthesis work

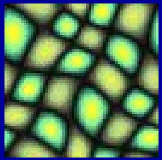
Results

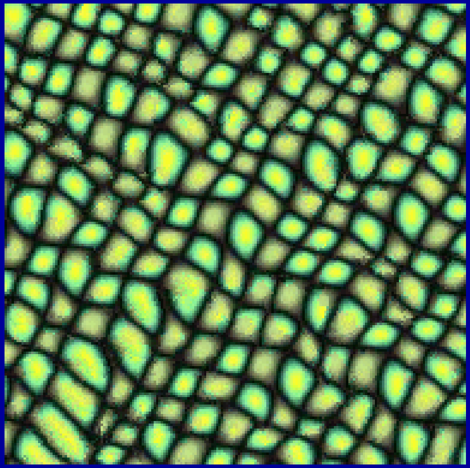


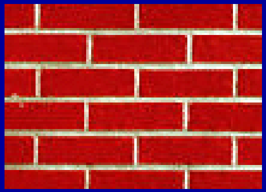
Efros Leung 1999

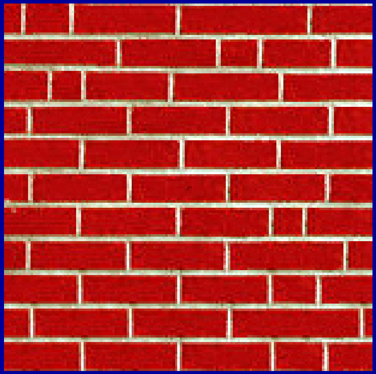
- Texture model:
  - MRF
- Avoiding copying:
  - MRF
- Neighborhood size = largest feature size
- Search is very slow with large neighborhoods

