Texture Synthesis and Manipulation

Project Proposal

Douglas Lanman

EN 256: Computer Vision

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BROWN

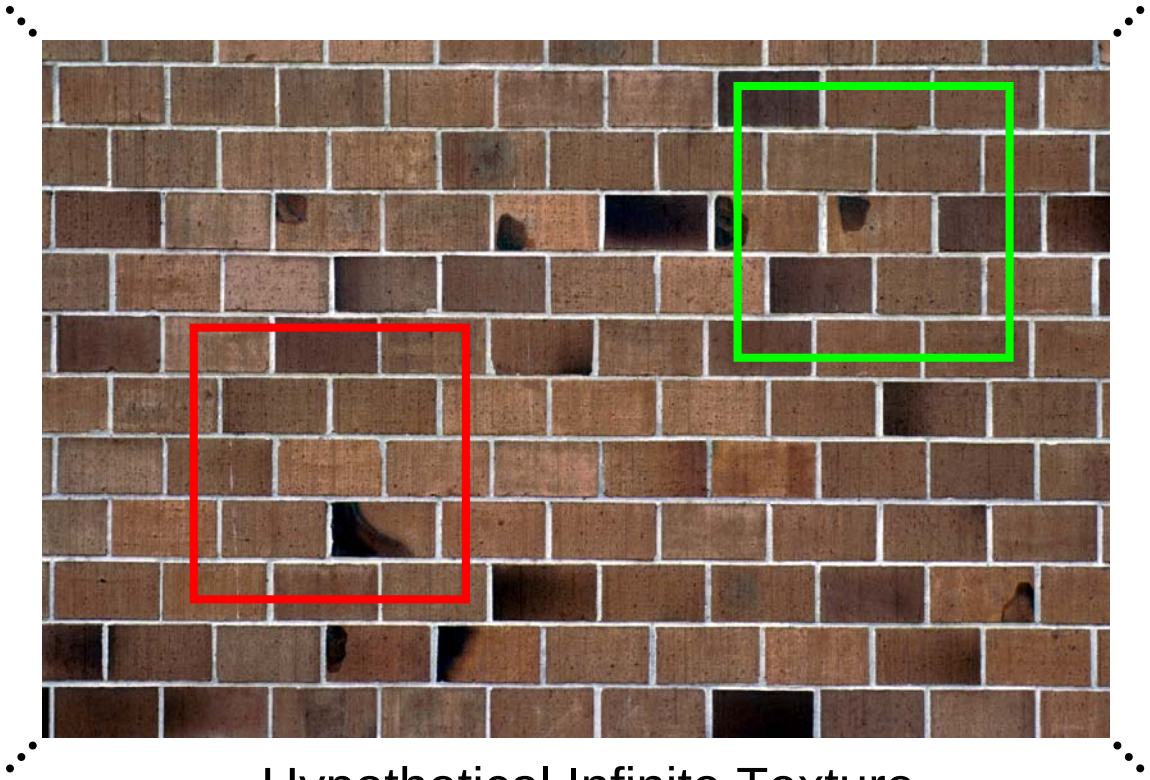
Outline

- *Introduction to Texture Synthesis*
- Previous Work
- Project Goals and Timeline

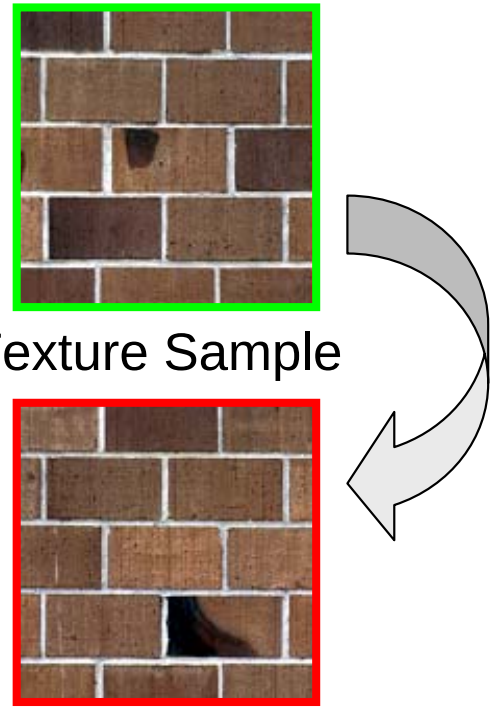
What is Texture Synthesis?

