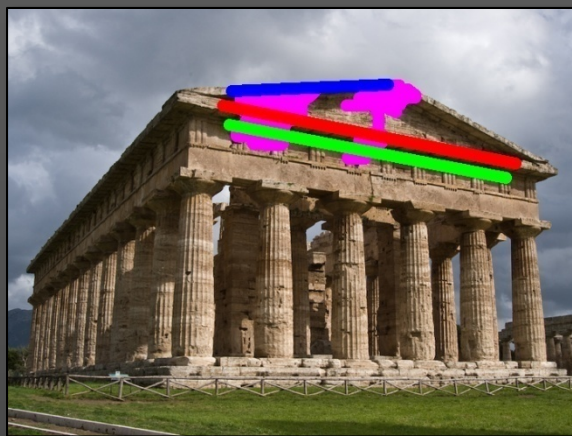


PatchMatch: A Randomized Correspondence Algorithm for Structural Image Editing



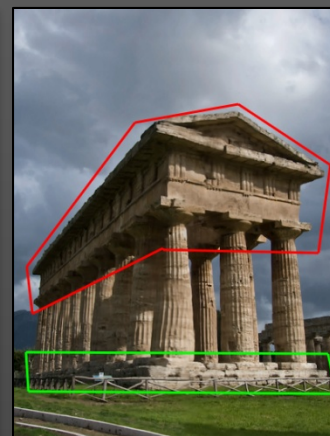
(a) Original



(b) Inpainting



(c) Retarget



(d) Reshuffle

Connelly Barnes¹, Eli Shechtman^{2,3}, Adam Finkelstein¹, Dan B Goldman²

¹Princeton University, ²Adobe Systems, ³University of Washington

PatchMatch: A Randomized Correspondence Algorithm for Structural Image Editing



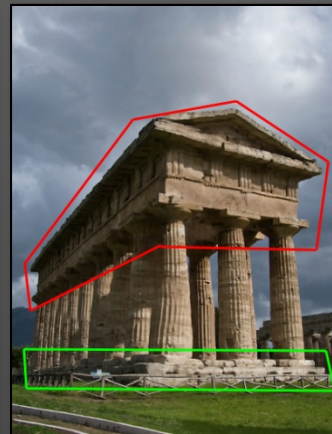
(a) Original



(b) Inpainting



(c) Retarget



(d) Reshuffle

Connelly Barnes¹, Eli Shechtman^{2,3}, Adam Finkelstein¹, Dan B Goldman²

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PatchMatch: A Randomized Correspondence Algorithm for Structural Image Editing



(a) Original



(b) Inpainting



(c) Retarget

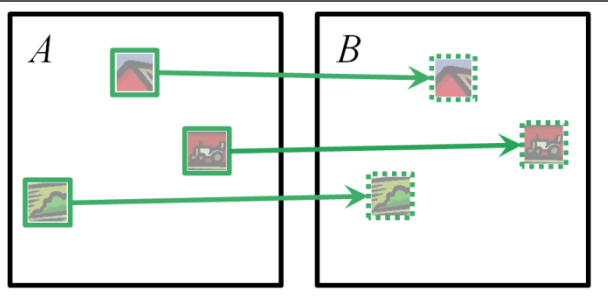


(d) Reshuffle

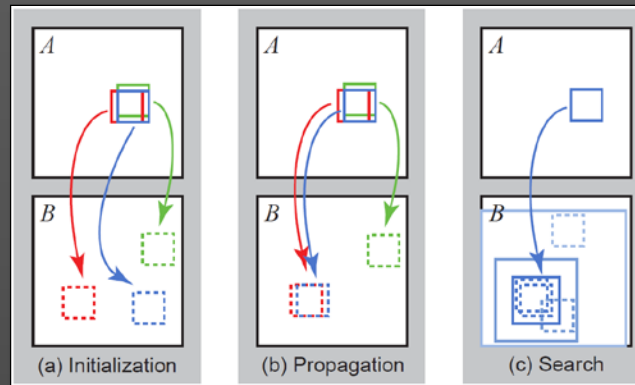
Connelly Barnes¹, Eli Shechtman^{2,3}, Adam Finkelstein¹, Dan B Goldman²

¹Princeton University, ²Adobe Systems, ³University of Washington

Roadmap



Motivation

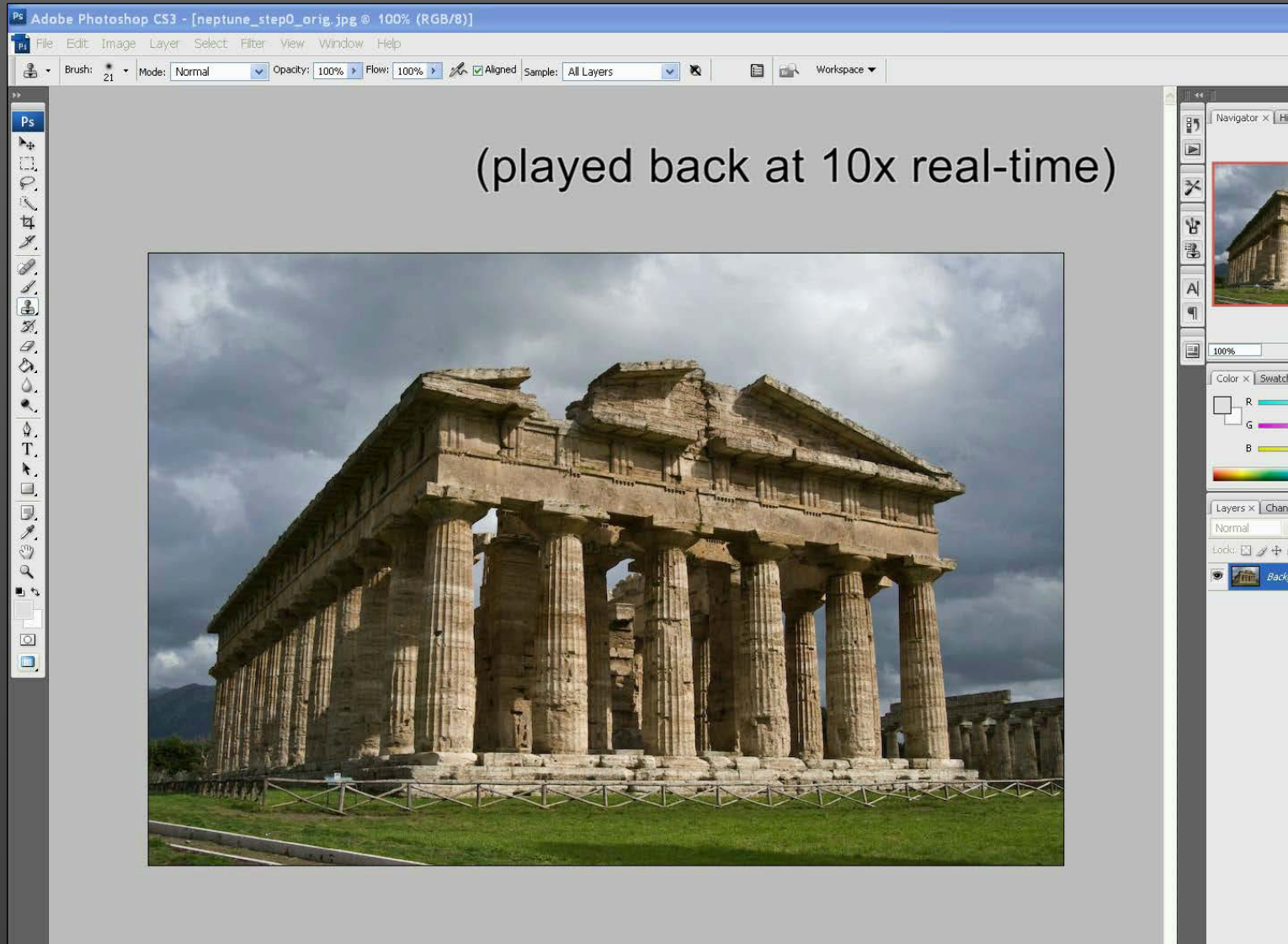


PatchMatch
Algorithm



Interactive
Editing

Traditional Photo Editing



Higher Level Editing



Retargeting [Avidan '07]



Hole filling [Sun '05]



Reshuffling [Simakov '08], [Cho '08]

User Interaction



Retargeting [Avidan '07]

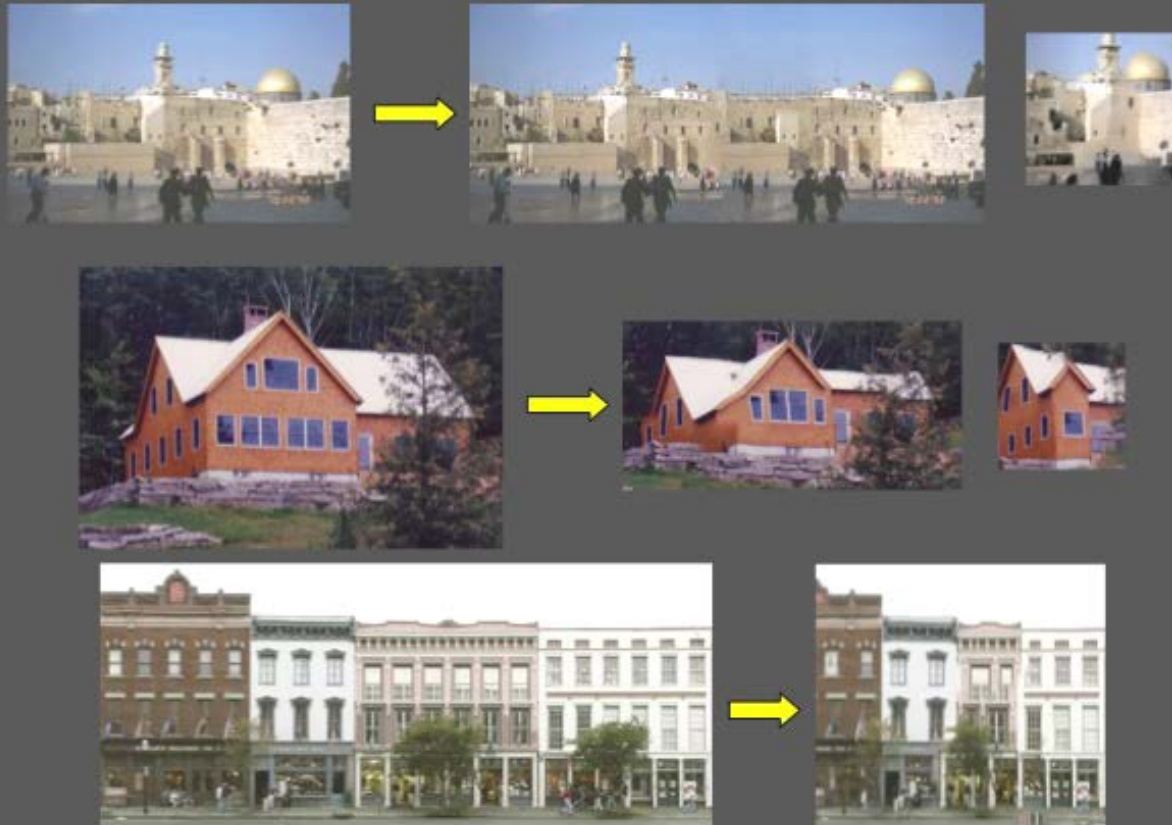


Hole filling [Sun '05]



Reshuffling [Simakov '08], [Cho '08]

Non-Parametric Patch Sampling



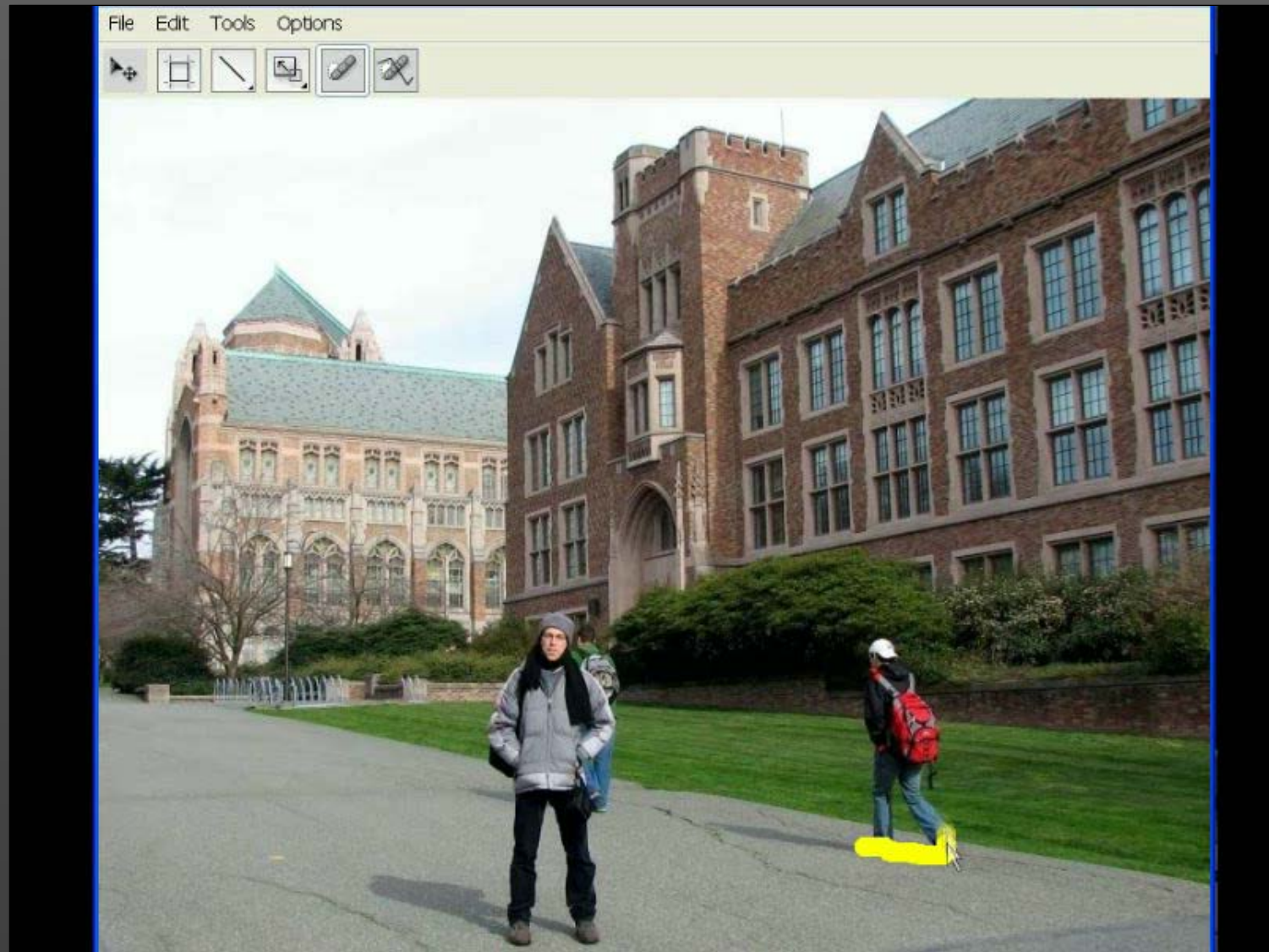
**Image retargeting [Simakov et al. '08]
(5 minutes per 250x200 input image)**

Non-Parametric Patch Sampling



Image reshuffling/collage [Simakov et al. '08]
(5 minutes per 250x200 input image)

PatchMatch



Iterative Optimization Methods



Retargeting and Reshuffling

[Simakov '08]



Texture Synthesis

[Kwatra '05]

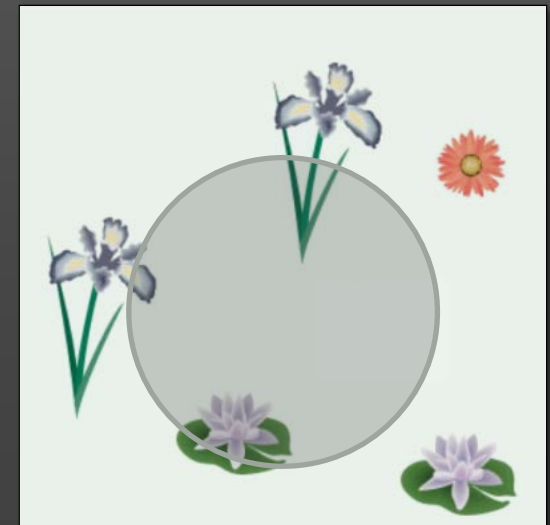
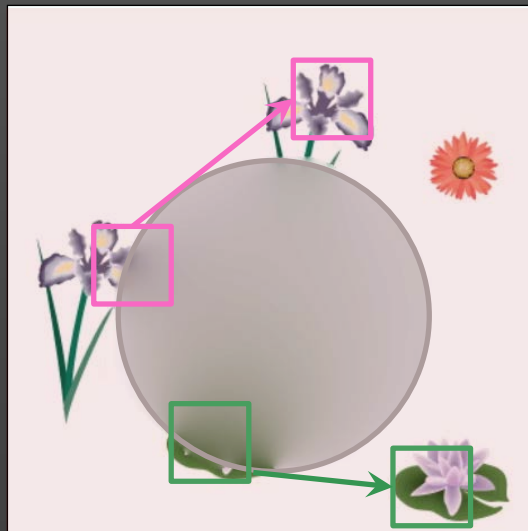
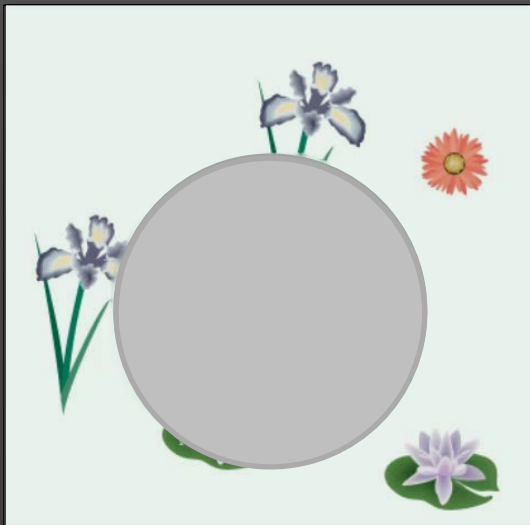
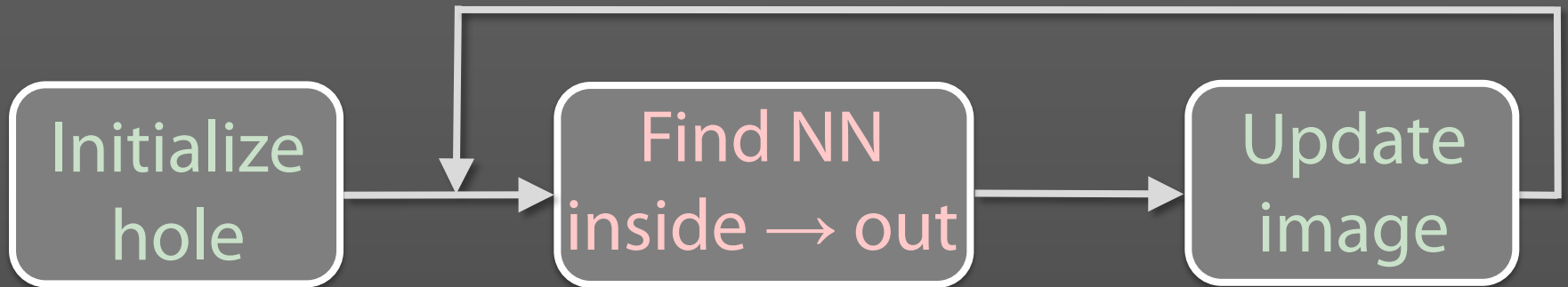


Hole Filling

[Wexler '04]

