

Parallel Patch Based Texture Synthesis

Anass Lasram

Sylvain Lefebvre

ALICE/INRIA



By-example Texture Synthesis



Exemplar



Synthesized

By-example Texture Synthesis

- Pixel-based synthesis
- Patch-based synthesis

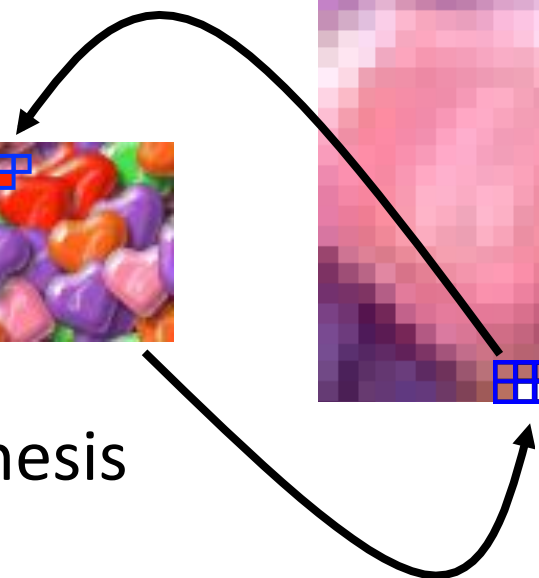
By-example Texture Synthesis

- Pixel-based synthesis

- Fast
 - [Lefebvre & Hoppe 05]
 - [Barnes et al. 09]
 - [Busto et al. 10]
 - ...

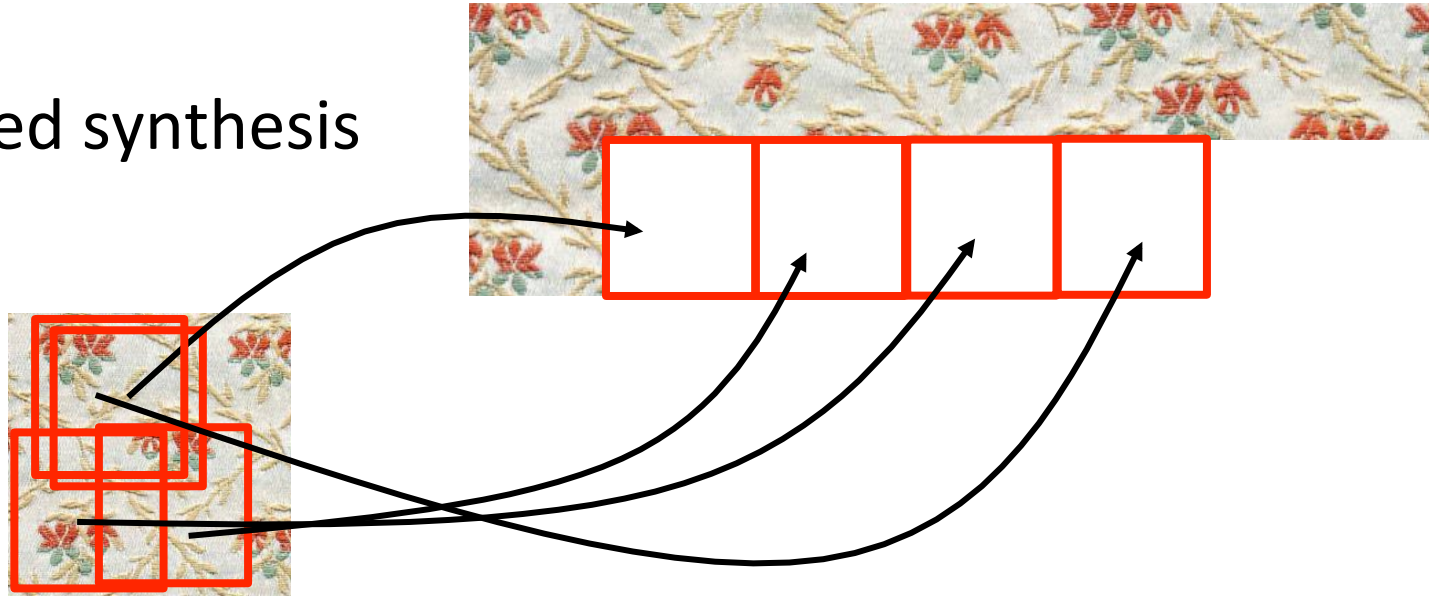


- Patch-based synthesis



By-example Texture Synthesis

- Pixel-based synthesis
 - Fast



- Patch-based synthesis
 - Preserve structure

By-example Texture Synthesis

- **Patch-based synthesis**

- Cutting the patches [Efros & Freeman 01]



- Deforming Patches [Wu and Yu 04]



- Hiding previous errors [Kwatra et al. 03]

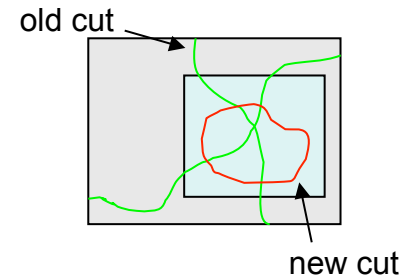


Image Quilting

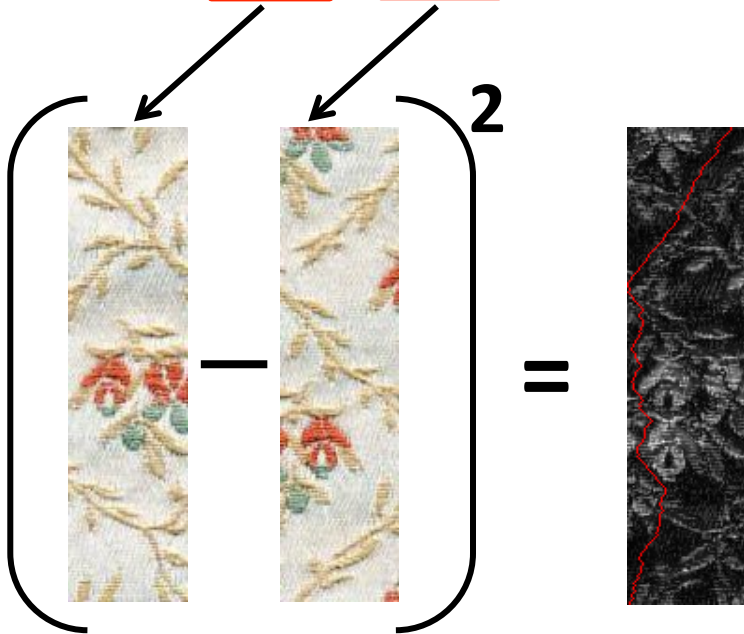
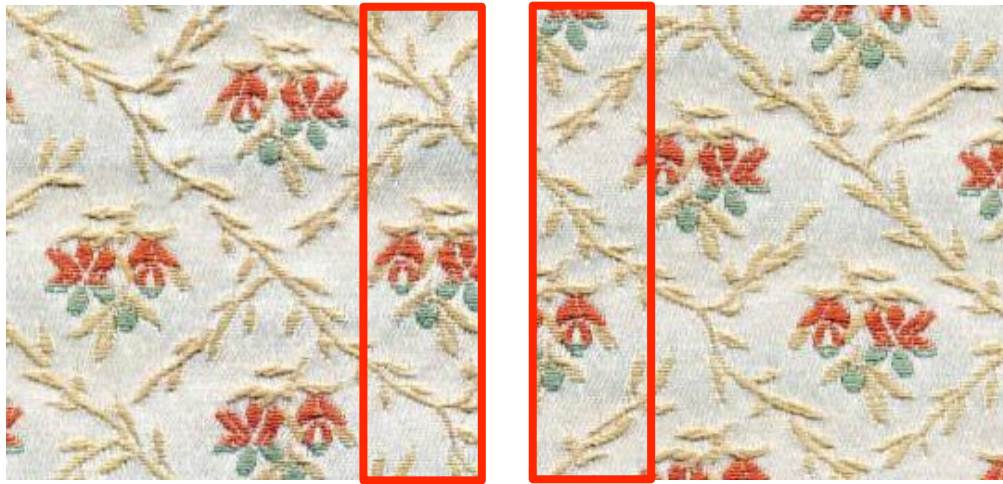


Image Quilting

- **Dynamic programming**

- Top-bottom cost computation

$$\text{cost}(x) = \text{bestCost}(a,b,c) + \text{transitionCost}$$

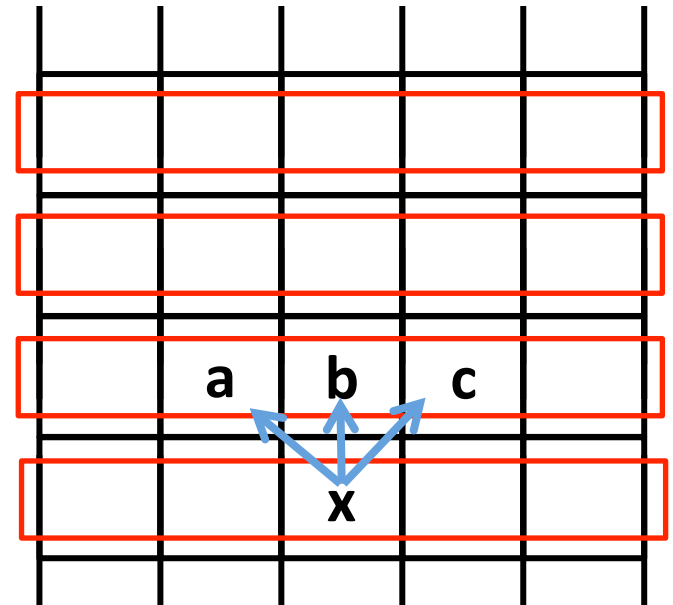
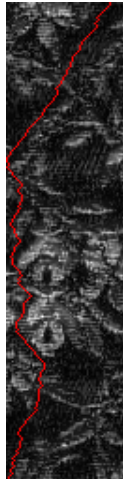
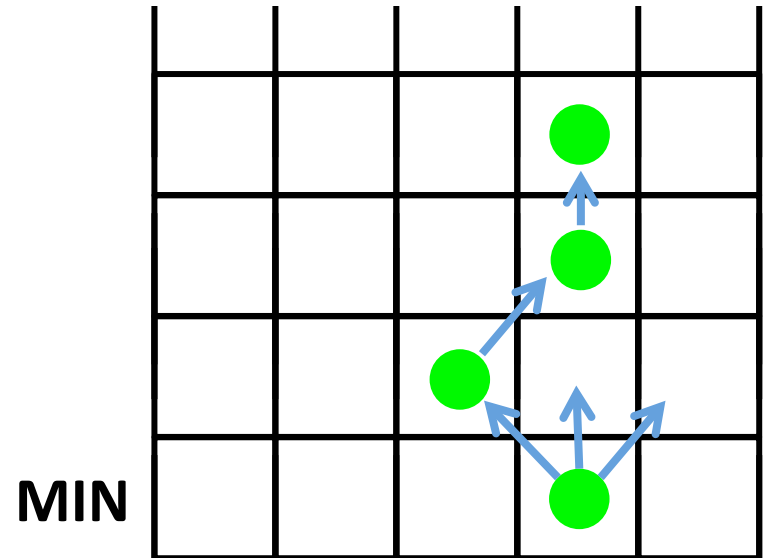
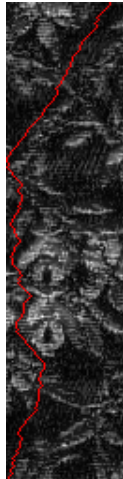


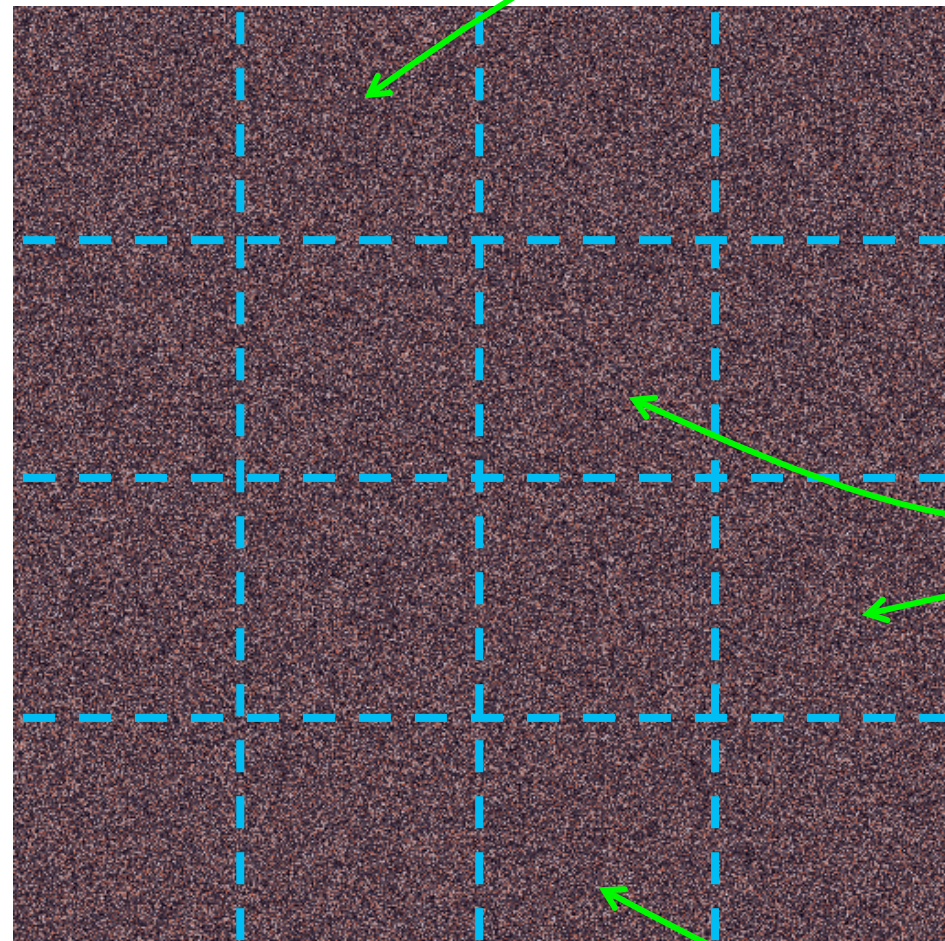
Image Quilting

- **Dynamic programming**
 - Top-bottom cost computation
 - Backtrack best solution

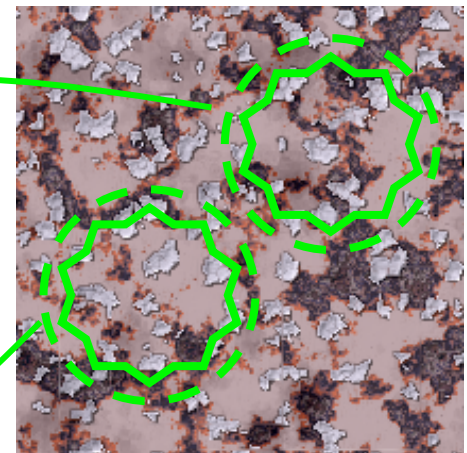
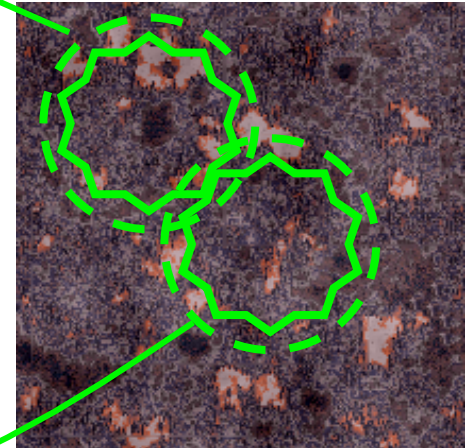


Overview

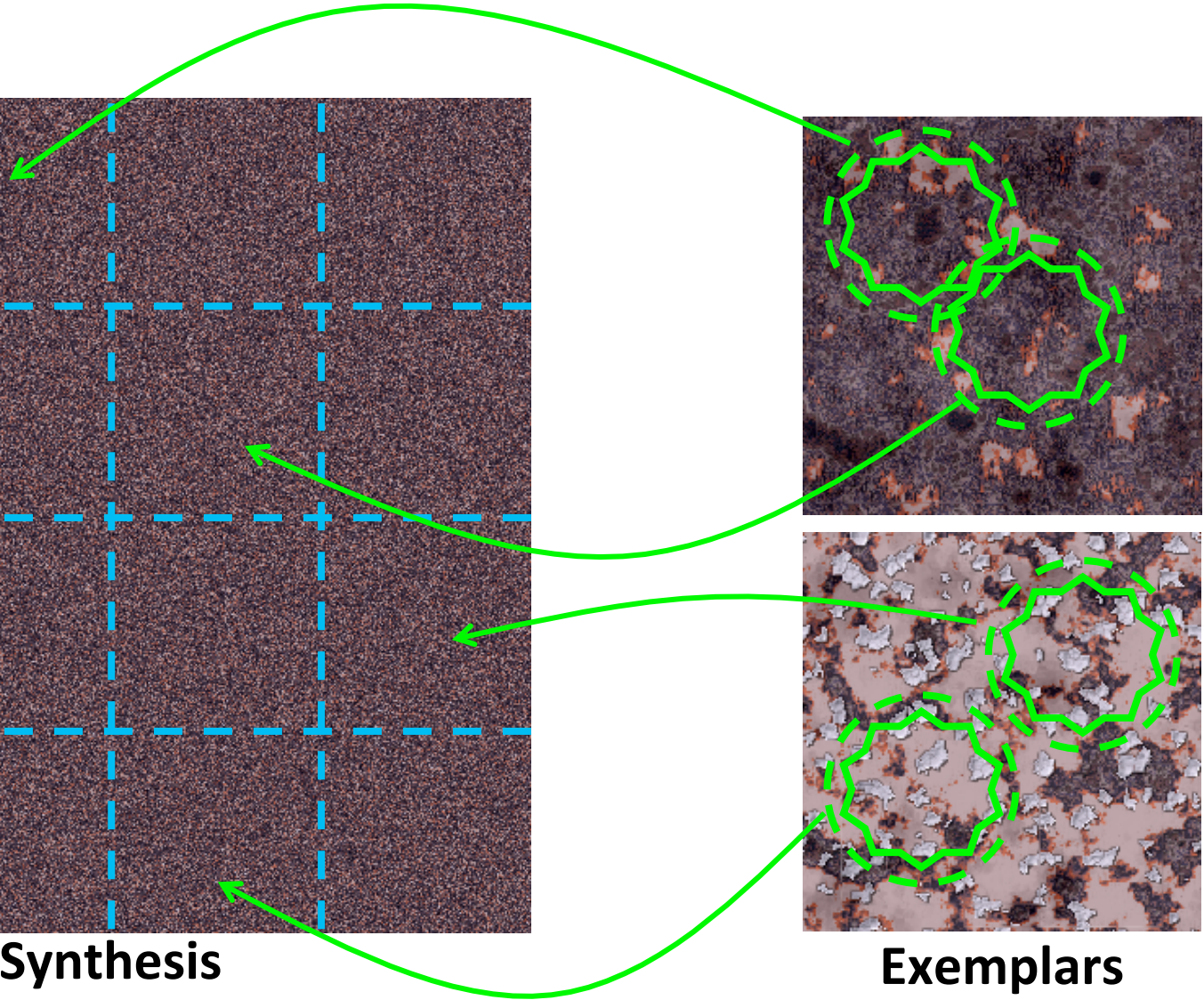
Overview



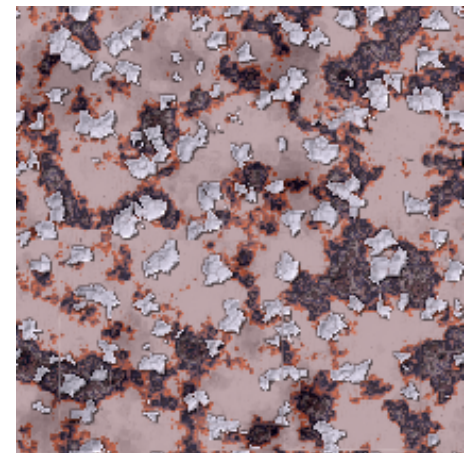
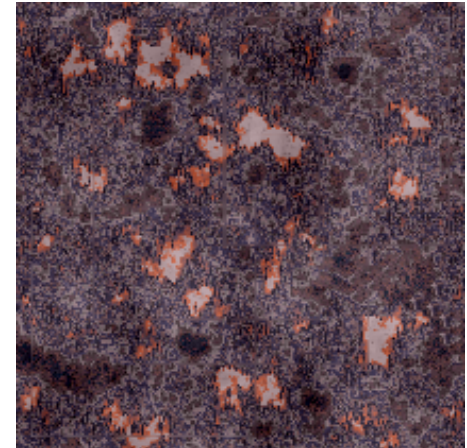
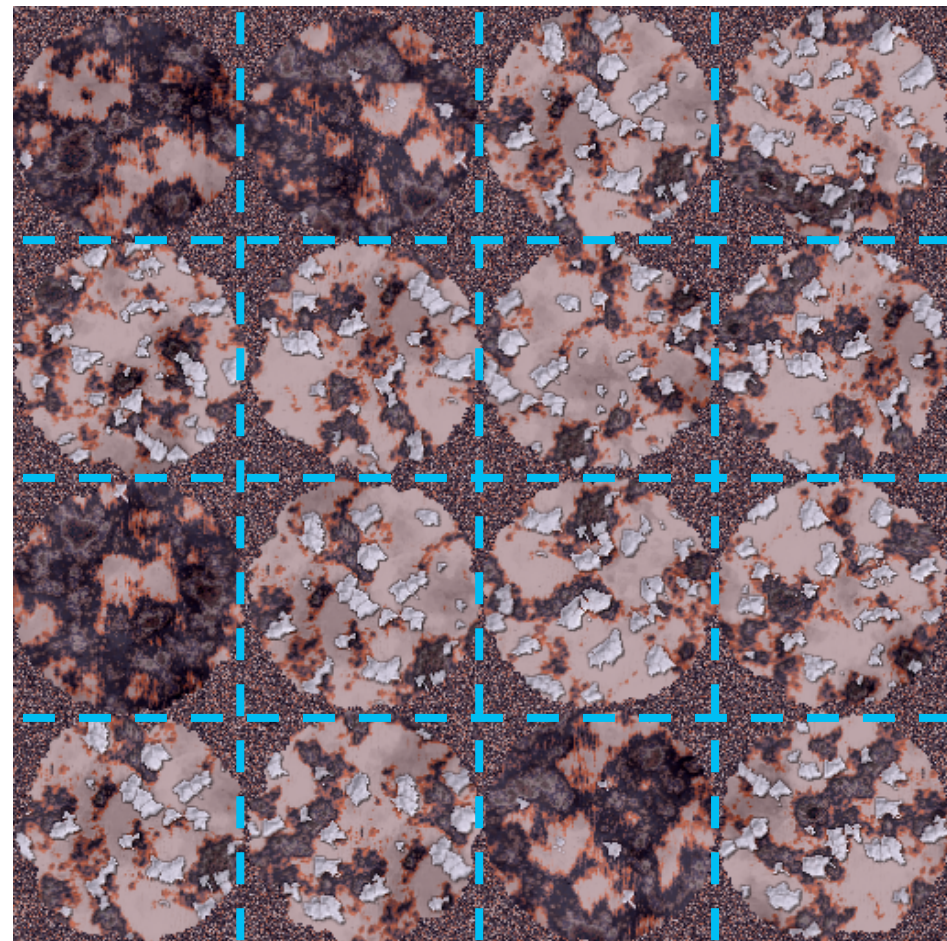
Synthesis