The Texture Synthesis Problem:

- Given a finite texture sample, synthesize additional samples which appear (to a human observer) to be generated from the same underlying stochastic process.



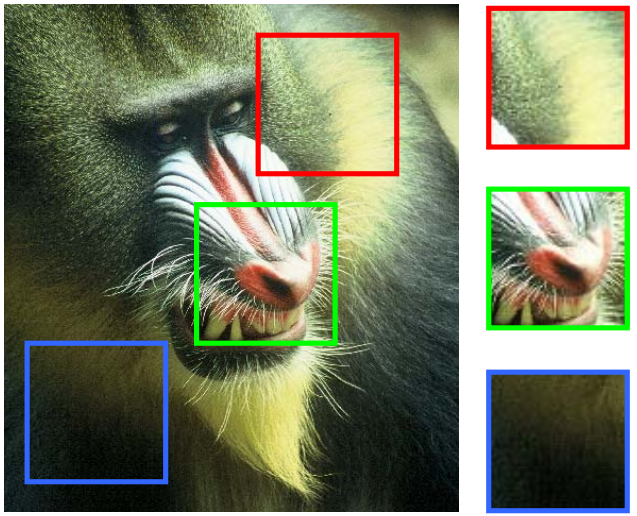
Hypothetical Infinite Texture

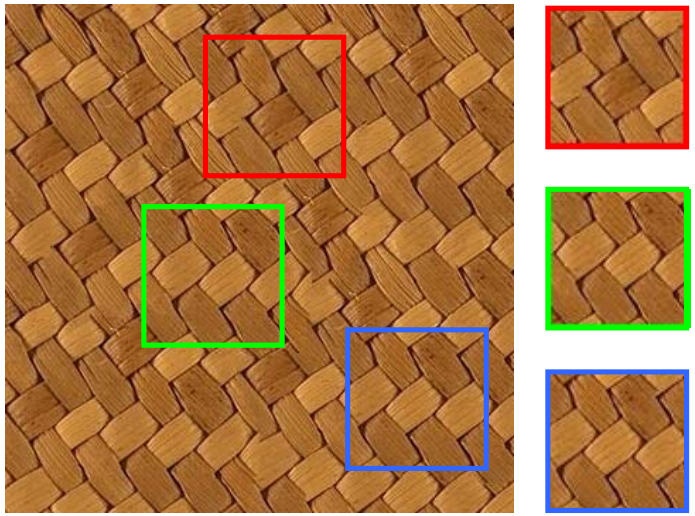


Synthesized Texture

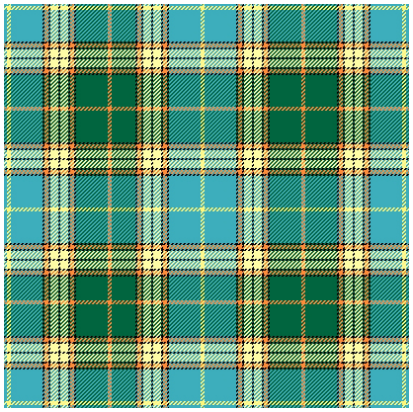
Characteristics of Natural Textures

Locality and Stationarity of Random Processes





Stochastic vs. Regular Textures

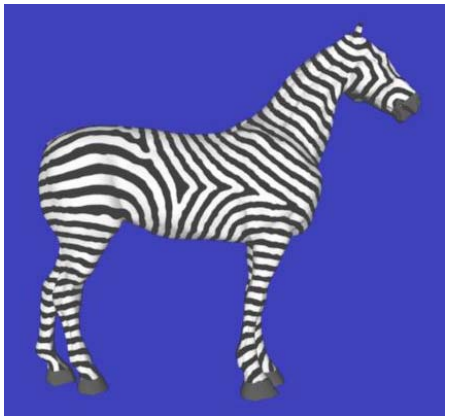


Regular Tiling

Stochastic

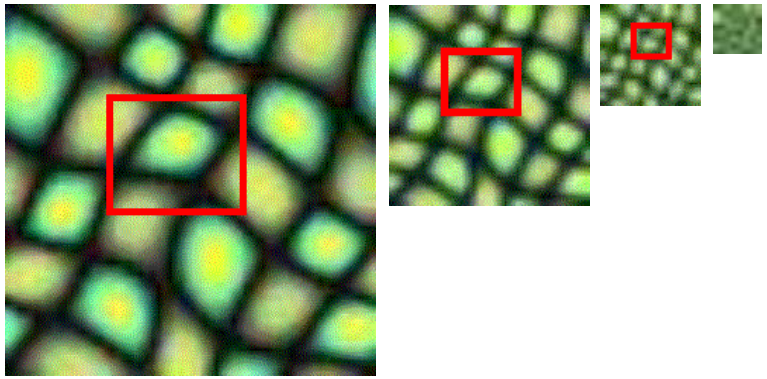
Weakly Homogeneous

General Approaches



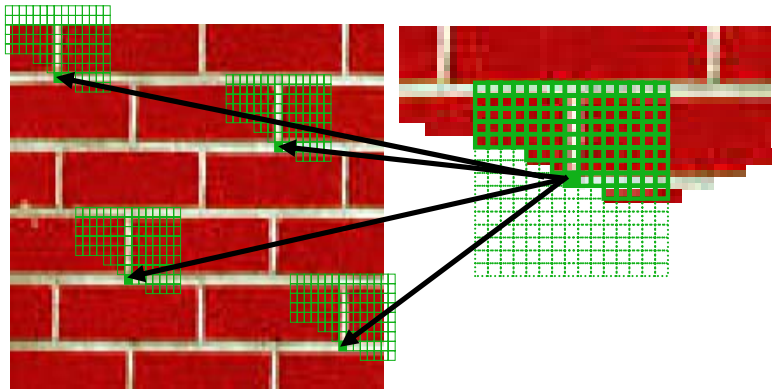
Physical Simulation

- Generate textures by modeling the underlying physical process.
- Reaction-diffusion [Witkin '91]
- Virtual weathering [Dorsey '00]



Parametric Feature Matching

- Modify a random noise image to have similar features as a sample.
- Multi-scale histogram matching [Heeger '95, De Bonet '97]