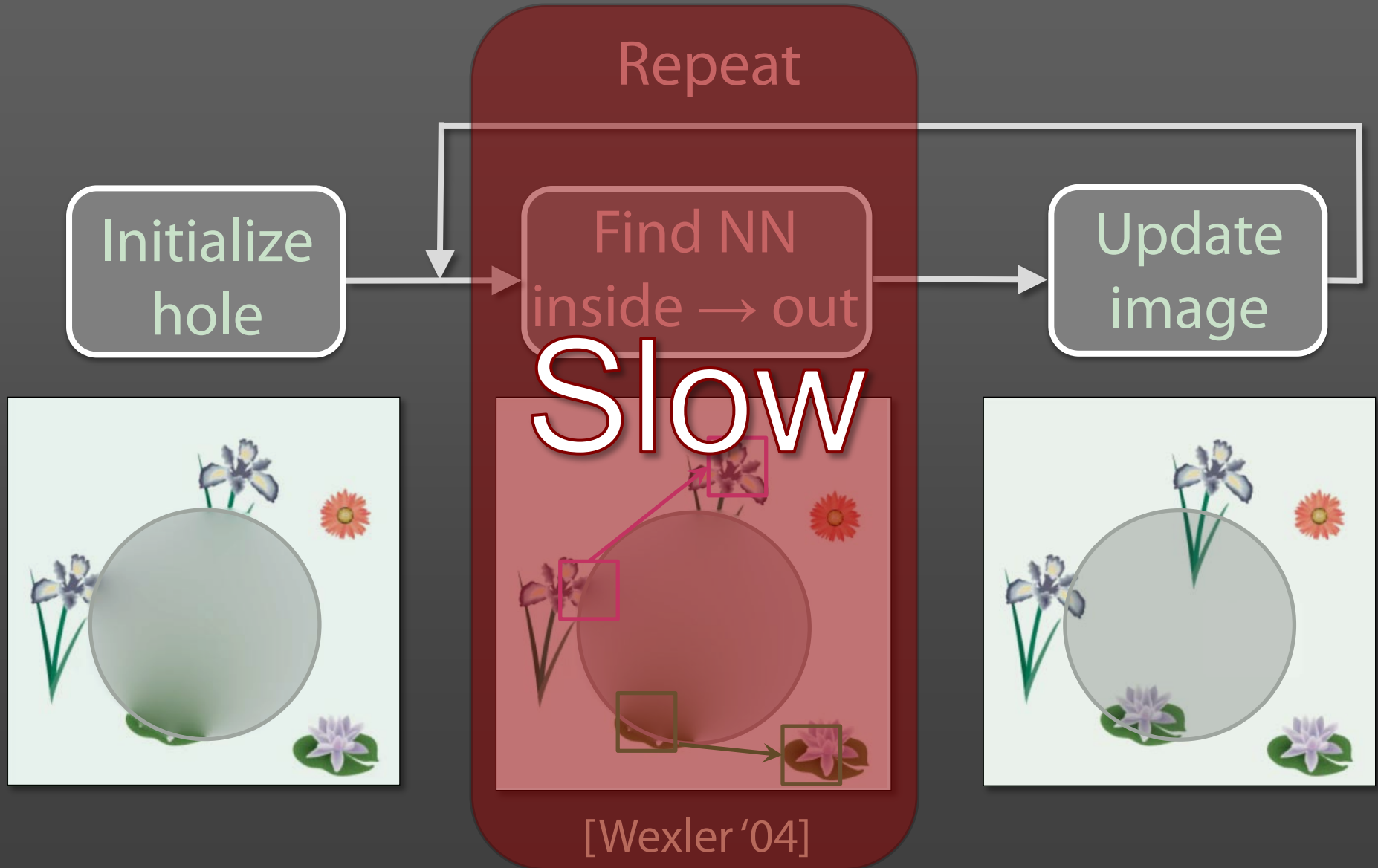
Hole Filling

Repeat



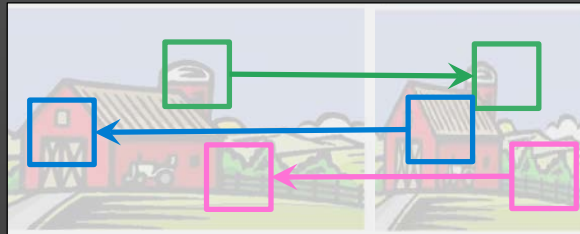
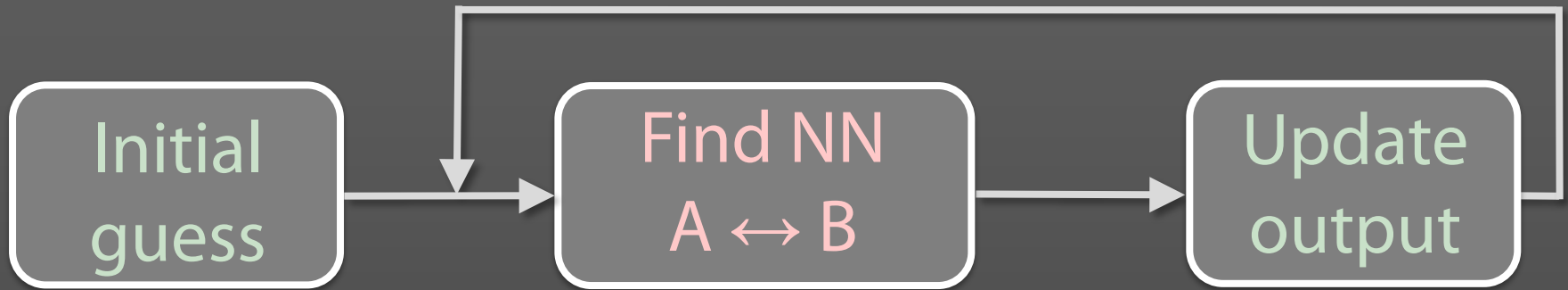
[Wexler '04]

Hole Filling



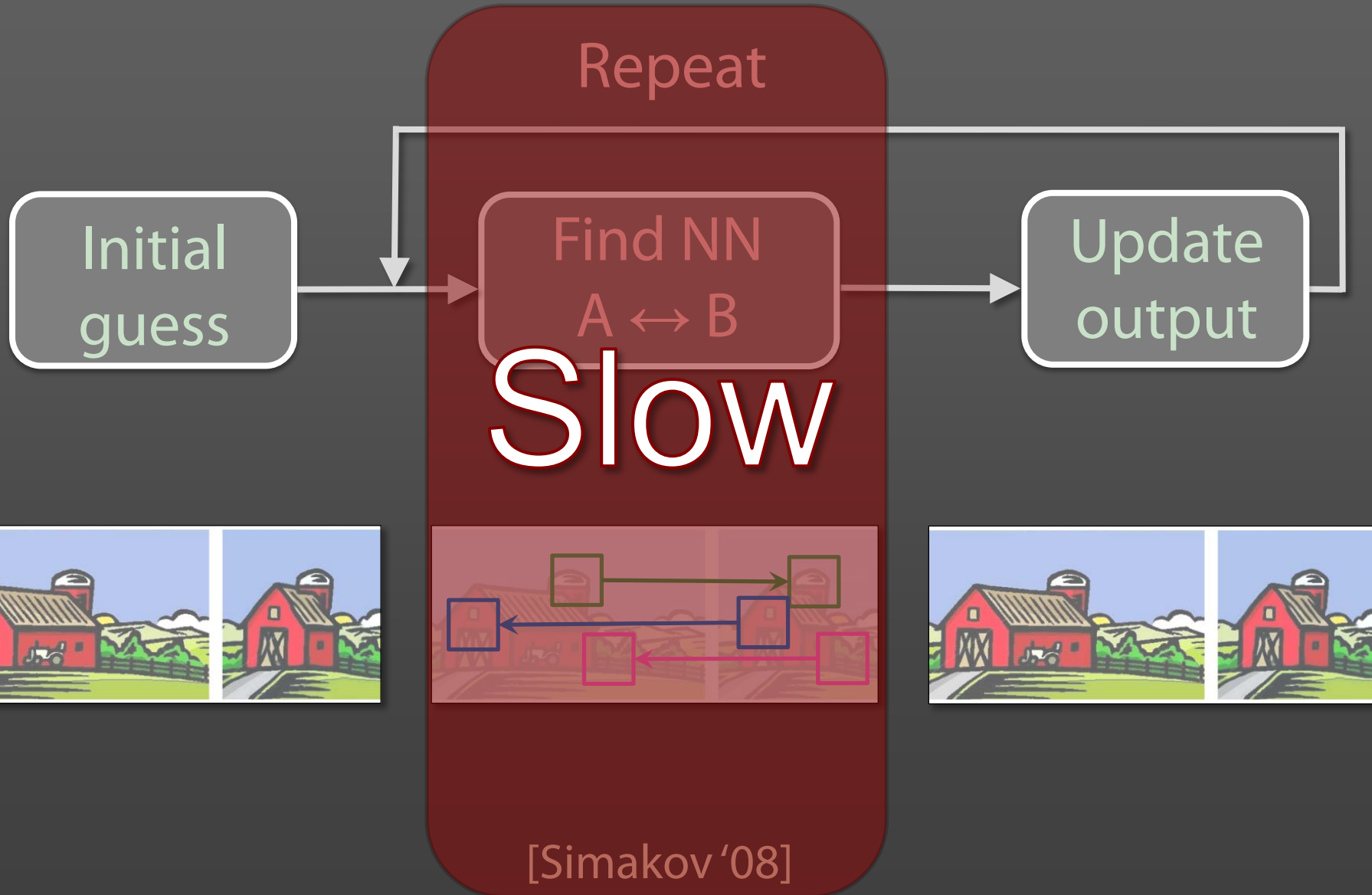
Retargeting / Reshuffling

Repeat

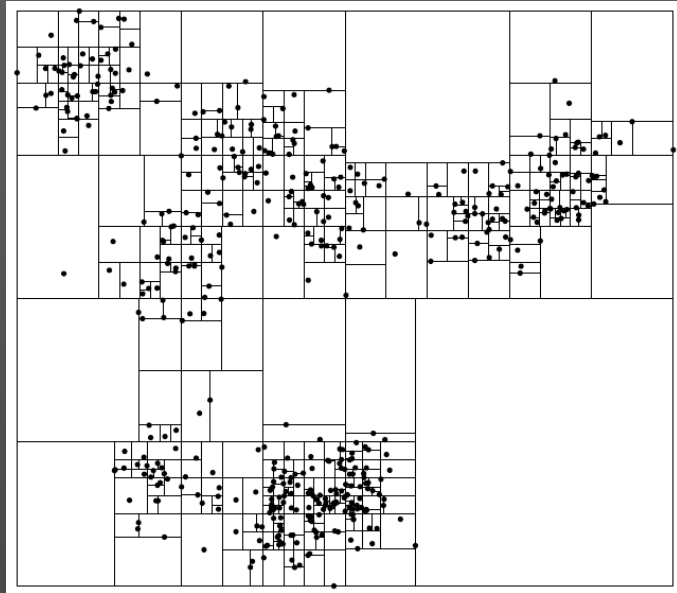


[Simakov '08]

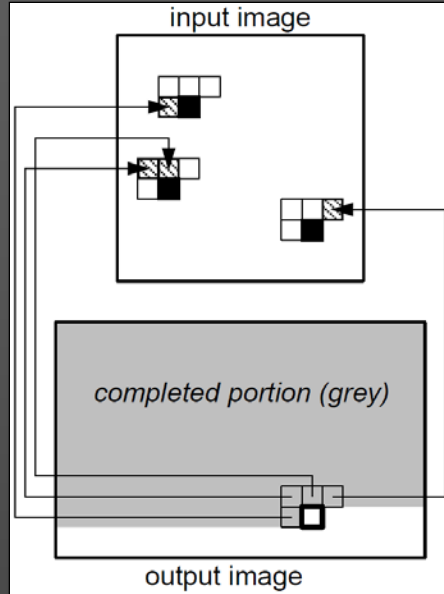
Retargeting / Reshuffling



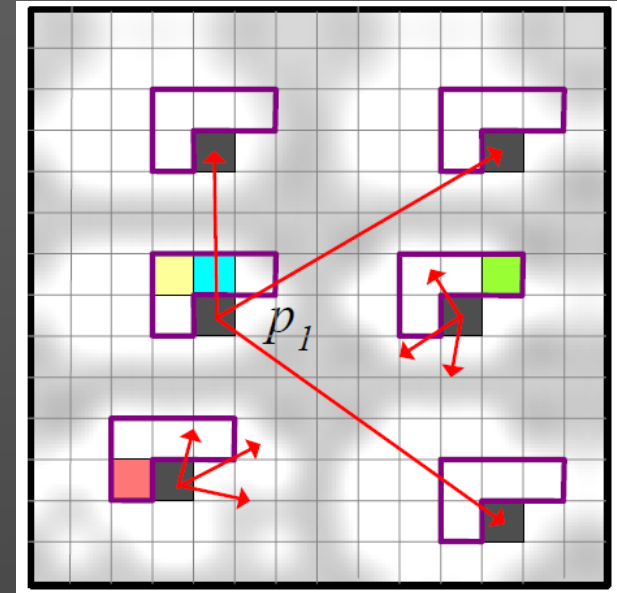
Related Work



kd-tree with PCA
[Hertzmann '01]

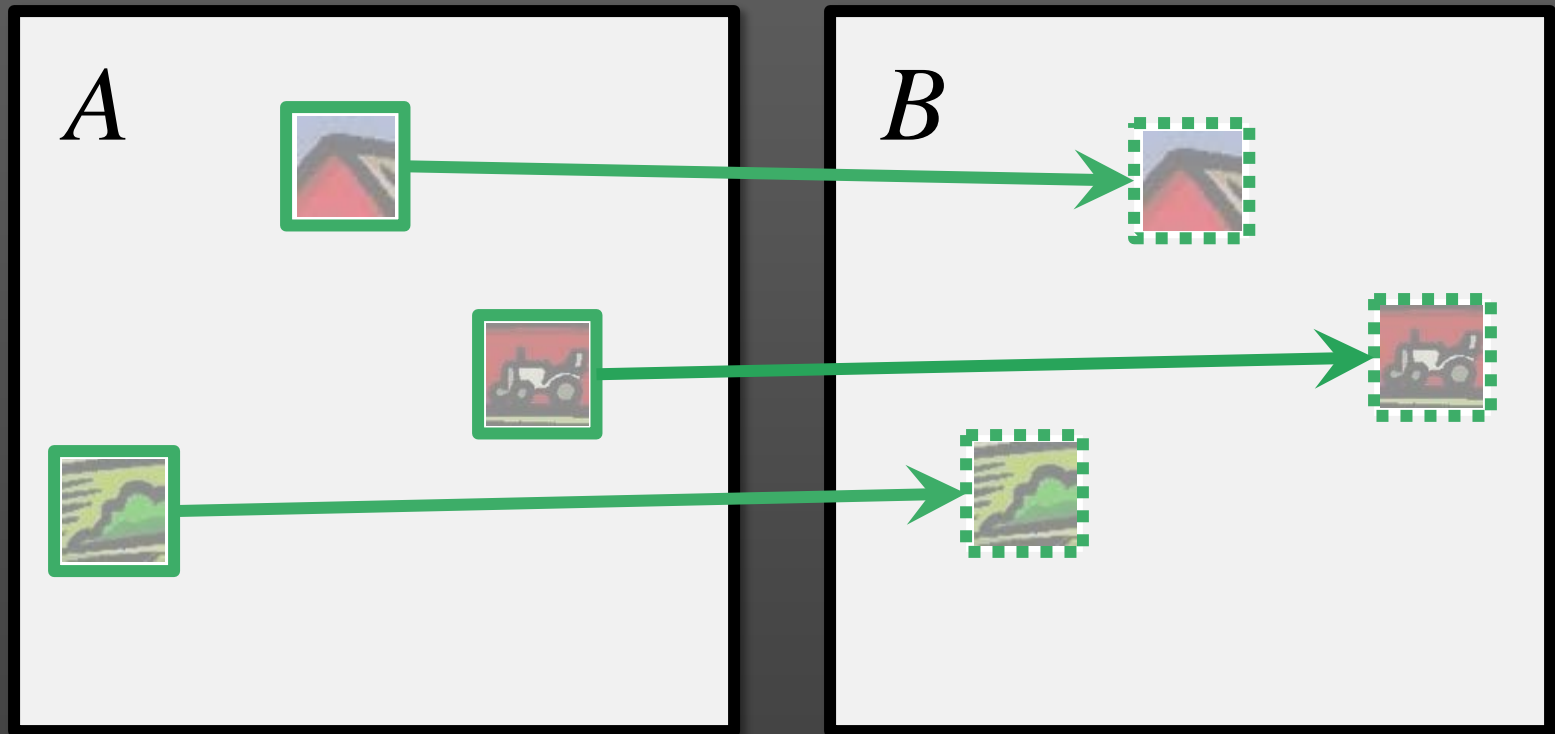


Propagation
[Ashikhmin '01]

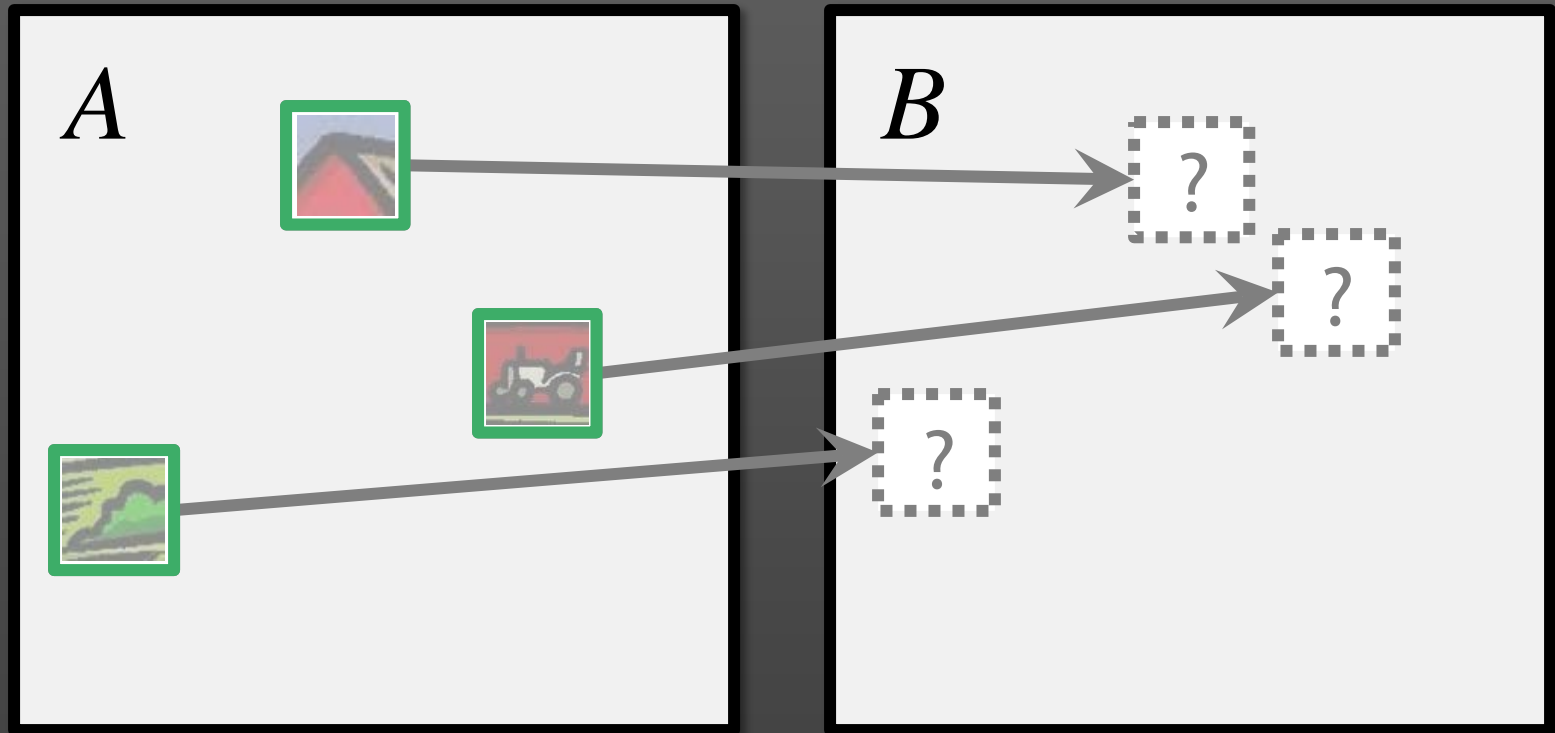


k-coherence
[Tong '02]