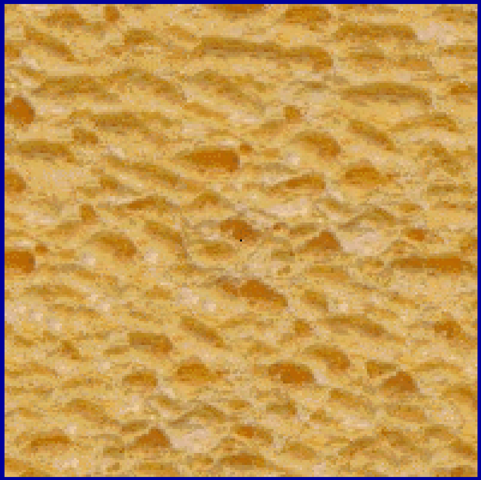
Results

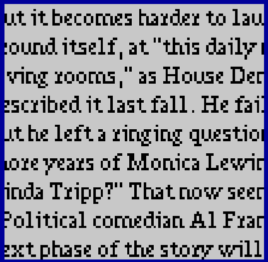








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ound itself, at "this daily
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scribed it last fall. He fai
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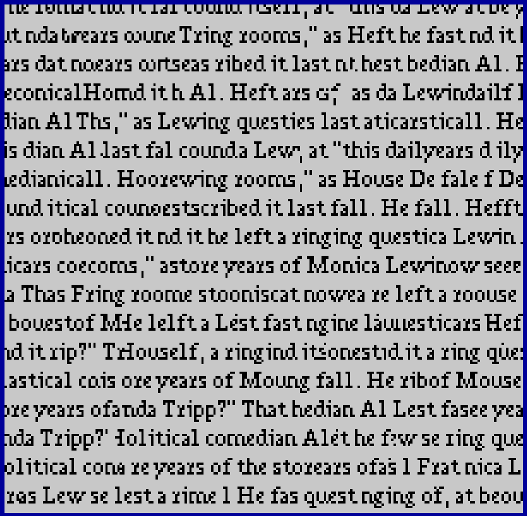
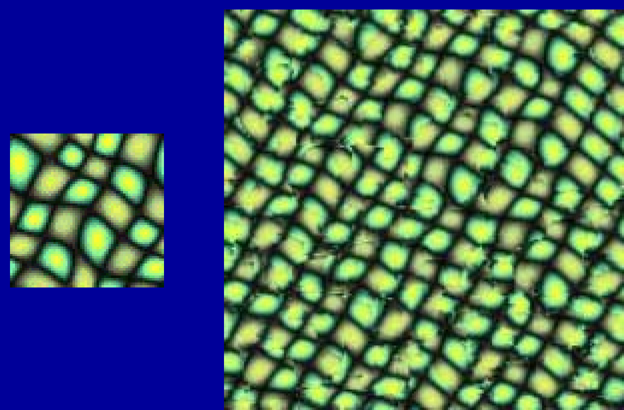
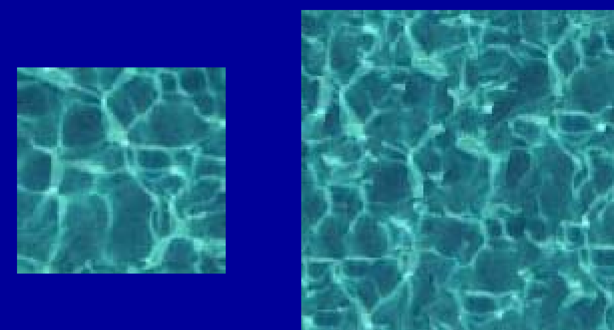


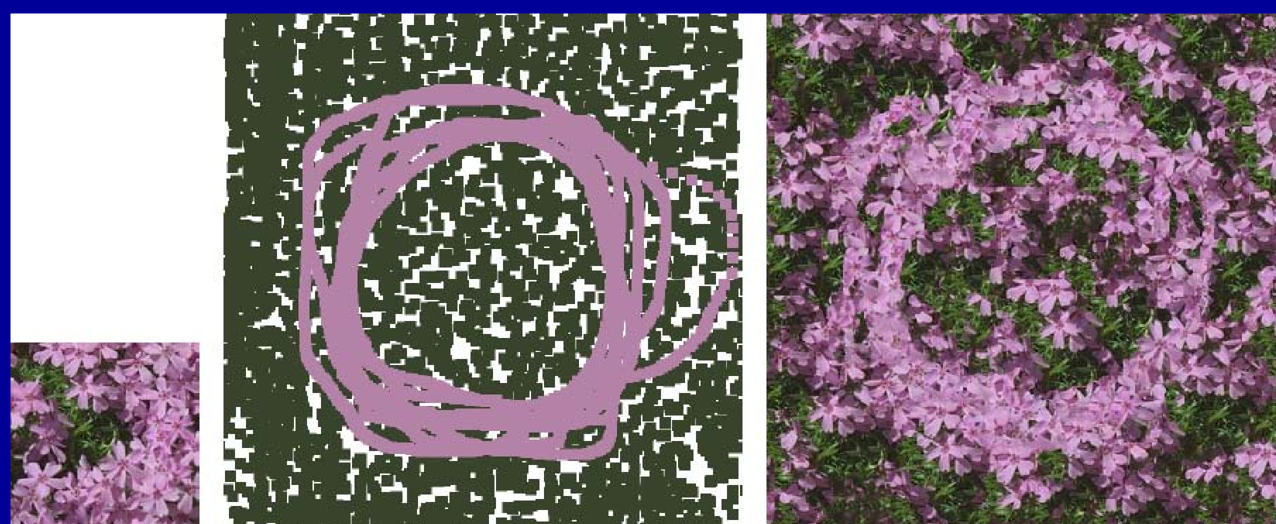
Ashikhmin 2001

- Texture model:
  - MRF
- Avoiding copying:
  - Actually, here it is encouraged on a small scale, but in practice it doesn't occur on a large scale
- Recognized that copying preserves fine detail

