Dynamic programming (DP) in computer vision

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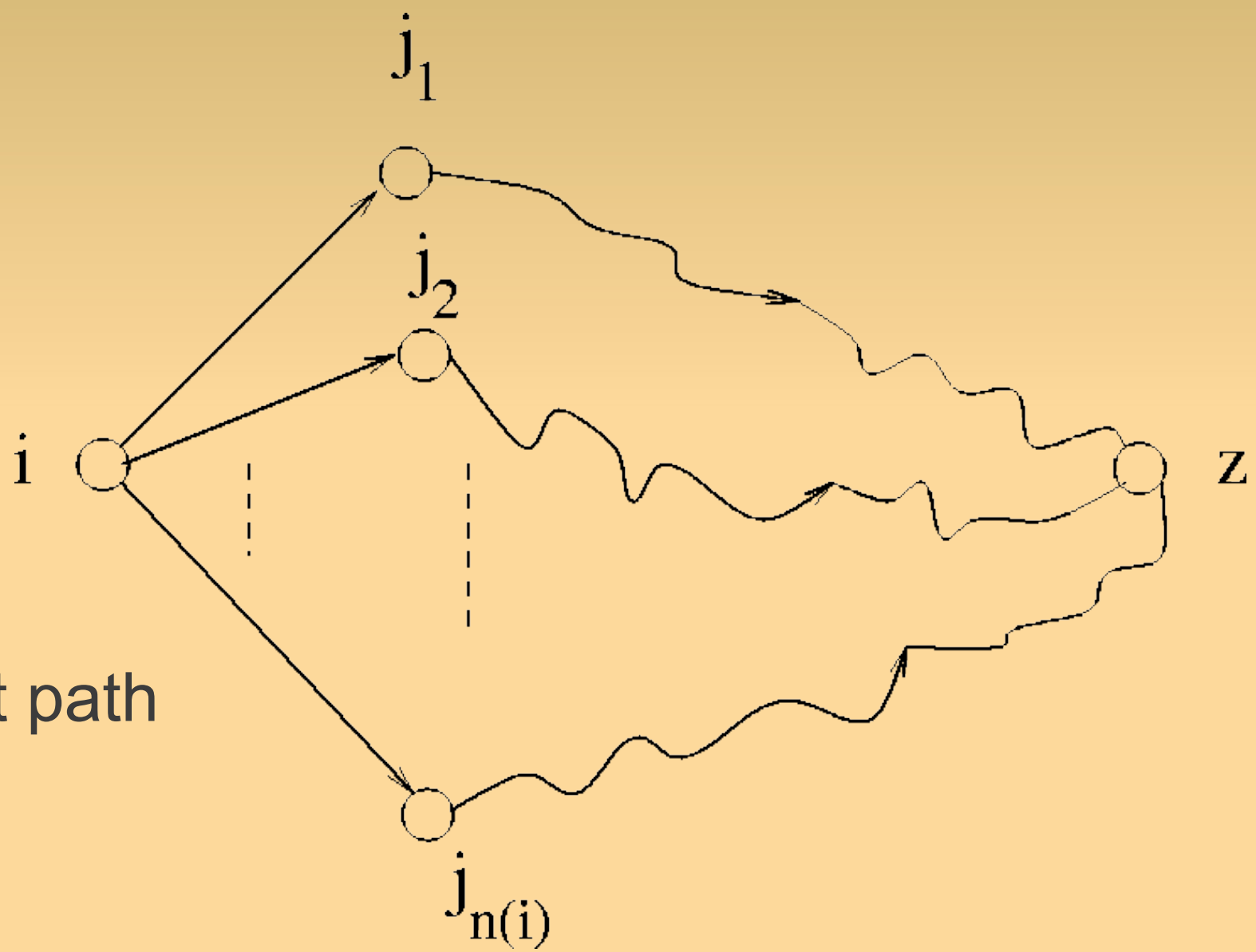
What is DP?