Exemplars

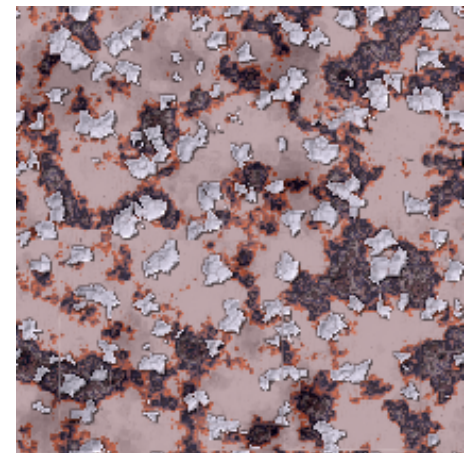
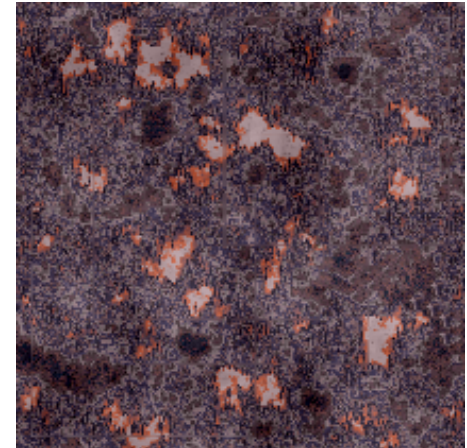
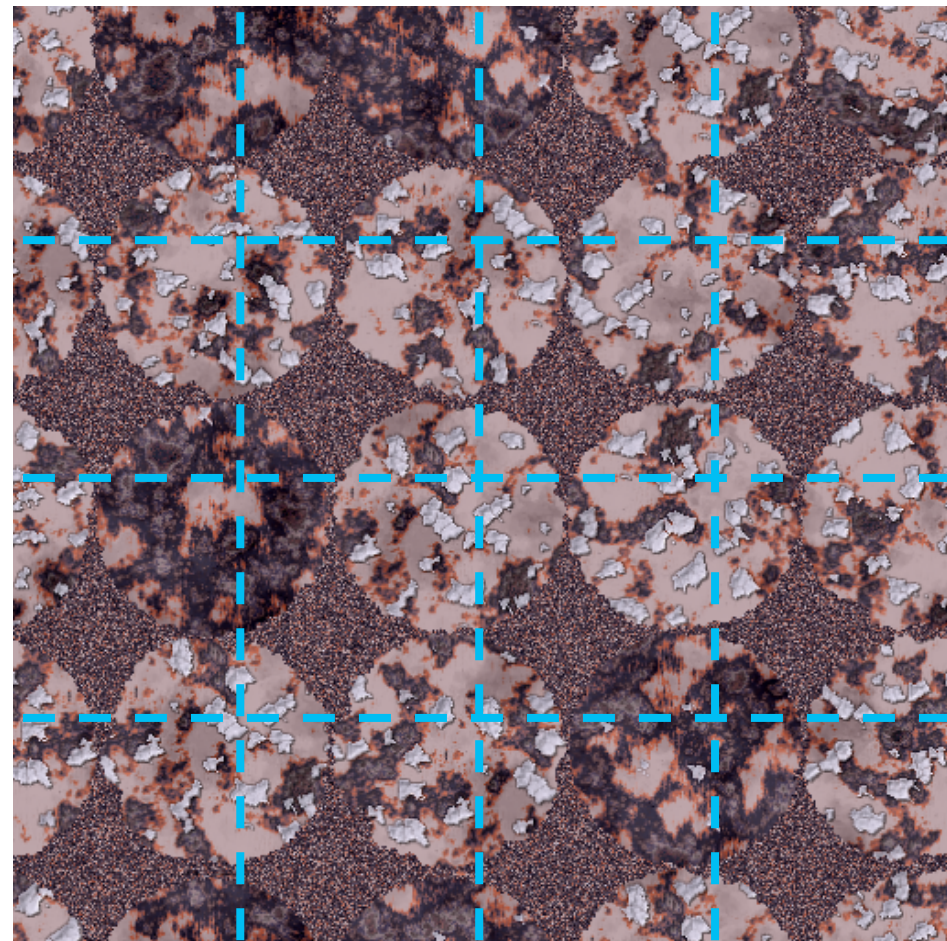


Overview



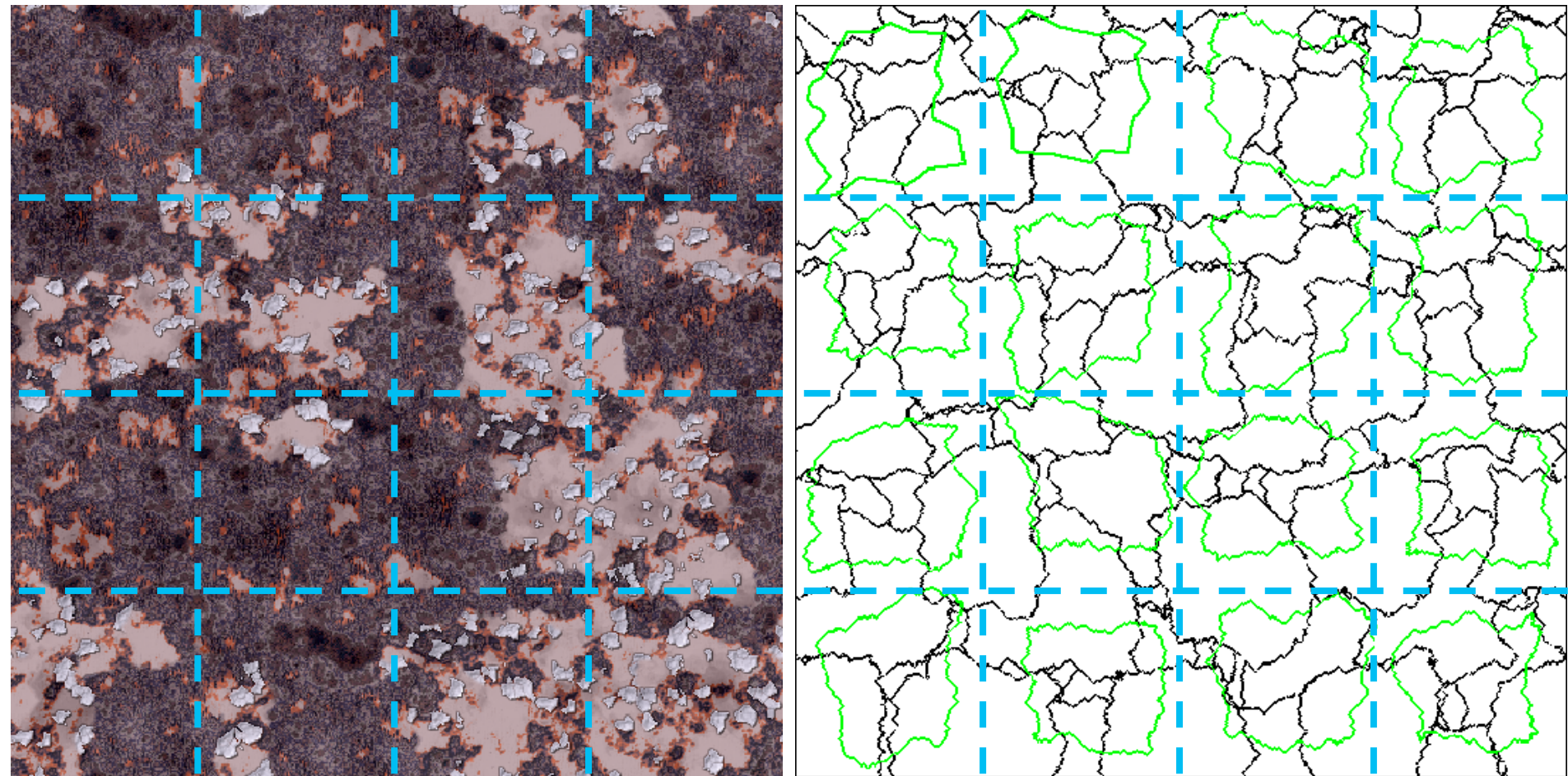
Exemplars

Overview

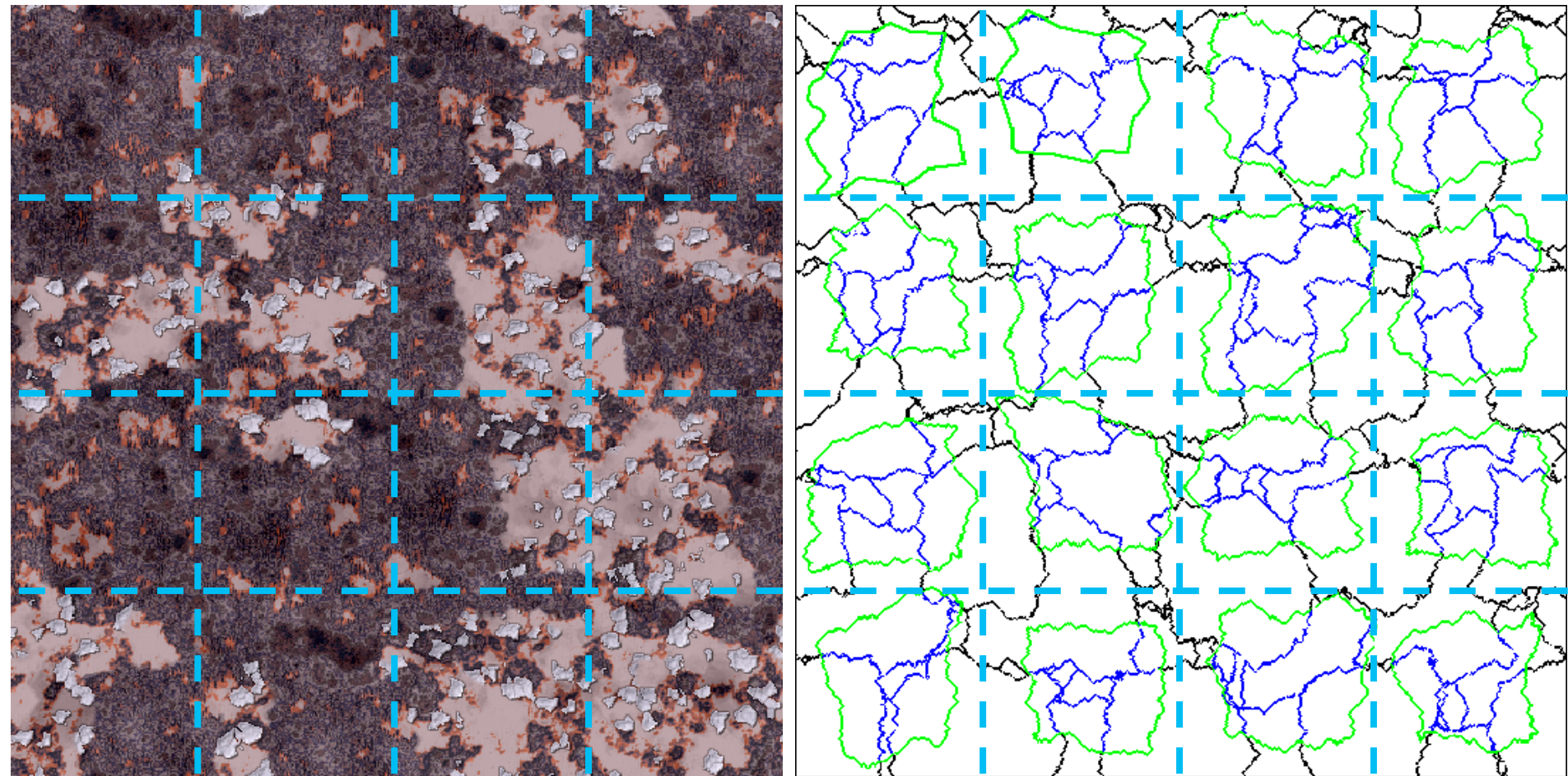


Exemplars

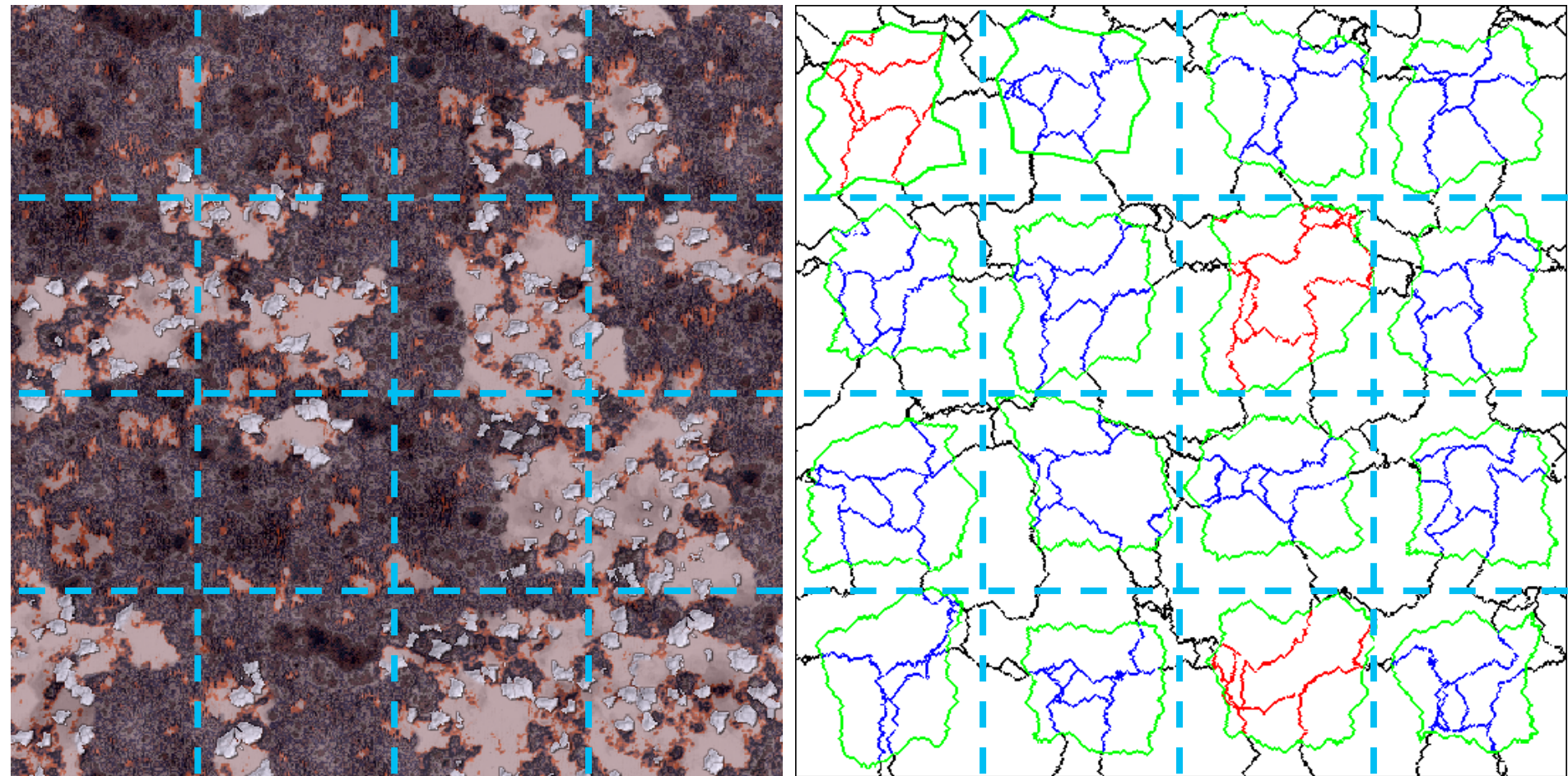
Overview



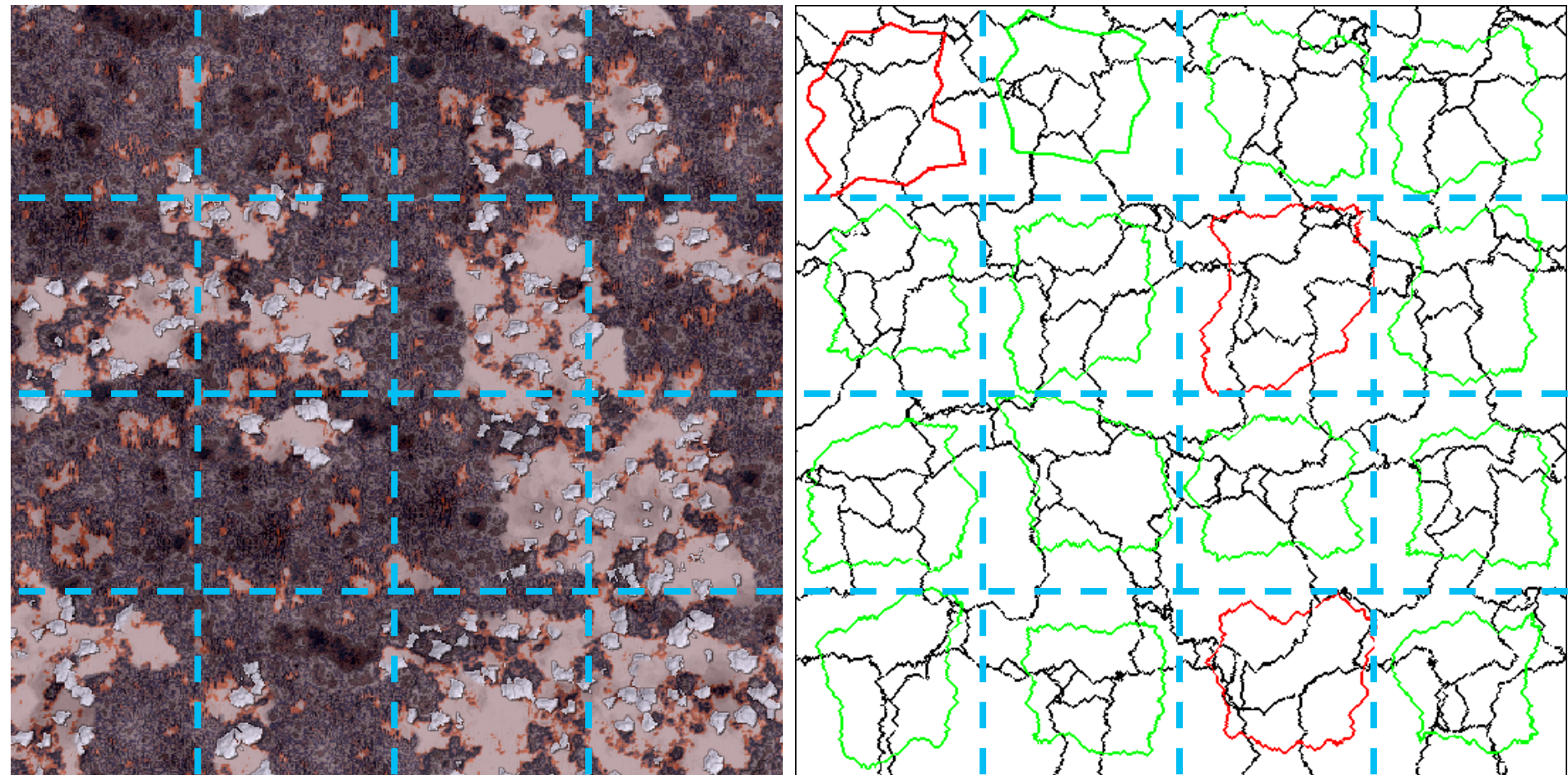
Overview



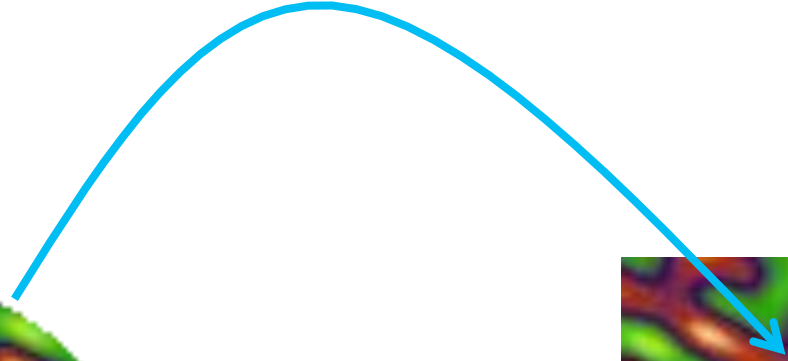
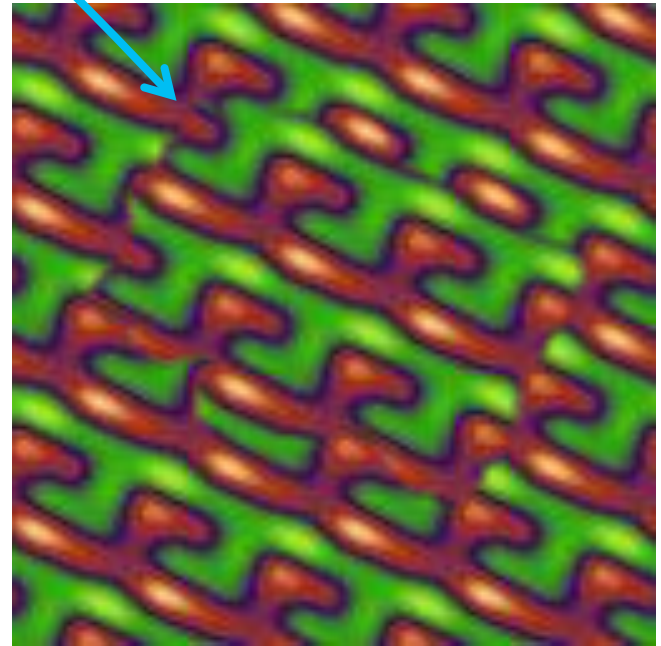
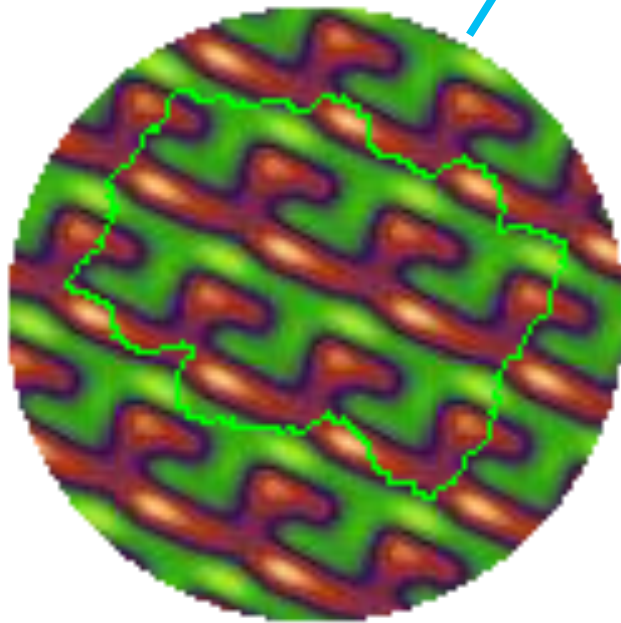
Overview