Results

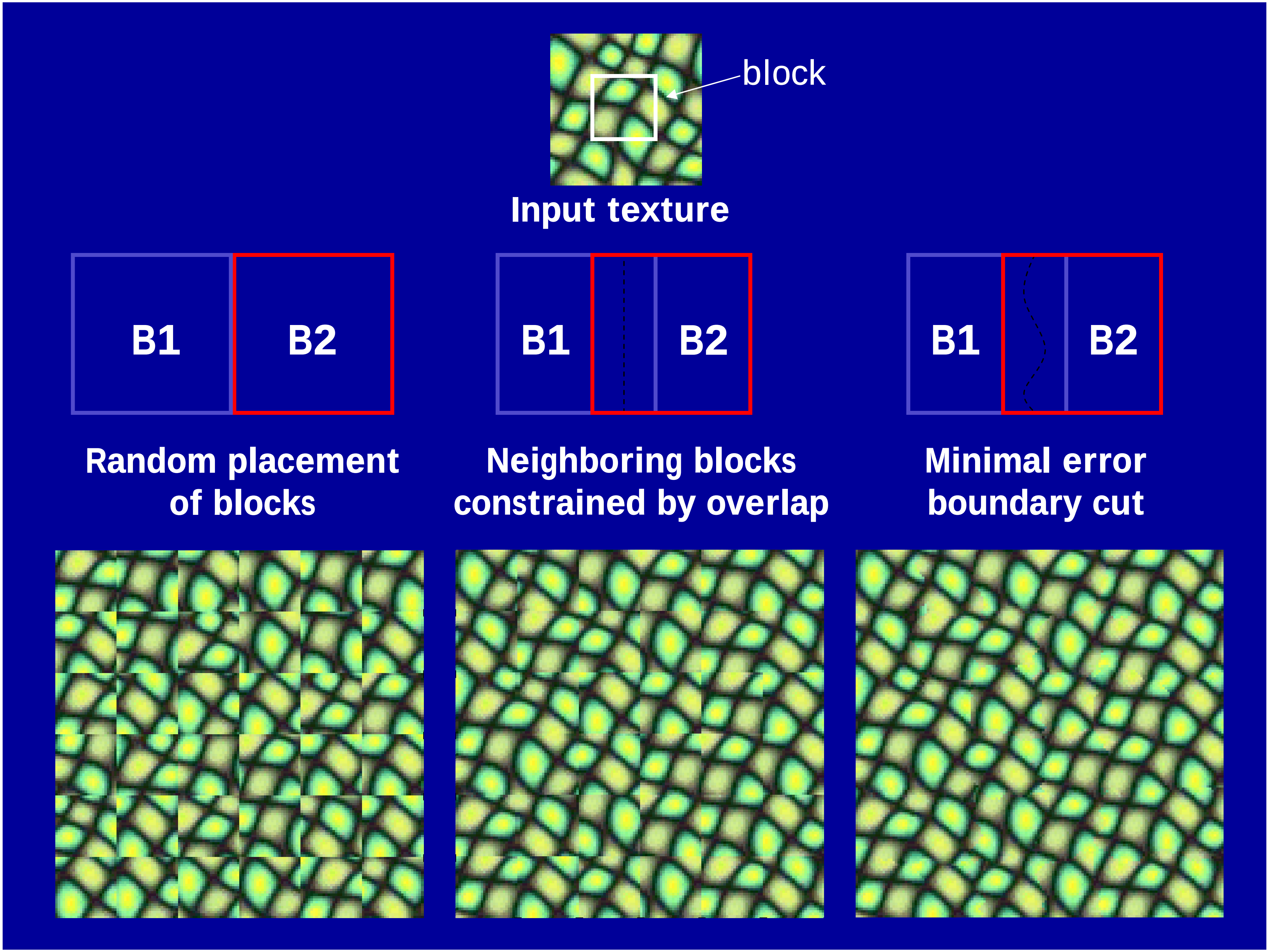




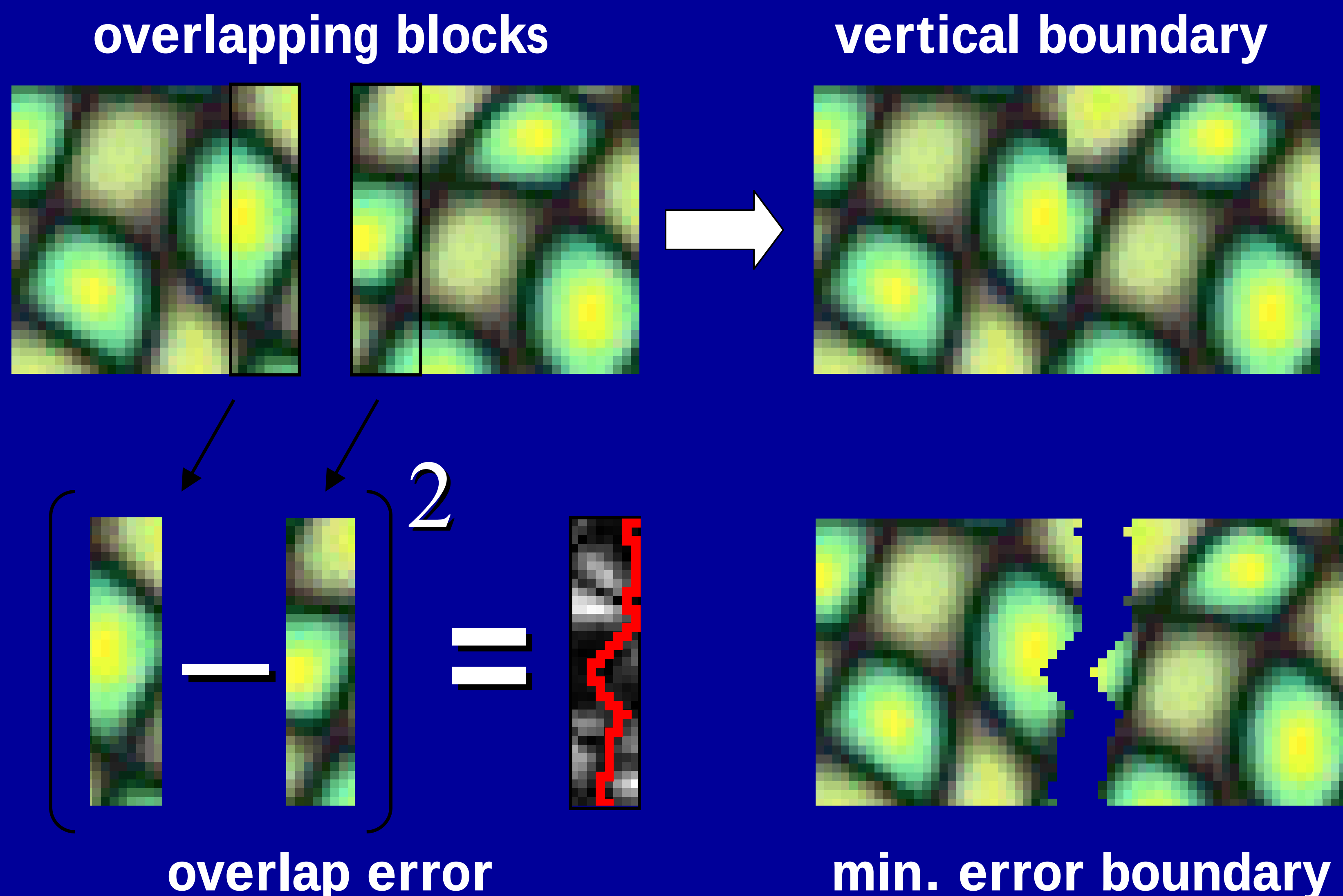


Efros Freeman 2001

- Texture model:
  - ??
- Avoiding copying:
  - Randomized patch selection, but still noticeable
- Patch size is a hard parameter to understand


block
Input texture
B1
B2
B1
B2
B1
B2
Random placement of blocks
Neighboring blocks constrained by overlap
Minimal error boundary cut

Minimal error boundary



Results

Graph Basics

A graph is defined as

$G = \{V, E\}$ $\rightarrow$ $V=\{s, t\} \mathrm{U}\ P$ $\rightarrow$ $w(p,q)$ □ (p,q) □ E