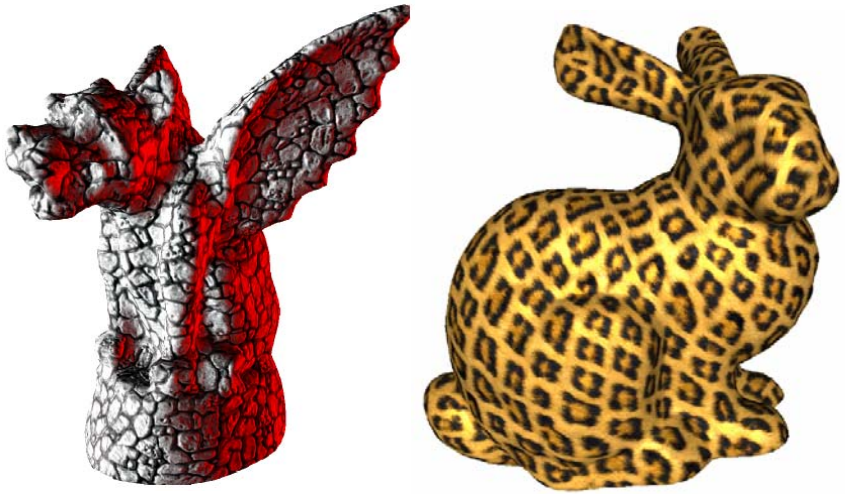


Non-parametric Synthesis

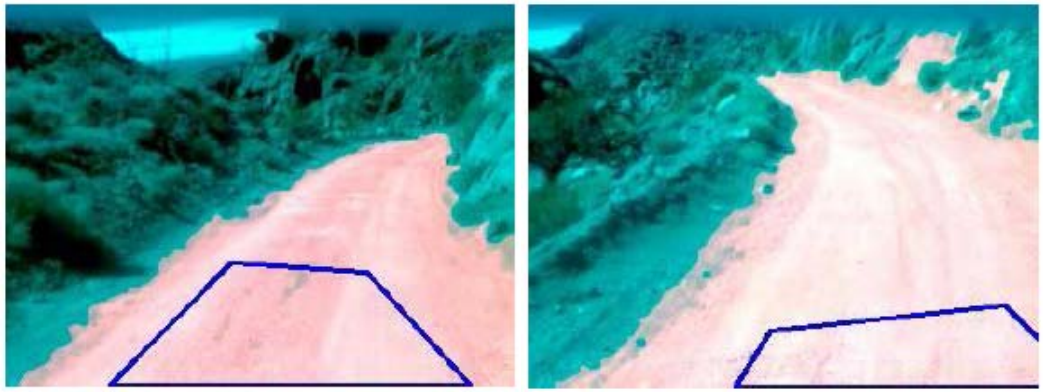
- Draw samples from the input image to generate a similar output texture.
- Pixel-based and patch-based methods [Wei '00, Efros '01, Kwatra '03]

Applications of Texture Synthesis

Image Retouching (e.g., scratch removal)



Non-periodic Texture Mapping



Texture Analysis and Classification

Texture Modification

Outline

- Introduction to Texture Synthesis