Shortest path

DP compared to other methods

Greedy – when an optimal choice can be done at each step

DP – when overlapping subproblems are presented and recursive formula exists

More complicated algos

Divide and conquere algorithms

Fibonacci numbers

Topologically sorted:

- Fib(1), Fib(2), …
- Fib(n) = function(Fib(k)), k<n

Overlapping subproblems:

- Fib(n) = Fib(n-1) + ***Fib(n-2)***
- Fib(n-1) = ***Fib(n-2)*** + Fib(n-3)
- …

Examples of DP in CV

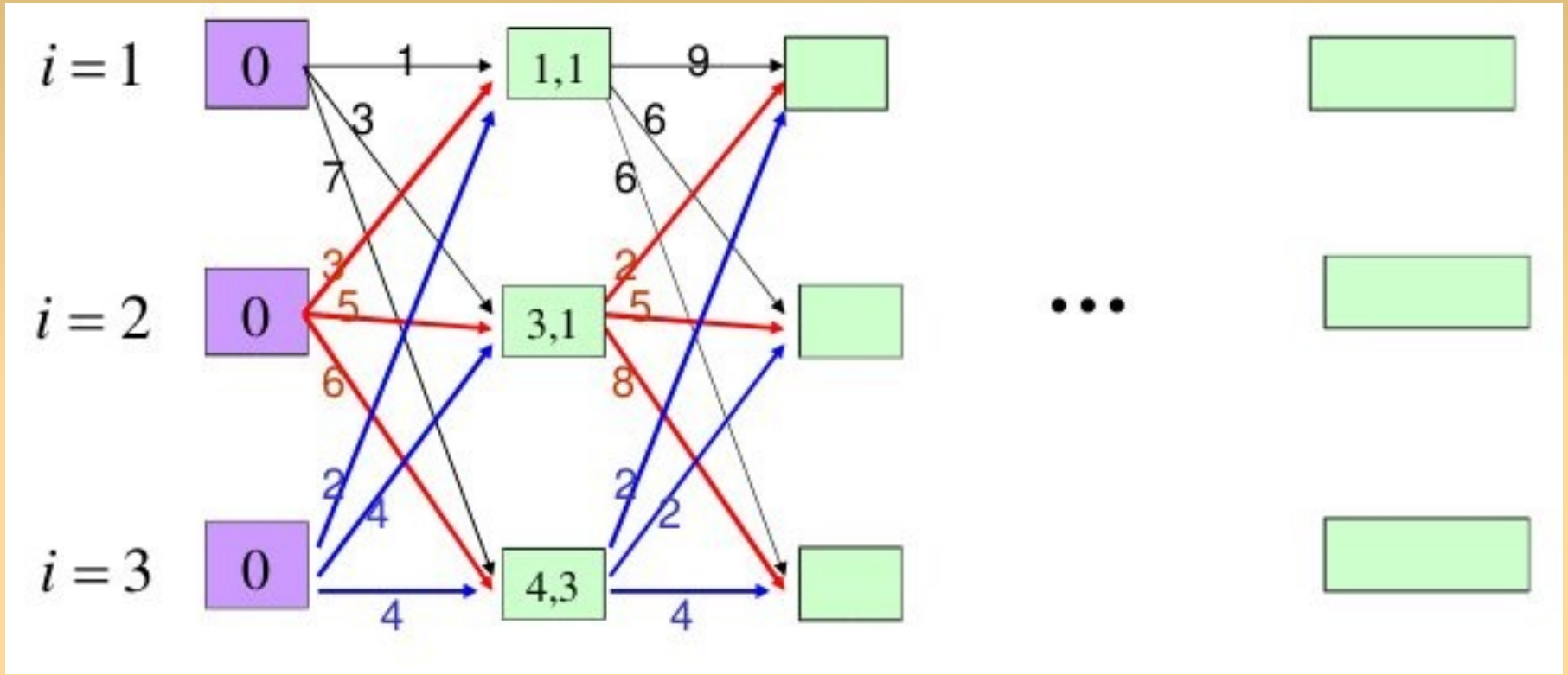
- **Active contours**
- Seam carving
- Cell analysis
- Stereo Correspondence
- Trajectory approximation
- Inpainting and quilting

Active contours using DP

(Felzenszwalb and Ramin Zabih)