V…….. Set of nodes
E…….. Set of links
P…….. Set of non-terminal nodes V \{s,t}
s, t....... Terminal nodes
w(p,q).. Weight of the link (p,q)
note: the reverse weight (q,p) might have an other value

Graph-Cuts

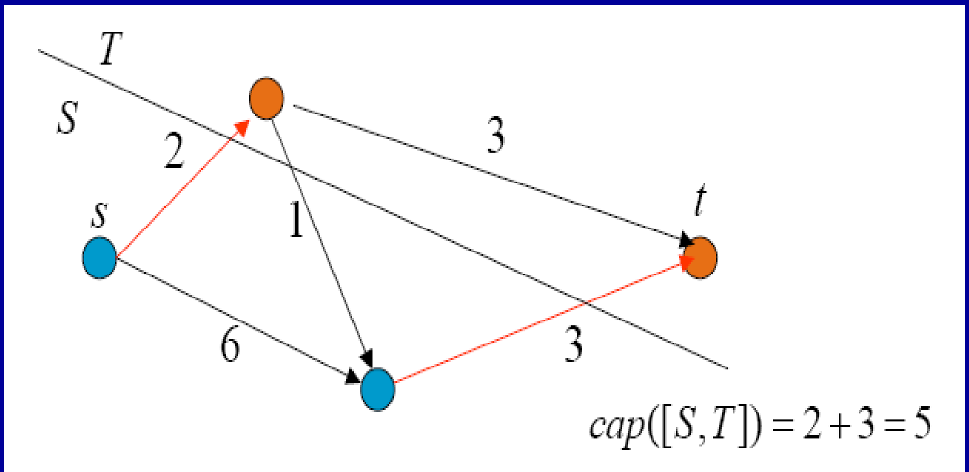
A s/t cut on a graph is a partition of the node-set V in two disjoint subsets, writing: $C = \{S, T\}$

The cost of a cut is defined as:

$|C| = \Sigma w(p,q)$, $(p,q) \in E$, $p \in S$, $q \in T$

That is, the sum over all "boundary links" of the cut.

The Minimum-Cut is the cut with the lowest cost of all possible cuts.