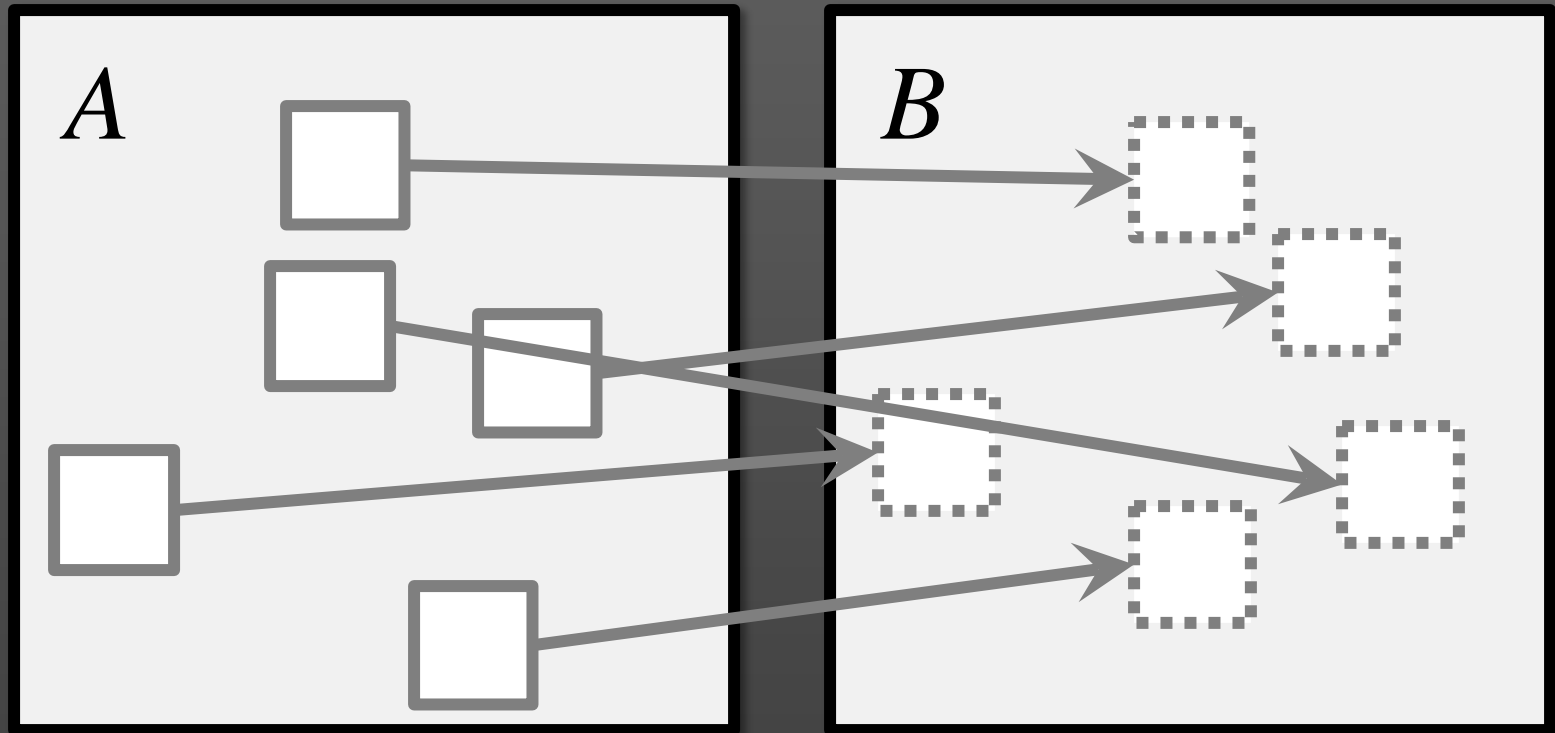
Problem



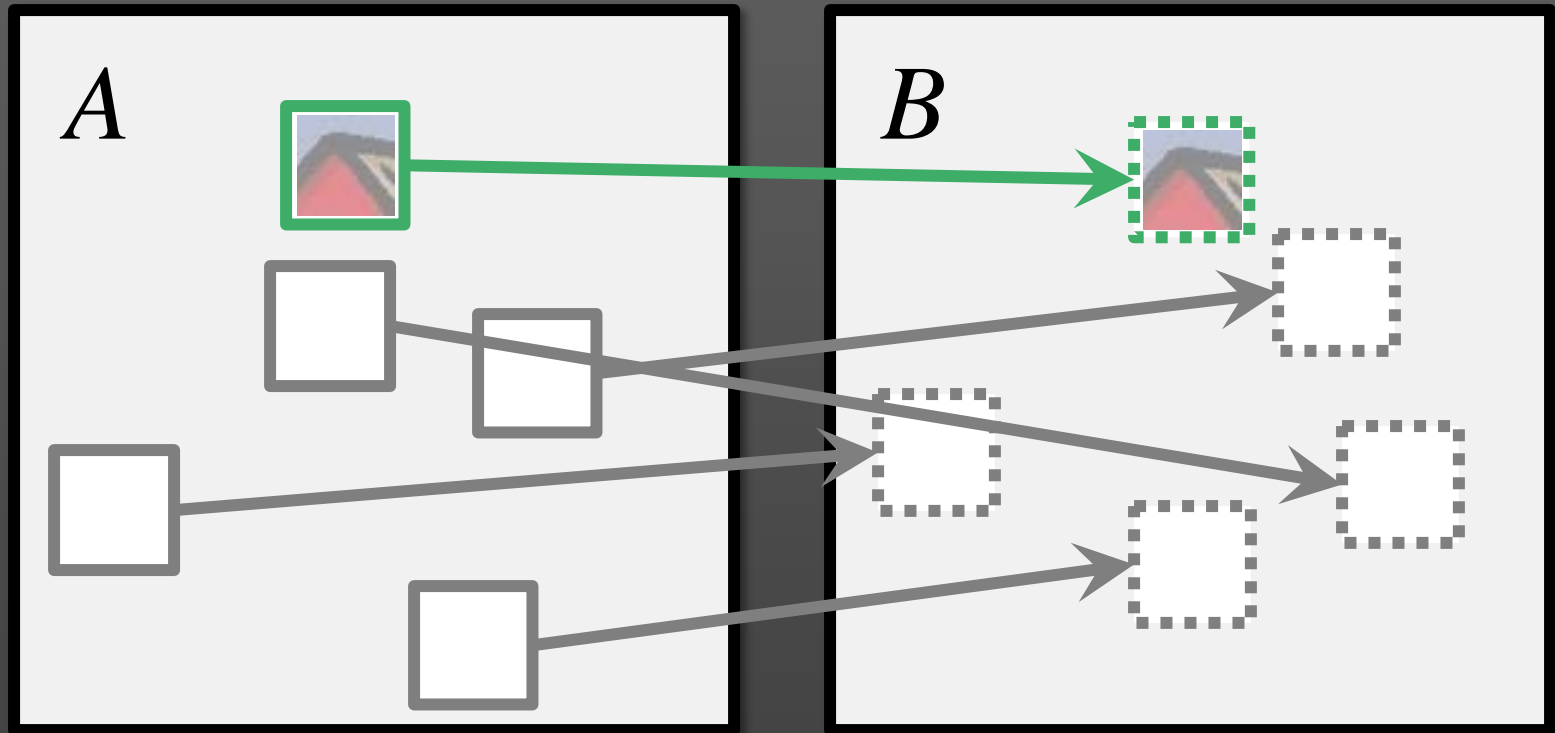
Intuition for PatchMatch



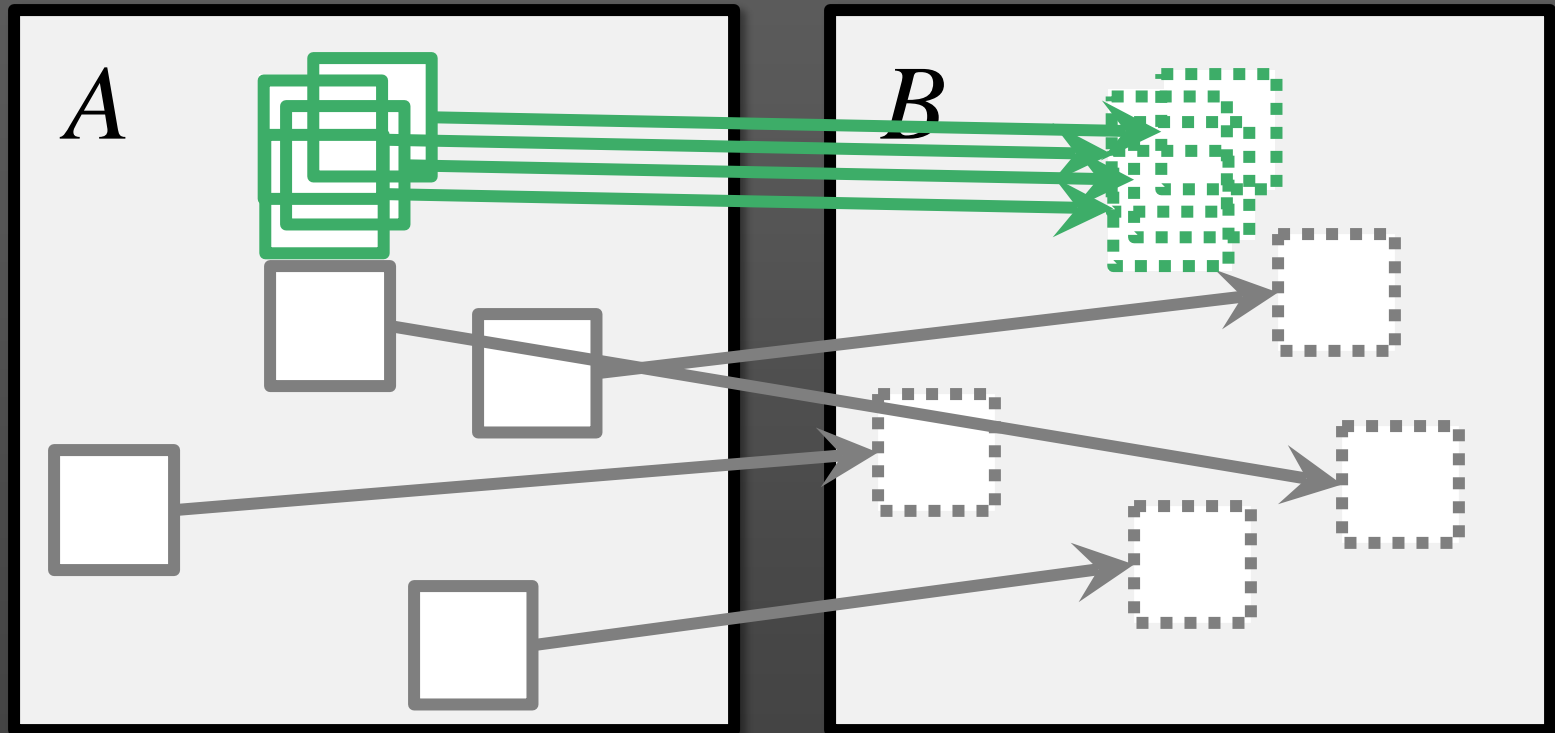
Intuition for PatchMatch



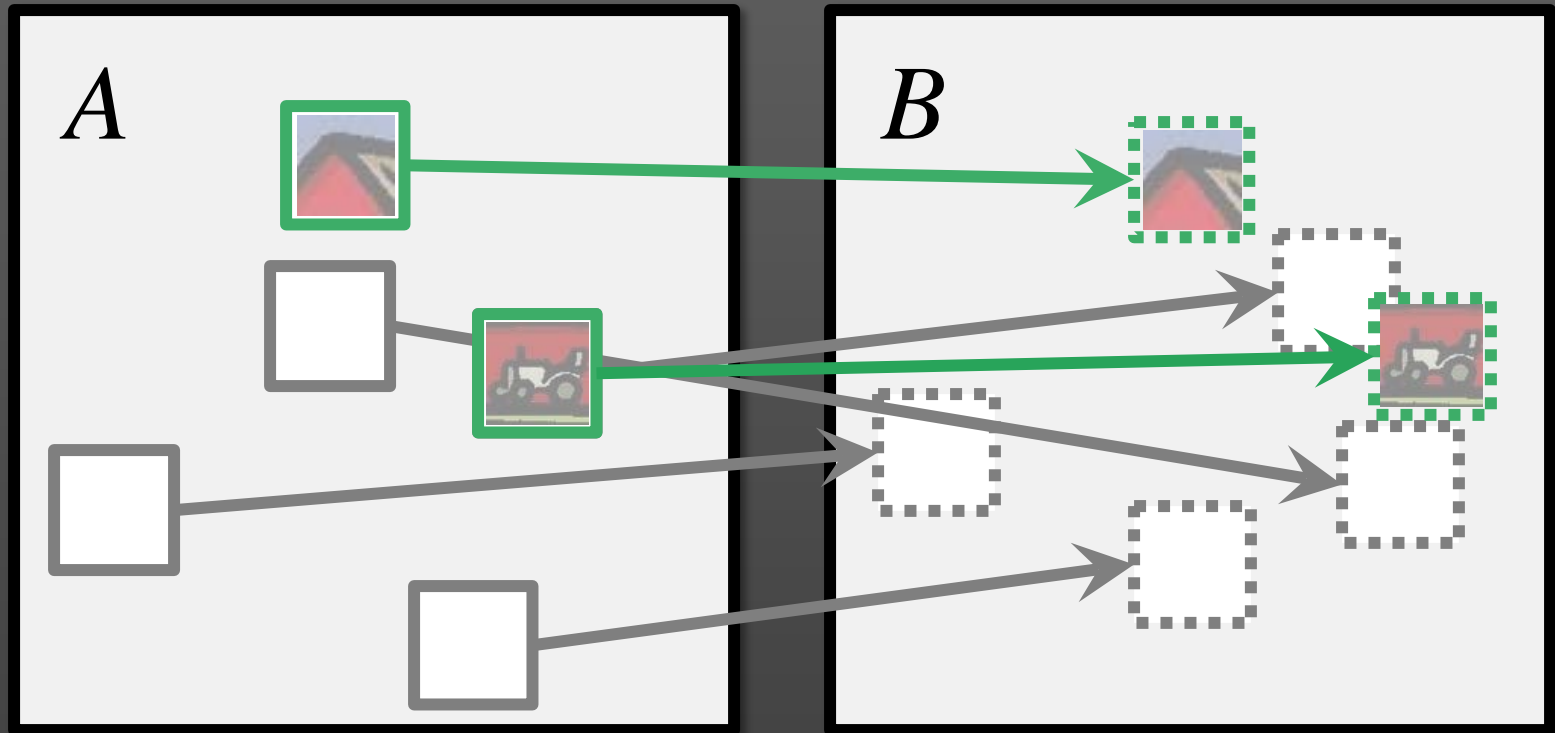
Intuition for PatchMatch



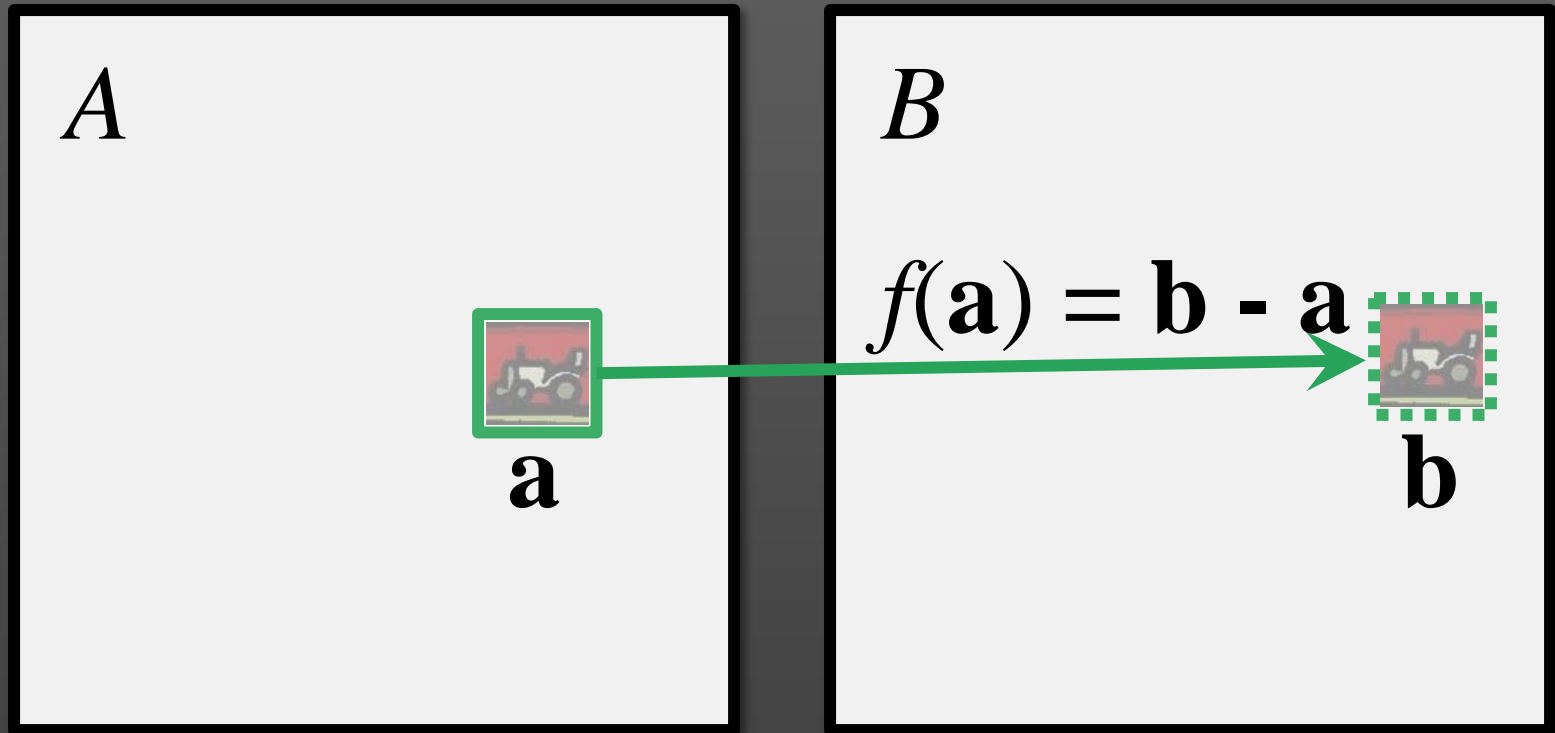
Intuition for PatchMatch



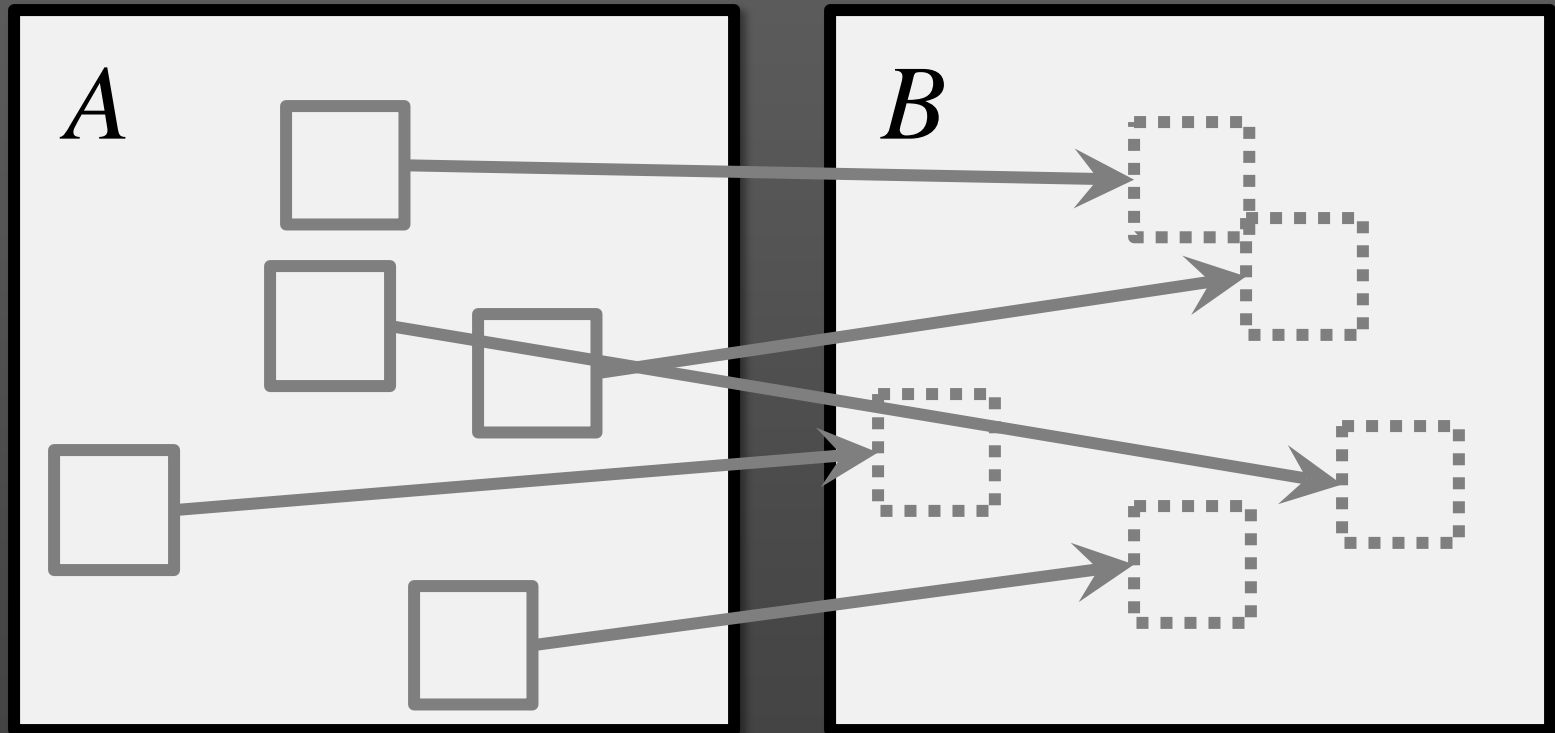
Intuition for PatchMatch



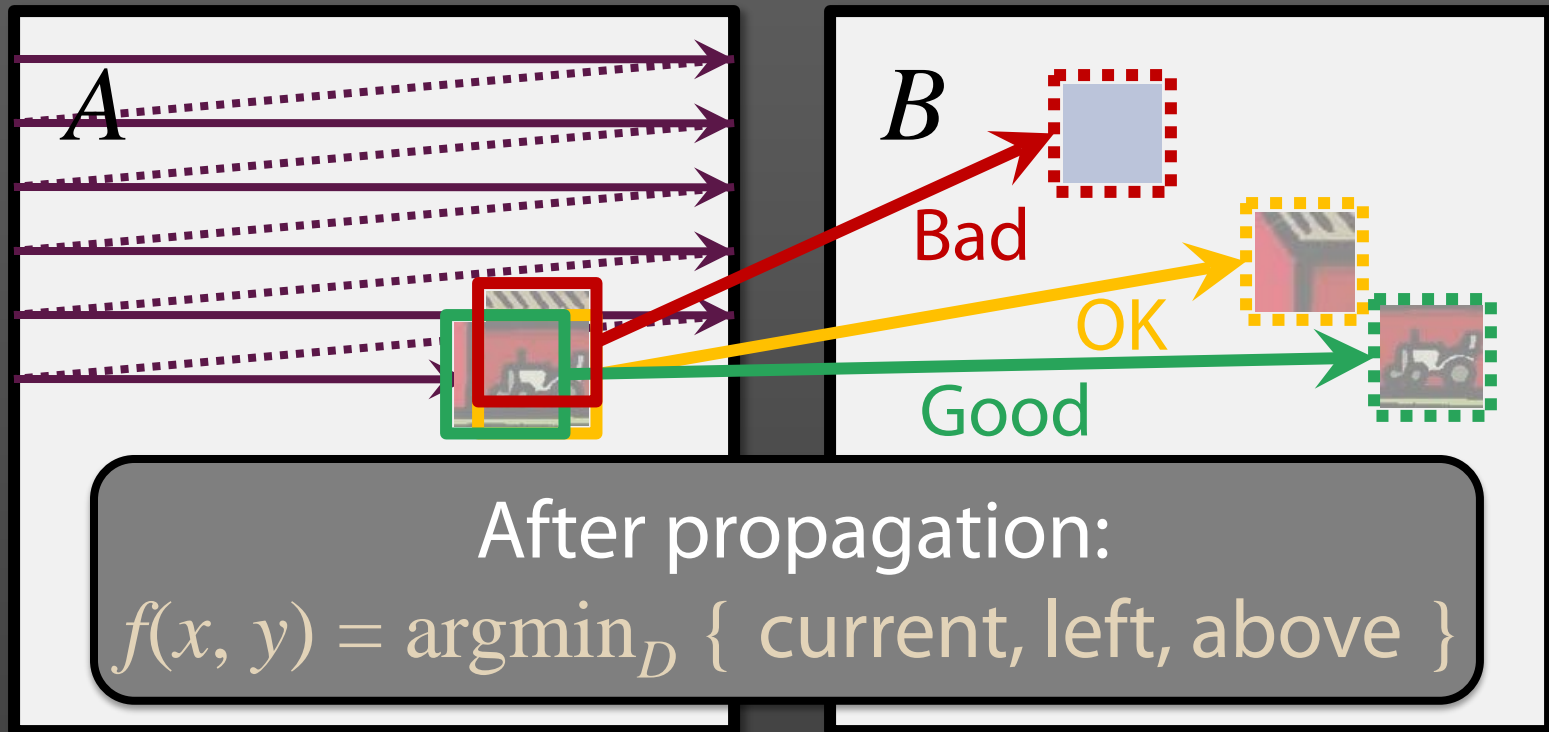
Nearest Neighbor Field



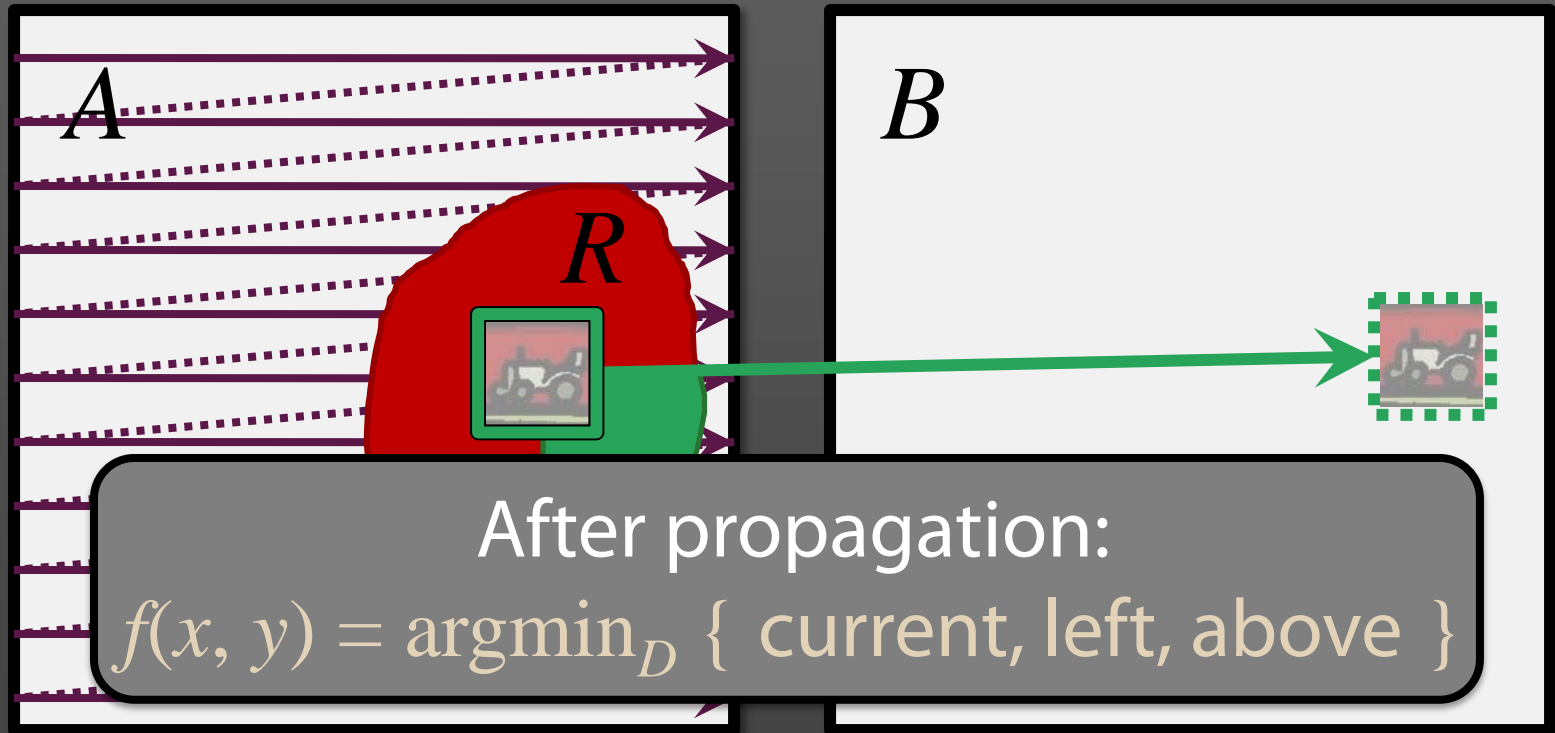
Random Initialization



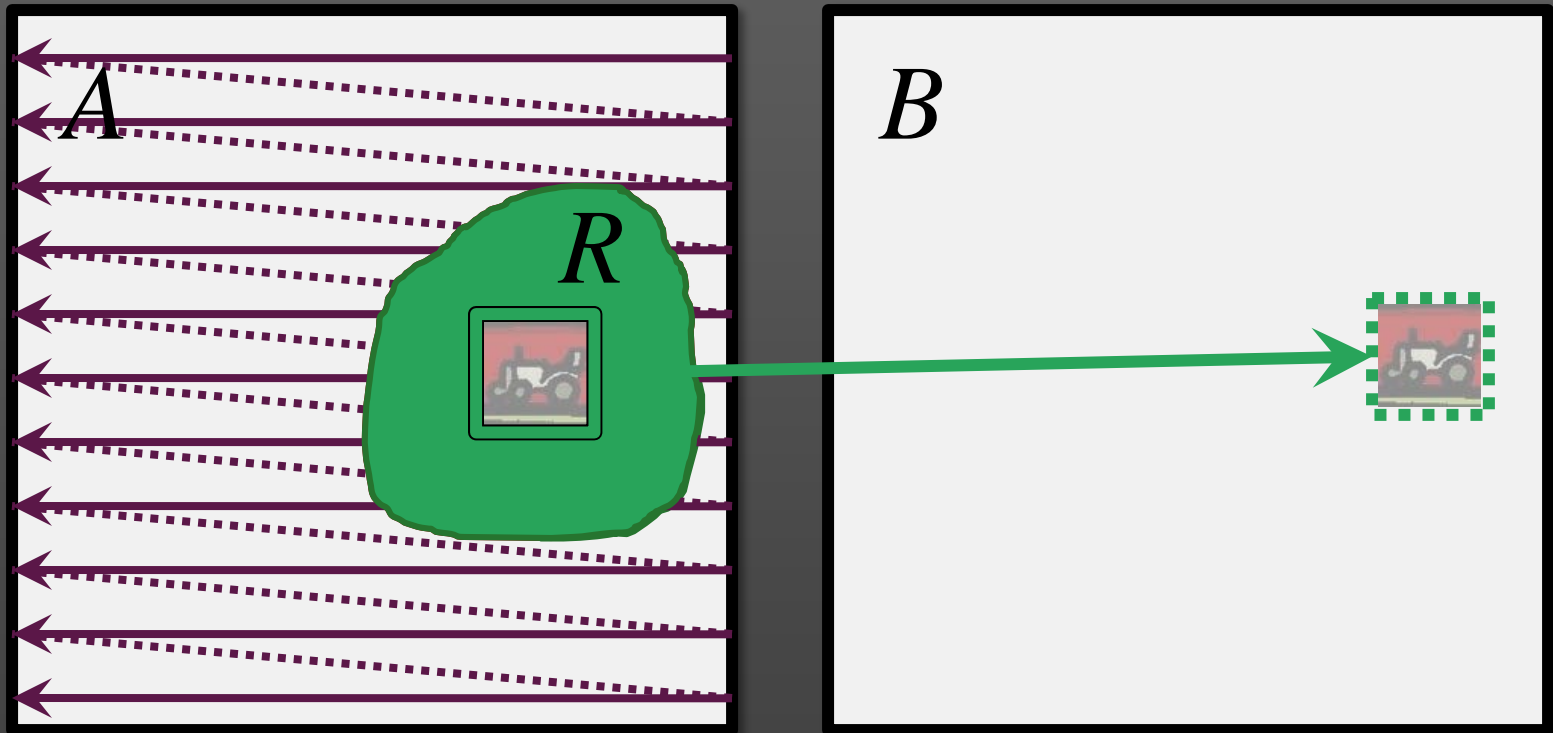
Propagation



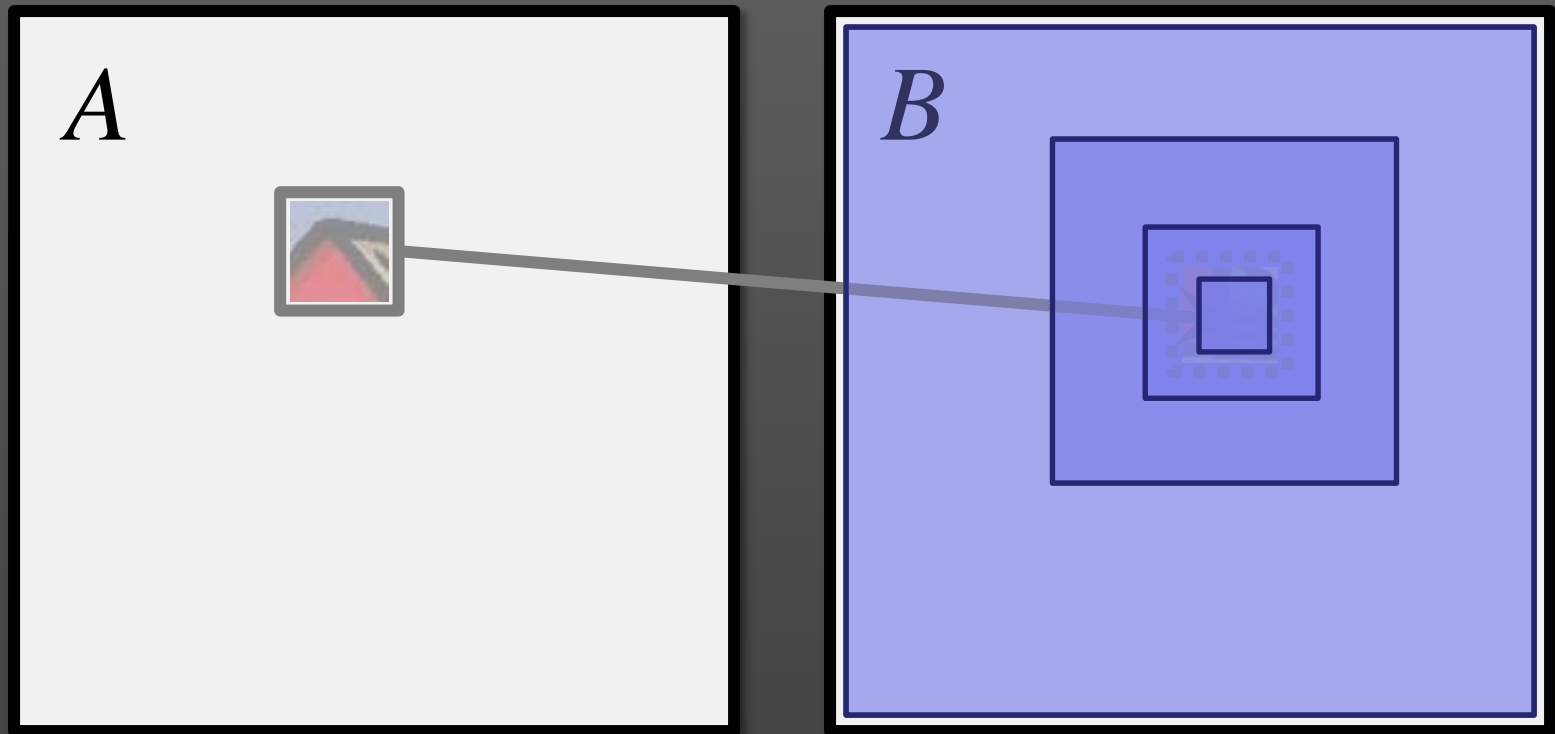
Propagation



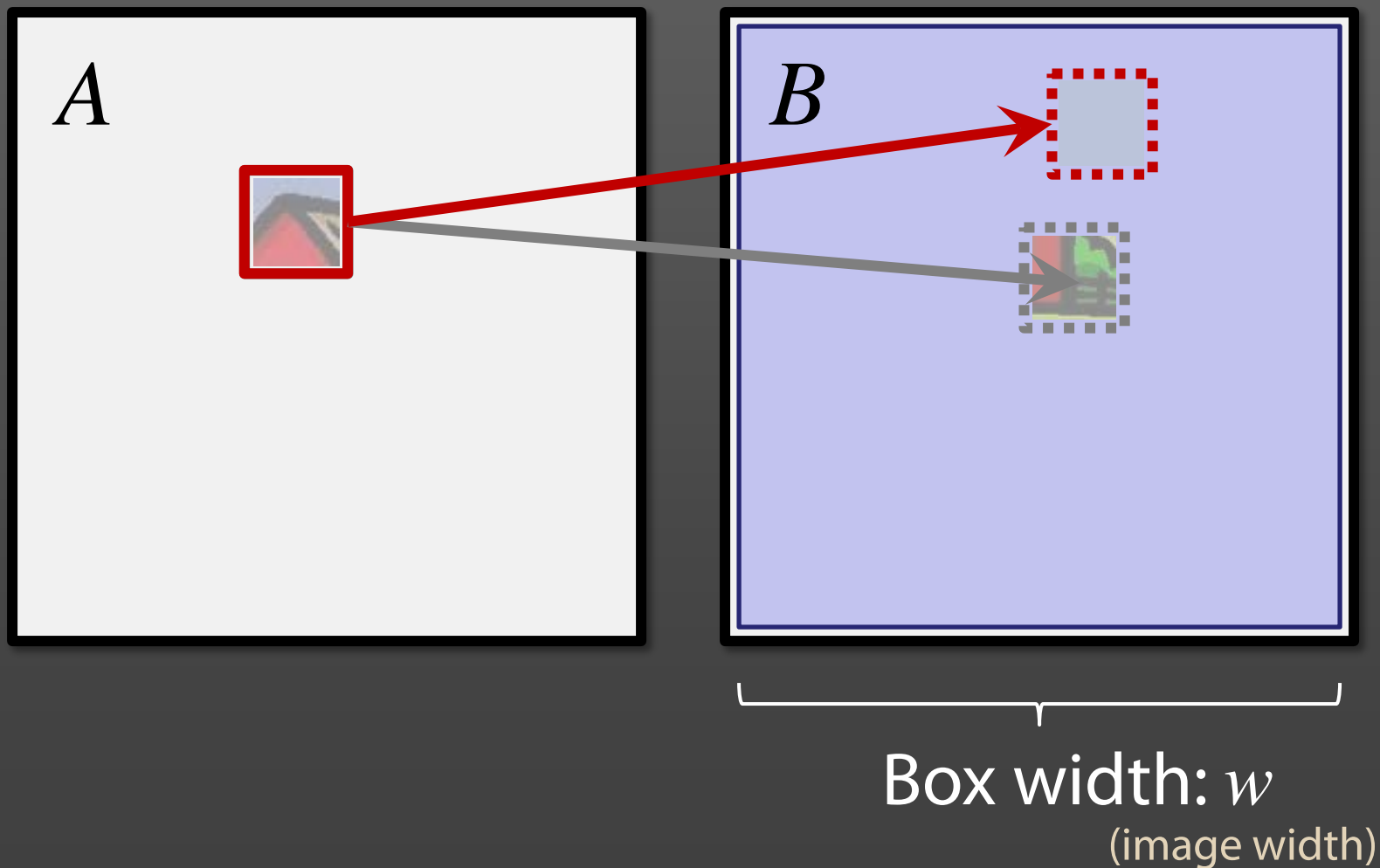
Propagation



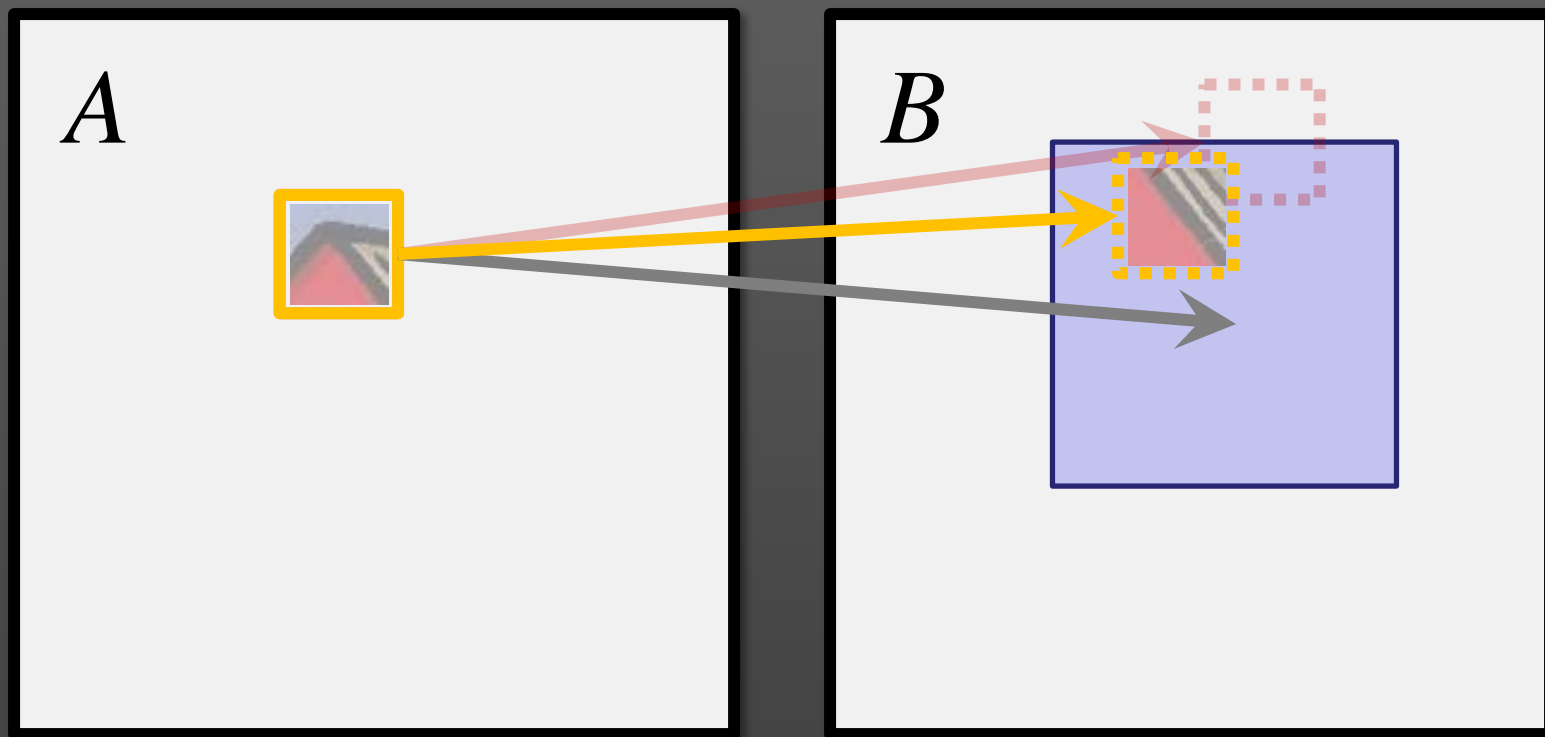
Random Search