Overview



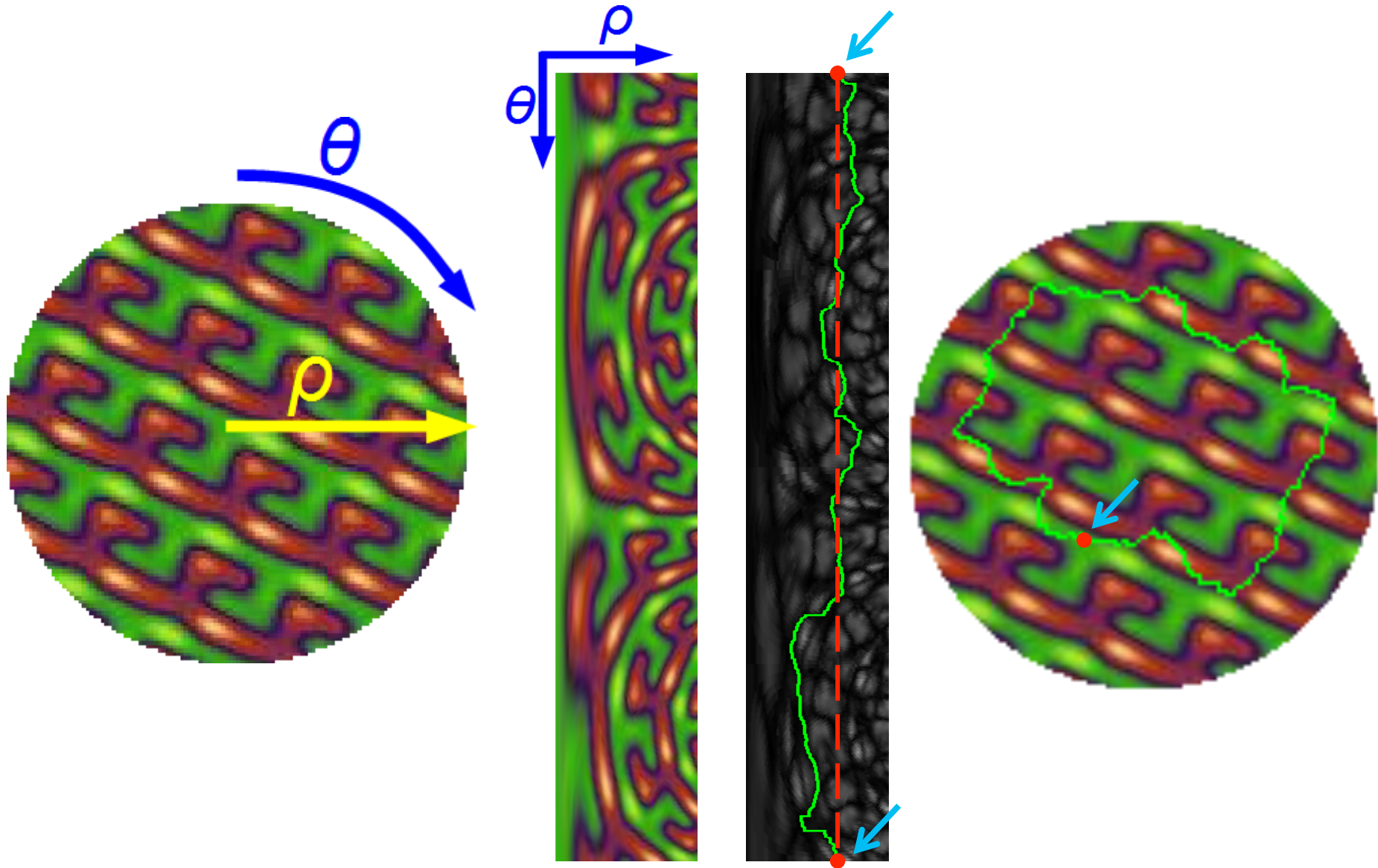
Cut determination



Graph-Cut
Parallel Push Re-label $O(N^3)$

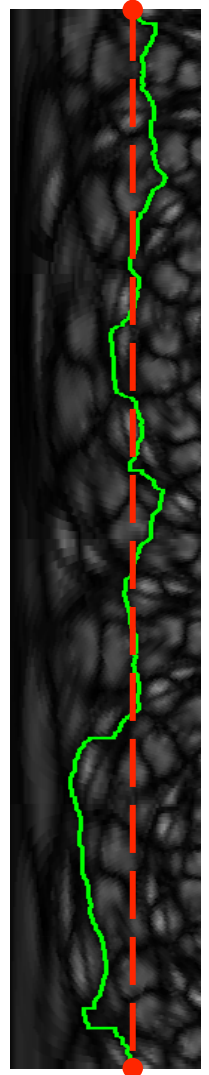
Dynamic programming $O(N)$
Closed Cut

Cut determination

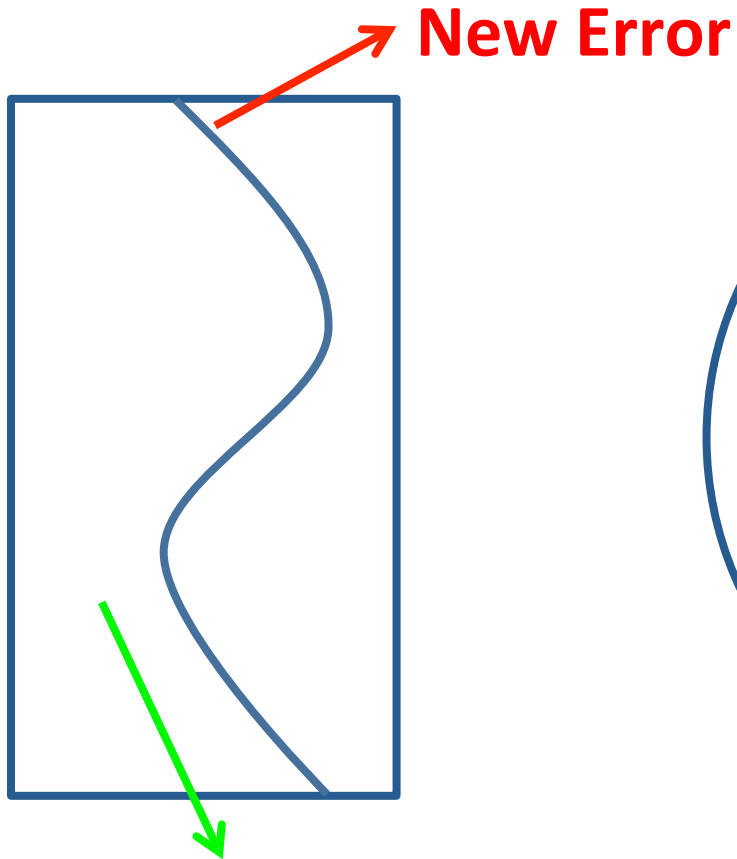


Cut determination

- Closed loop (same start/end abscissa)
 - Repeat DP for all start/end abscissas $O(N^2)$
Drag-and-Drop Pasting [Jia et al. 06]
- Approximation $O(N)$
 - Backtrack all cuts
 - Keep the best cut that starts/ends at the same abscissa
 - The cyclic cut always exists
 - Proof and measurements (paper)

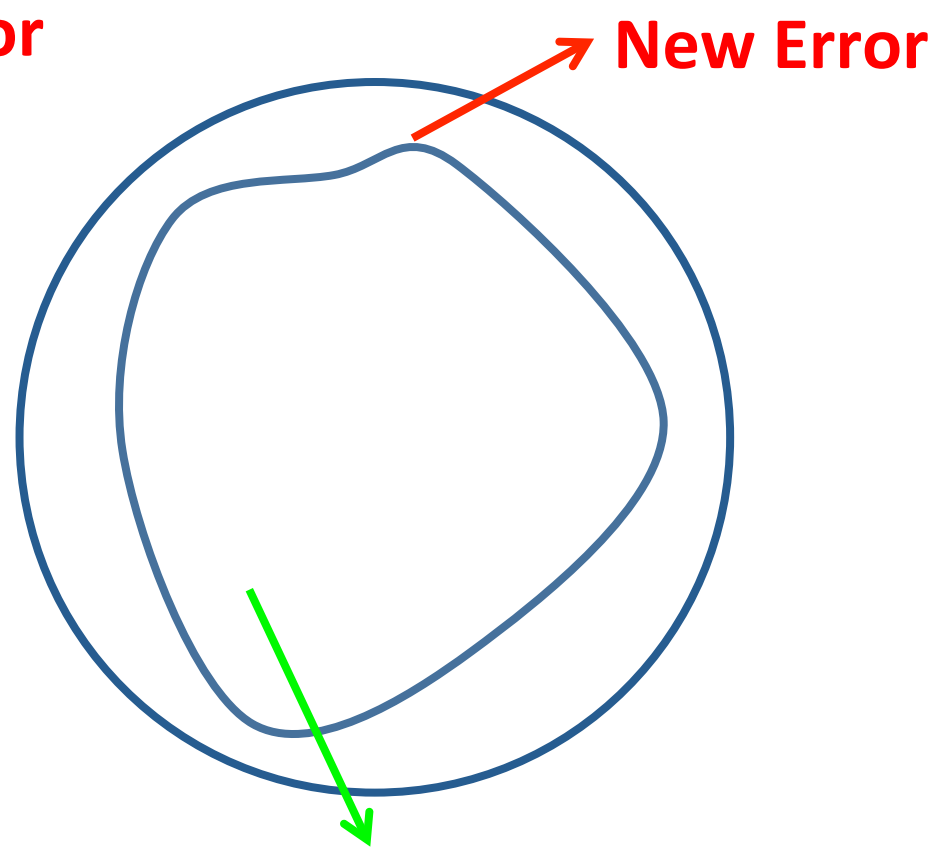


Hiding existing errors



Existing Error

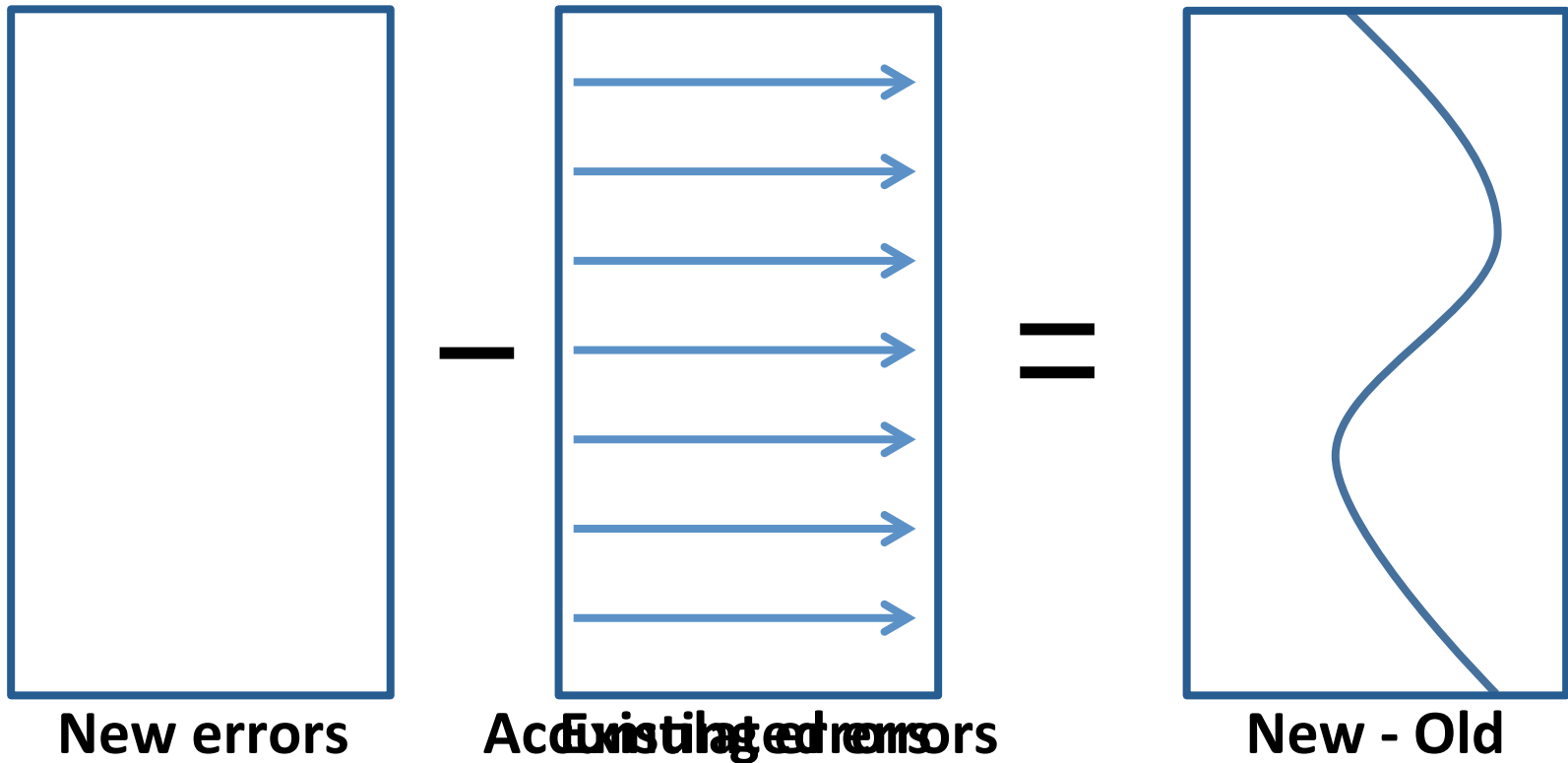
Polar



Existing Error

Cartesian

Hiding existing errors

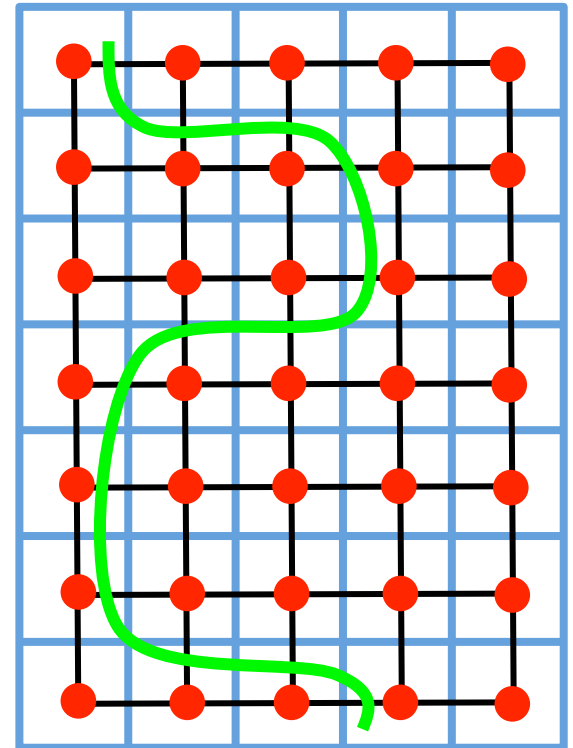


Path cost = new errors along the path — sum of hidden existing errors

Path cost > 0 => The path is not improving the quality

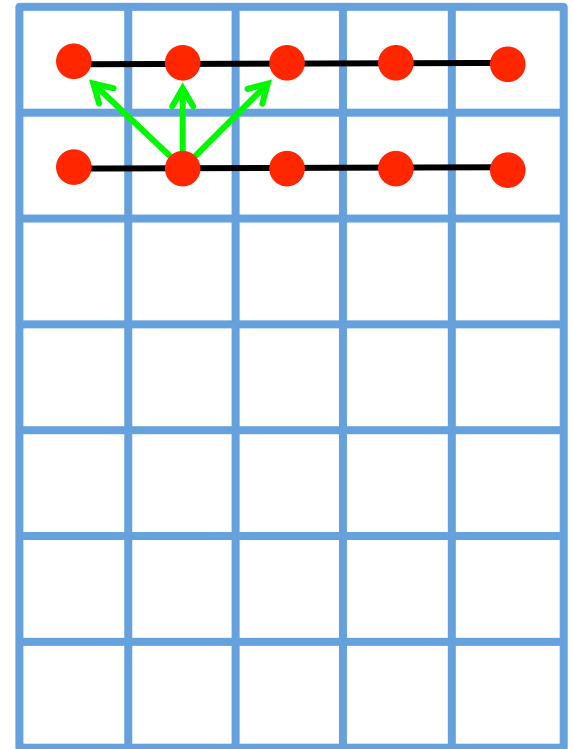
Error Metric

- [Kwatra et al. 03]
- Vertical/horizontal errors
- Consider frequency
- Y-monotone cuts



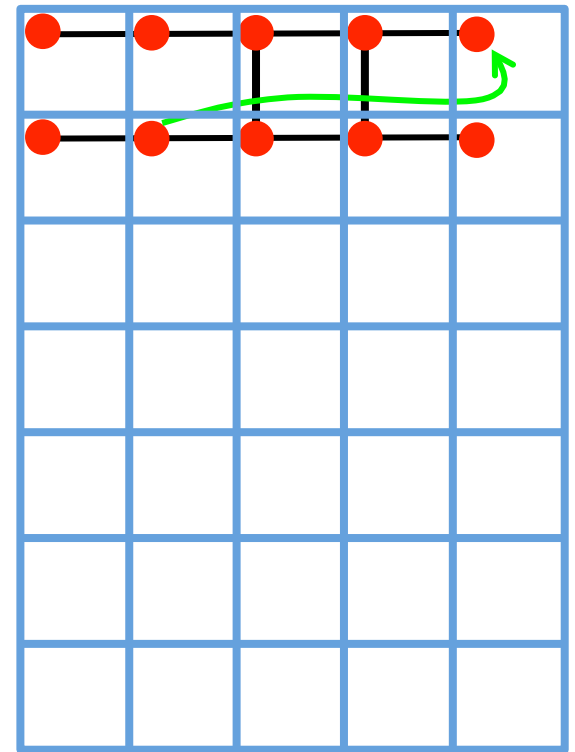
Error Metric

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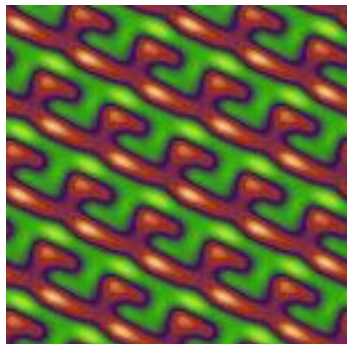


Error Metric

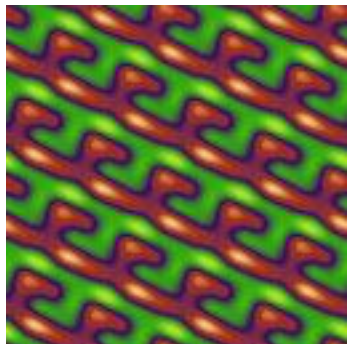
- [Kwatra et al. 03]
- Vertical/horizontal errors
- Consider frequency
- Y-monotone cuts