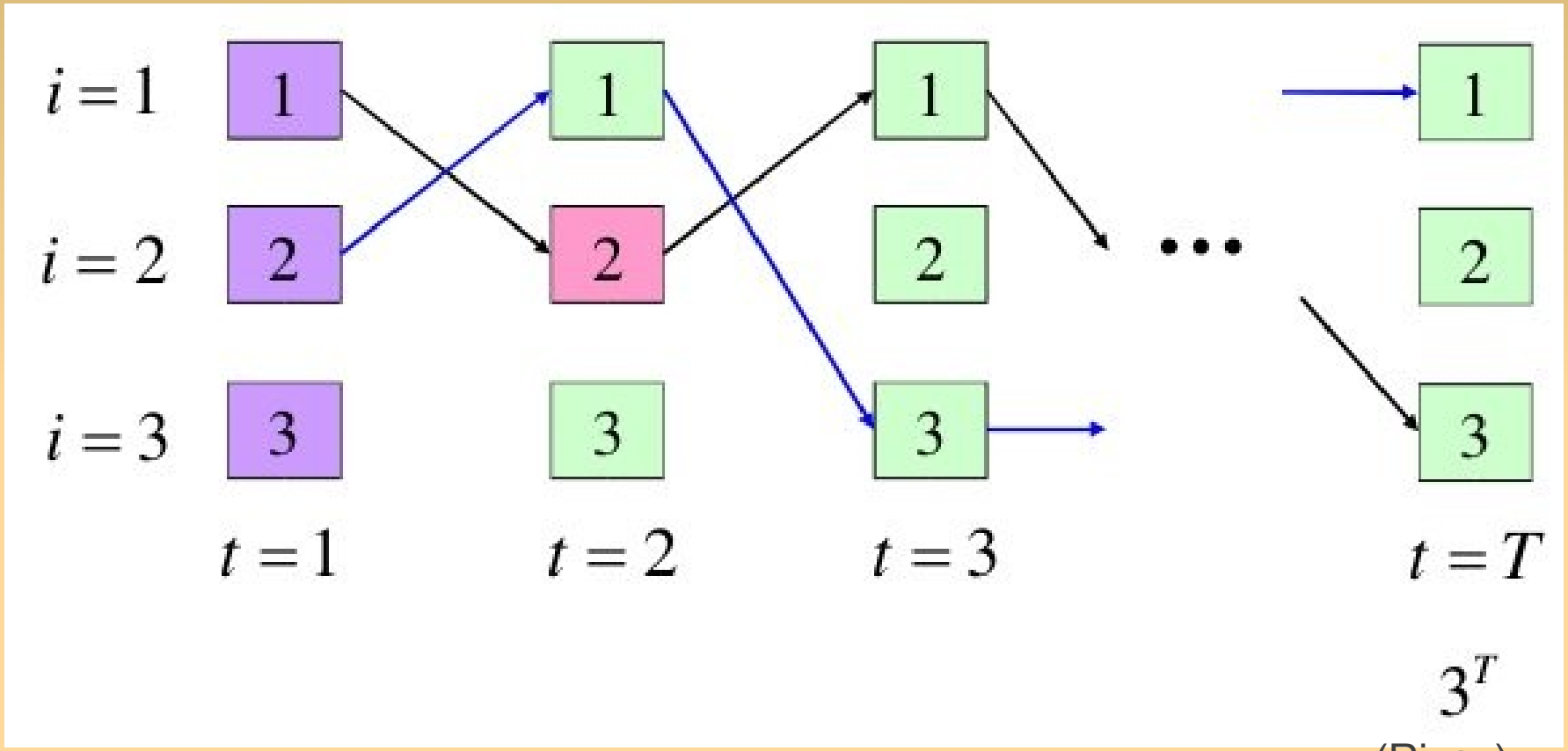
Choose control points and get the contours