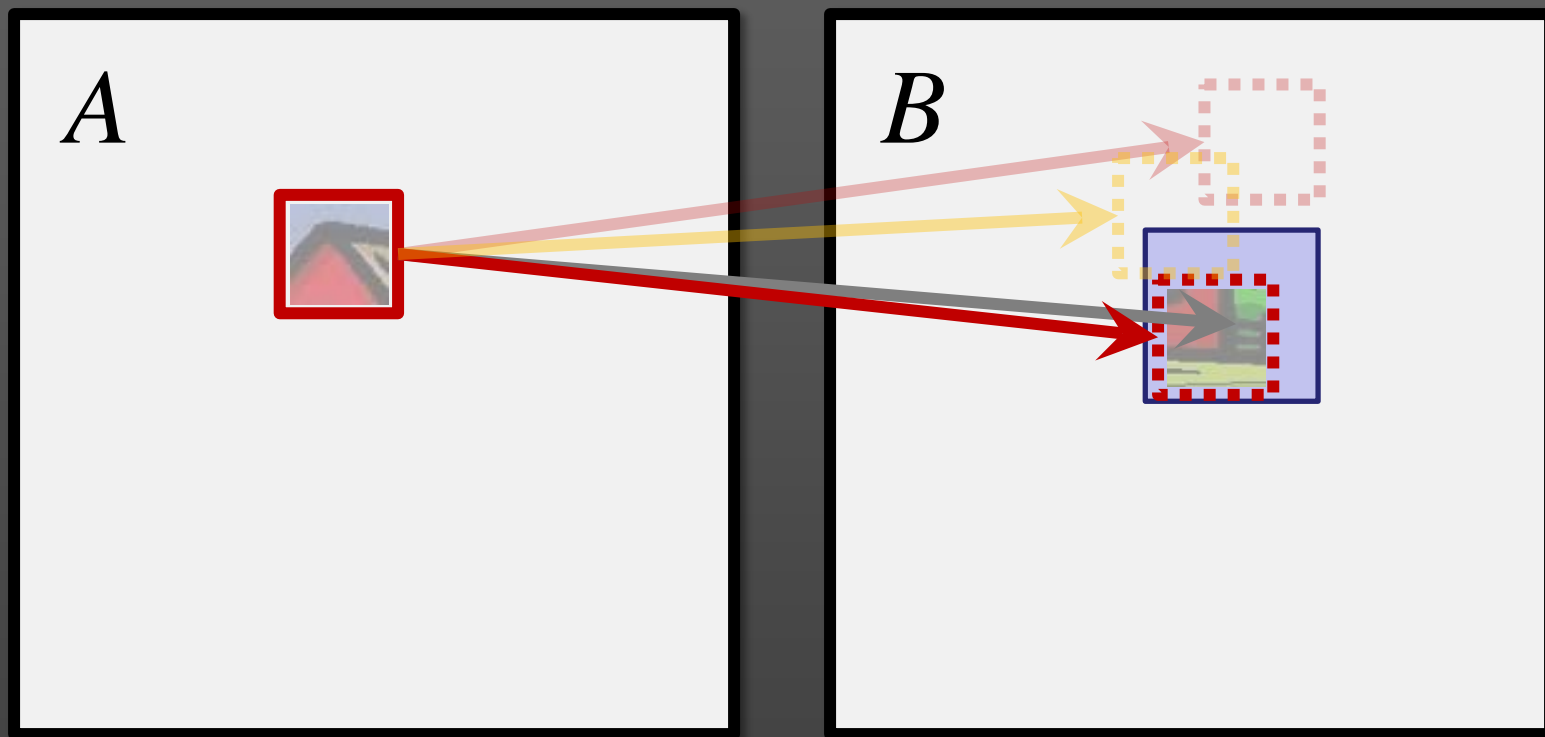
Random Search



Random Search

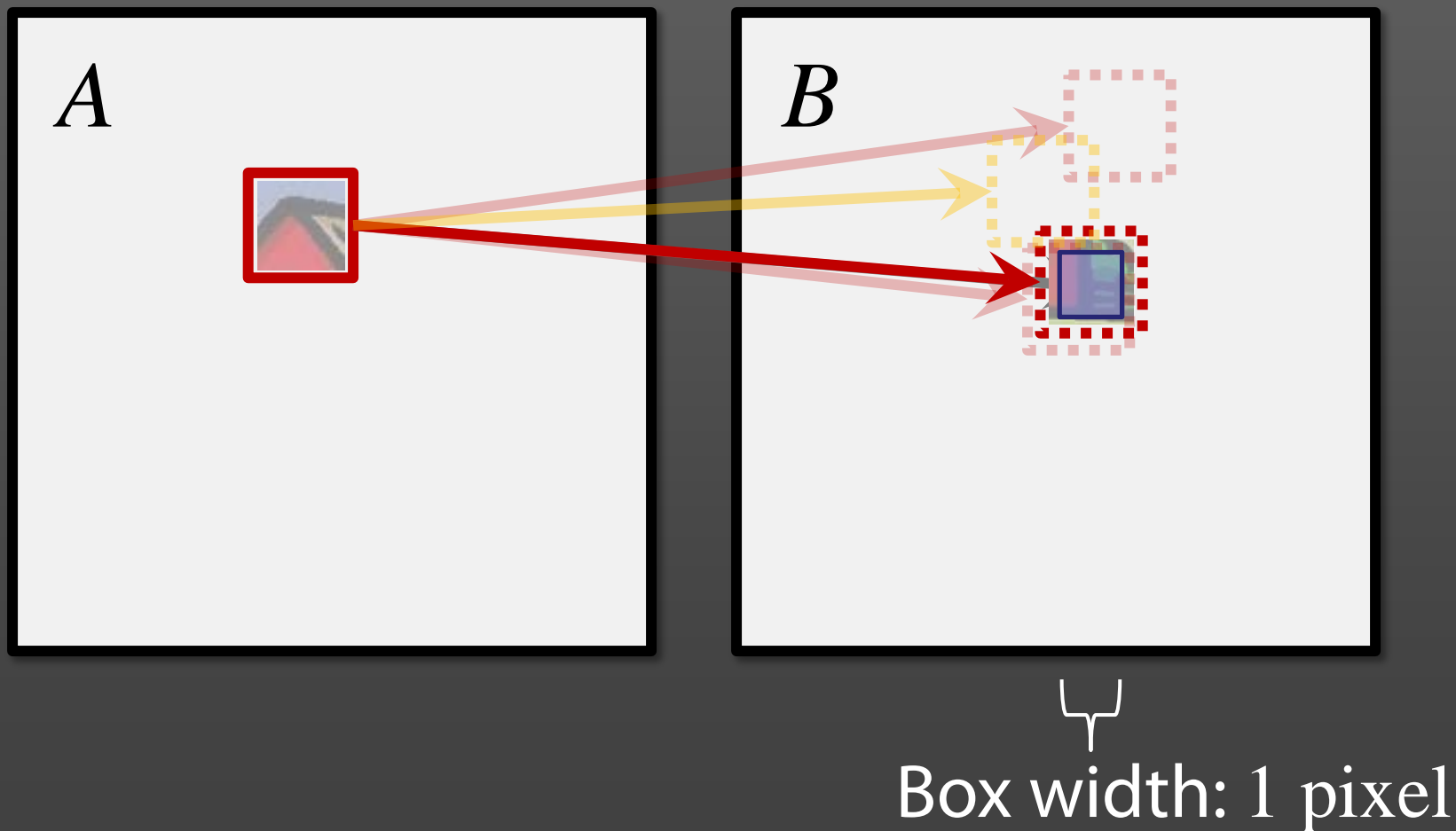


Random Search

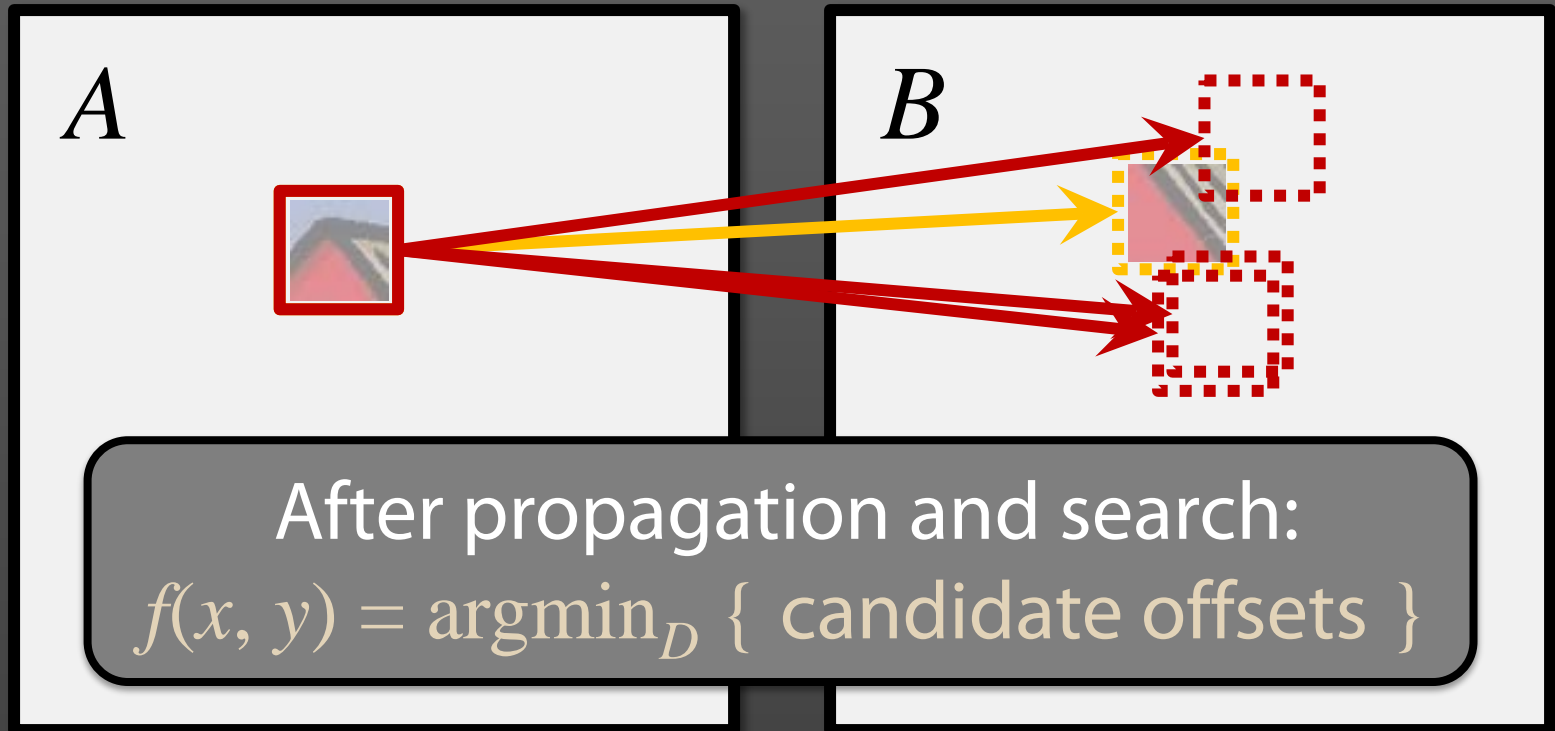


Box width: $\alpha^2 w$

Random Search



Propagation and Search



Propagation Only



Image A



Image B

First
Pass



Correspondence Vectors
(red: x, blue: y)



Reconstruction of image A
using patches from image B

Propagation Only

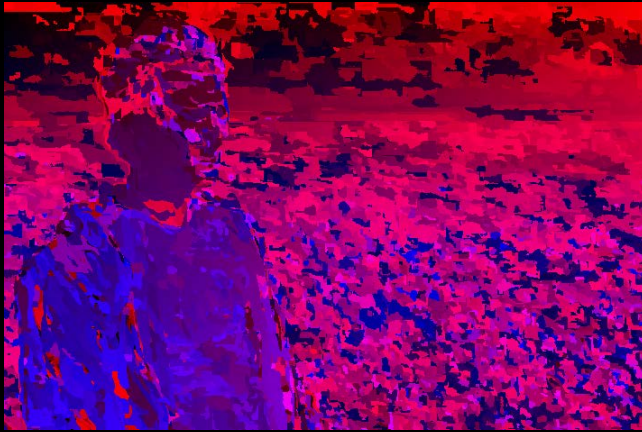


Image A



Image B

Second
Pass



Correspondence Vectors
(red: x, blue: y)



Reconstruction of image A
using patches from image B

Propagation Only

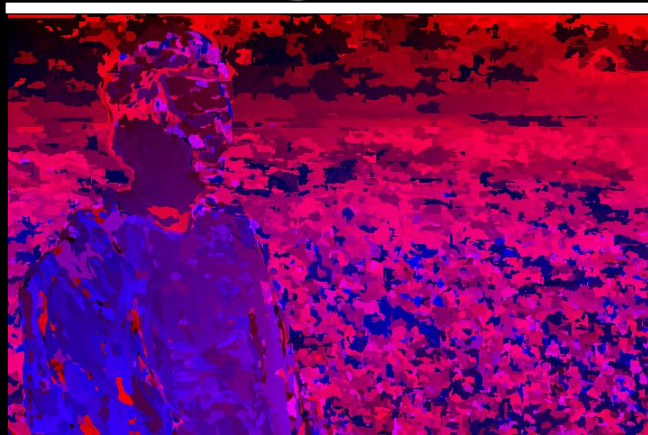


Image A



Image B

Third
Pass



Correspondence Vectors
(red: x, blue: y)



Reconstruction of image A