Error Metric



Left



Right

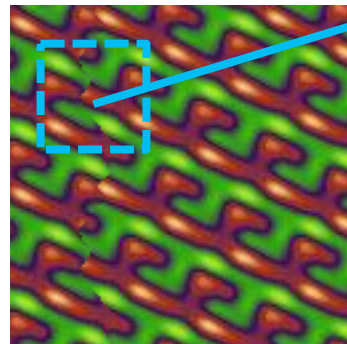
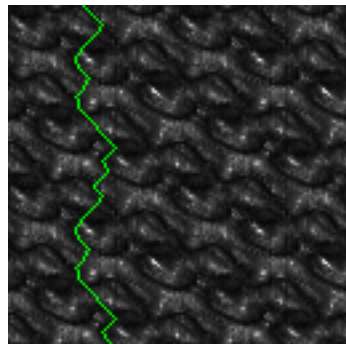
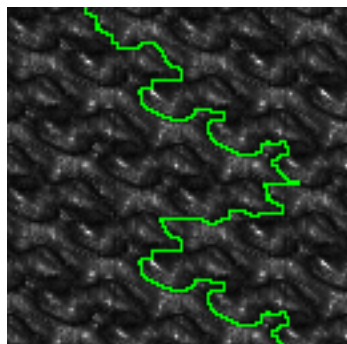
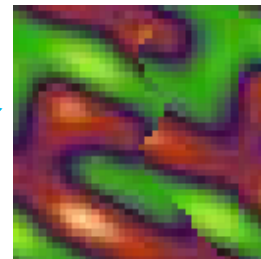
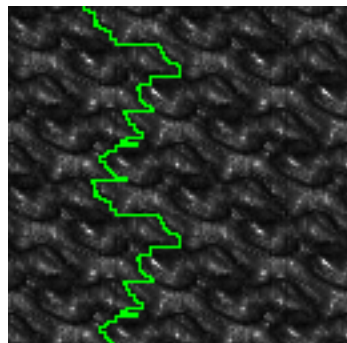
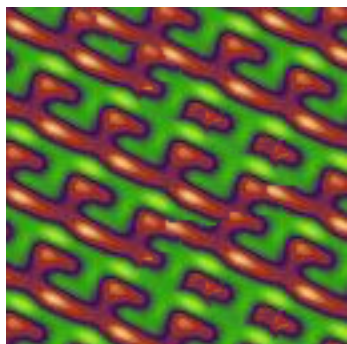


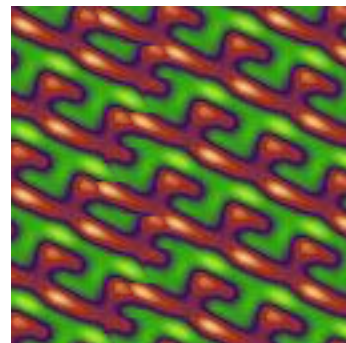
Image Quilting



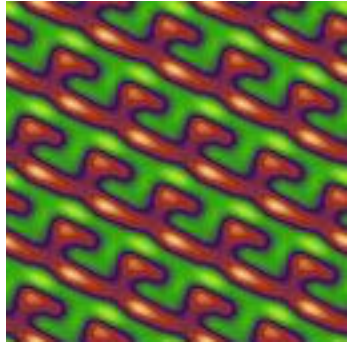
Graph-Cut



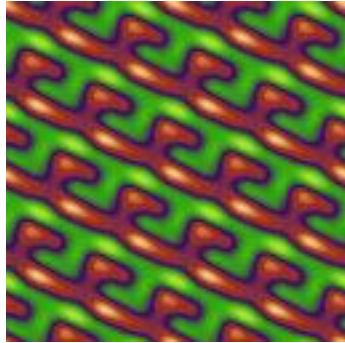
Ours



Cut discontinuities



Left



Right

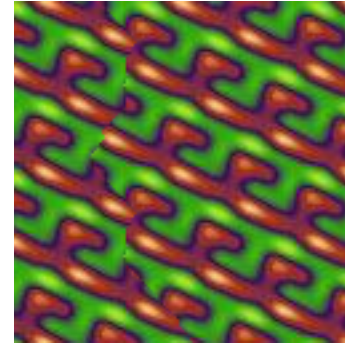
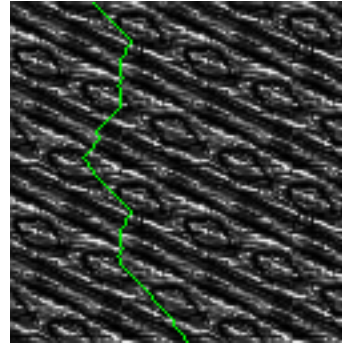
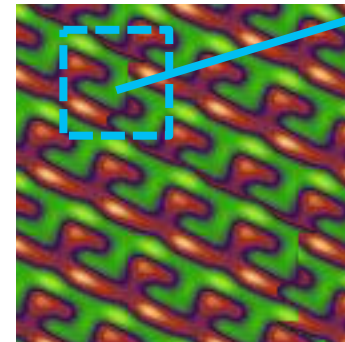
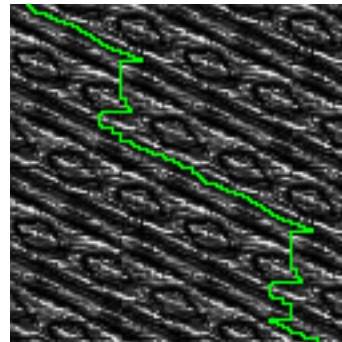
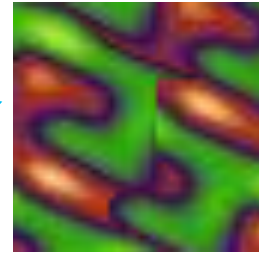


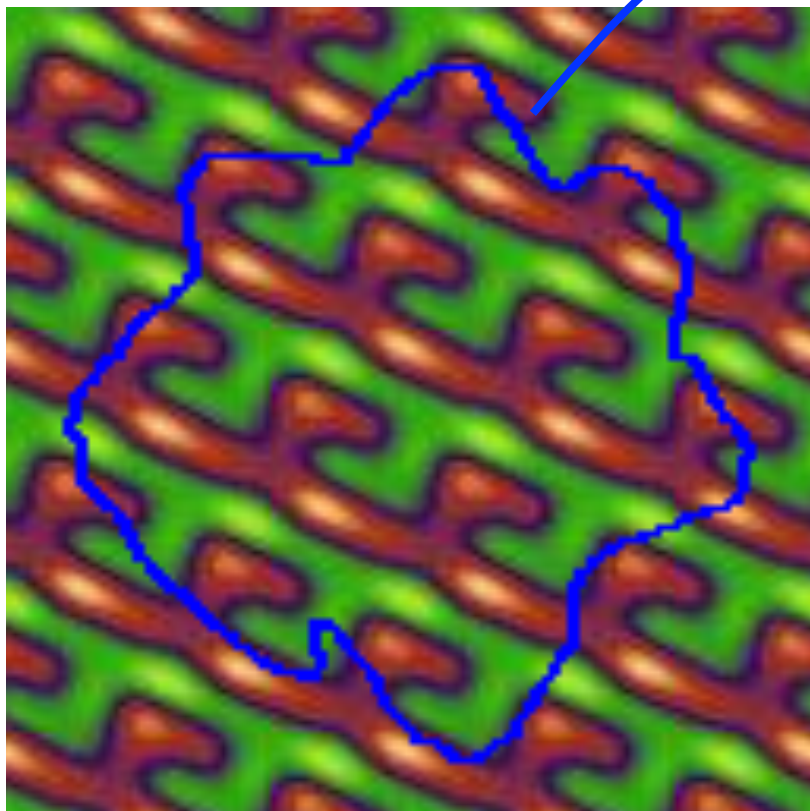
Image Quilting



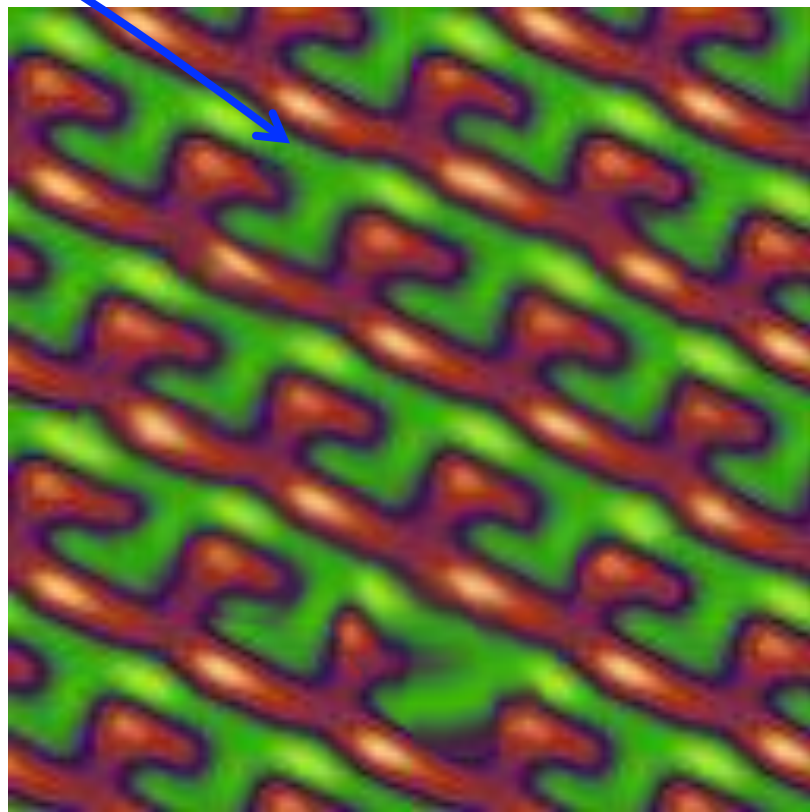
Ours



Deformation

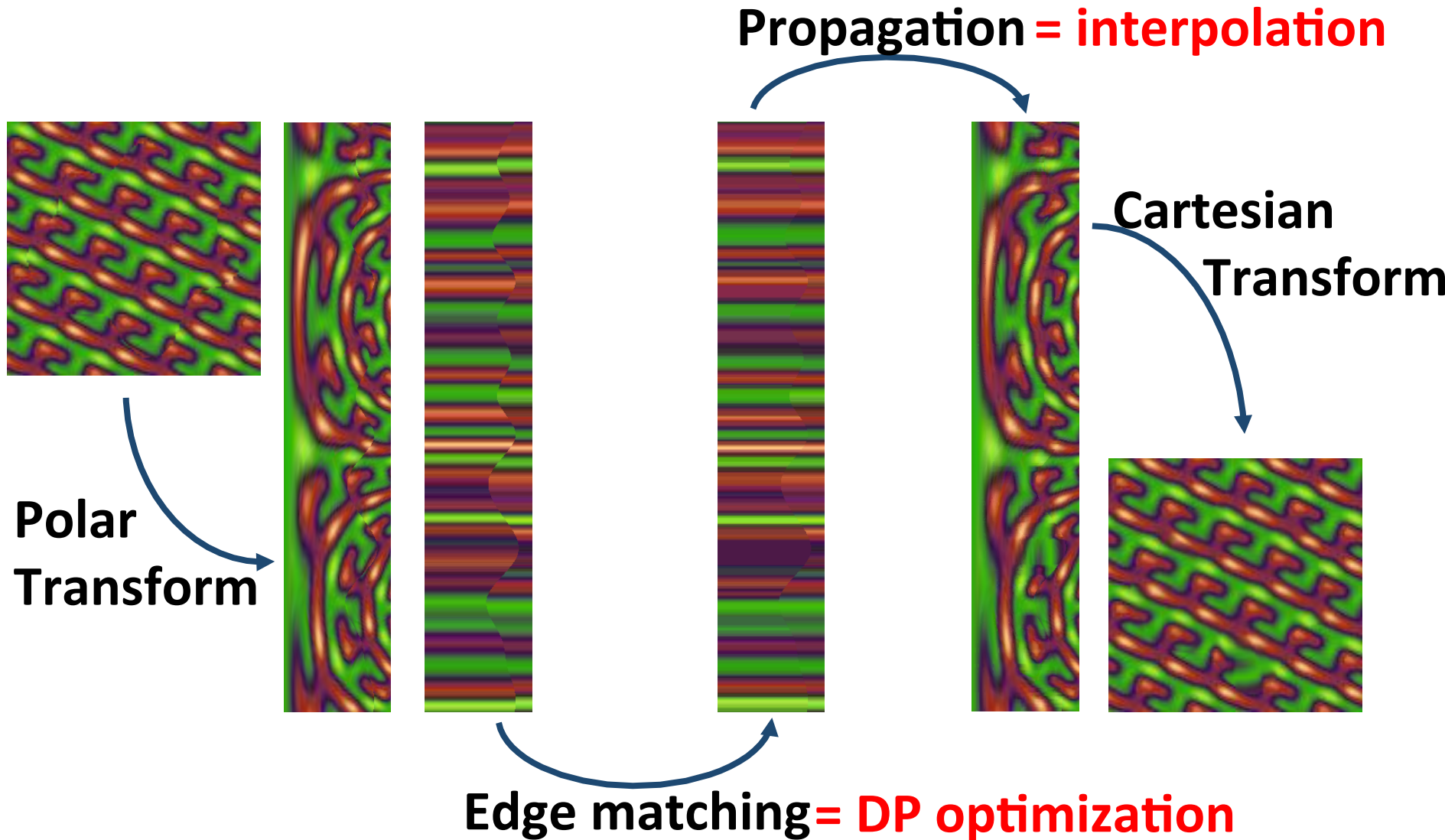


Source

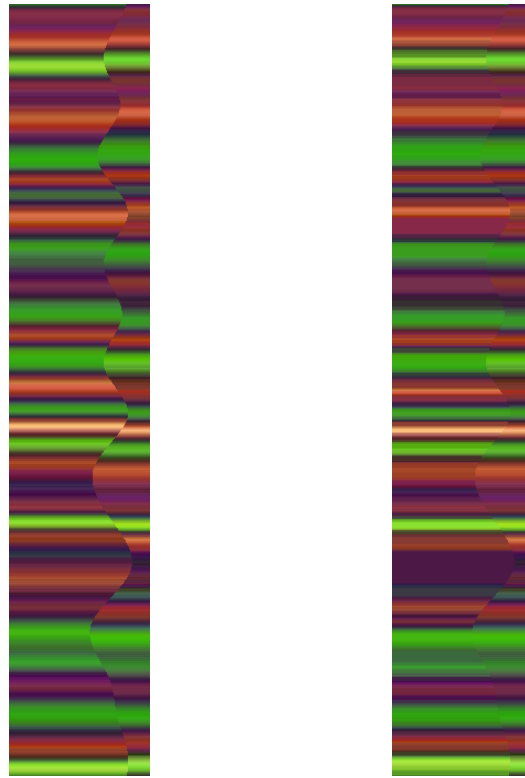


Target

Deformation

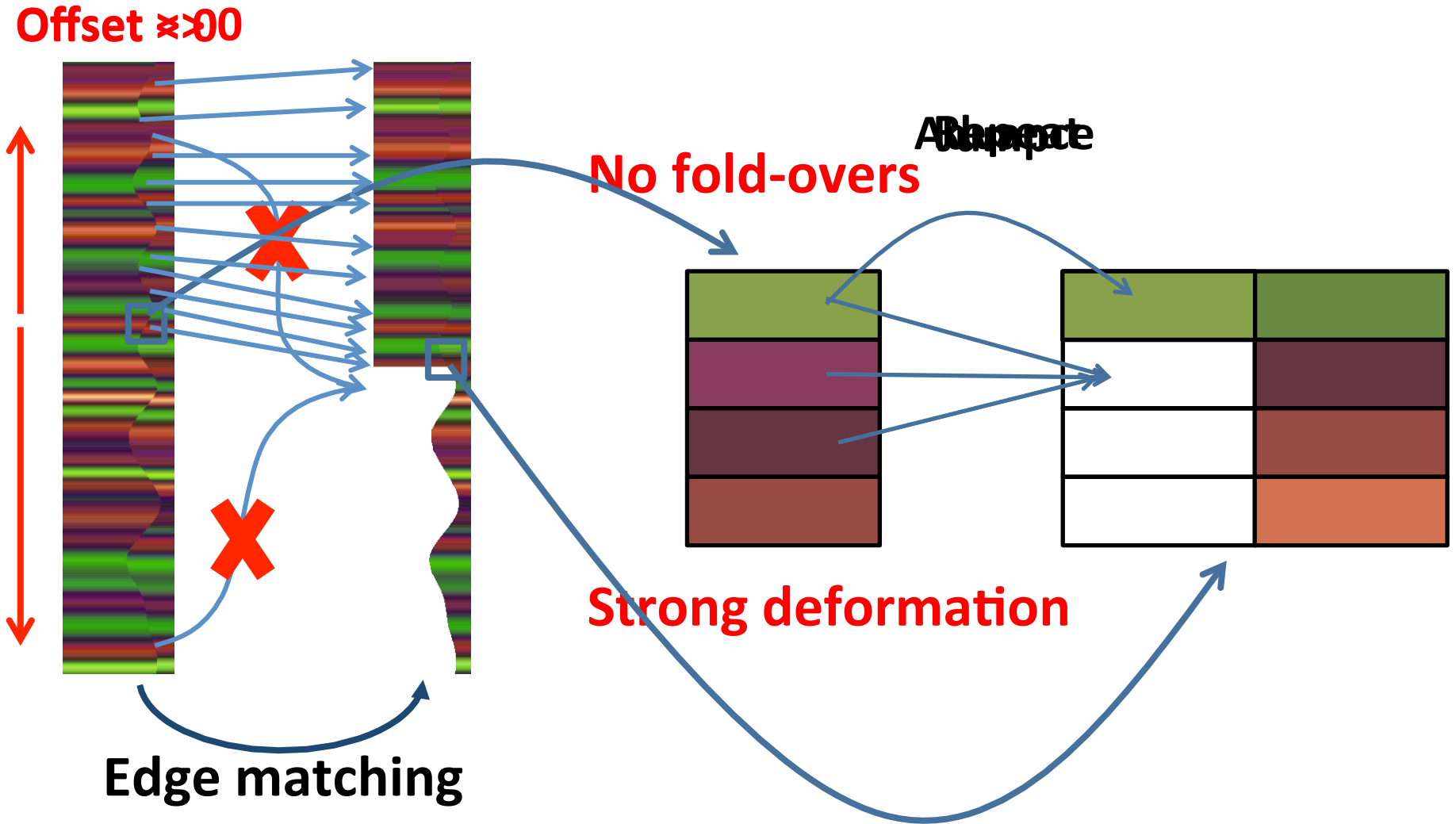


Deformation



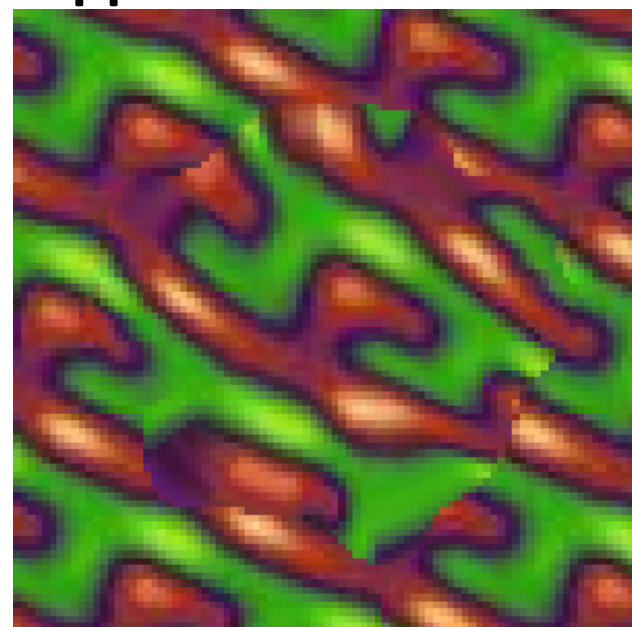
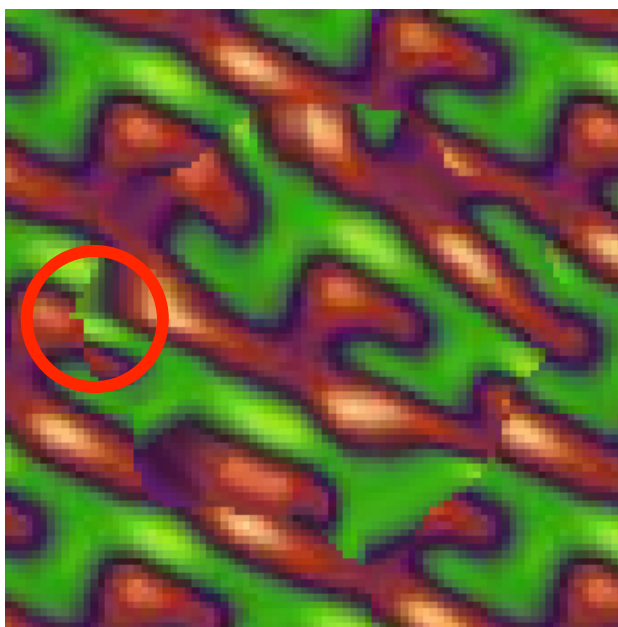
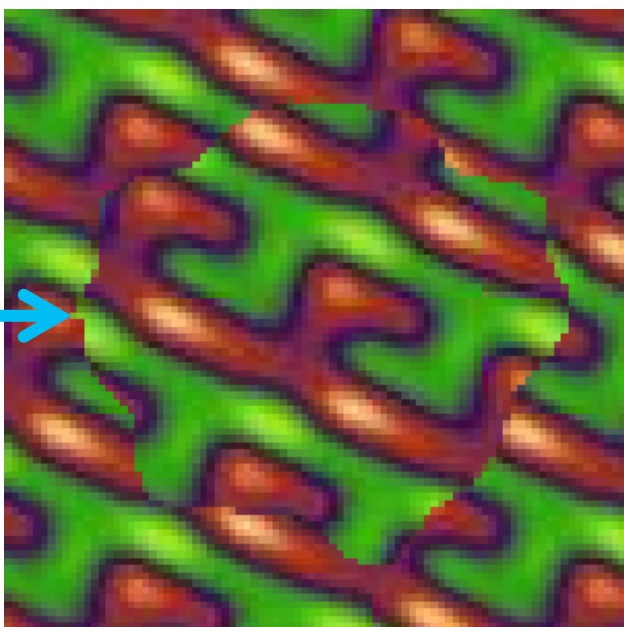
Edge matching