Active contours



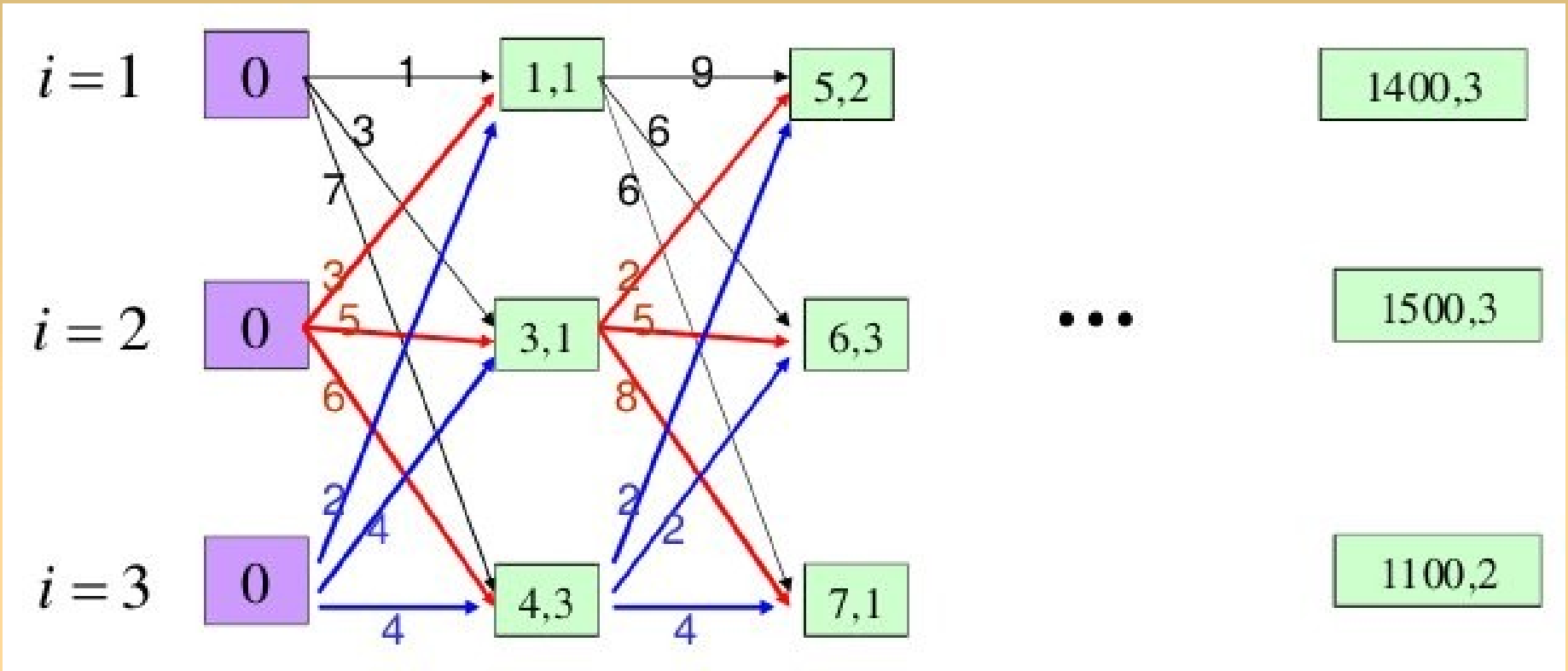
(Rivaz)

Active contours



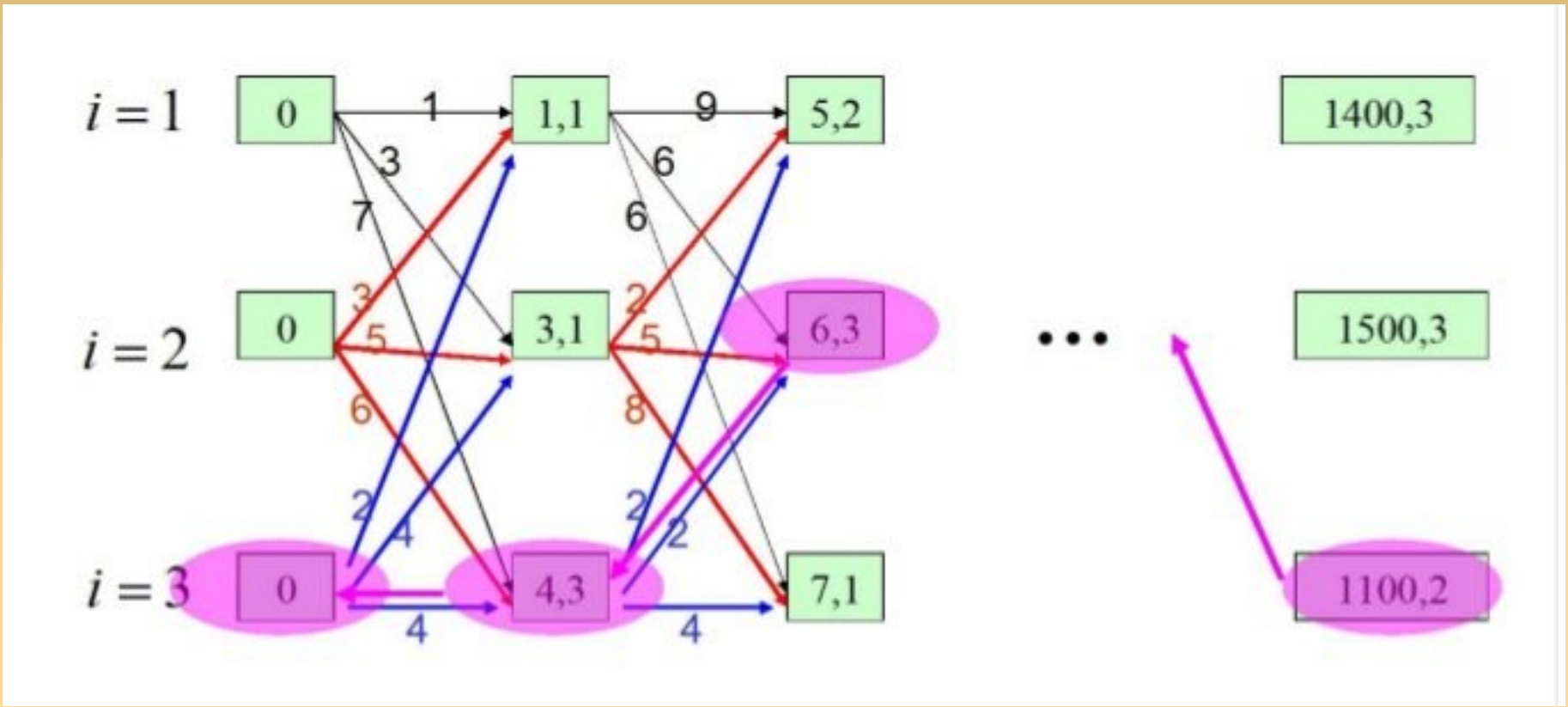
(Rivaz)