using patches from image B

Random Search Only

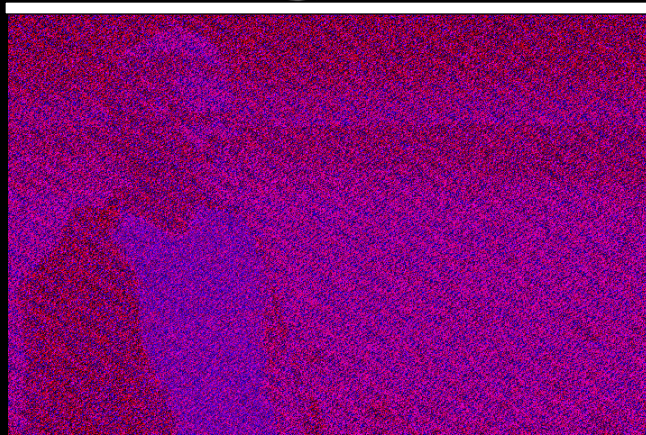


Image A



Image B

First
Pass



Correspondence Vectors
(red: x, blue: y)



Reconstruction of image A
using patches from image B

Random Search Only

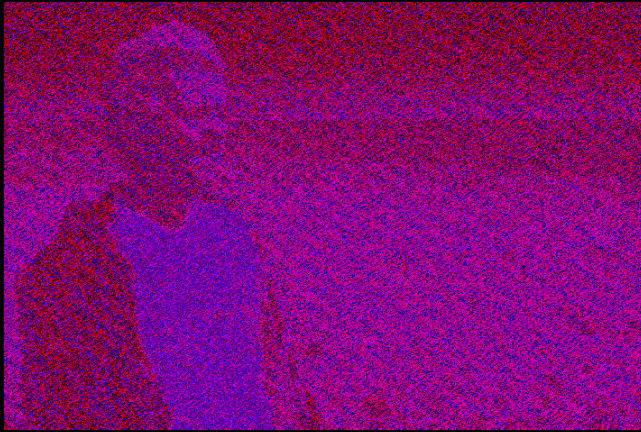


Image A



Image B

Second
Pass



Correspondence Vectors
(red: x, blue: y)



Reconstruction of image A
using patches from image B

Random Search Only

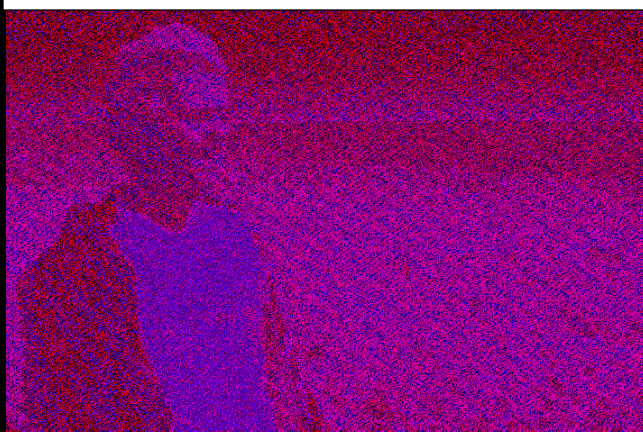


Image A



Image B

Third
Pass



Correspondence Vectors
(red: x, blue: y)



Reconstruction of image A
using patches from image B

Convergence

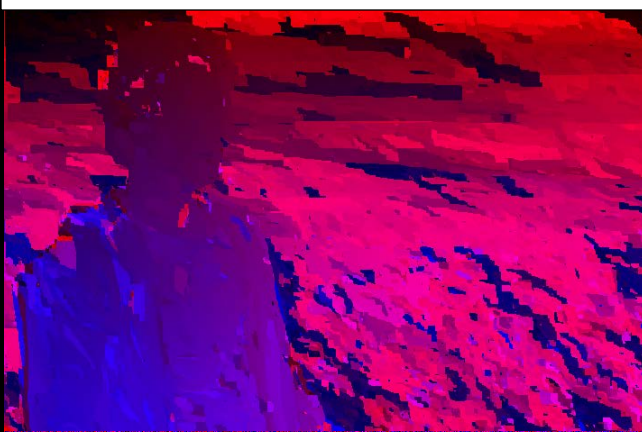


Image A



Image B

First
Pass



Correspondence Vectors
(red: x, blue: y)