Deformation



Deformation

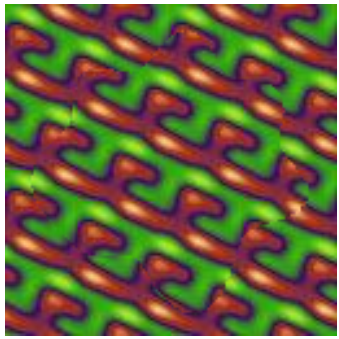
Approximate solution



Constraint : start abscissa == end abscissa

Deformation

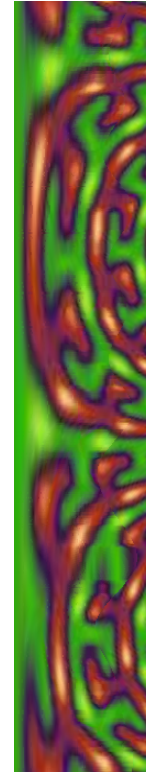
Propagation = interpolation



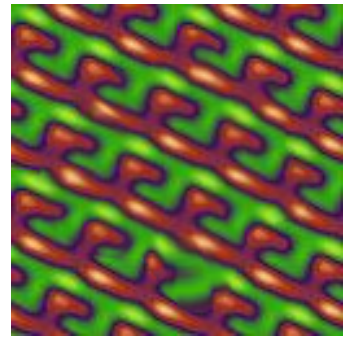
Polar Transform



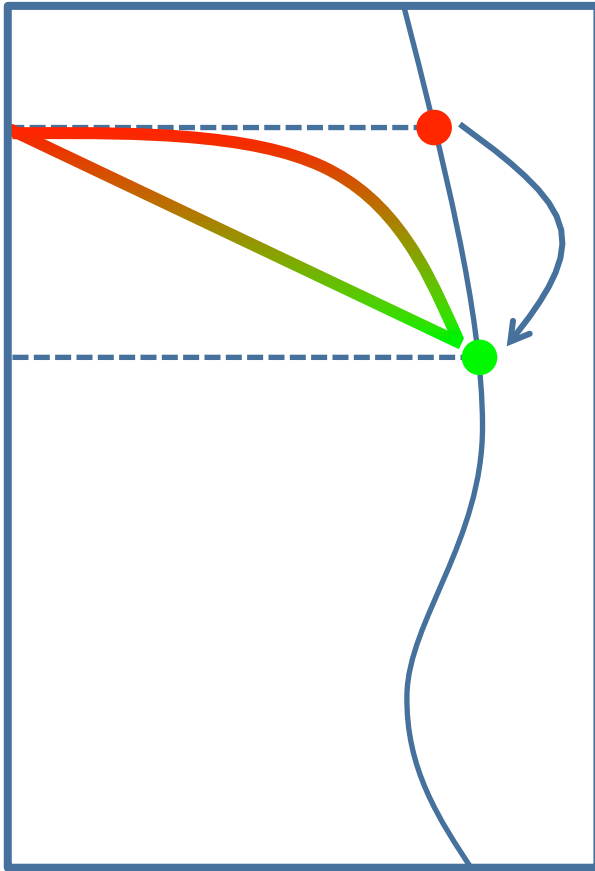
Edge matching



Cartesian Transform

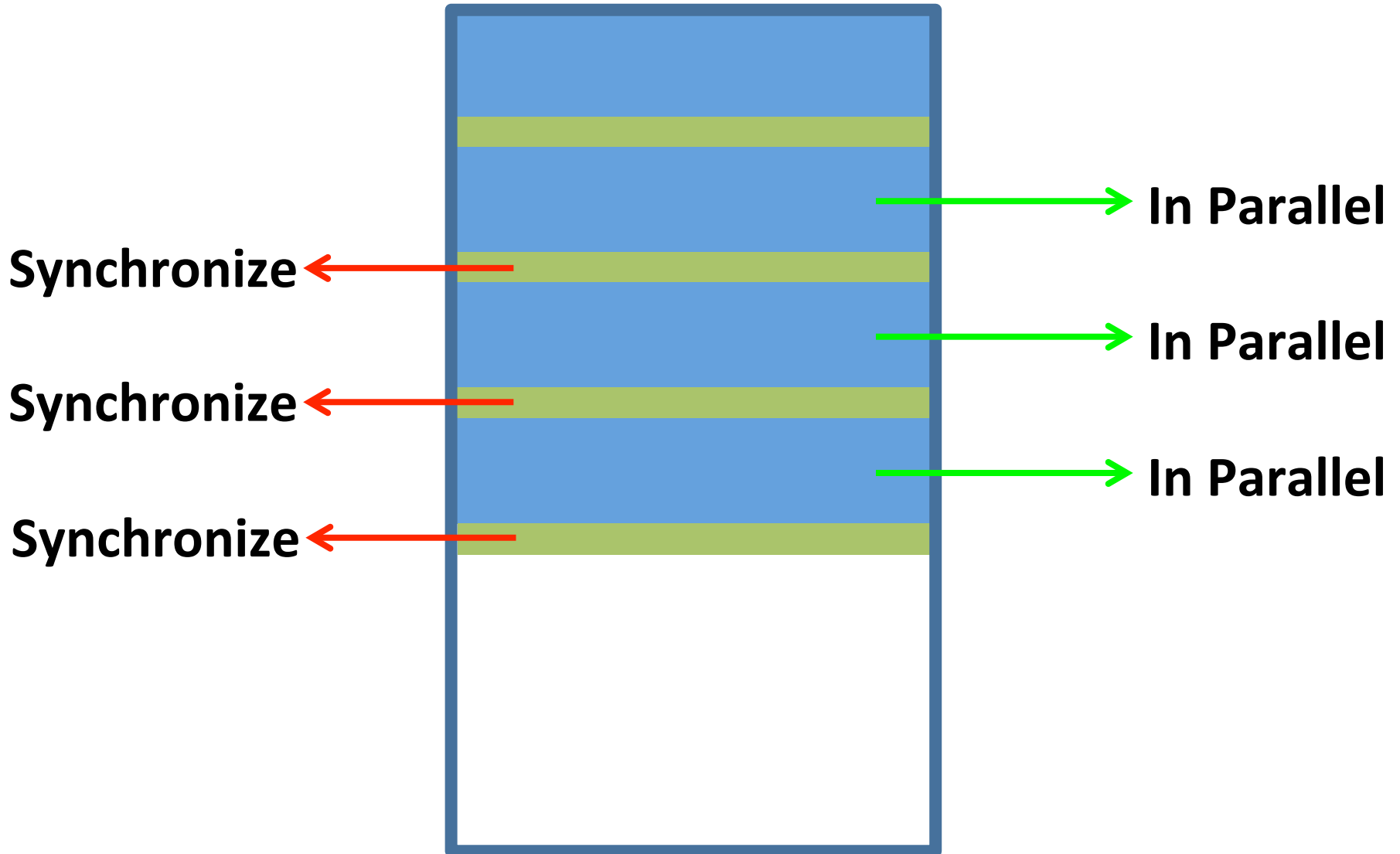


Deformation

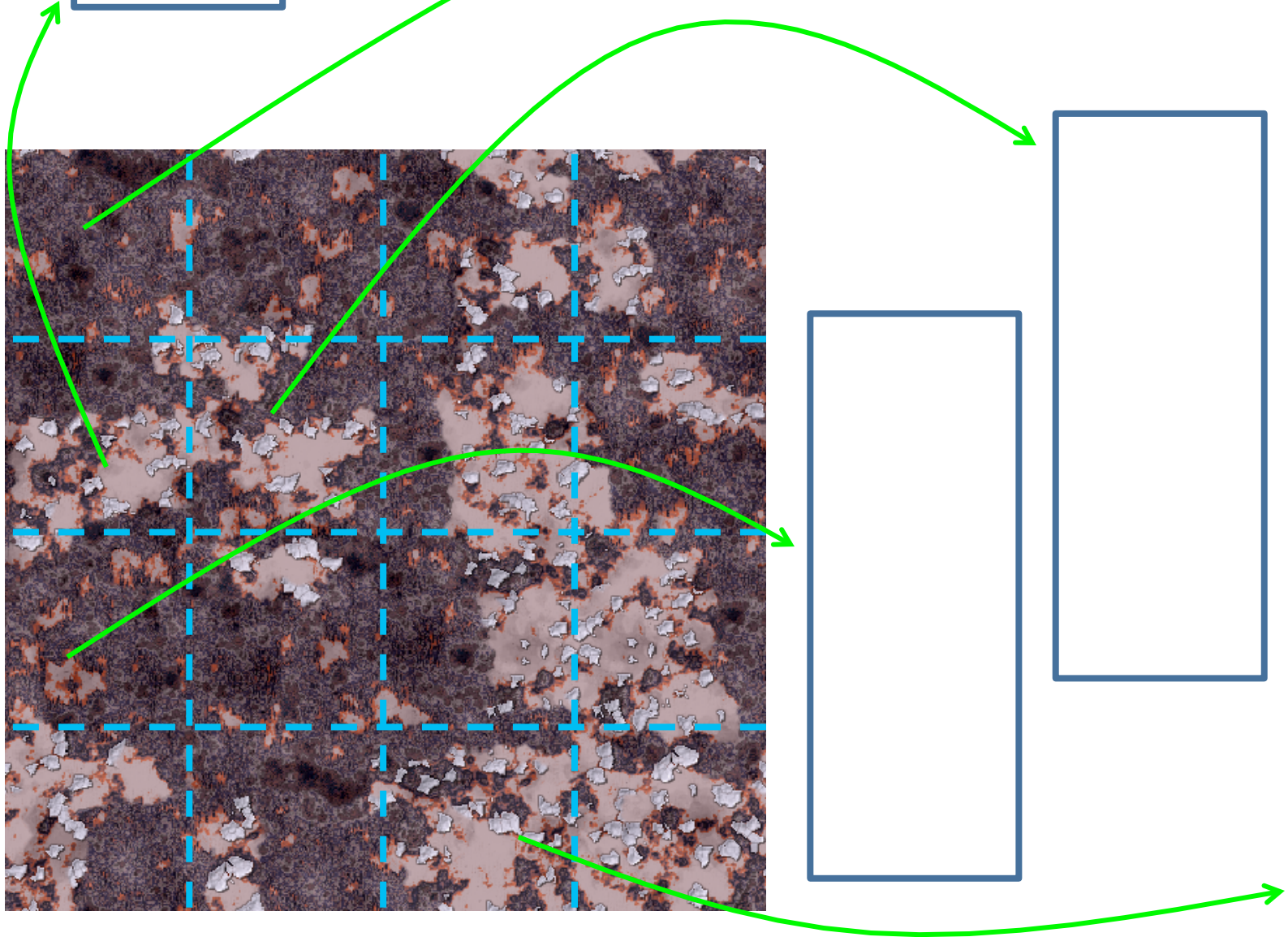
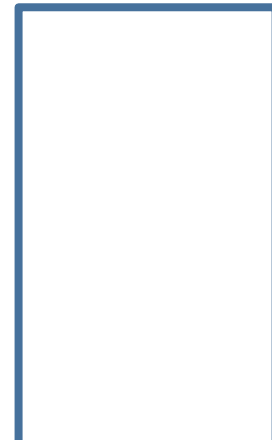
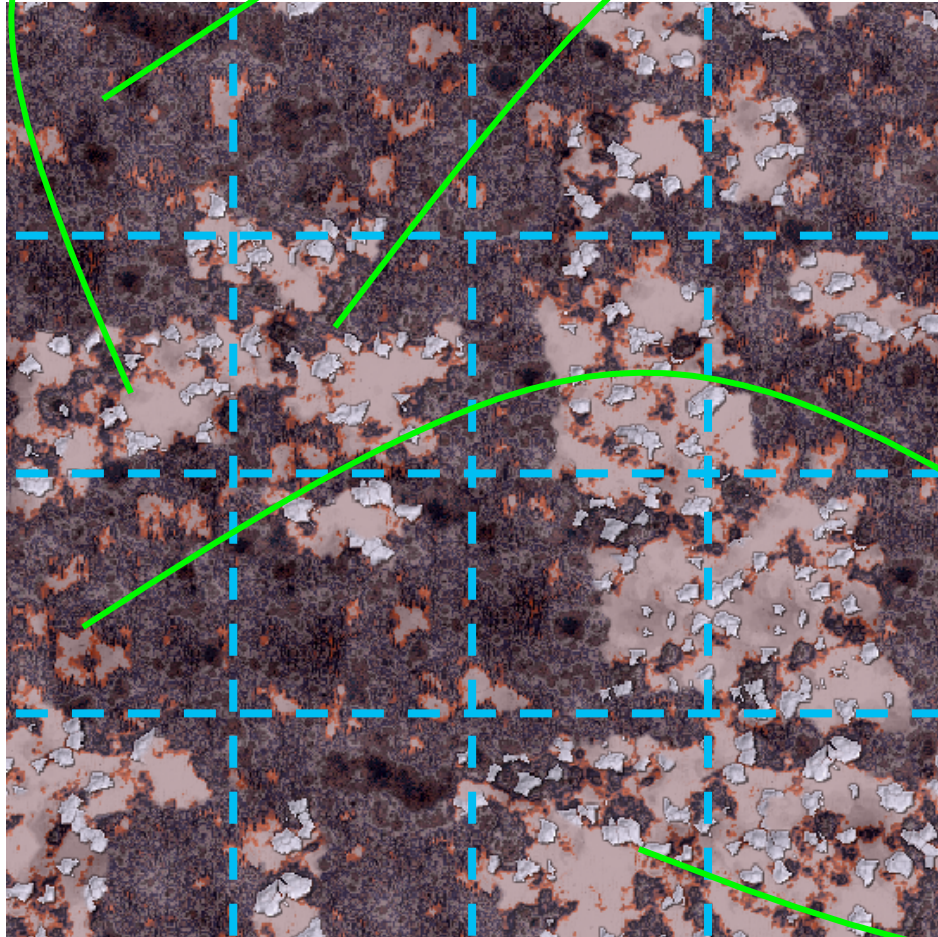


LERP(● , ● , α^y)