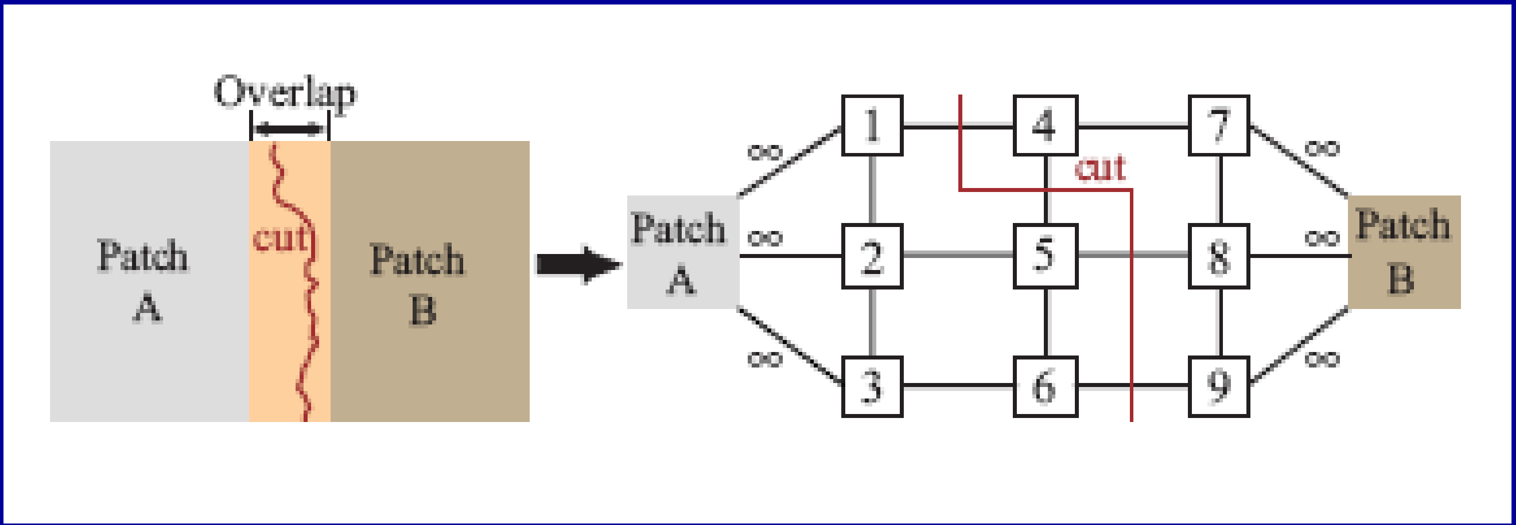
Patch Fitting and Seam Computation

- Recovering the visually optimal seam by computing the minimum cut in the constructed graph:

Labels in this problem indicate whether a pixel in the output texture patch needs to come from the old patch or the new texture patch. The boundary of the new patch with the old texture is the new seam that is computed.

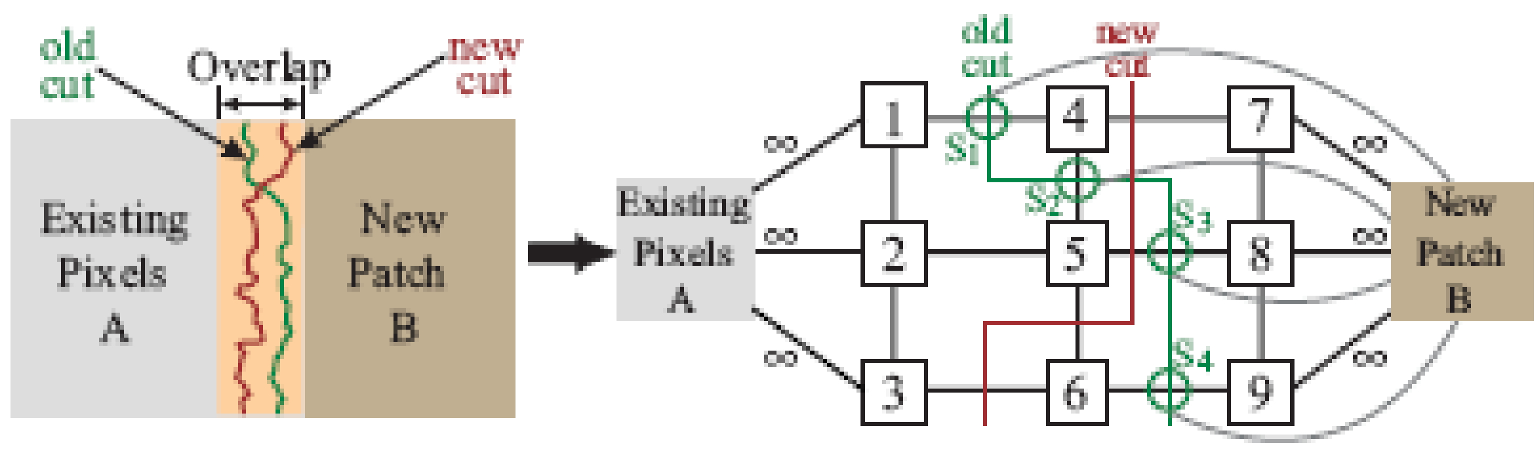
A new way to find the cut

- **Model overlapping patches as directed graphs**
- **Assign sources and sinks, and set the edges of adjacent pixel equal color difference**
- **M(1, 4, A, B) = ||A(1) - B(1)|| + ||A(4) - B(4)||**
- **run the min cut algorithm to find optimal seam**