- *Previous Work*
  - *Texture Synthesis*
  - Texture Manipulation
- Project Goals and Timeline

An Illustrative Example: Text Generation

Generating Text using Markov Chains [Shannon '48]

- Assume next word is dependent only on the preceding *N* words
- Estimate conditional probability distribution using a large sample text
- Starting with a random seed word, sample from conditional density

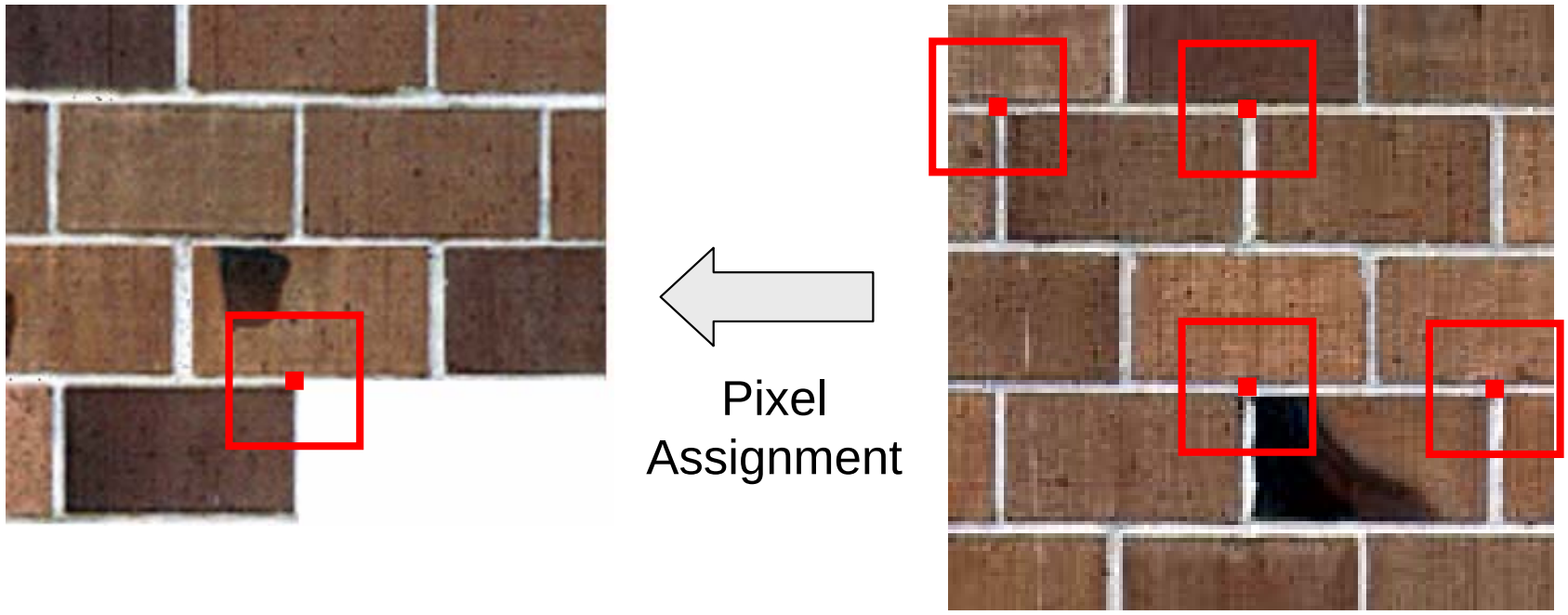
Examples [Dewdney '89]