Reconstruction of image A
using patches from image B

Convergence



Propagation



Random
Search



PatchMatch



Ground
Truth

Convergence



Iteration 1



Iteration 3

Third
Pass



Correspondence Vectors
(red: x, blue: y)



Reconstruction of image A
using patches from image B

Convergence



Image A



Image B

Fourth
Pass



Correspondence Vectors
(red: x, blue: y)



Reconstruction of image A
using patches from image B

Convergence



Image A



Image B

Fifth
Pass



Correspondence Vectors
(red: x, blue: y)

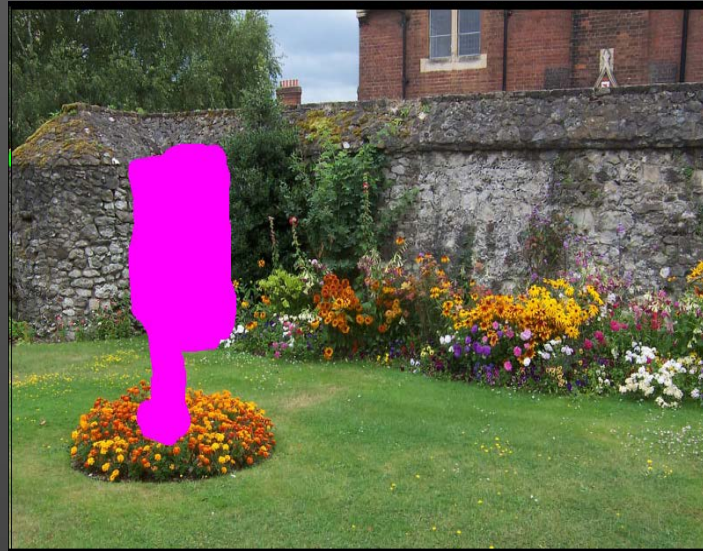


Reconstruction of image A
using patches from image B

Image Completion



Input



Hole

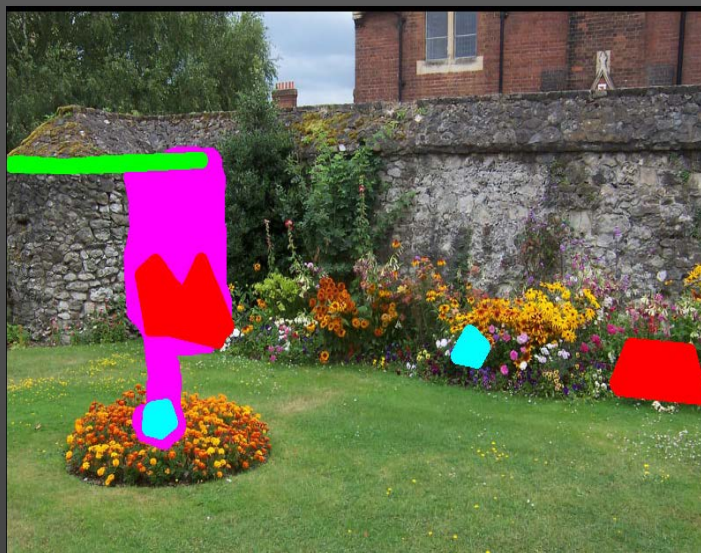


Output
(enlarged)

Image Completion



Input



Hole + constraints



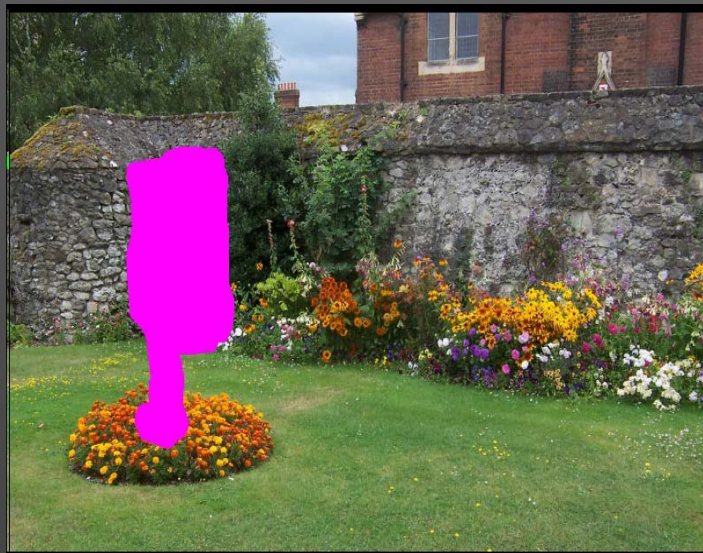
Output
(enlarged)

Image Completion

(without constraints)



Input



Hole



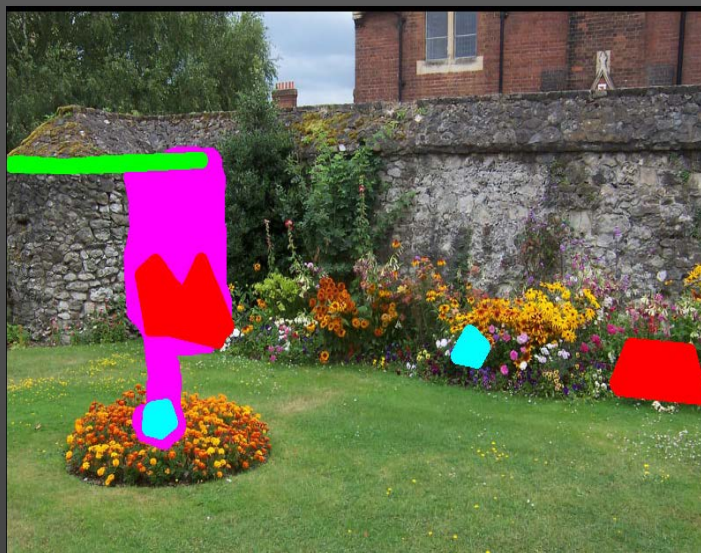
Output
(enlarged)

Image Completion

(with constraints)



Input

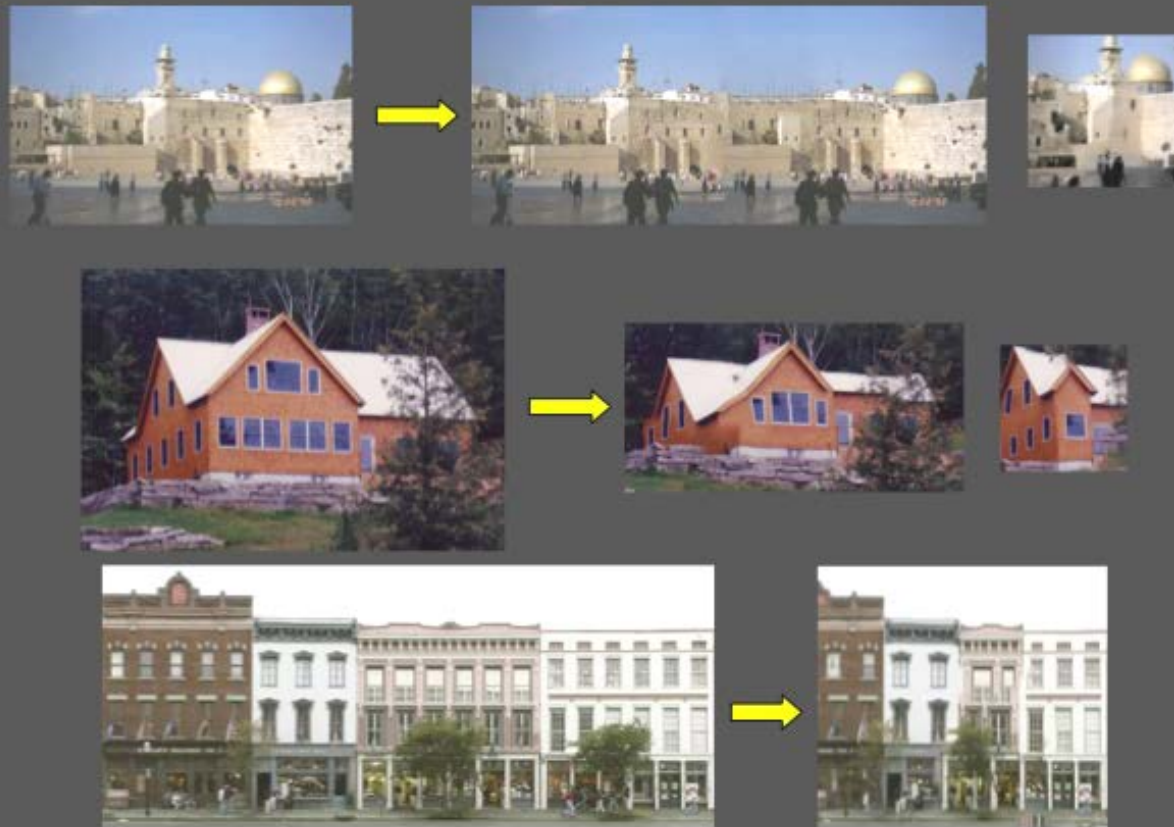


Hole + constraints



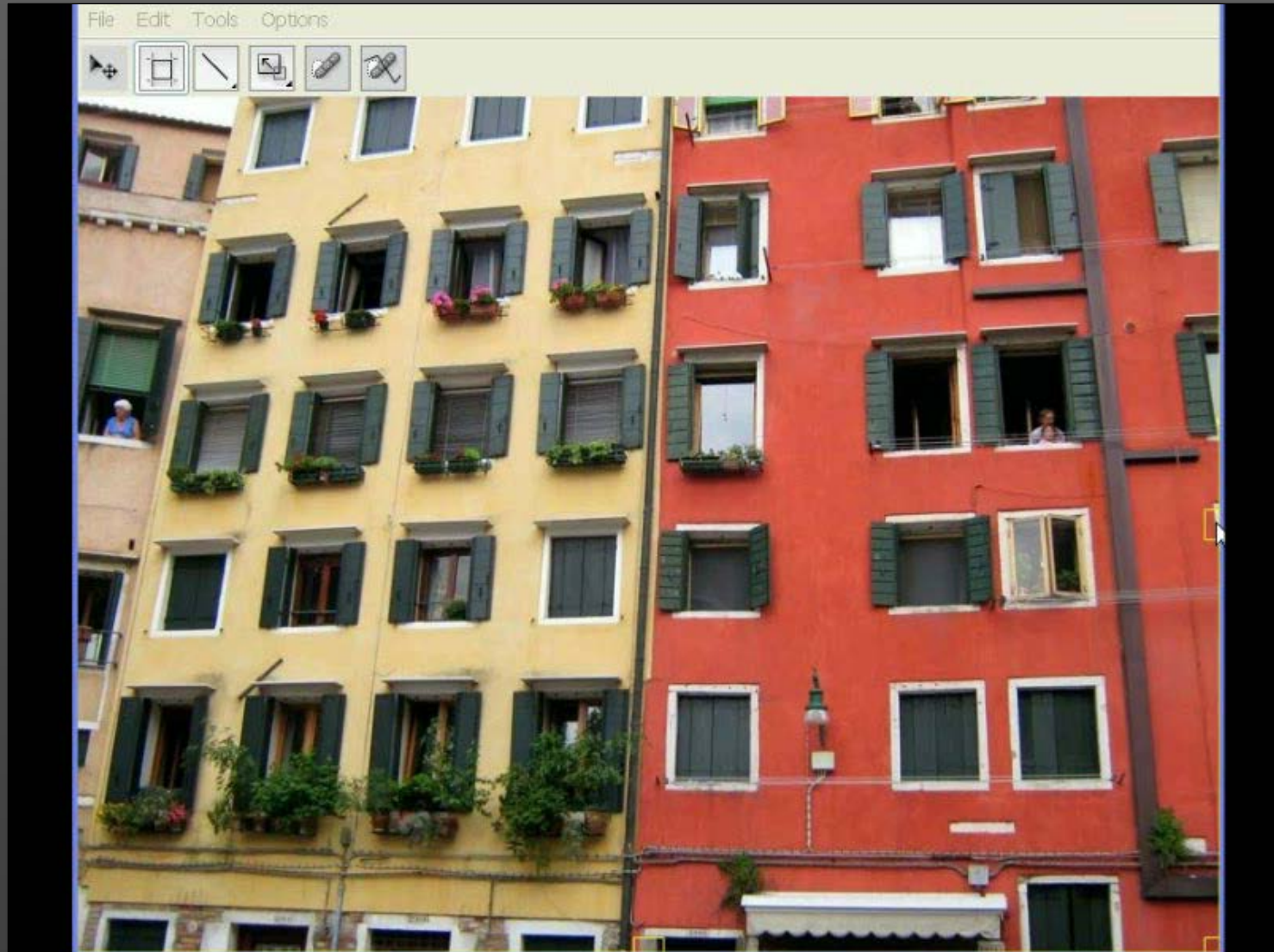
Output
(enlarged)