Active contours



(Rivaz)

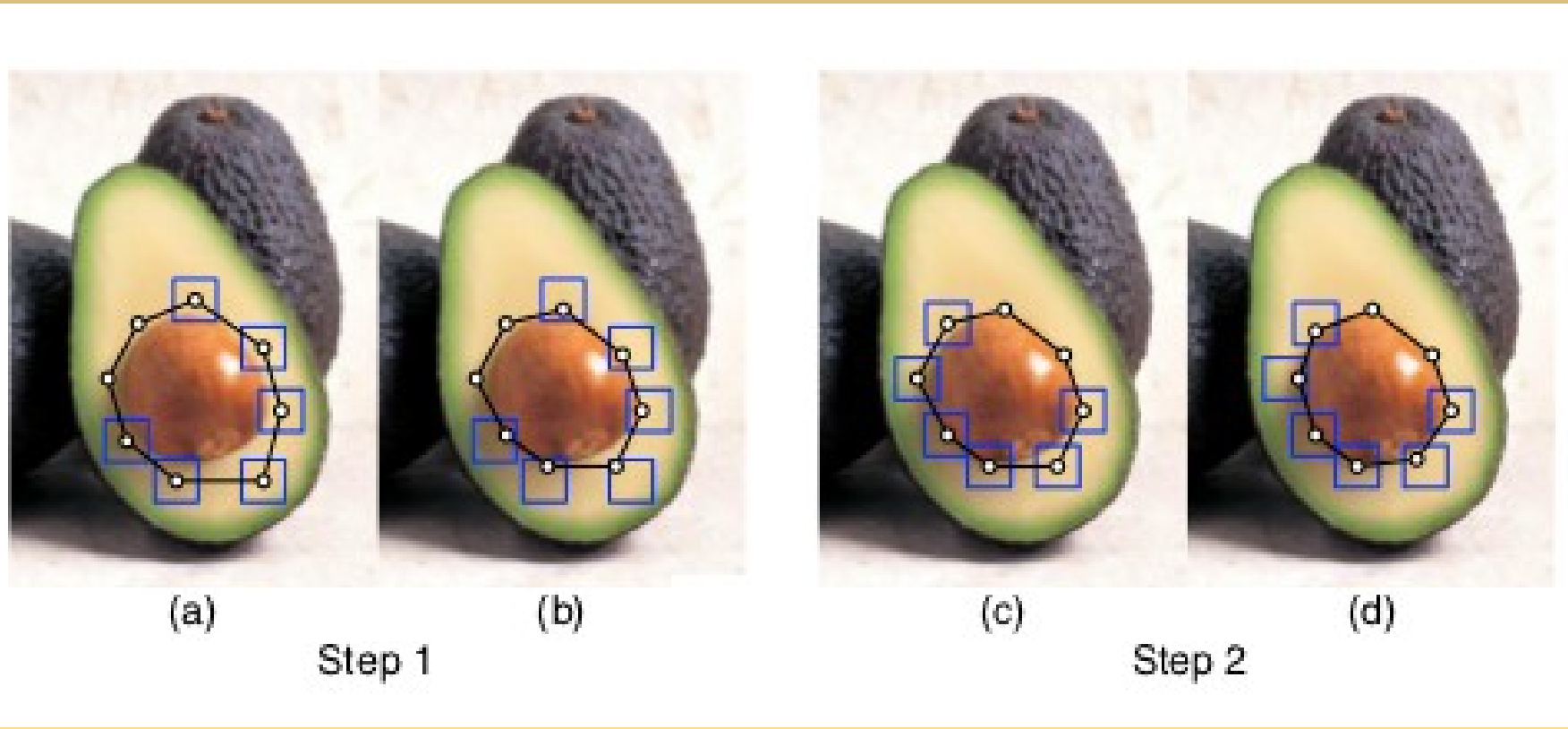
Active contours



(Rivaz)

Time complexity: $O(NK^3)$

Active contours: Iterations



(Felzenszwalb and Ramin Zabih)

Choose K near candidate positions for each