- *"I spent an interesting evening recently with a grain of salt."*
- *"People often get used to me knowing these things and then a cover is placed over all of them."*

Observations

- Results preserve "local" grammatical structure
- As alternative to generative model, find closest match at each step

Pixel-based Texture Synthesis



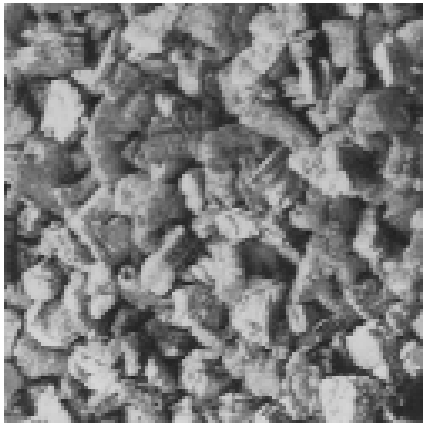
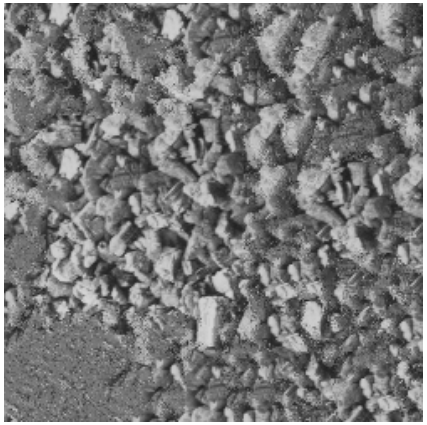
Pixel-based Synthesis Procedure [Wei and Levoy '00]

- Assume a Markov Random Field (i.e., local and stationary process)
- Rather than estimating conditional density, simply sample image
- Starting from a set of initial seed values, search the input texture for similar neighborhoods and assign randomly from this set