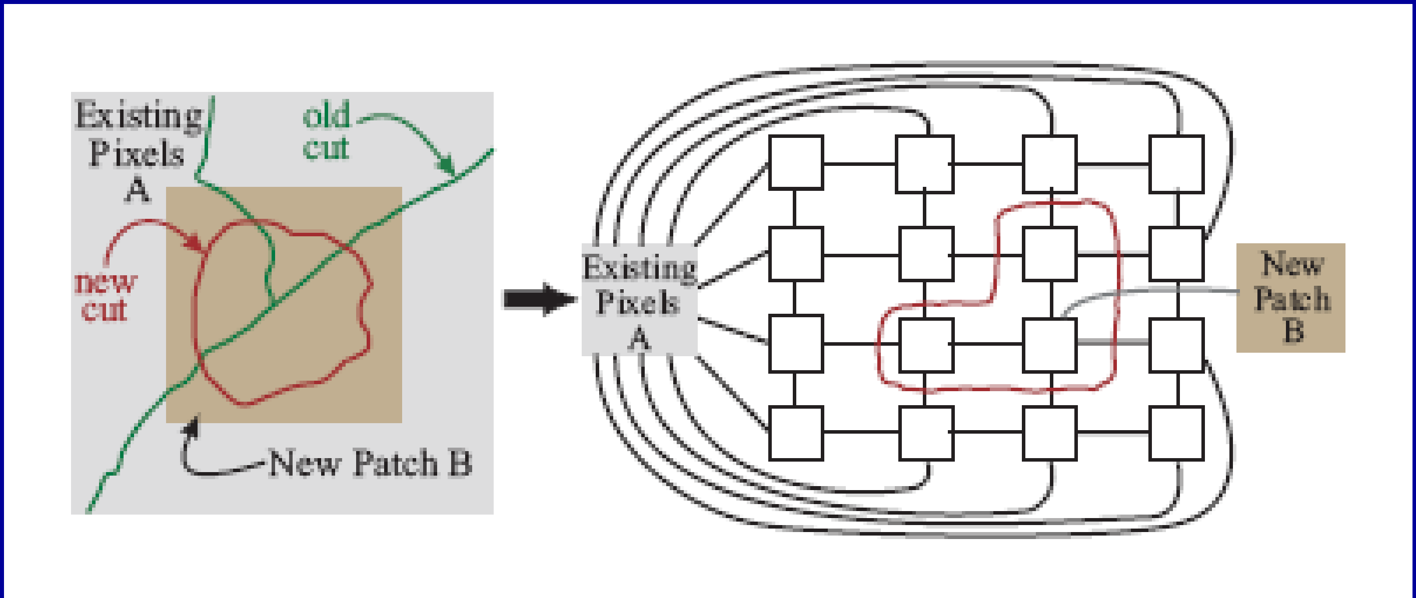
Accounting for Old Seams

- We can incorporate old seam costs into the problem, and thus determine which pixels (if any) from the new patch should cover over some of the old seams.



Surrounded Regions

- Sometimes we may want to cover old seams



Patch Placement

- We've talked about how to fit the patch, but how do we lay down the texture patches?
  - Random Placement: Fast and works well for random textures
  - Entire Patch Matching: Normalize the sum-of-squared-differences and divide by area of patch. Pick a random, but good match.
  - Sub-Patch Matching: Pick a place in the output texture to place a patch, then search the input texture for the best match

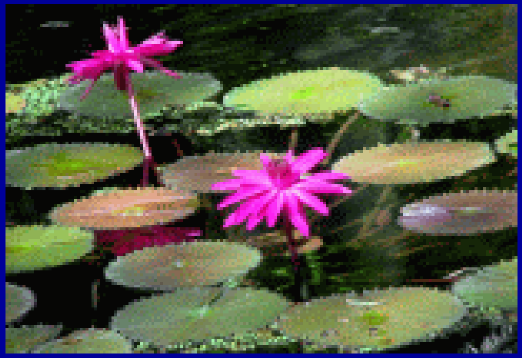
Results

Extensions and Refinements

- Adapting the Cost Function: Pay attention to frequency content present in the image or video
- Feathering and multi-resolution splining: Reduces ability to notice obvious seams
- FFT-Based Acceleration: For patch matching. SSD can be expensive. One example had a reduction of 10 minutes to 5 seconds after switching to the FFT method.