Dynamic programming



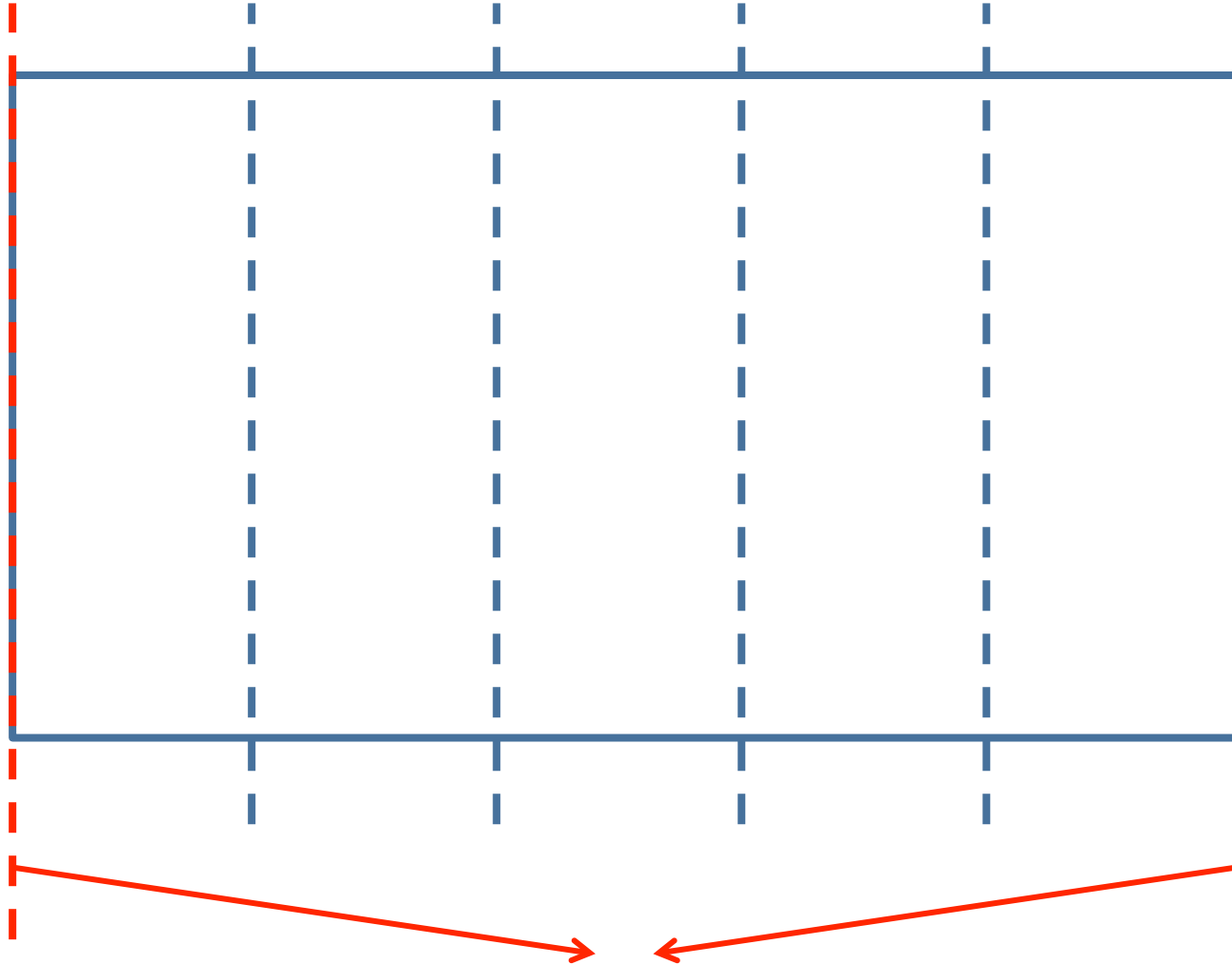
Dynamic programming





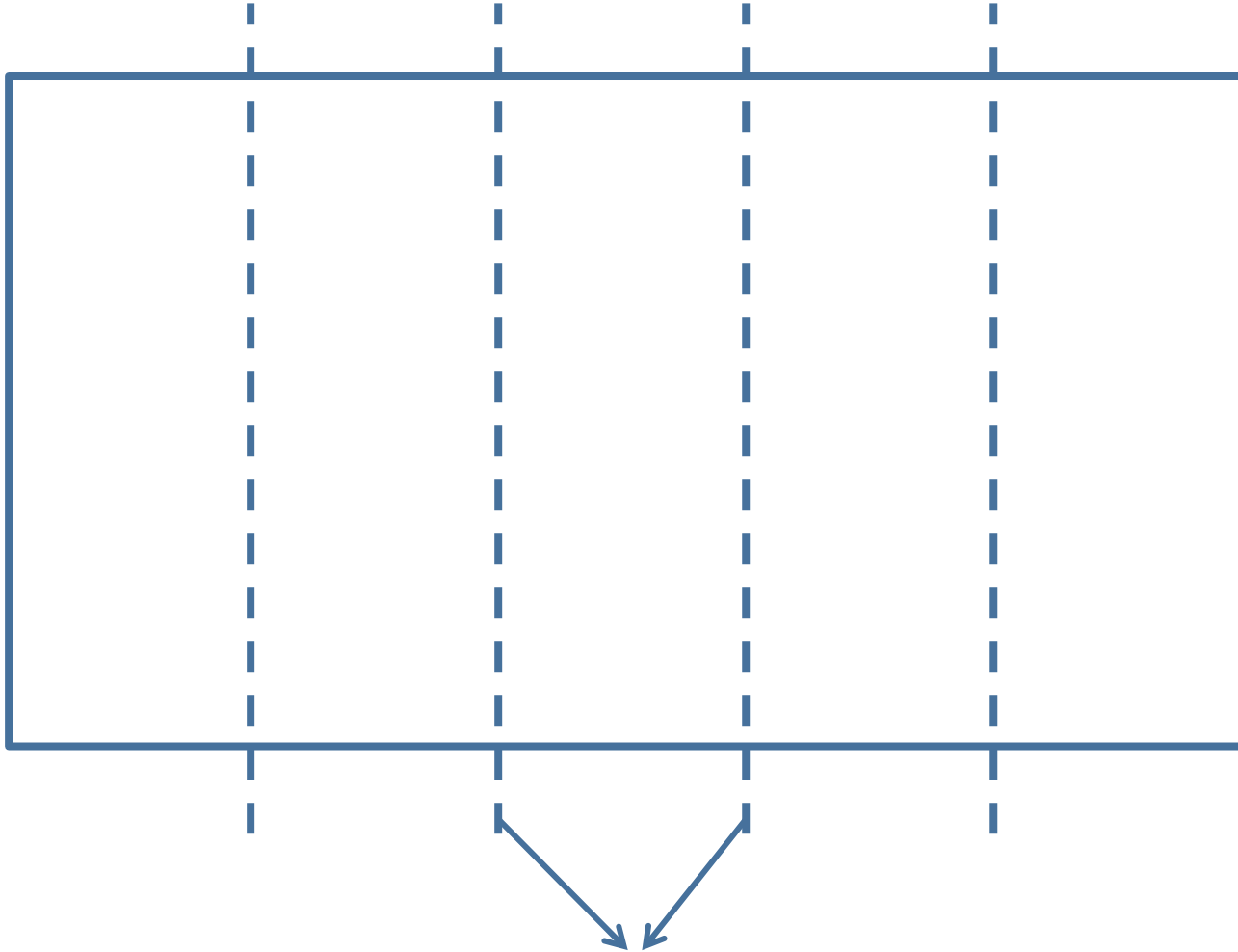
Dynamic programming

Dynamic programming



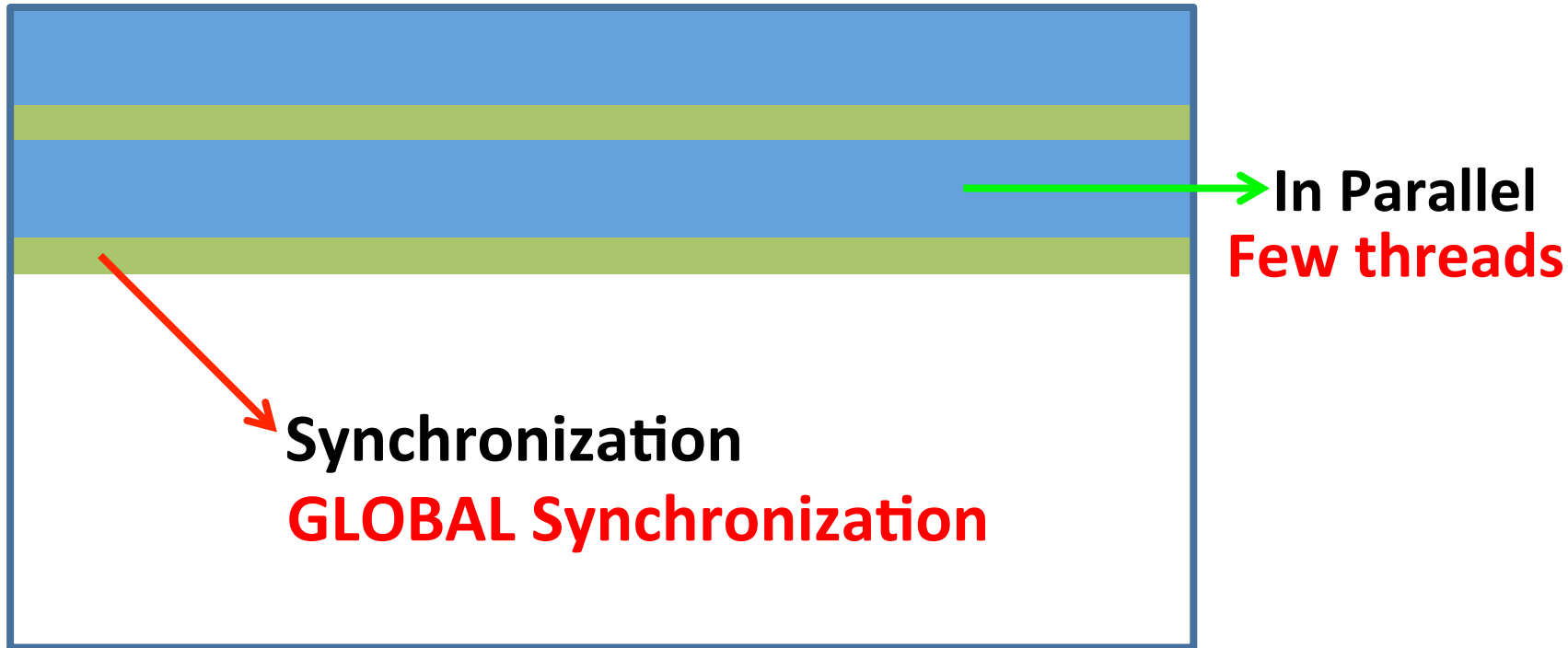
`Clamp(0 , width)`

Dynamic programming

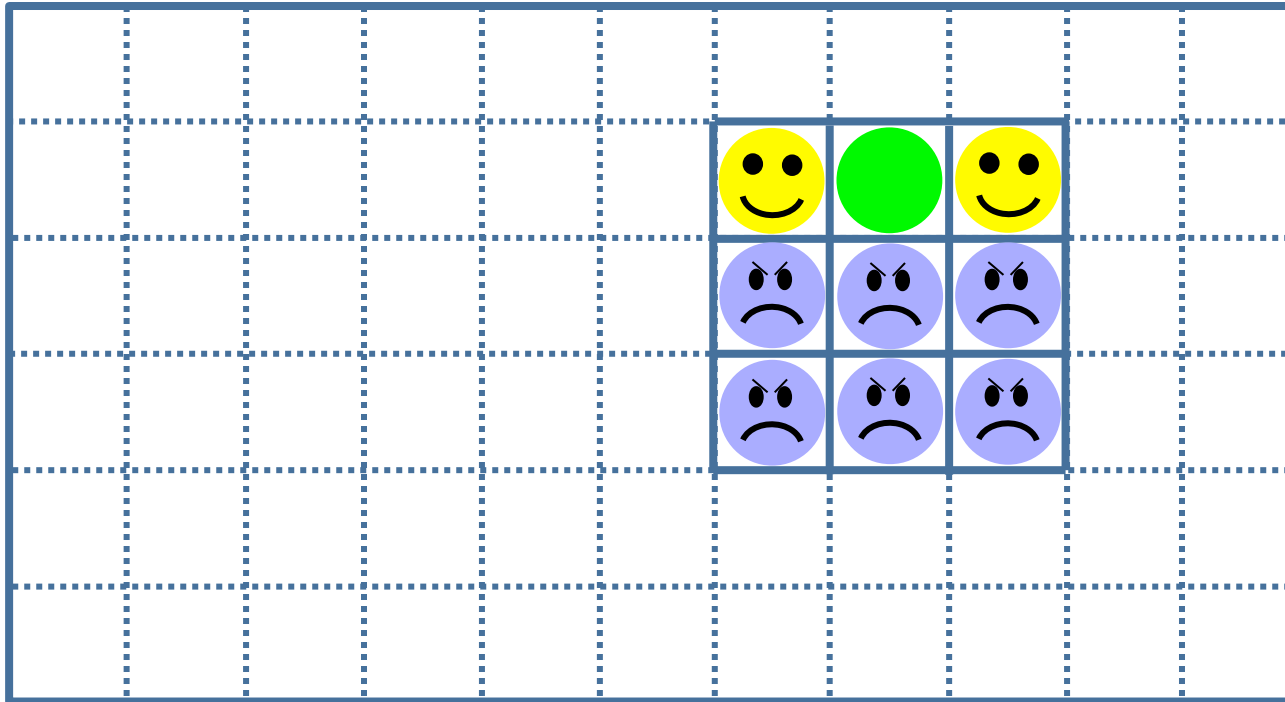


Clamp(start_table(thread_i) , end_table(thread_i))

Dynamic programming

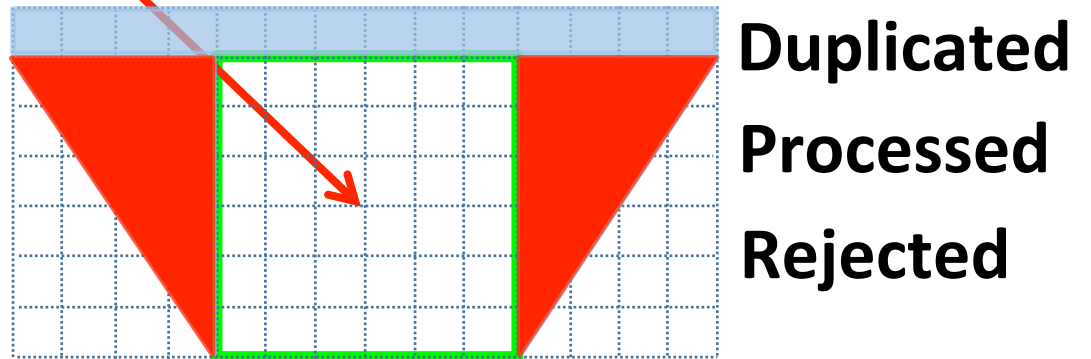
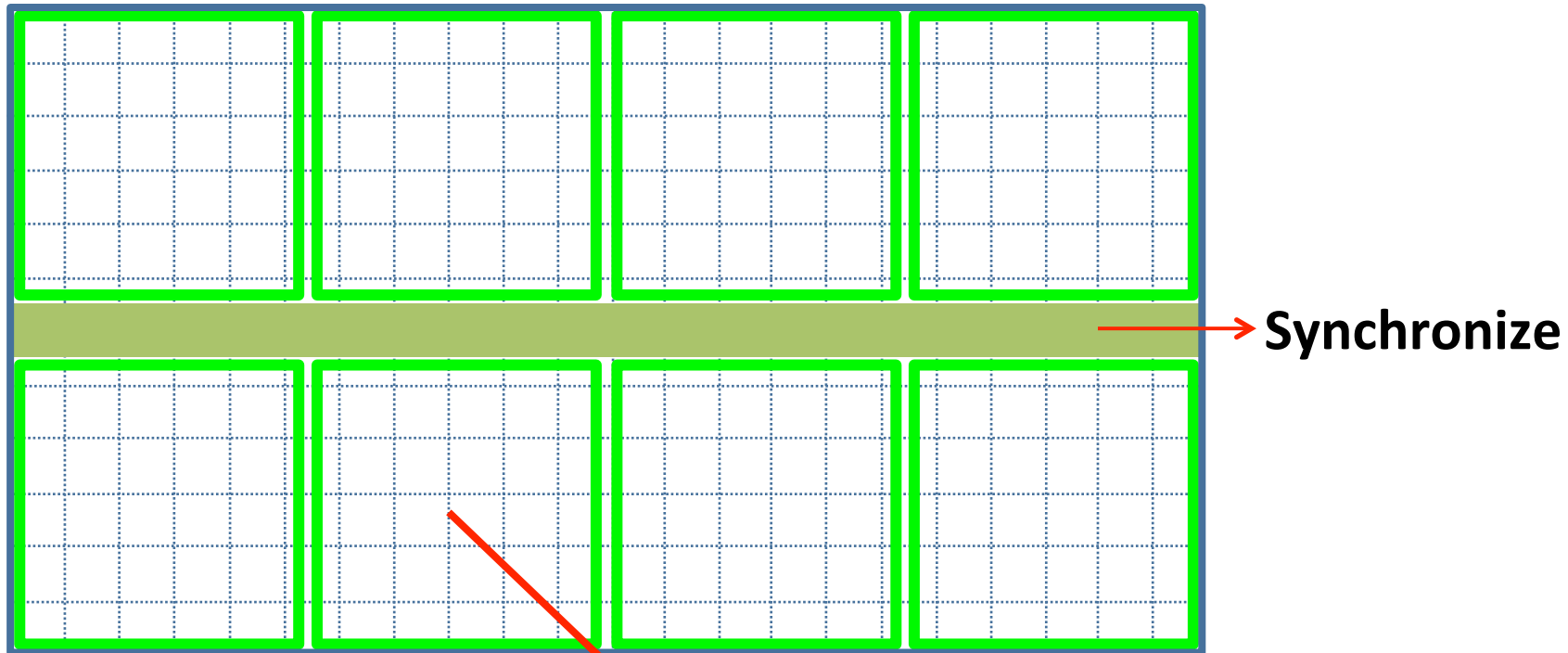