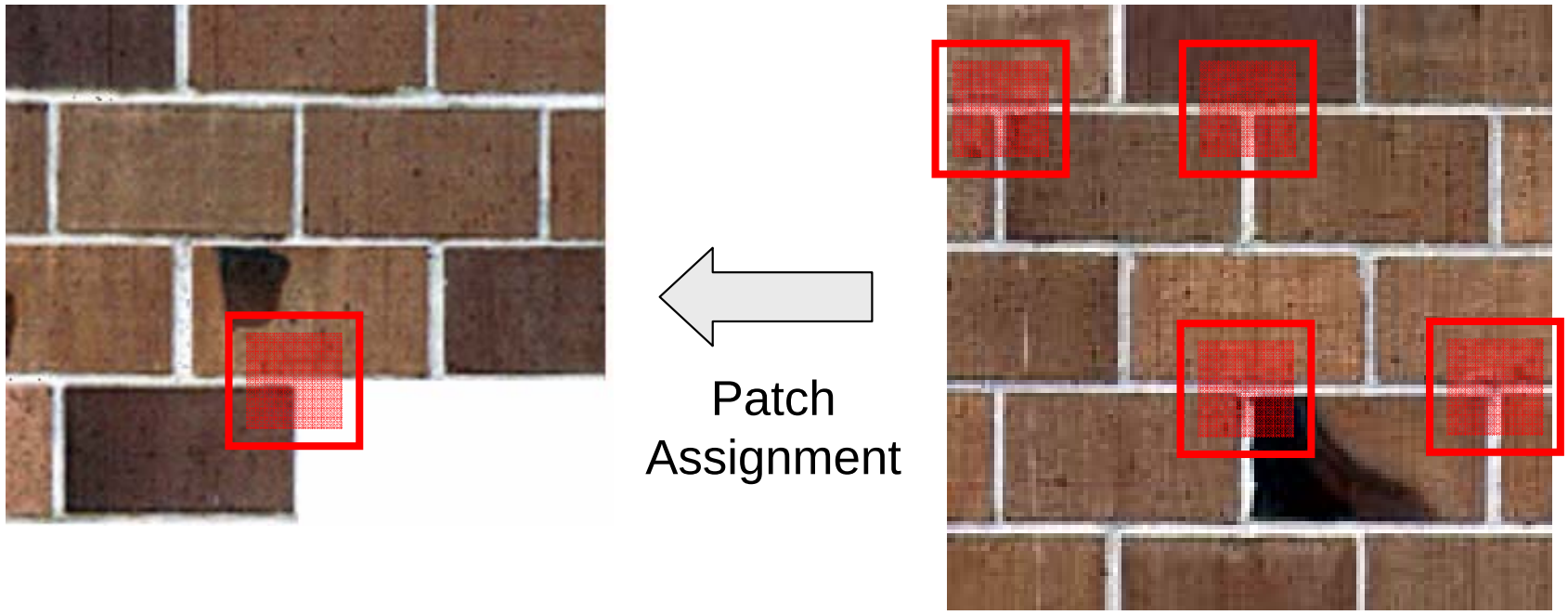
Pixel-based Texture Synthesis Results

Input Sample	Wei and Levoy	Ashikhmin	Hertzmann et al.
			
			

Limitations and Failure Modes

"Garbage"	Verbatim Copying	Blurring
		
		

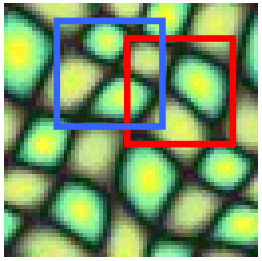
Patch-based Texture Synthesis



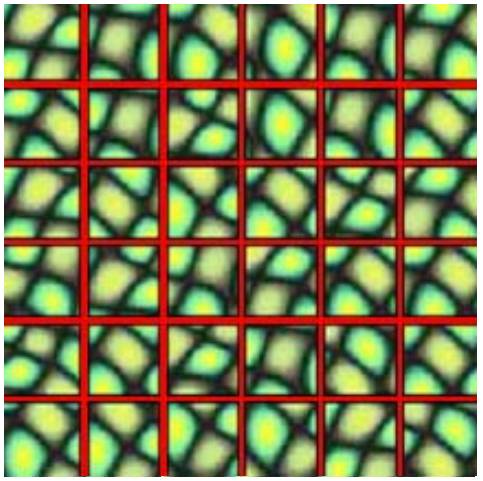
Patch-based Synthesis Procedure [Efros and Freeman '01]

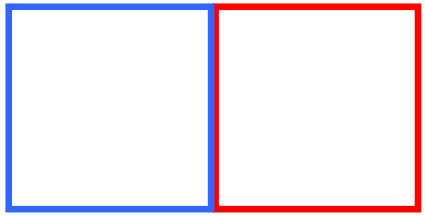
- Pixel-based methods result in correlated neighboring pixels
- To accelerate synthesis, simply assign patches rather than pixels
- Starting from an initial patch, search the input texture for similar neighborhoods and assign next patch randomly from this set