Retargeting / Reshuffling

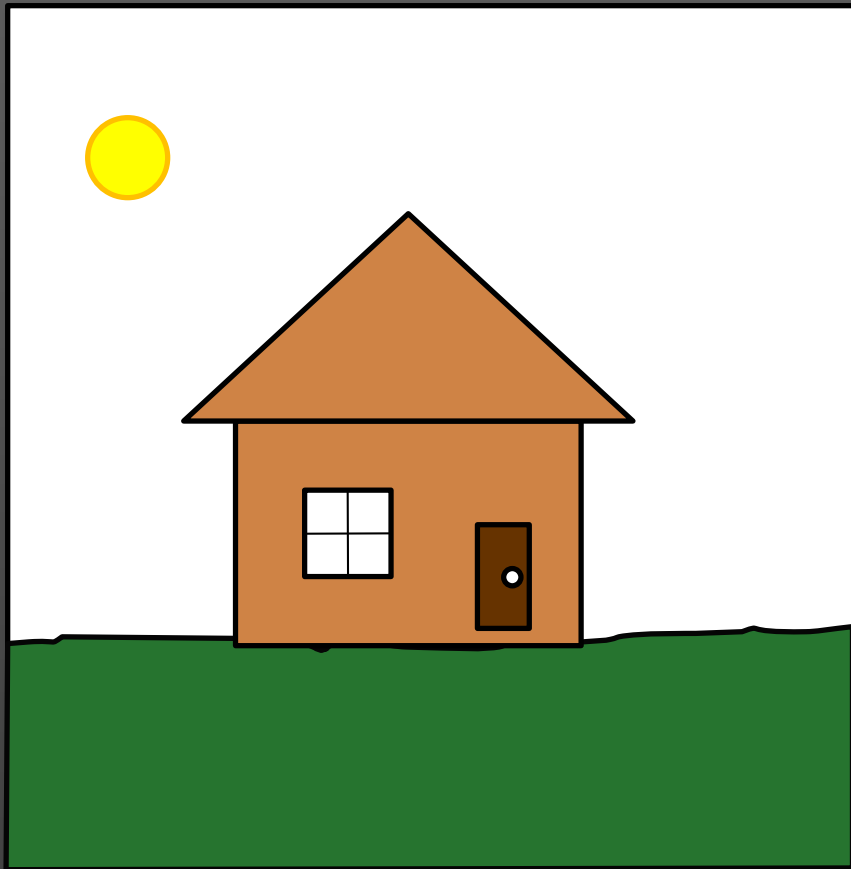


**Image retargeting [Simakov et al. '08]
(5 minutes per 250x200 input image)**

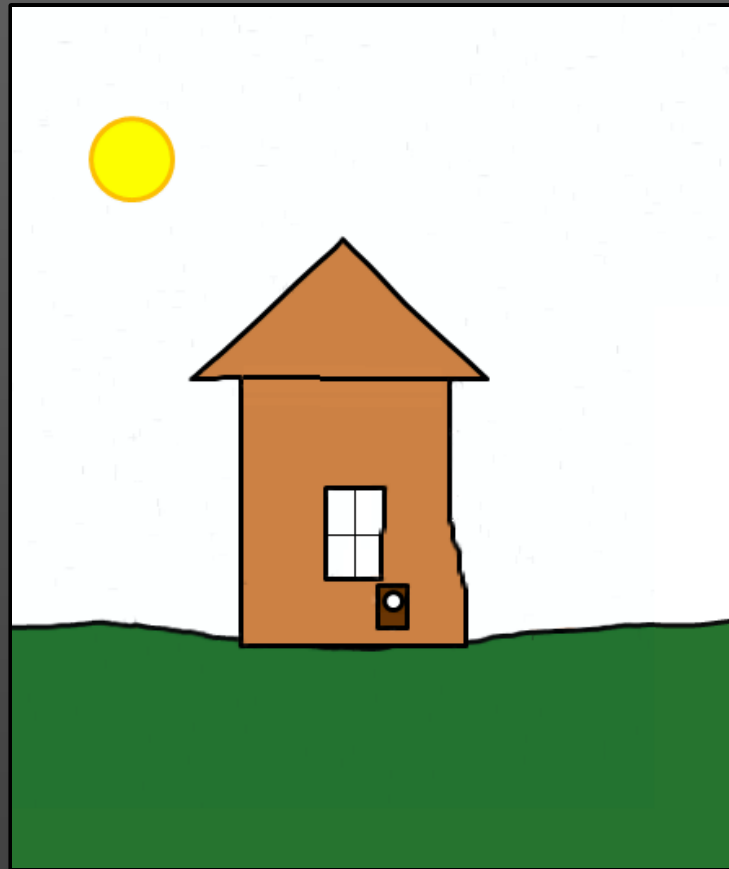
Deformation Constraints



Deformation Constraints

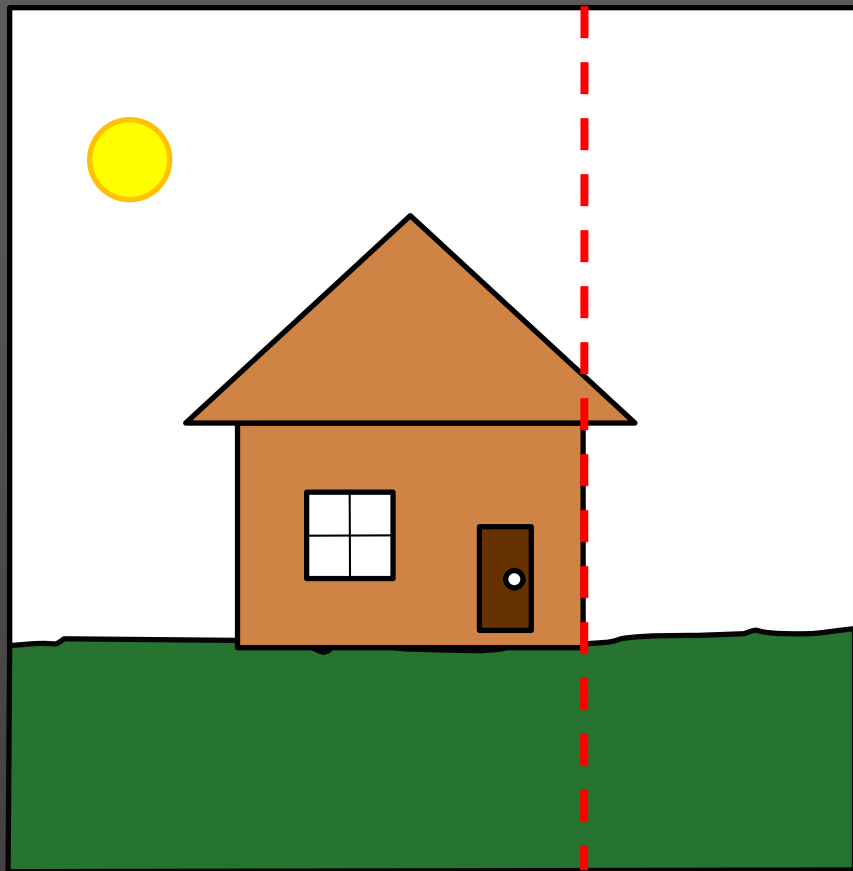


Input

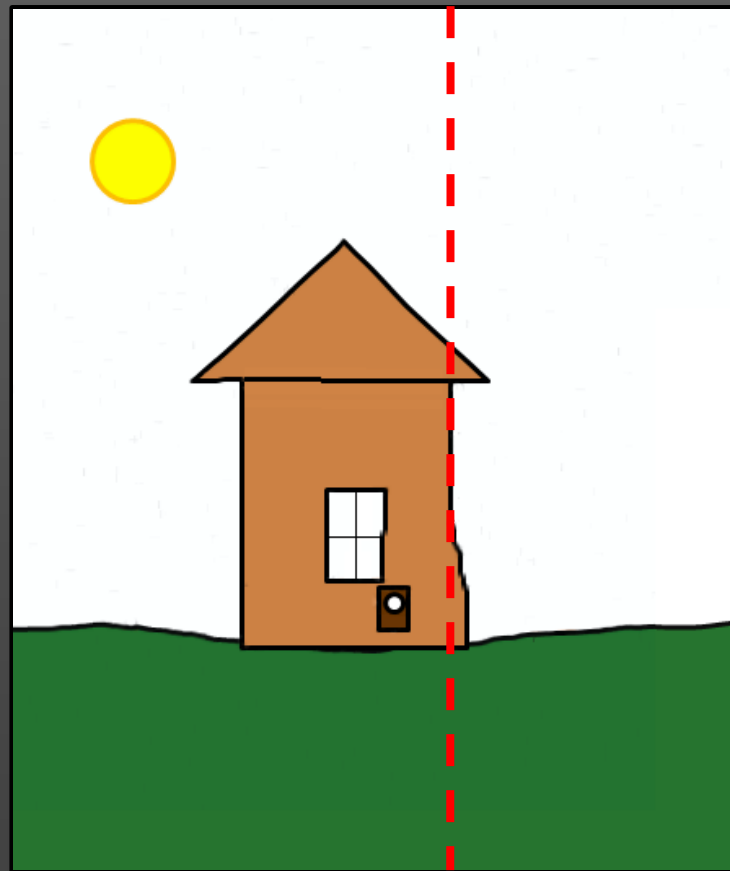


Partially retargeted

Deformation Constraints

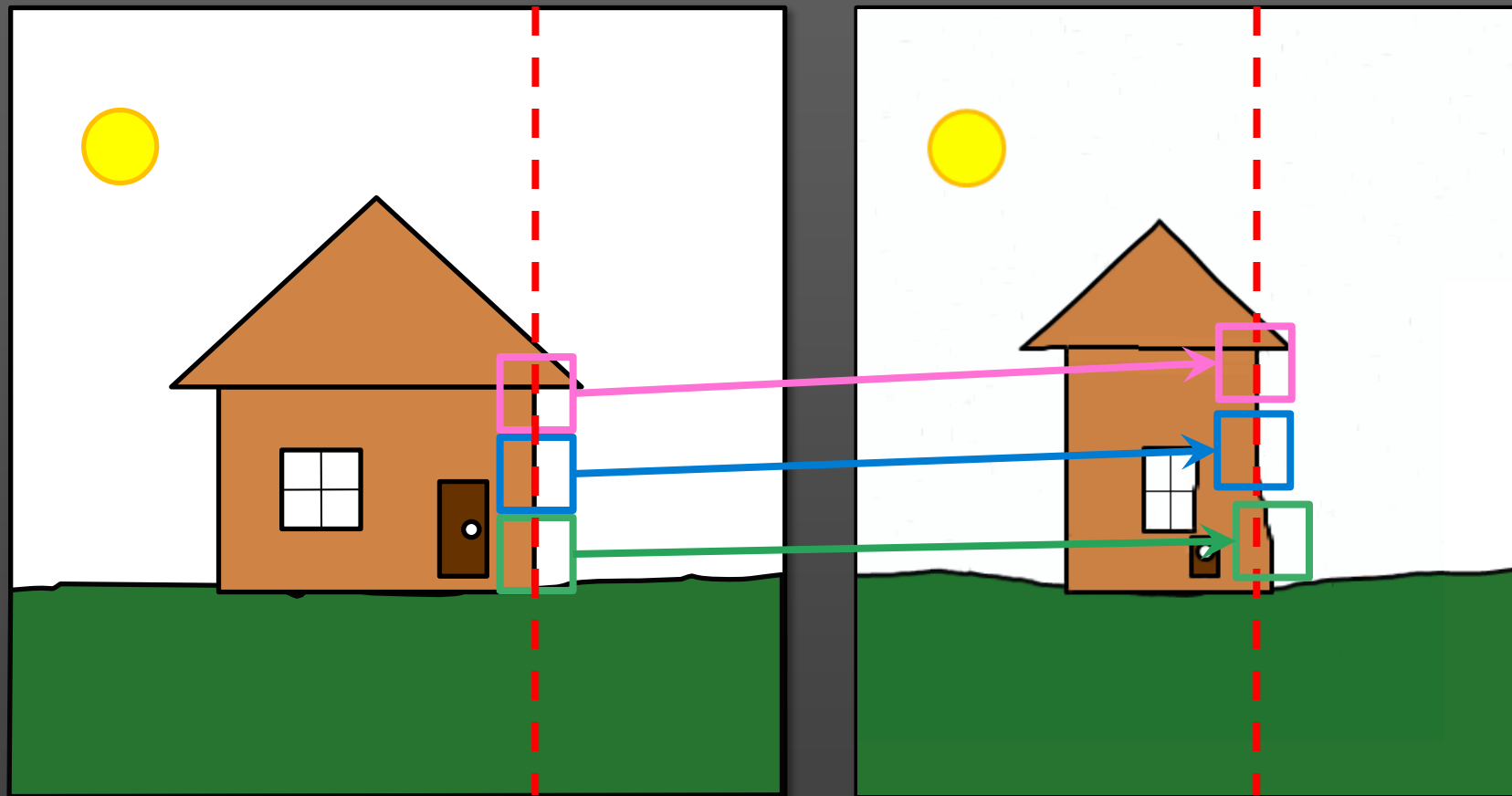


Input



Partially retargeted

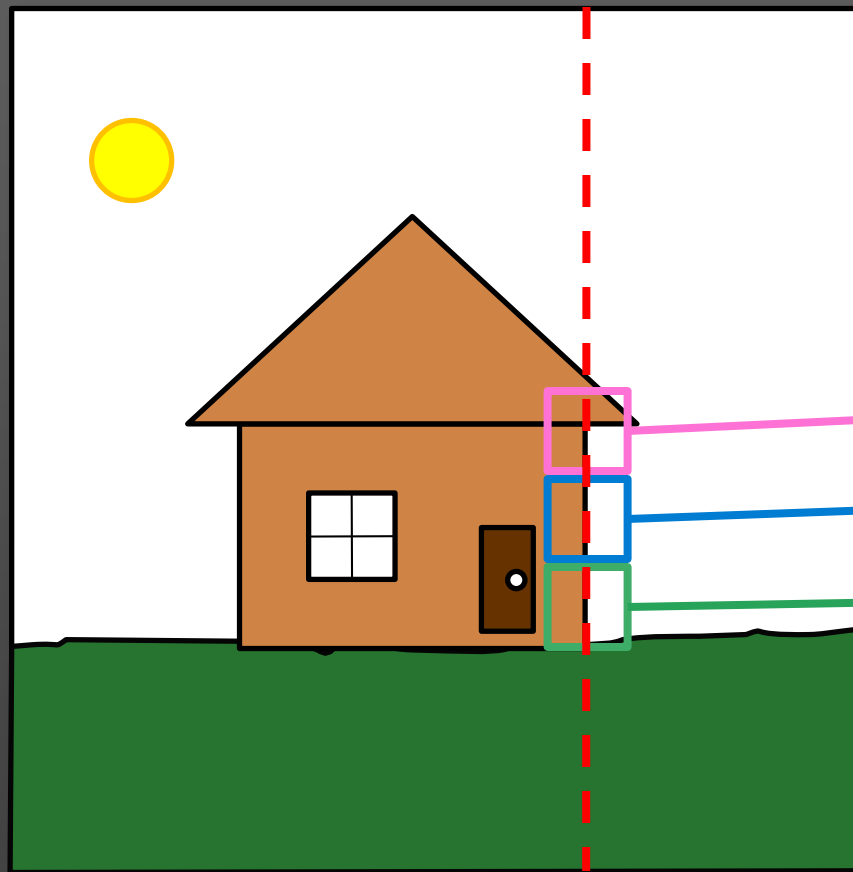
Deformation Constraints



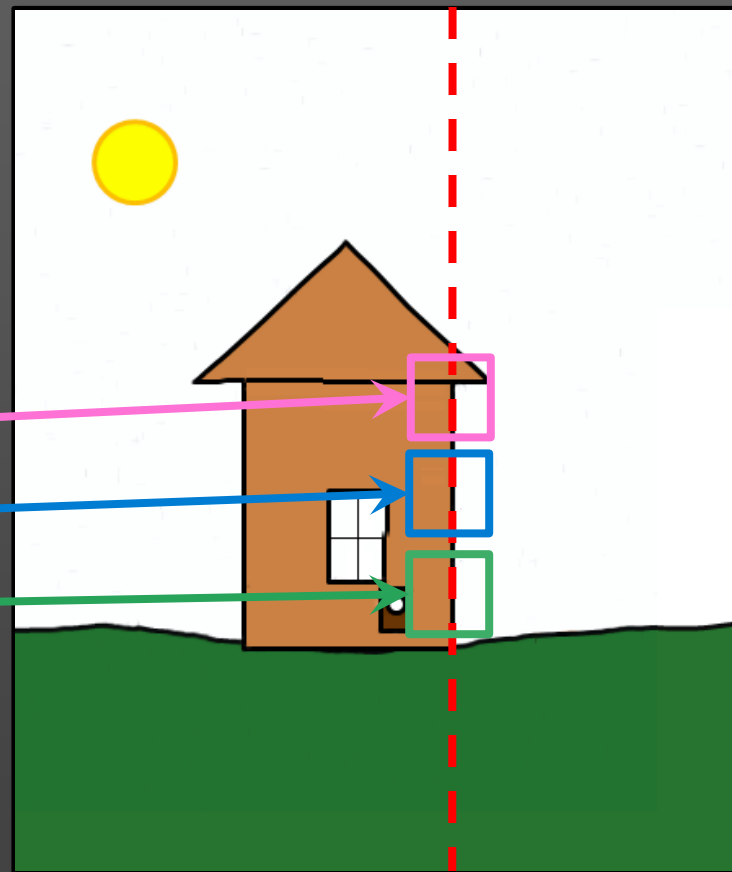
Input

Partially retargeted

Deformation Constraints

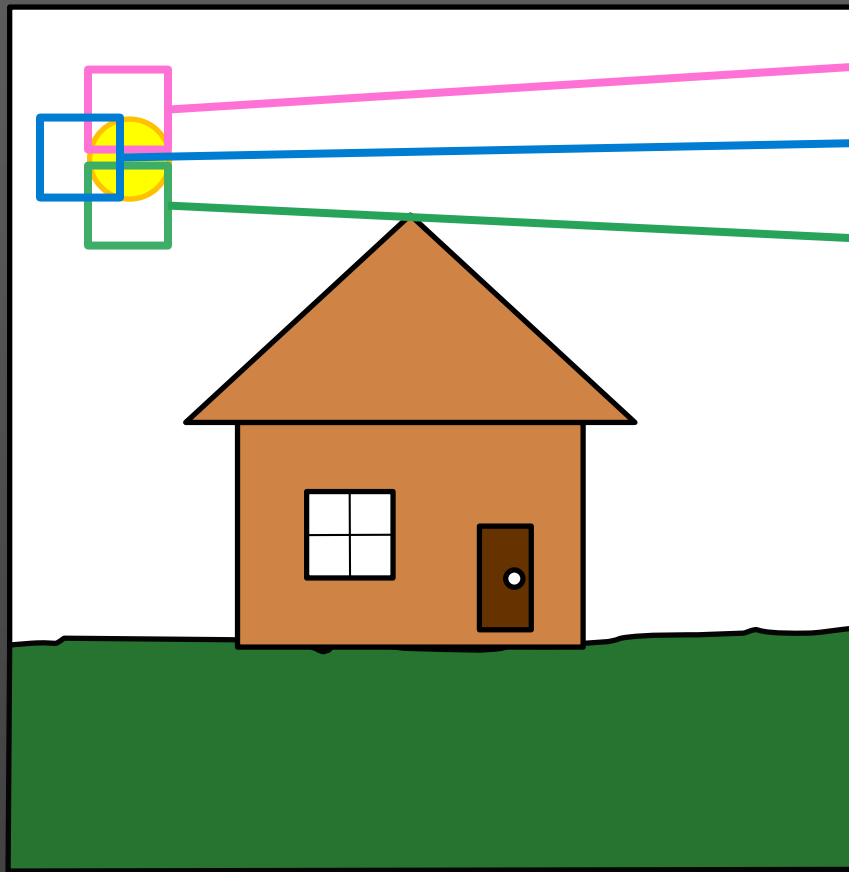


Input

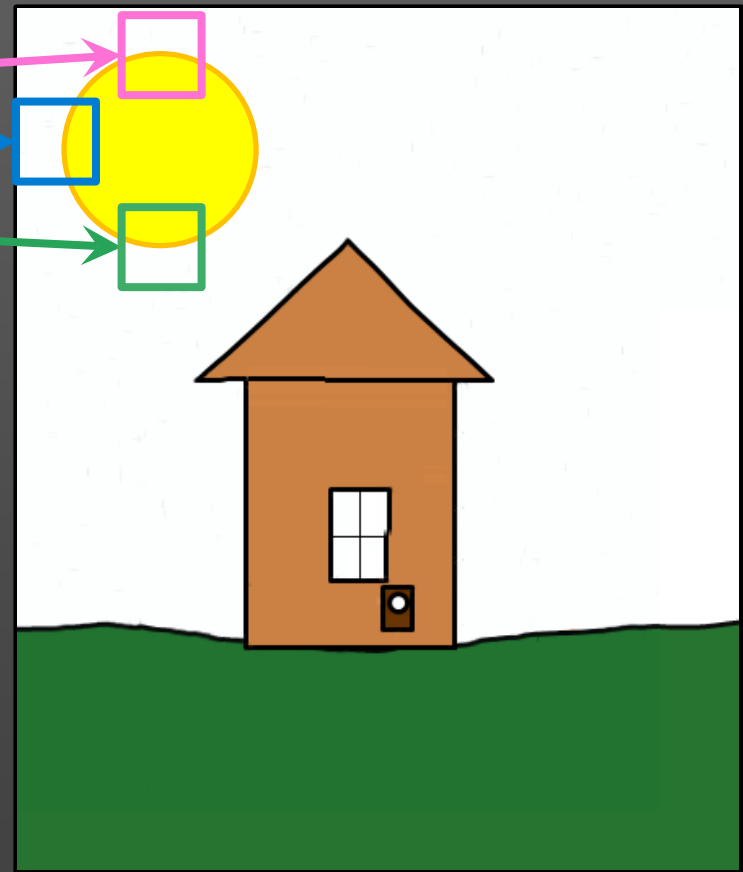


Partially retargeted

Deformation Constraints

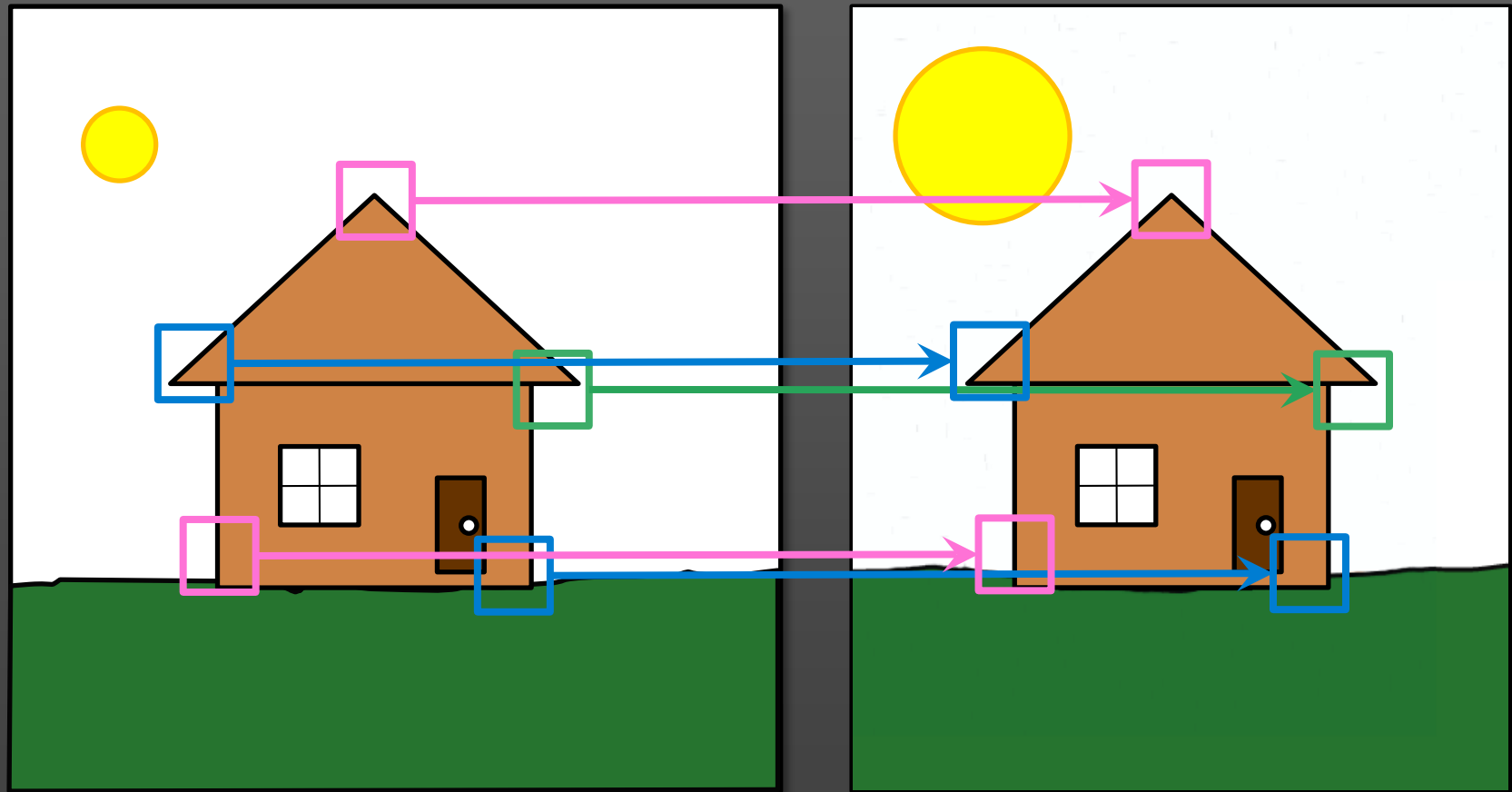


Input



Partially retargeted

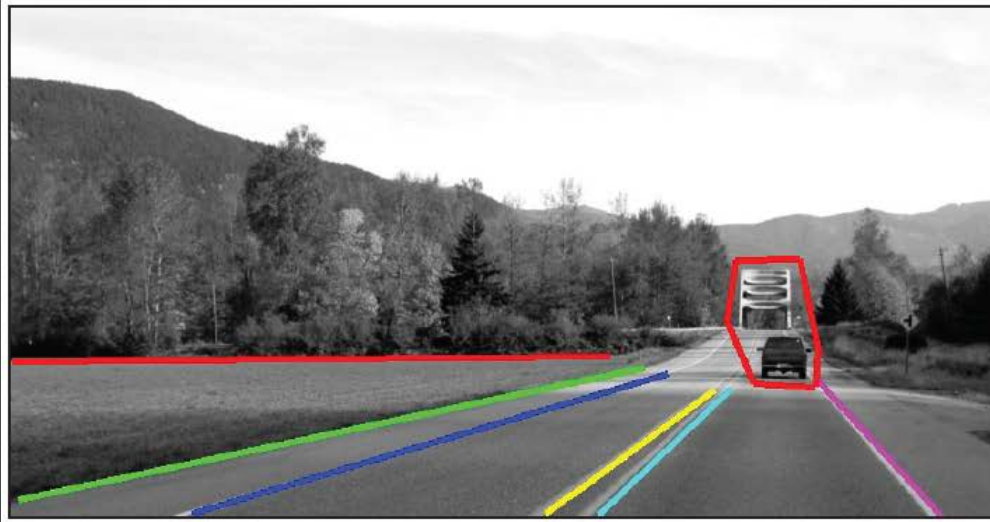
Deformation Constraints



Input

Partially retargeted

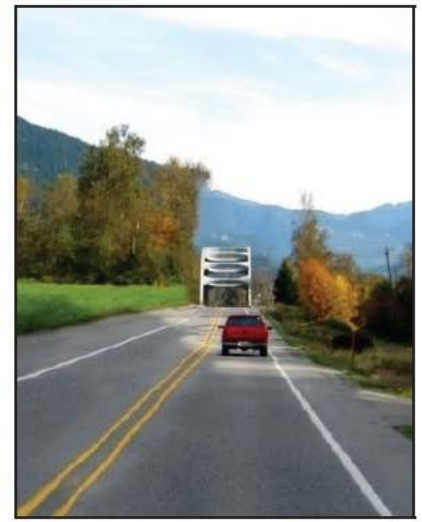
Line Constraints



Input



Improved
seam carving
[Rubinstein '08]