Dynamic programming



Spatial coherence

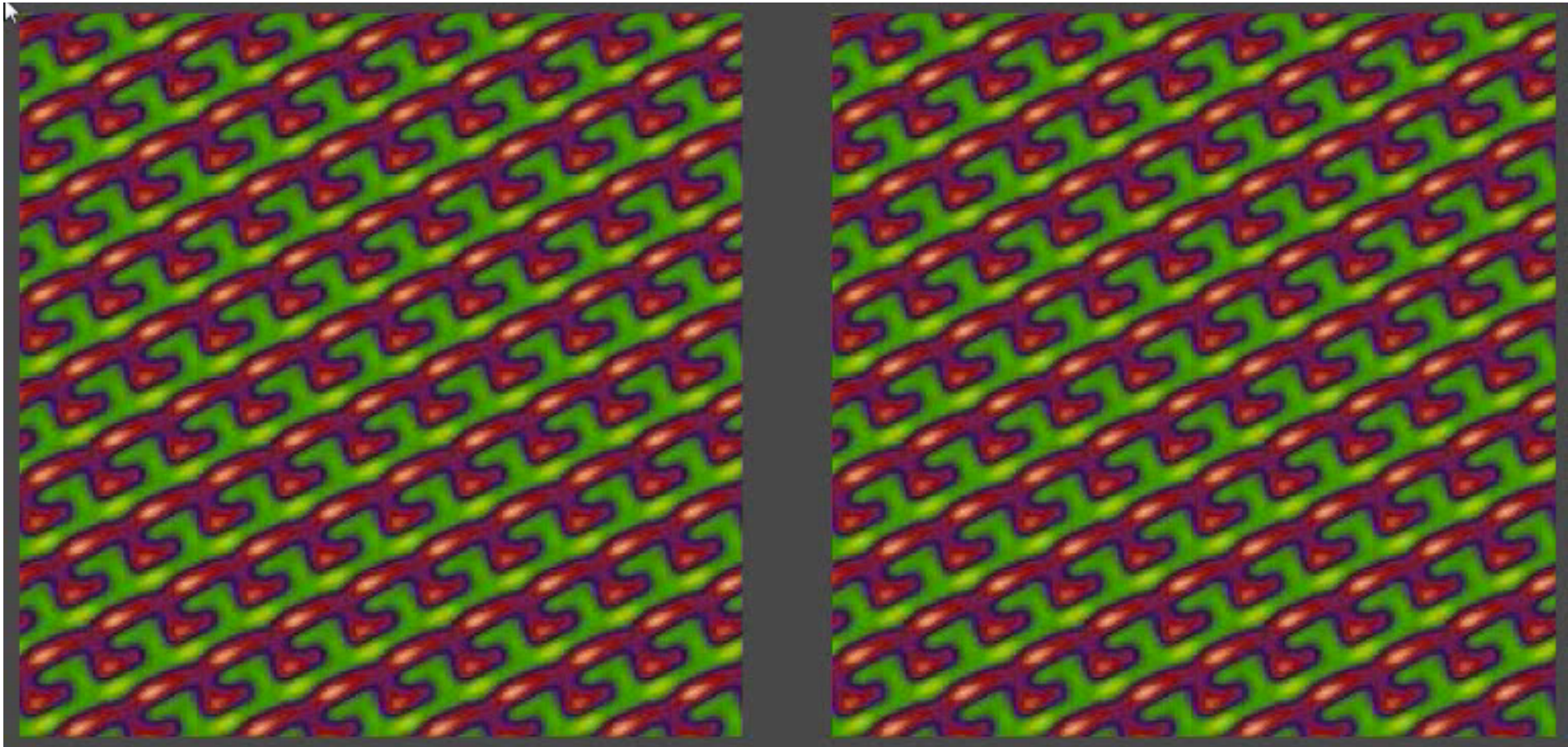
Dynamic programming



Results

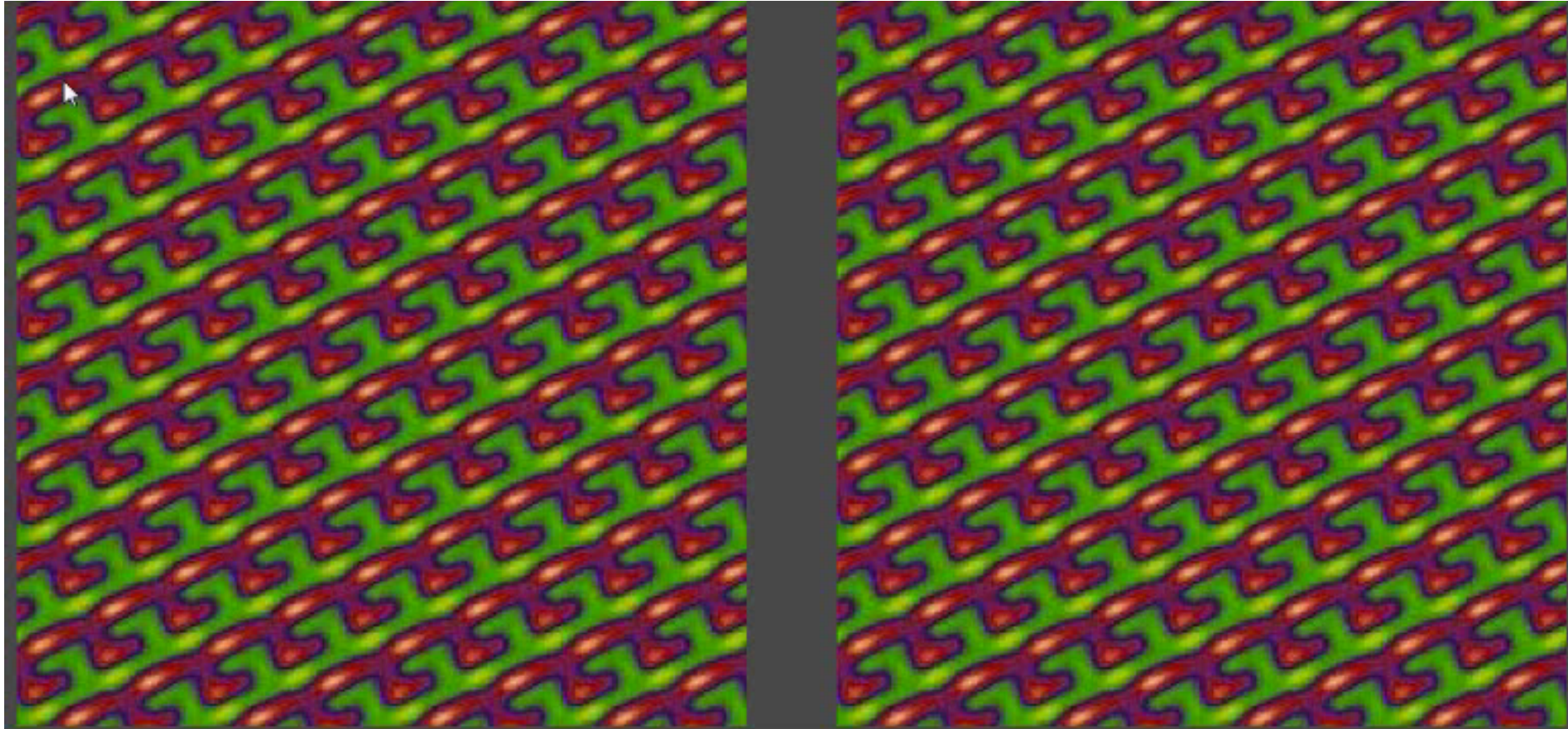
Results

No Deformation



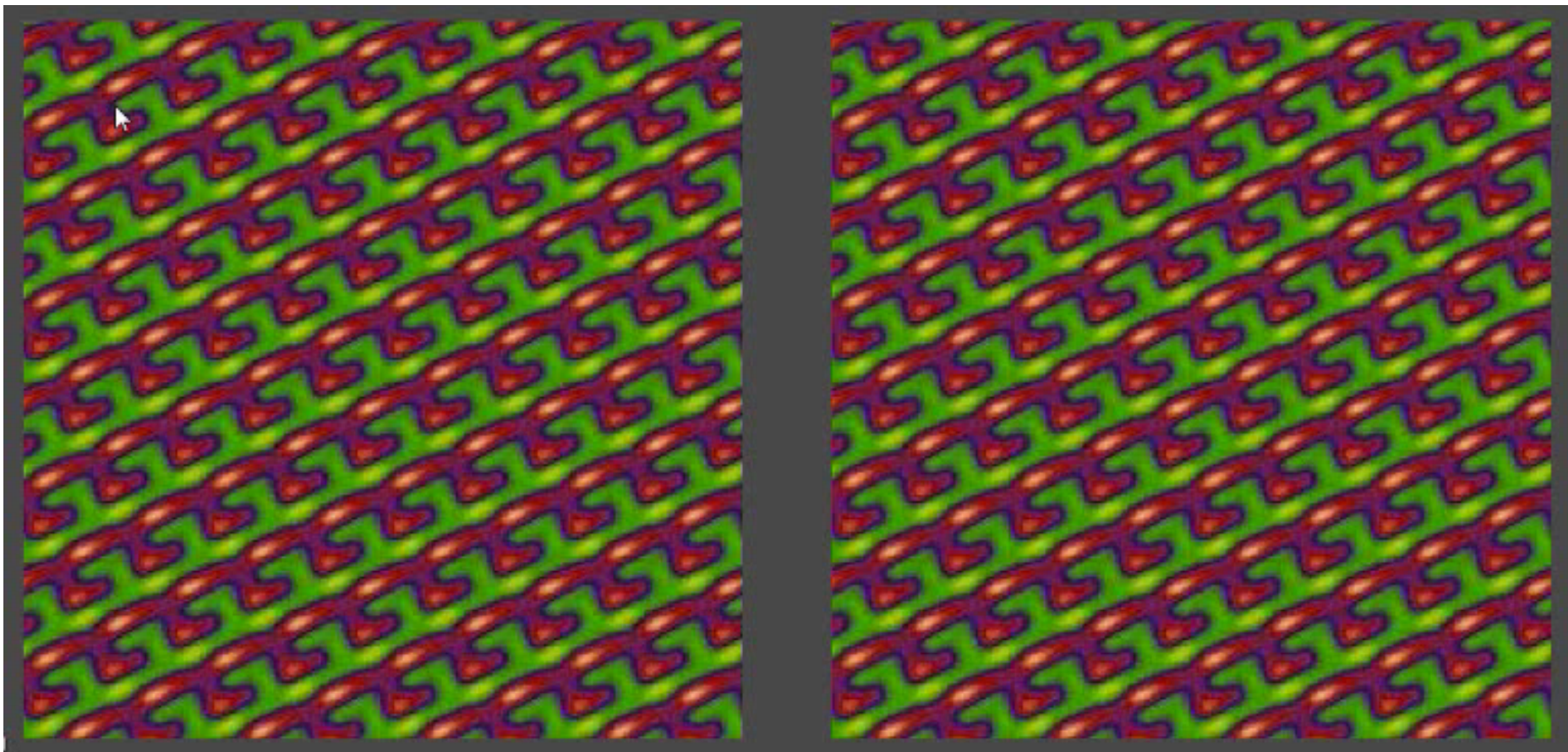
Results

No Cut



Results

Both Cut and Deformation



Results



Results



Results



Results

Max Patch Radius : 8 pixels



Results

Max Patch Radius : 64 pixels



Results

Automatically reducing radius



Results

Completion



Results

Completion

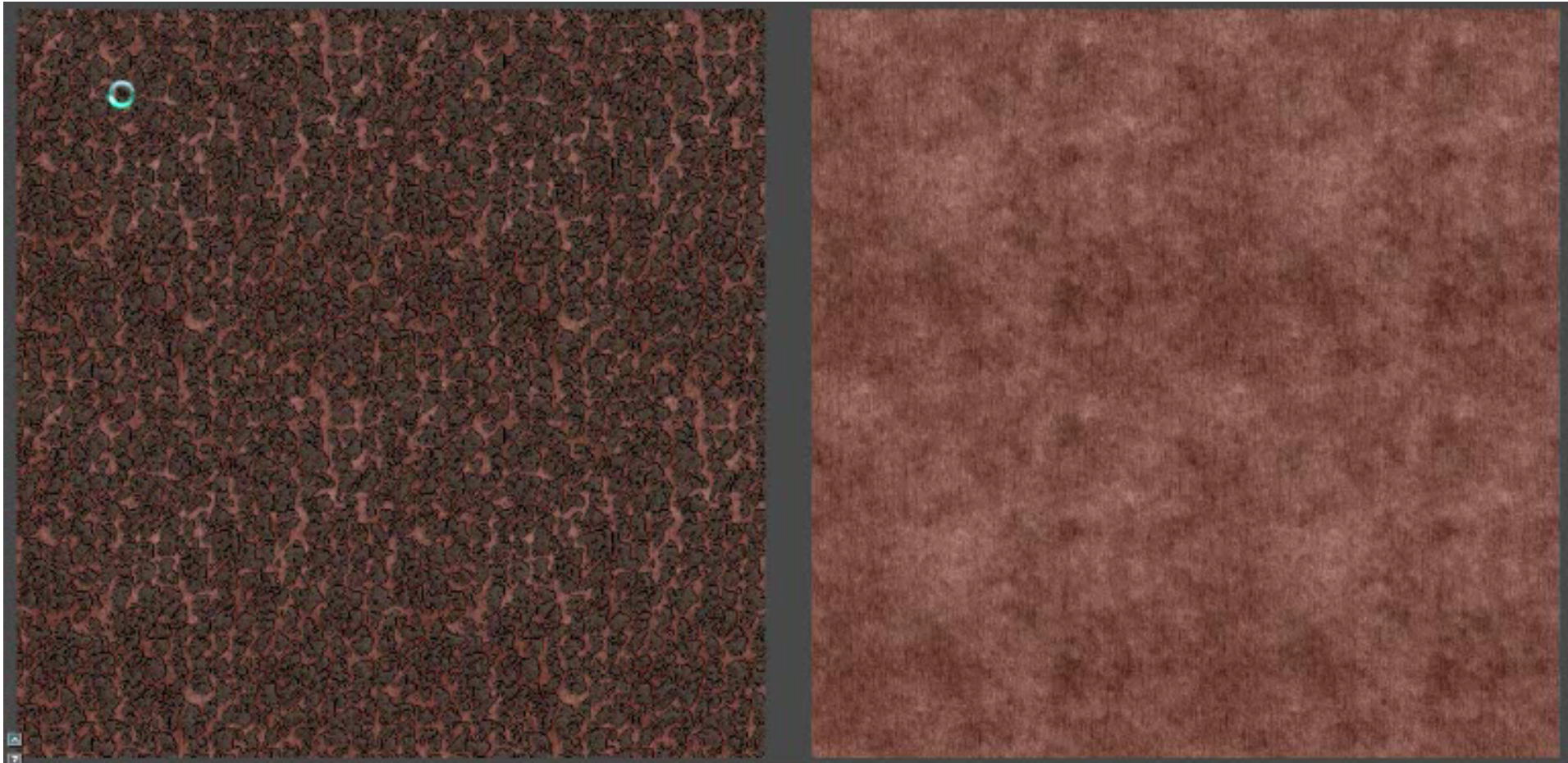


Results



Results

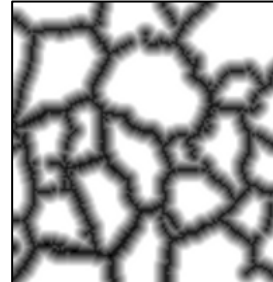
Paint



Limitations

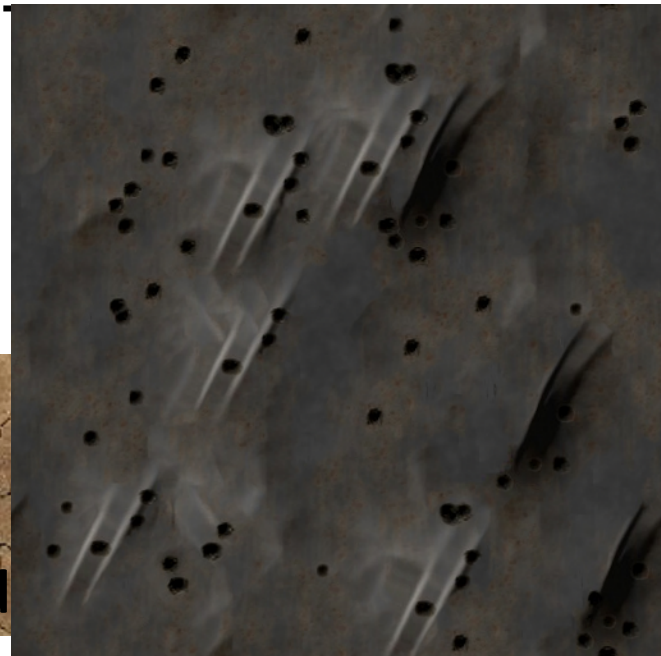
- Pixel-based synthesis

- Structure preservation
- Large structures
- Faster(2-4 iterations)

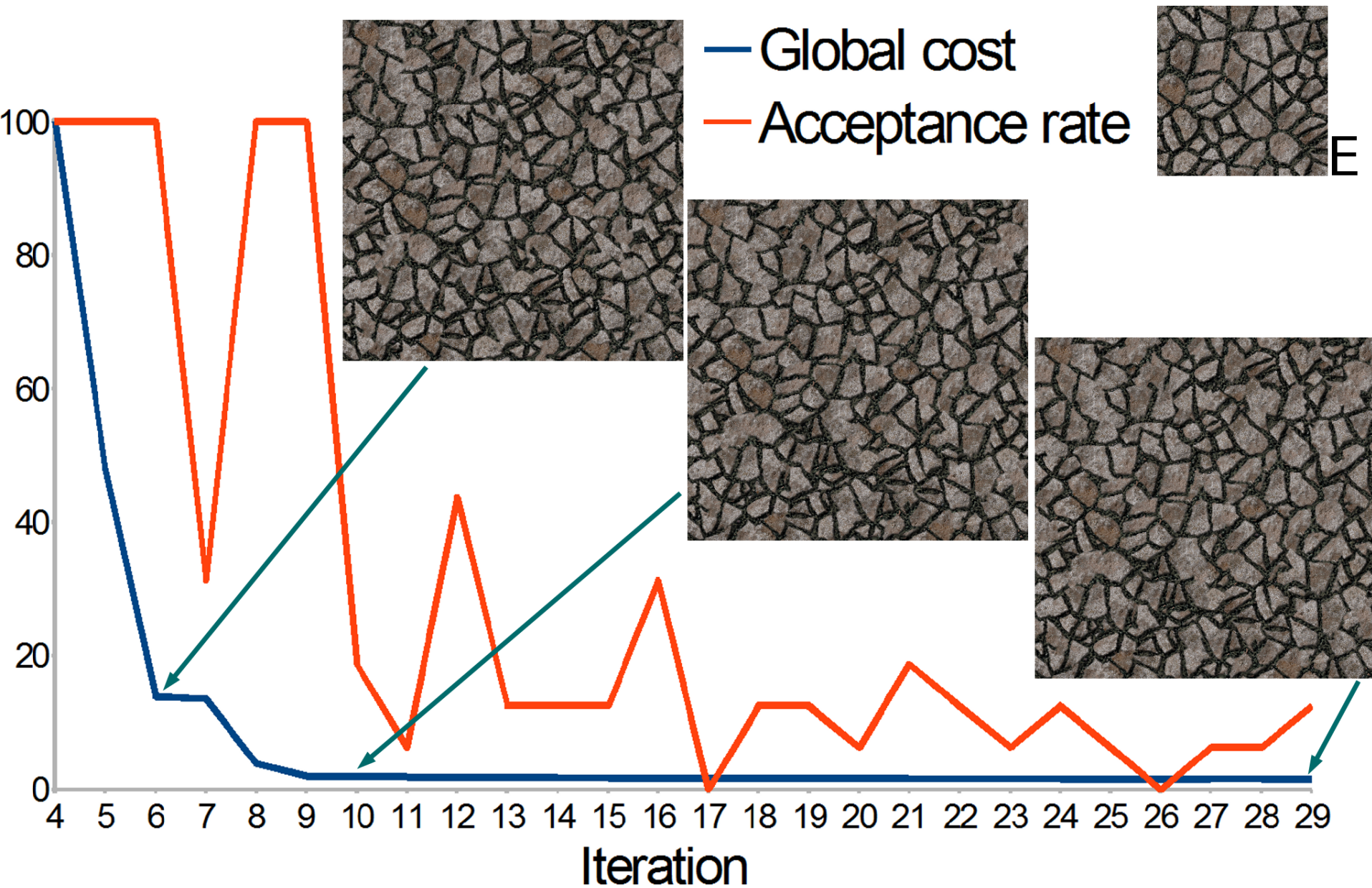


- Patch-based synthesis

- Structure preservation
- Large structures
- Fast (16-32 iterations)

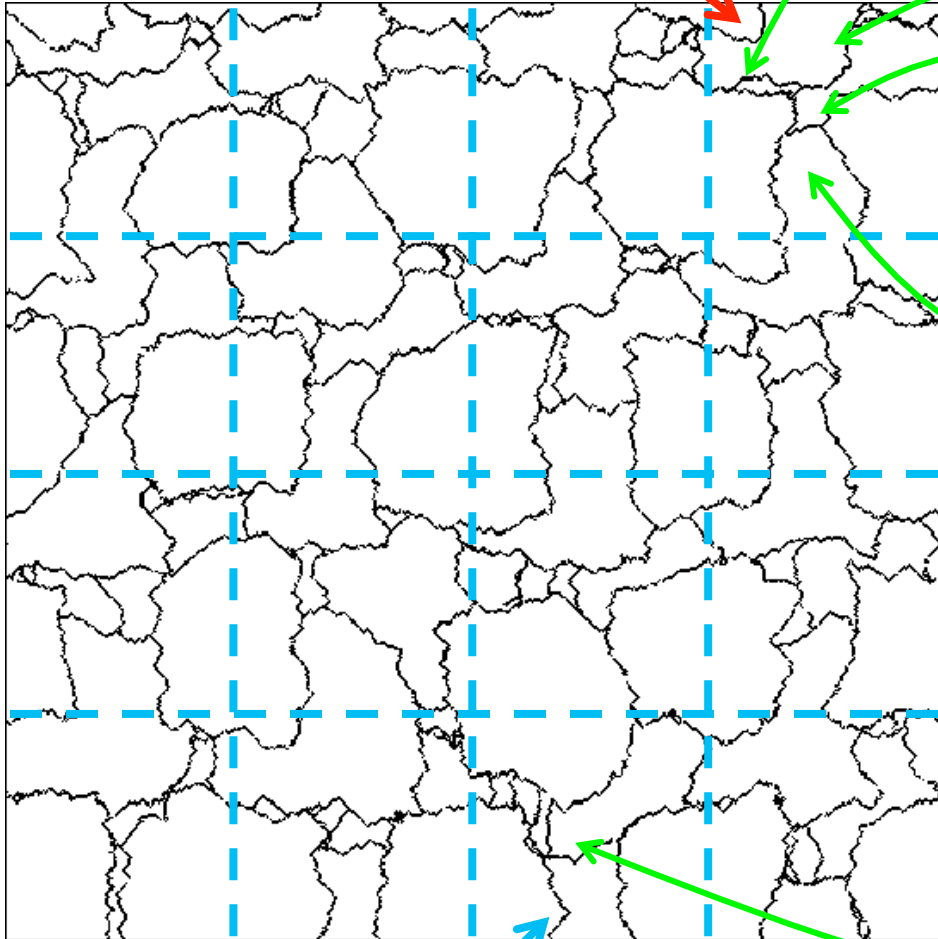
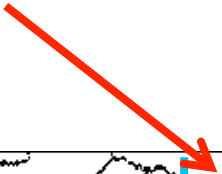


Limitations



Future Work

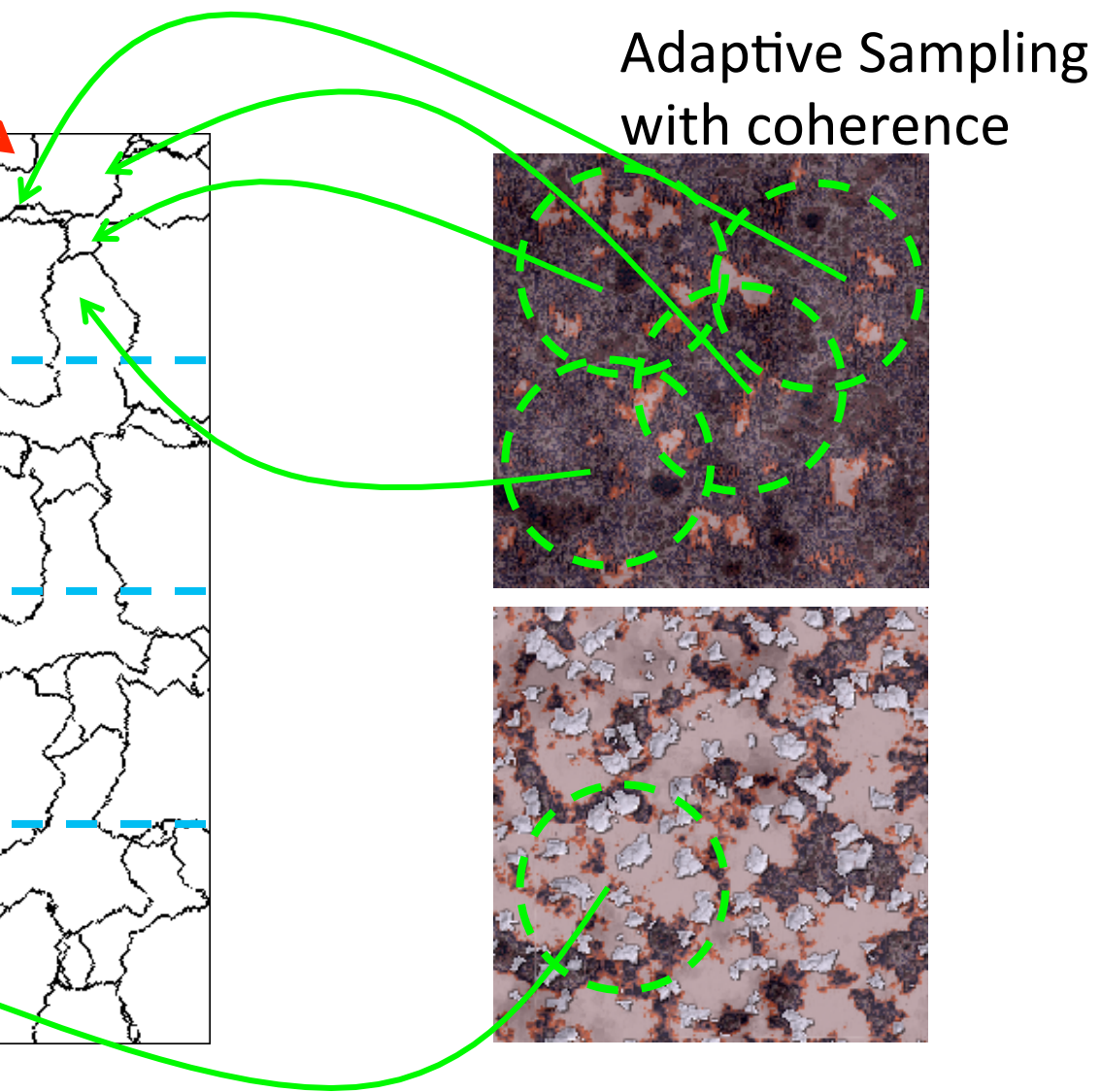
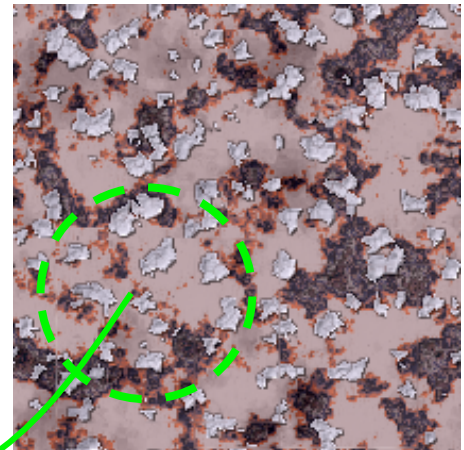
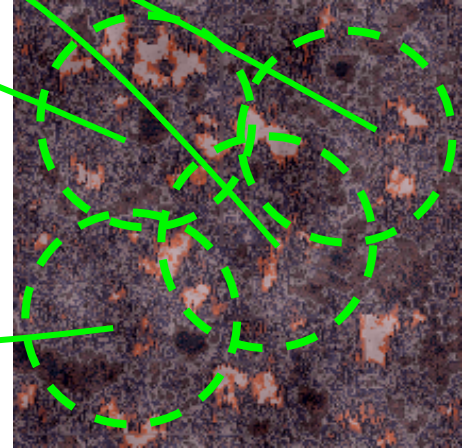
High Error



Low Error



Adaptive Sampling
with coherence



Thank you


Pixel-based Texture Synthesis

- Acceleration
 - Multi resolution, TSVQ [Wei & Levoy 00]
 - Coherence [Ashikhmin 01]
 - K-Coherence [Tong et al. 2002]
 - PCA [Lefebvre & Hoppe 06]

 - GPU [Lefebvre & Hoppe 05]

 - Patch Match [Barnes et al. 09]
 - Coherent random walk [Busto et al. 10]

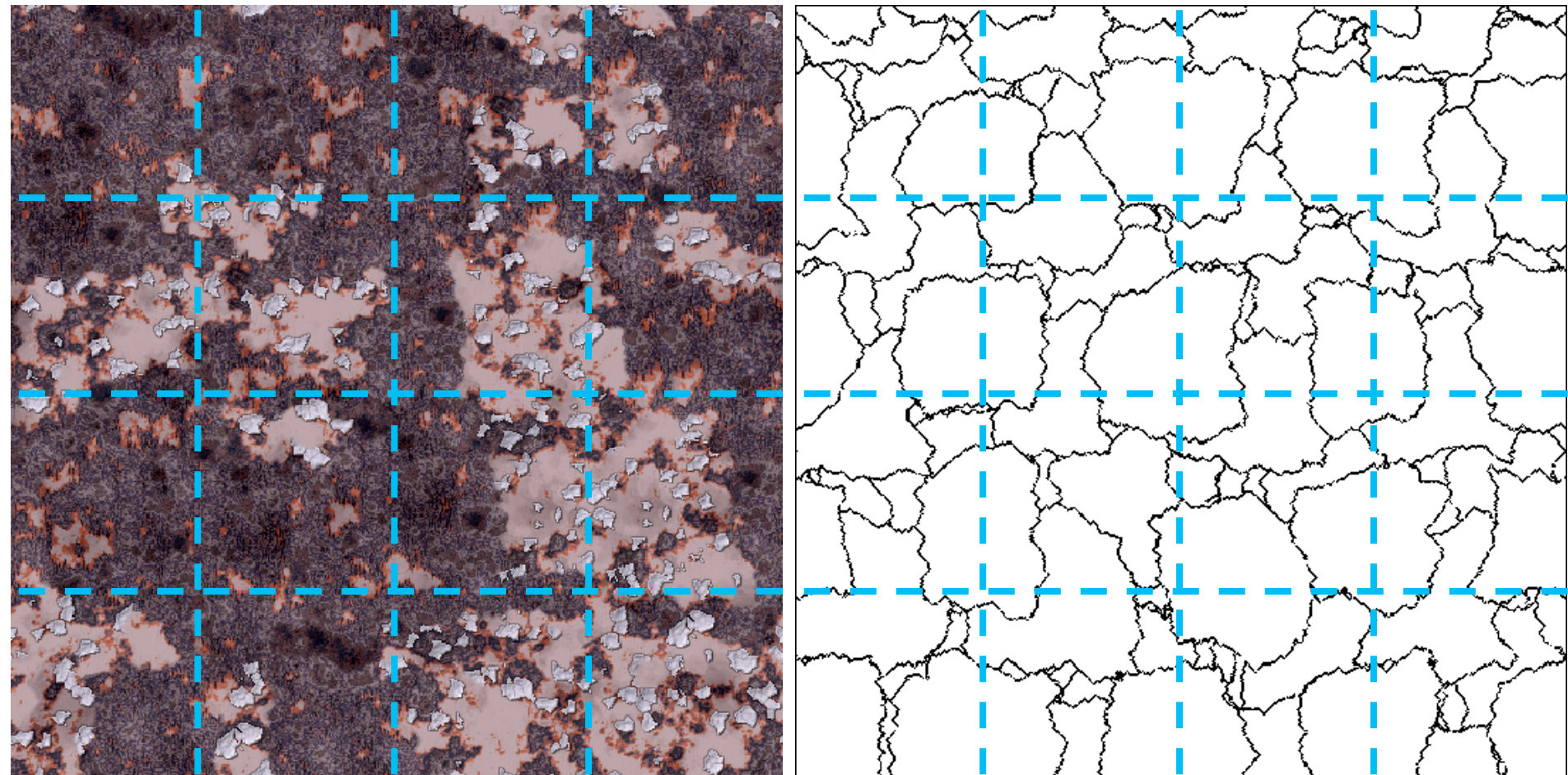
By-example Texture Synthesis

- Pixel-based Texture synthesis
 - Structure preservation
 - Fast
 - Patch-based Texture synthesis
 - Structure preservation
 - Slow
- Our approach**  **FAST**

What have been done

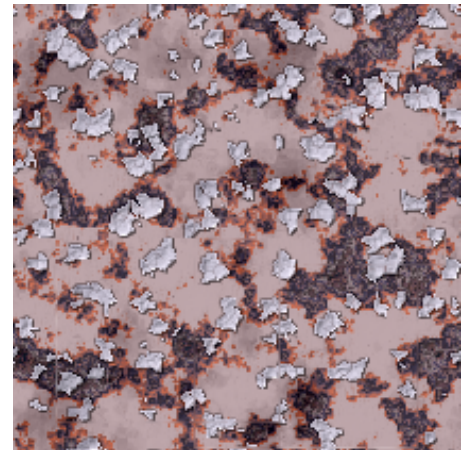
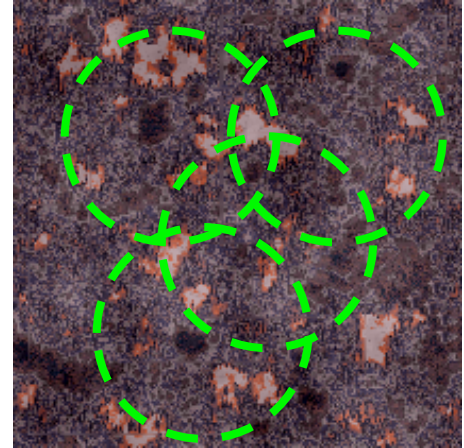
- How to search patches ?
 - Random $O(1)$
 - Exhaustive search $O(N^2)$
 - FFT-based block matching $O(N \log(N))$
- How to stitch patches ?