Image Quilting

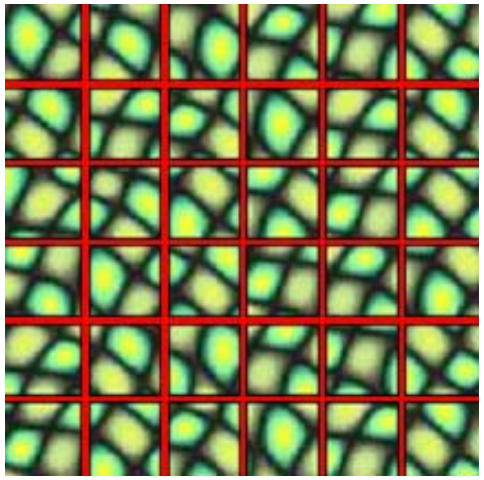


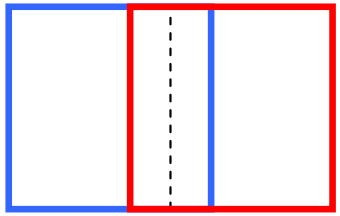
Input Sample



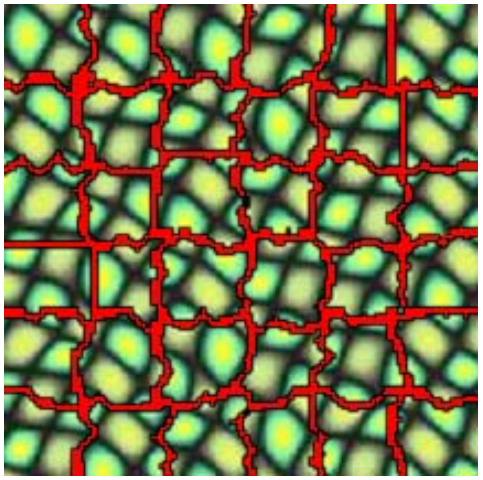


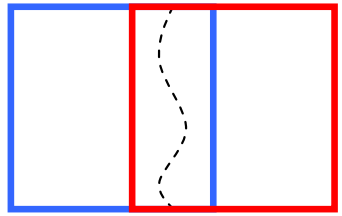
Random Placement





Constrained Overlap





Minimal Error Cut

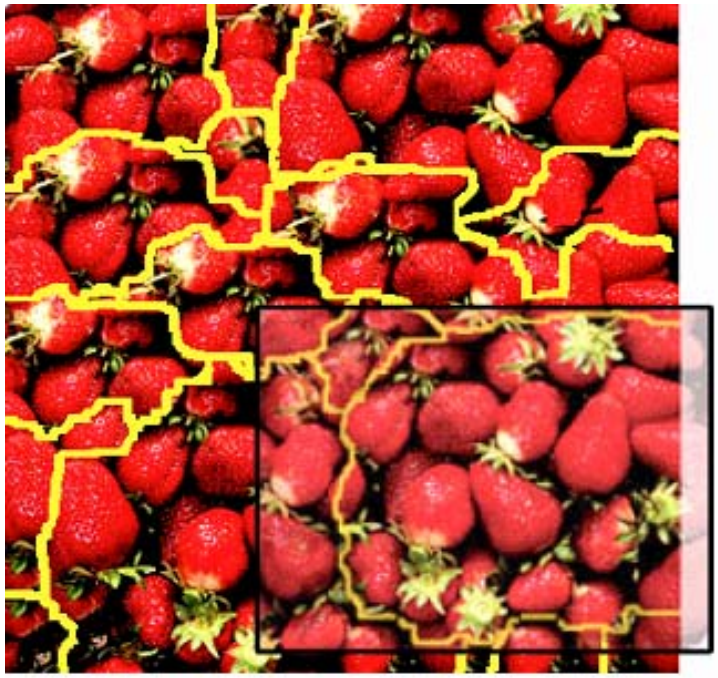
Image Quilting Procedure [Efros and Freeman '01]

- Append blocks to initial seed so that region of overlap is similar
- Define boundary by minimum cost path through overlap error

Graphcut Texture Synthesis

Texture Sample

Graphcut Texture



Patch Boundaries

Graphcut Texture Synthesis Procedure [Kwatra et al. '03]

- Repeatedly paste image with random offset into the output texture
- Update seams by minimum cost cut through overlap error

Patch-based Texture Synthesis Results

Input Sample	Image Quilting	Graphcut Texture
		
		

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Texture Transfer and Image Analogies

Texture Transfer [Efros and Freeman '01]