control point. Iterate DP steps with the new candidate postitions until convergence.

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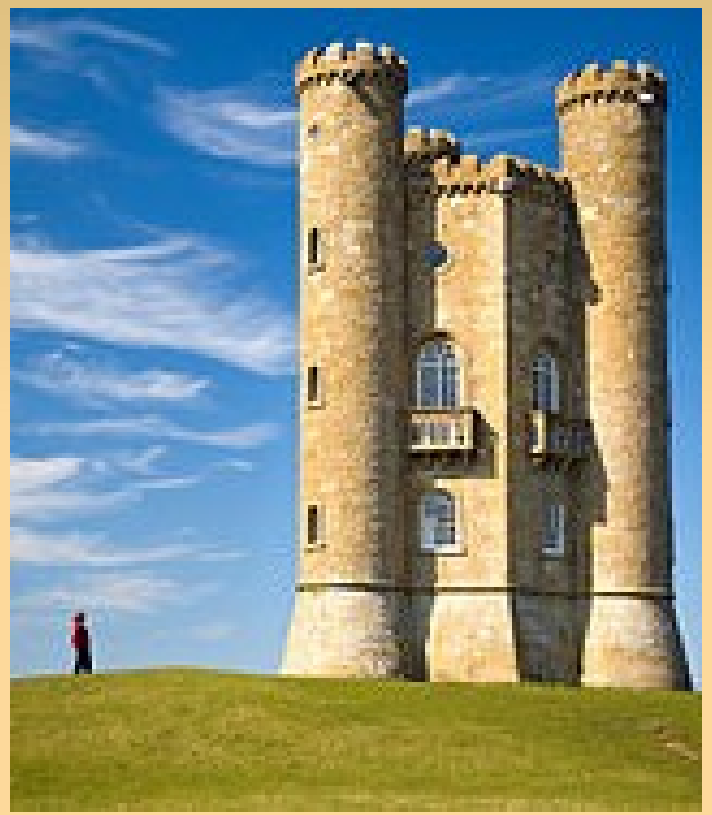
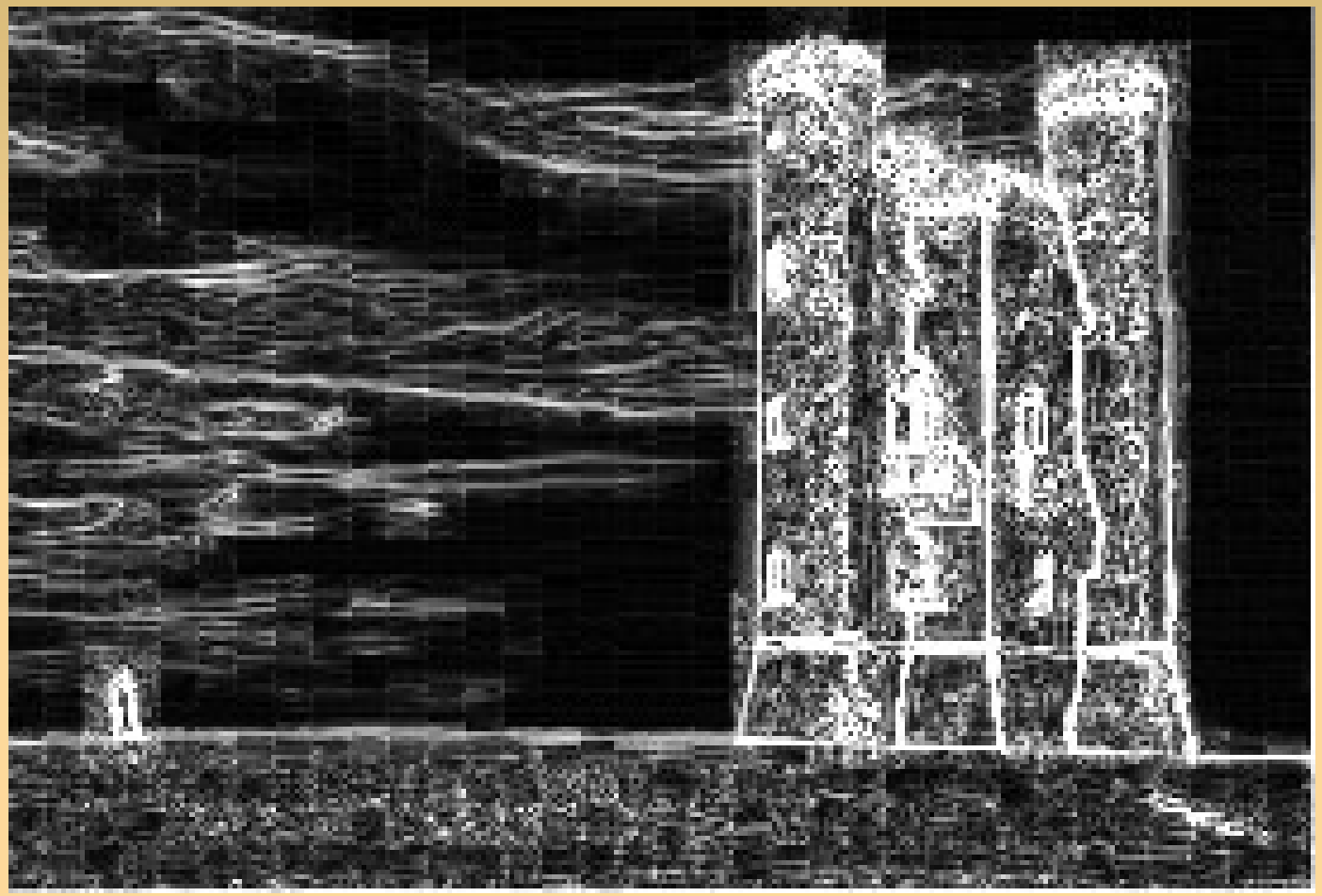
Seam carving