Overview



Future Work

- Uniform Sampling
- Patch Match(neighborhood!)
- [Darabi et al. 12]
 - Patch diversification
 - Gradients



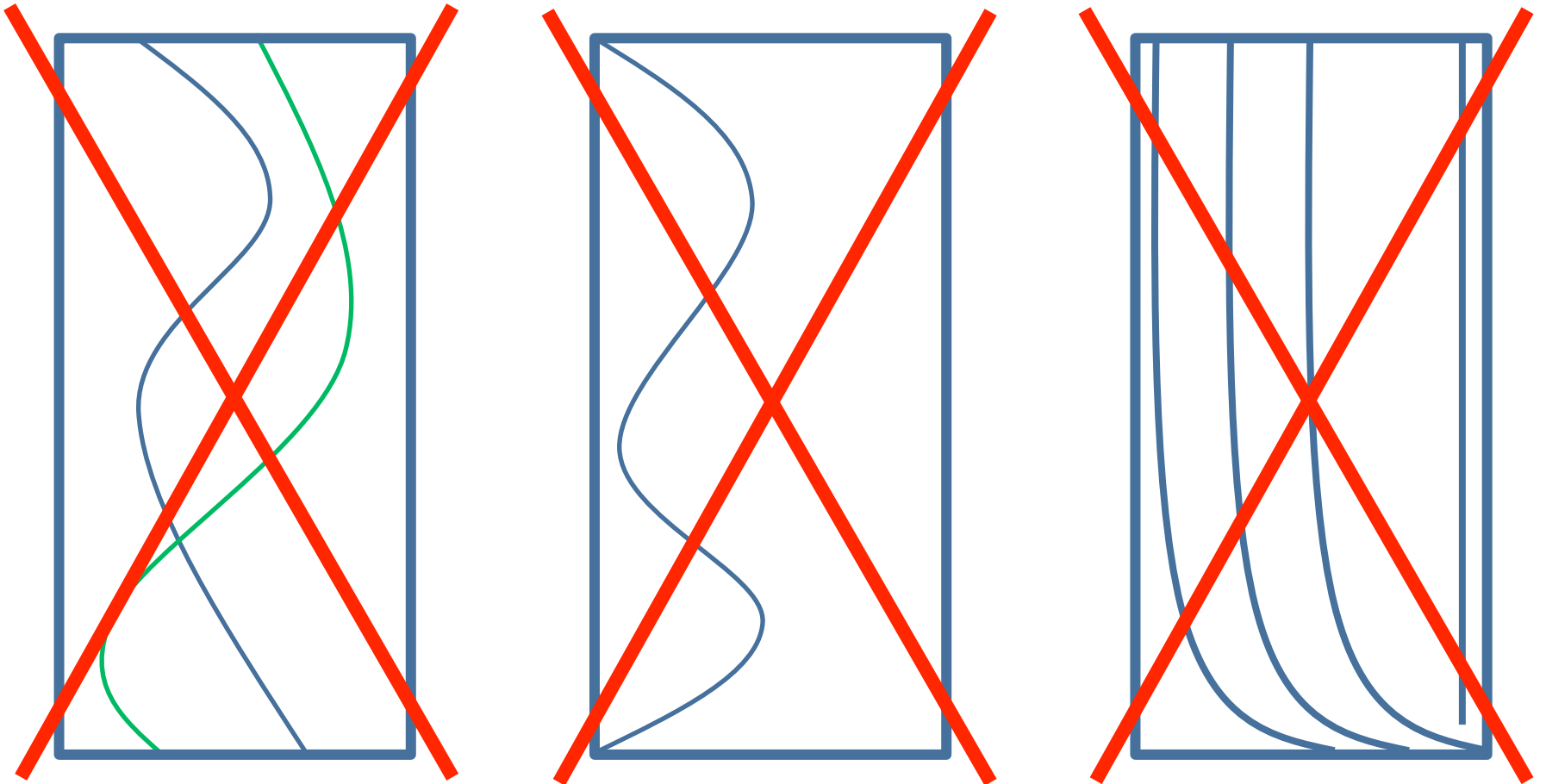
Exemplars

By-example Texture Synthesis

- **Patch-based synthesis**
 - Image Quilting [Efros & Freeman 01]
 - Graph-cut textures [Kwatra et al. 03]
 - **High quality**
 - **Slow**

Cut determination

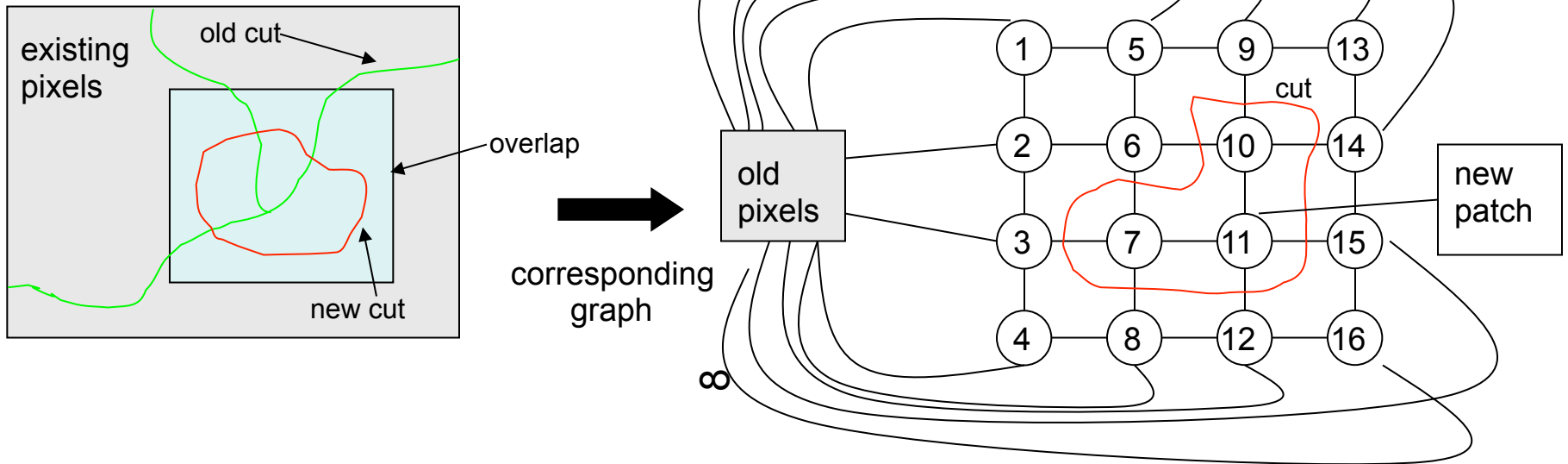
- The approximate solution does always exist



By-example Texture Synthesis

- Pixel-based synthesis
 - Fast [Wei & Levoy 00, Ashikhmin 01, Tong et al. 2002, Lefebvre & Hoppe 05, Lefebvre & Hoppe 06, Barnes et al. 09, Busto et al. 10]
- Patch-based synthesis
 - Structure preservation without additional data

Graph-cut textures



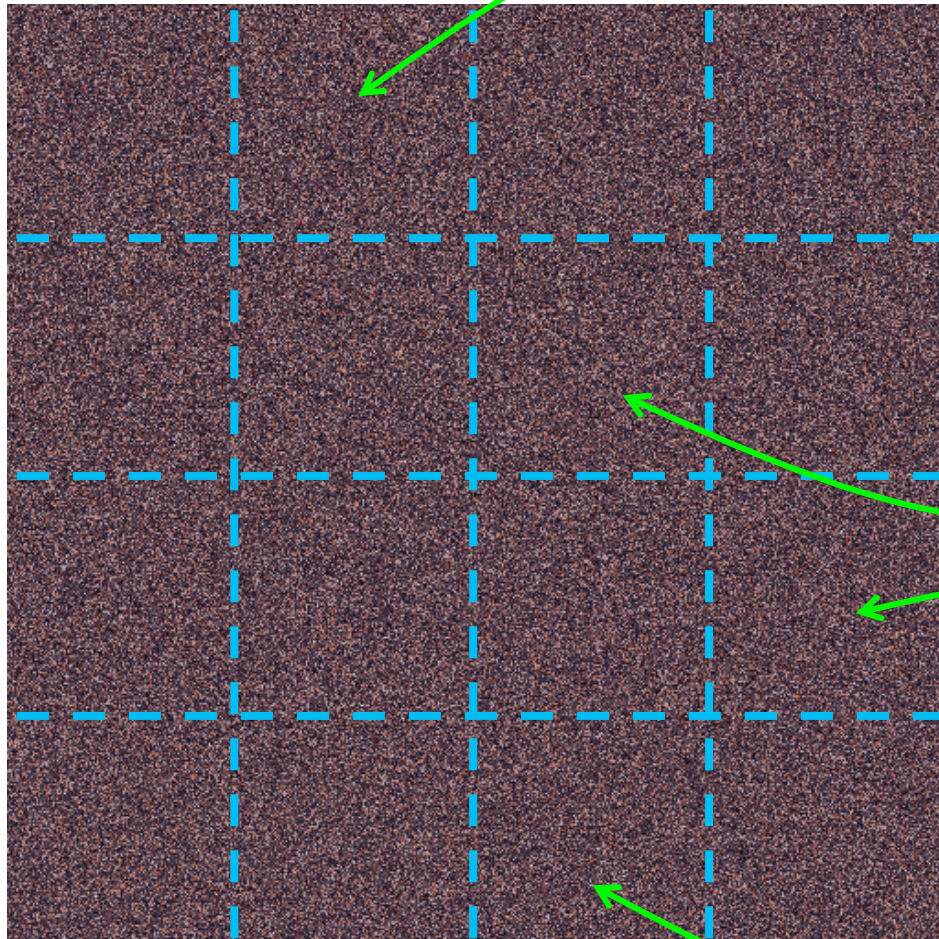
Cut determination

- The approximate solution does always exist

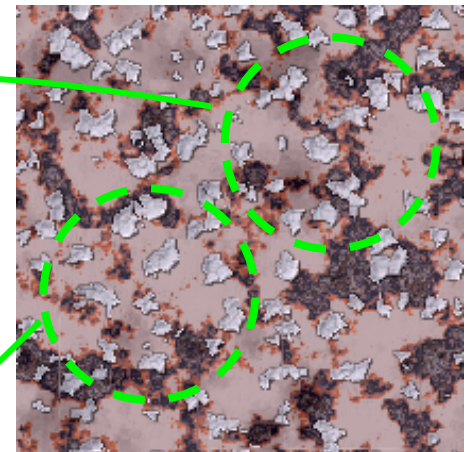
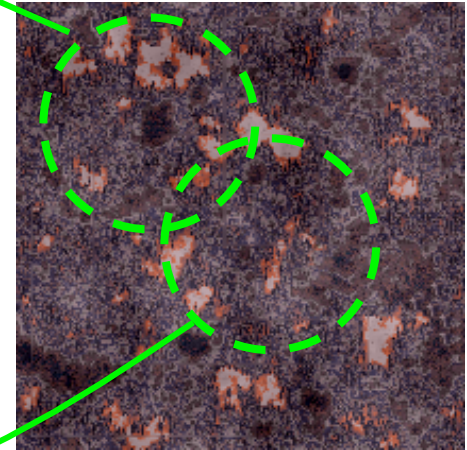
Number of textures	3000
Optimal cut average error	50.855
Approximate cut average error	53.633
All cuts average error	81.962
Approximate cut average ranking	8.59/256

Future Work

One patch per cell



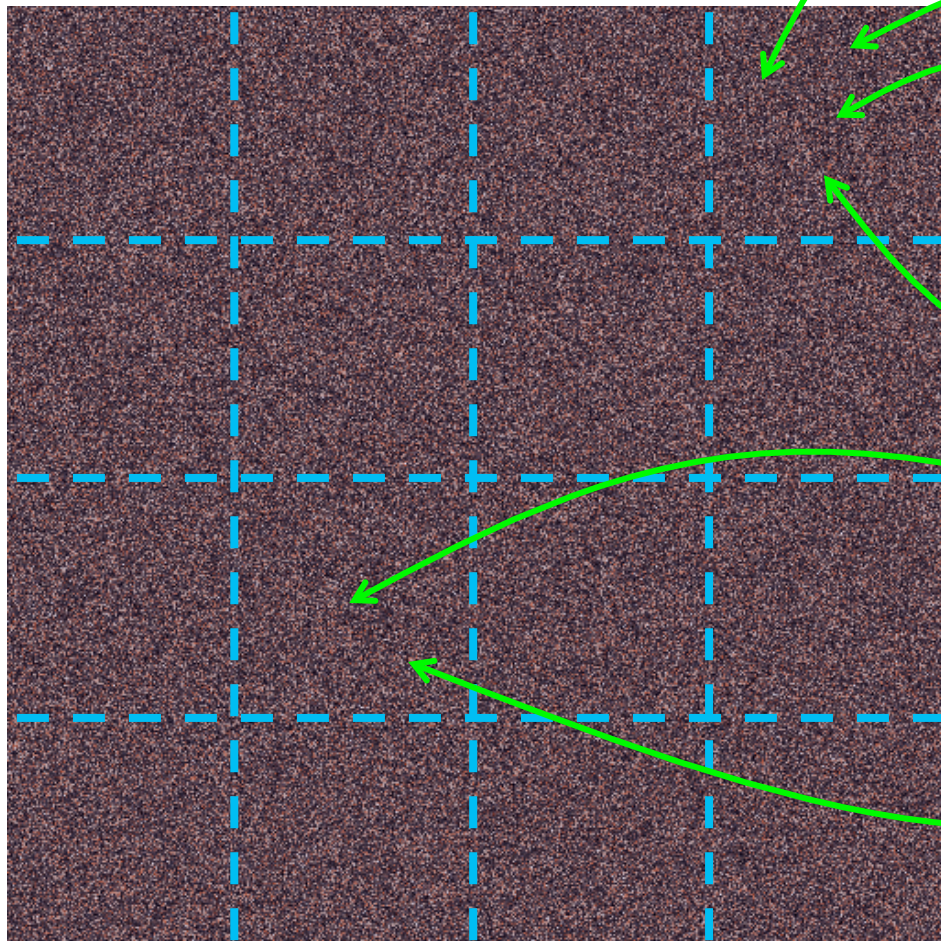
Synthesis



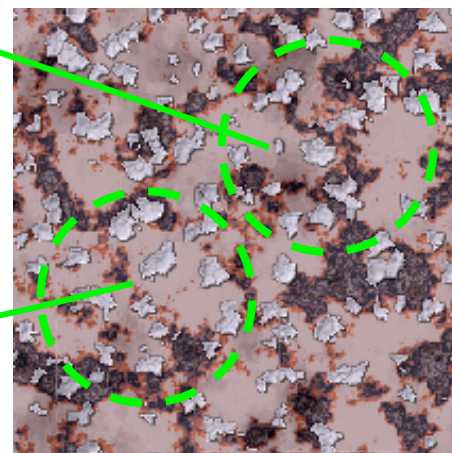
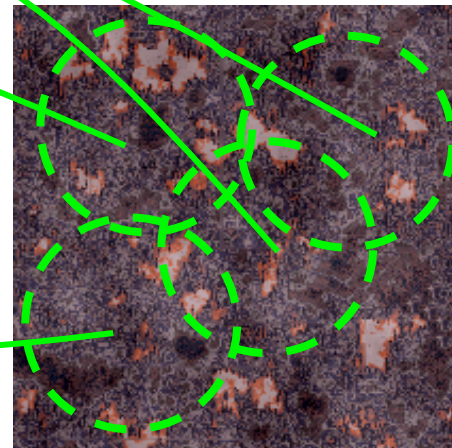
Exemplars

Future Work

Multiple patches per cell



Synthesis

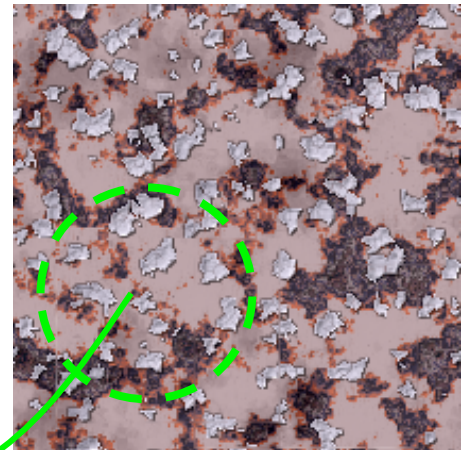
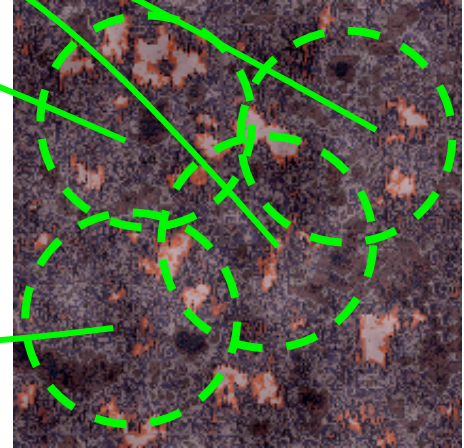
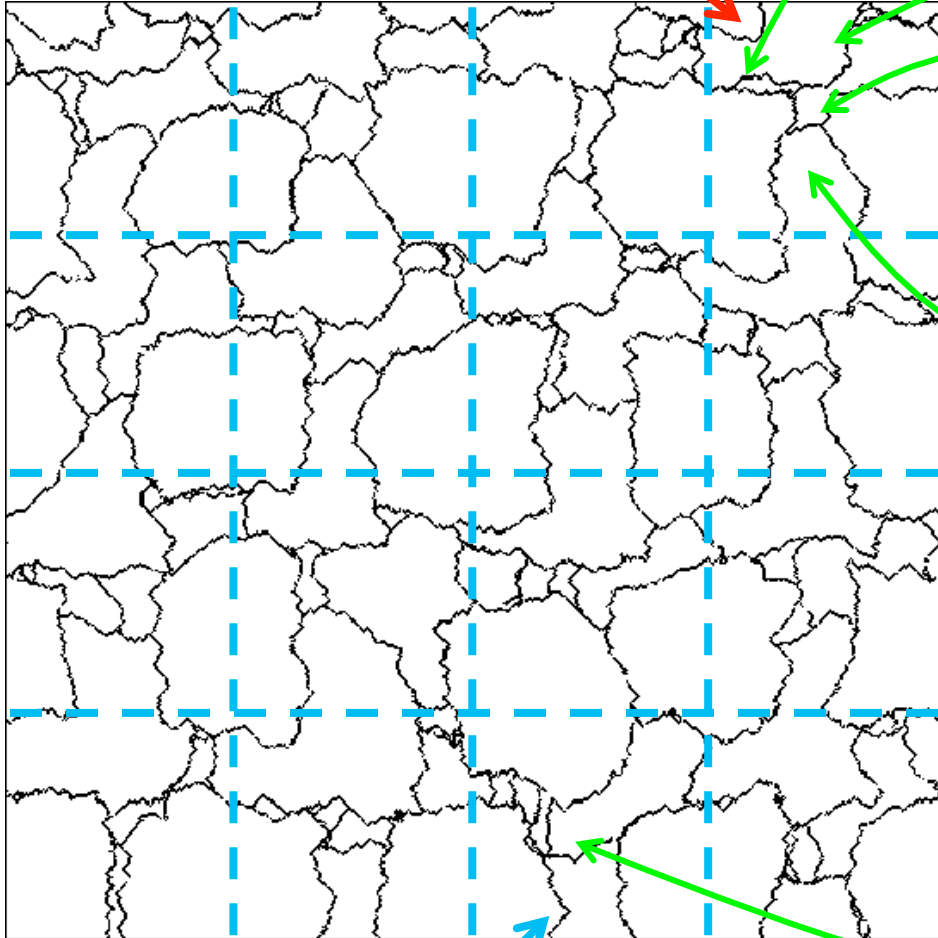


Exemplars

Future Work

High Error

Adaptive Sampling



Low Error

Future Work

- Coherence

- [Ashikhmin 01, Tong et al. 2002, Barnes et al. 09, Busto et al. 10]

- Patch diversification

- [Kwatra et al. 03, Ma et al. 11, Darabi et al. 12]

- Gradient Domain

- [Perez et al., Darabi et al. 12]