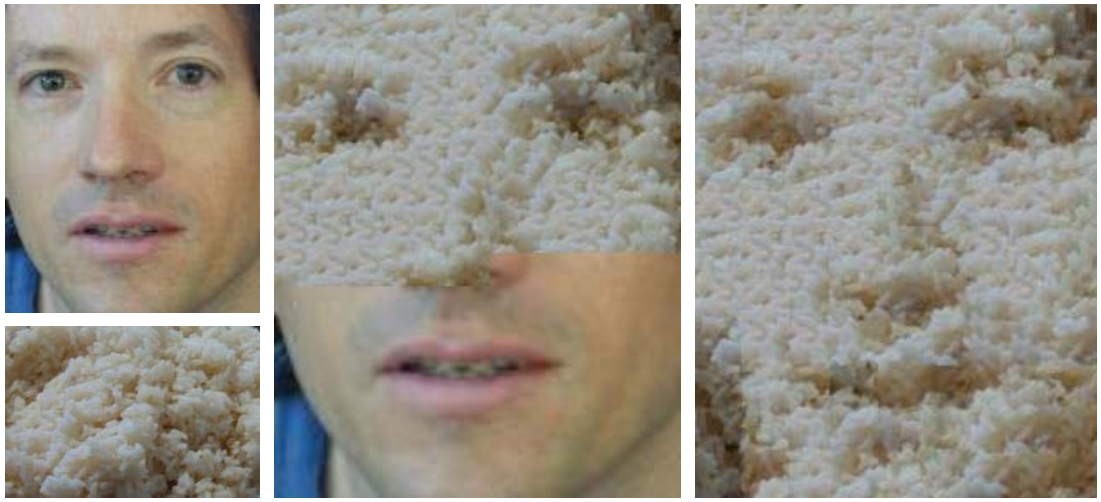

Image Analogies [Hertzmann et al. '01]

Source (A) : Filtered Source (A′) :: Target (B) : Filtered Target (B′)

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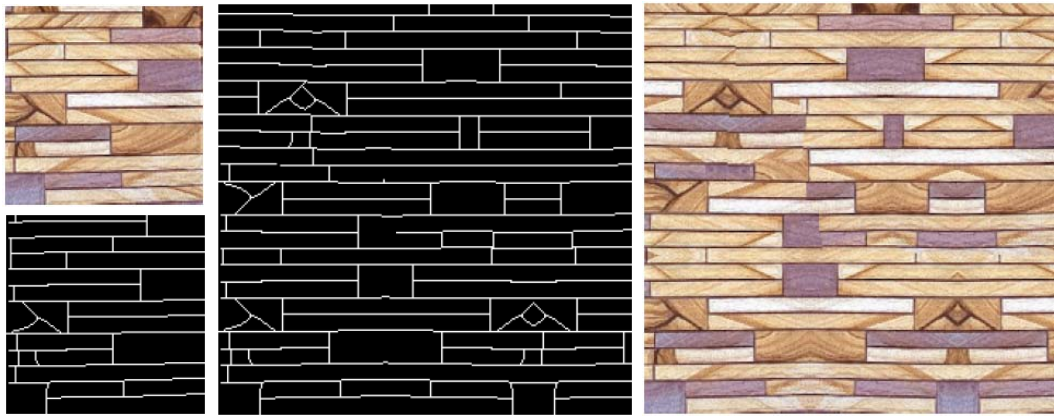
Project Goals and Timeline

Primary Goals (for Progress Report)

- *Implement patch-based texture synthesis using Image Quilting*
- Use texture transfer to allow user-controlled synthesis
- Evaluate regular, stochastic, and weakly-homogeneous samples
- Compare results to existing methods using available implementations

Secondary Goals (for Final Report)

- Implement graphcut-based texture synthesis
- Extend texture transfer to allow patch-based image analogies
- Evaluate feature matching and texture deformation
- Examine extensions for inpainting and retouching



Feature Matching and Image Deformation

References

"Early" Approaches: Texture Analysis and Psychophysics

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2. J.S. De Bonet, "Multiresolution Sampling Procedure for Analysis and Synthesis of Texture Images", SIGGRAPH '97.

Pixel-based Texture Synthesis

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Patched-based Texture Synthesis

7. Y. Xu, B. Guo, and H. Shum, "Chaos Mosaic: Fast and Memory Efficient Texture Synthesis", Microsoft Research Technical Report, MSR-TR-2000-32, 2000.
8. A.A. Efros and W. Freeman, "Image Quilting for Texture Synthesis and Transfer", SIGGRAPH '01.
9. V. Kwatra, A. Schödl, I. Essa, G. Turk, and A. Bobick, "Graphcut Textures: Image and Video Synthesis Using Graph Cuts", SIGGRAPH '03.
10. Q. Wu and Y. Yu, "Feature Matching and Deformation for Texture Synthesis", SIGGRAPH '04.