Our result

Region Constraints



Region Constraints



Original



Retargeted



With constraints

Reshuffling



Input



[Rubinstein '08]

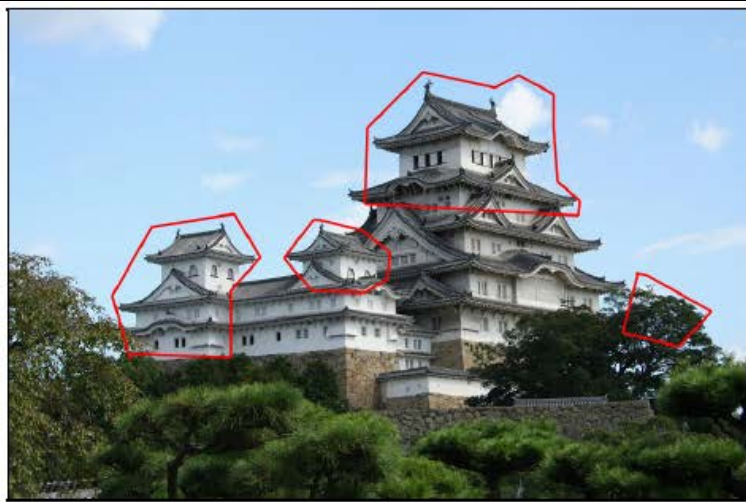


[Wang '08]



PatchMatch

Reshuffling



Input

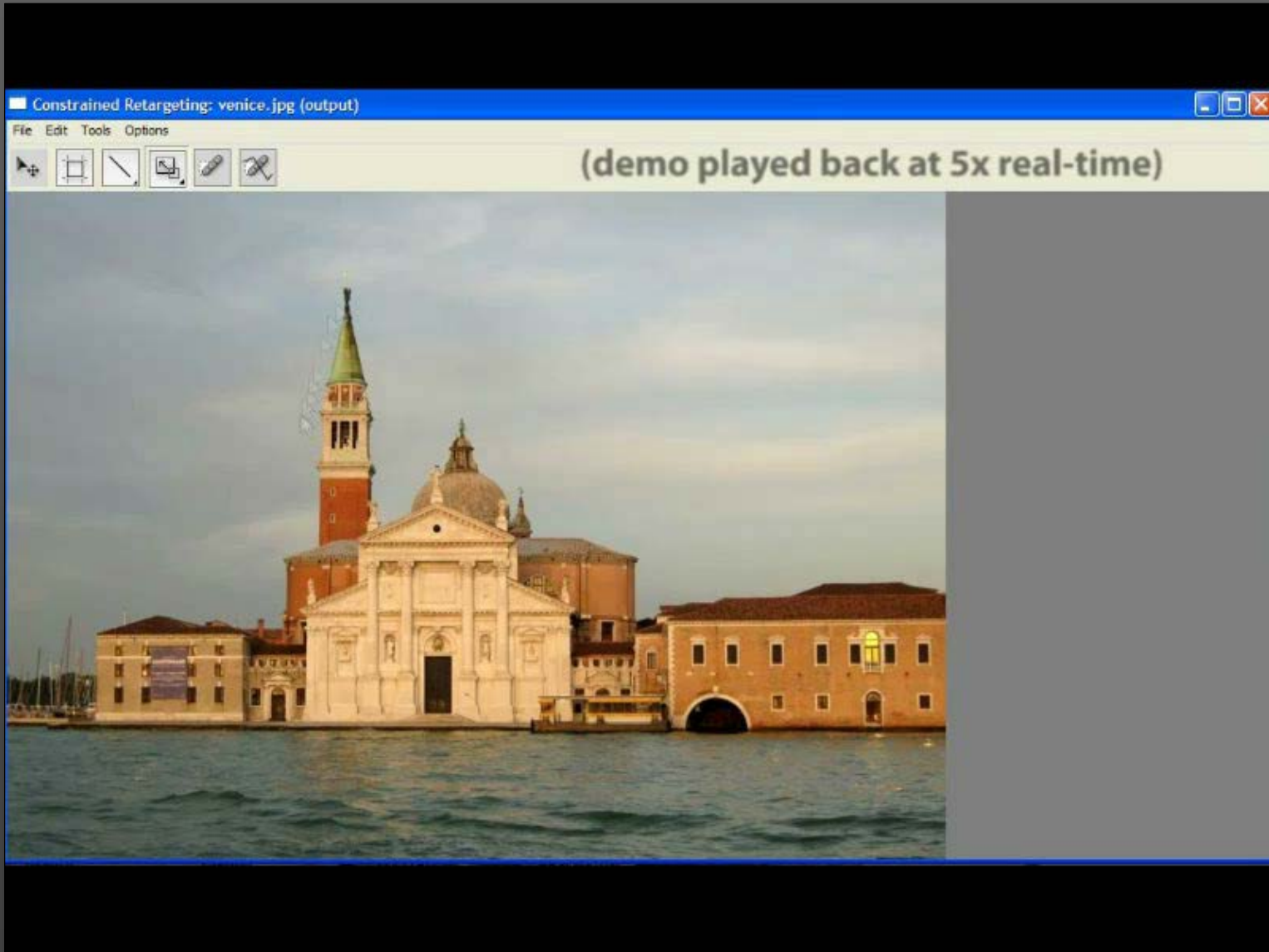


Enlarged



Reduced

Reshuffling



Local Scale



Boat marked by user



Scaled up, preserving texture



Tree marked by user



Scaled up, preserving texture

Demo

Limitations

- Poor convergence on pathological inputs
- Limits on scaling/rotation



Image A

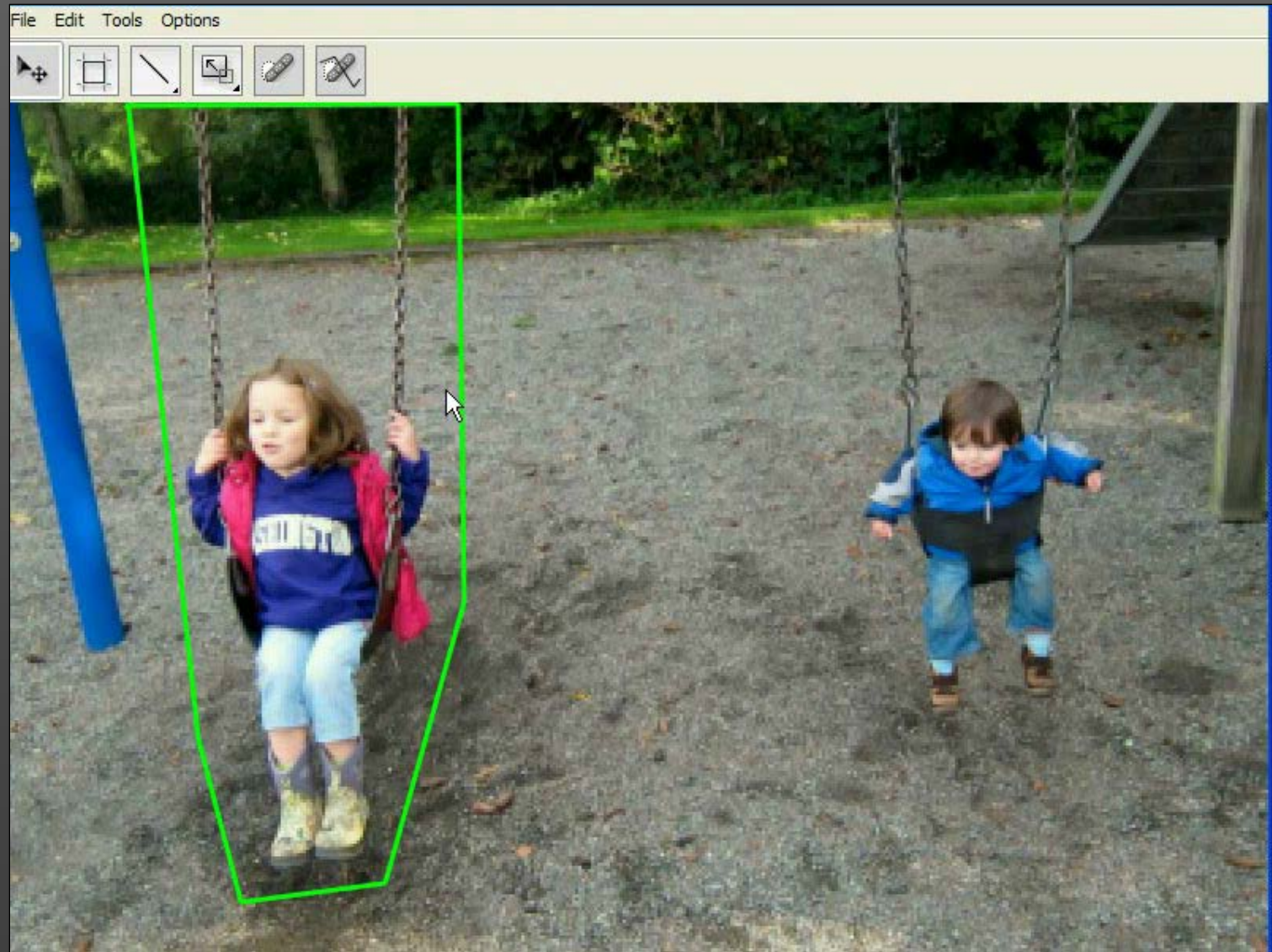


Image B



Reconstruction of A
from patches of B

Summary of Contributions



Future Work

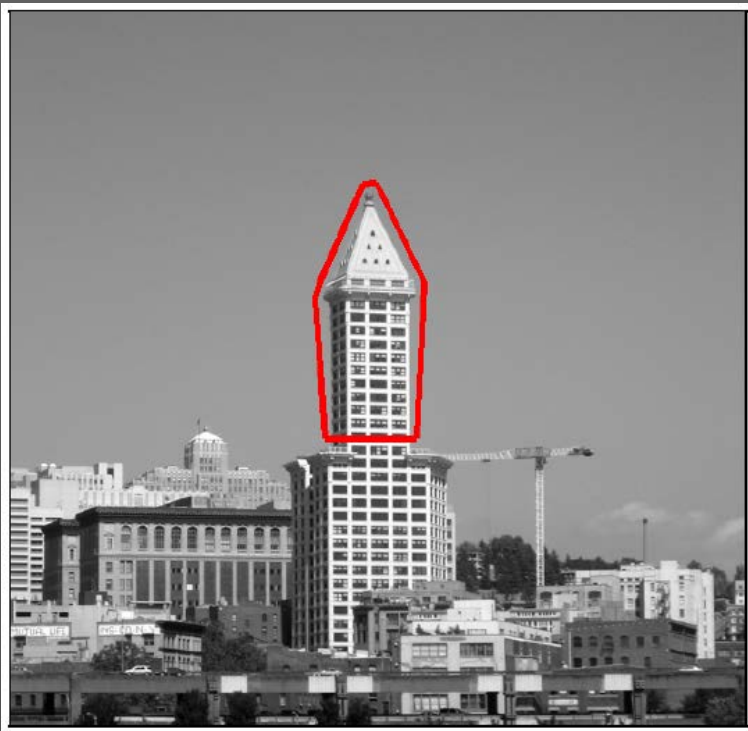
Graphics – collages, video, new view synthesis, 3D

Vision – denoising, super-res, segmentation, object detection/recognition, irregularity detection

Algorithm – extend to other domains, GPU, ...

Acknowledgements

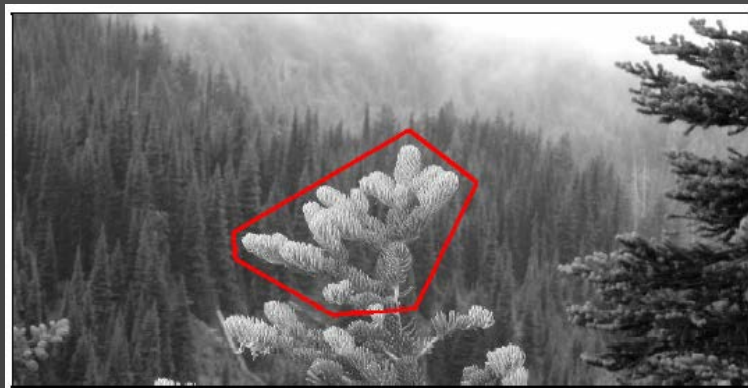
- Sponsored in part by:
 - Adobe Systems
 - NSF grant IIS-0511965
- Thanks to:
 - SIGGRAPH paper reviewers
 - Tiggraph and Adobe CTL retreat reviewers
 - Jon Goldman, film footage from *Kind of a Blur*
 - Flickr users for Creative Commons imagery:
Sevenbrane, Wili, Moi of Ra, Celie



Building marked by user



Scaled up, preserving texture

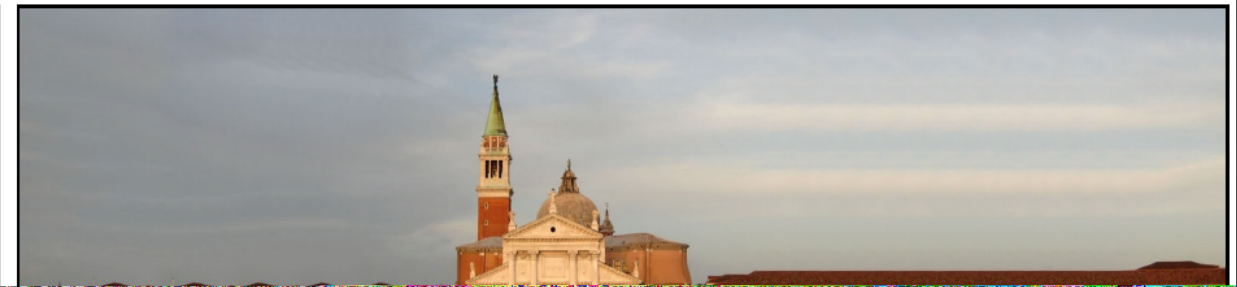


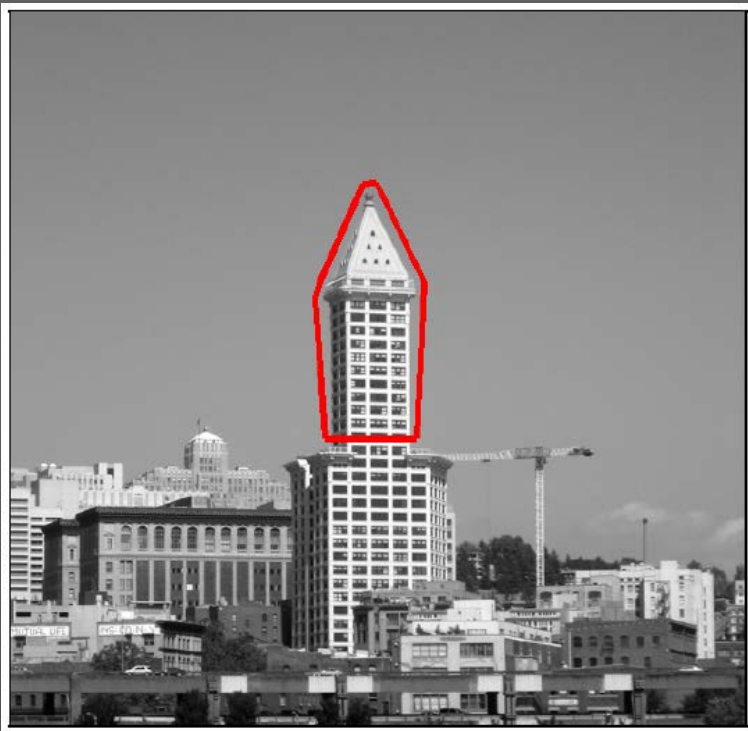
Tree marked by user



Scaled up, preserving texture



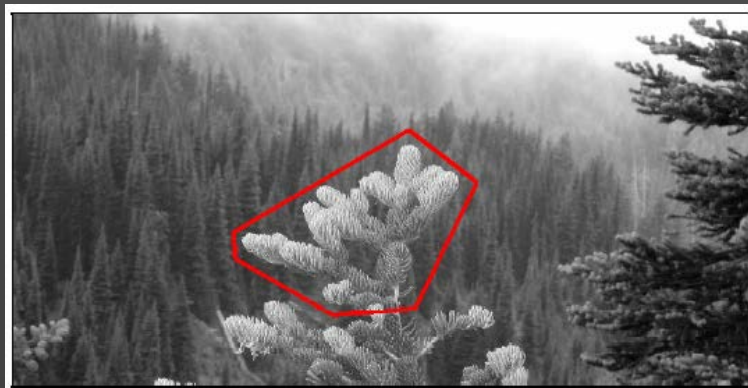




Building marked by user



Scaled up, preserving texture

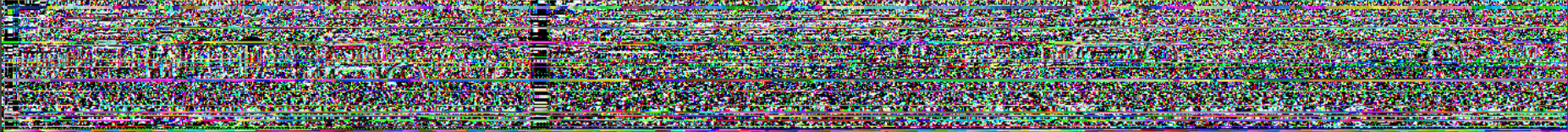


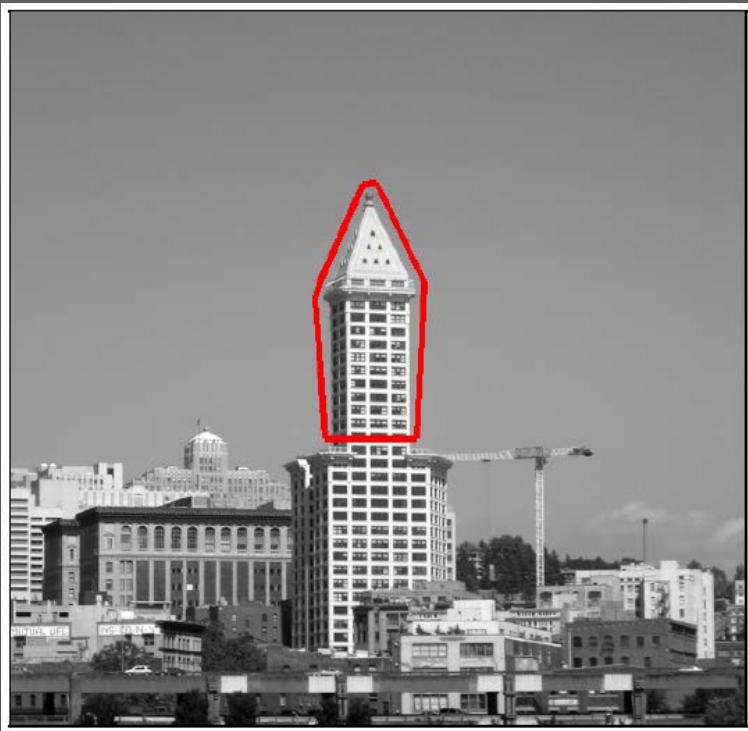
Tree marked by user



Scaled up, preserving texture



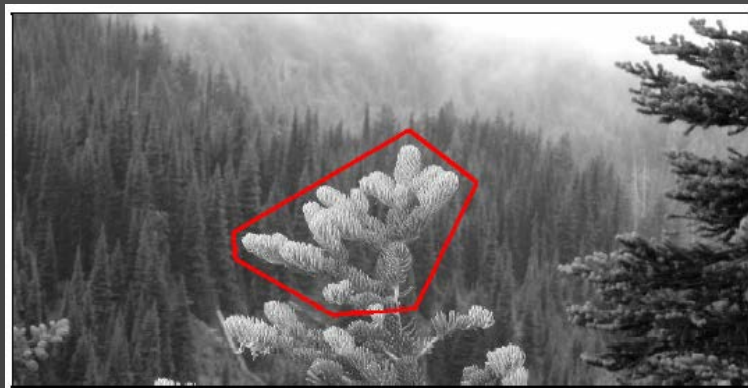




Building marked by user



Scaled up, preserving texture



Tree marked by user



Scaled up, preserving texture