Additional Transformations

- Input image can be rotated, mirrored and scaled to produce interesting results



Additional Transformations Continued

Rotation Example

- **Image Quilting vs Graph Cut**

Input

Graph Cut Result

Image Quilting Result

Interactive Graph Cuts

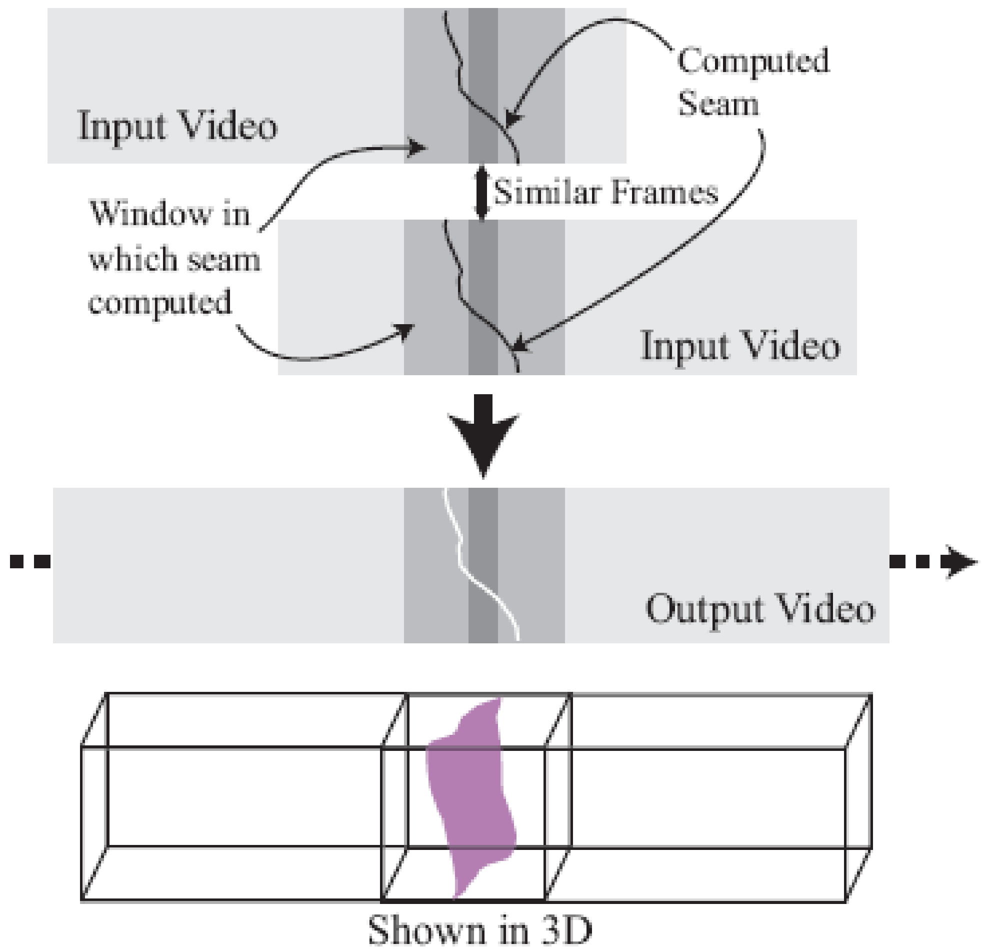
- **User has a hand in placing image, graph cut algorithm then finds the best cut**

Interactive Graph Cuts Continued

Video Synthesis

- Video textures turn existing video into an infinitely playing form by finding smooth transitions from one part of the video to another
- Patches in the case of video are the whole 3D space-time blocks of video

Video Synthesis Continued



Conclusion

- A new texture synthesis algorithm was introduced that works not only in 2D, but in 3D
- It's has advantages over previous patch based methods
- It's very fast, taking between 5 seconds and 5 minutes to generate results

Results of Video Synthesis

Results of Video Synthesis Continued

Questions ?

Acknowledge

HUT and MOUNTAIN	Erskine wood
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IMAGE QUILTING	Efros and Freeman 2001
	Ashikhmin 2001
	Heeger and Bergen 1995
	De Bonet 1997