Original image



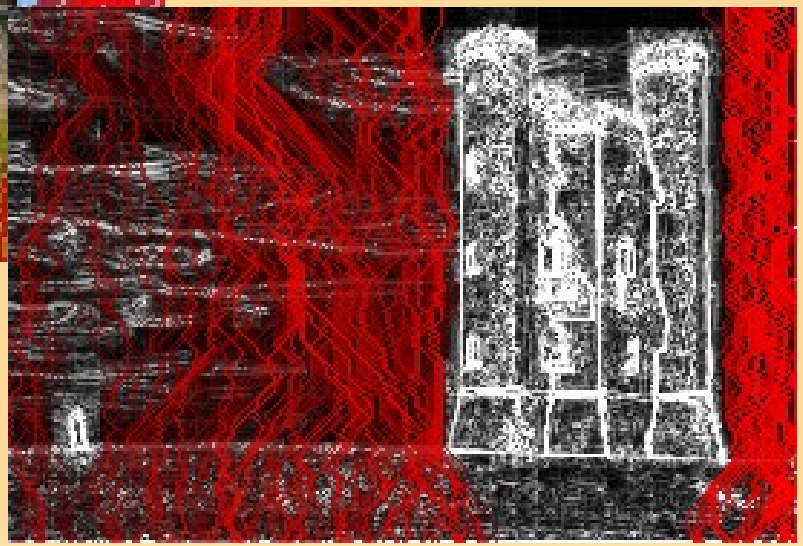
Least important
horizontal features removed

Seam carving: Feature estimation



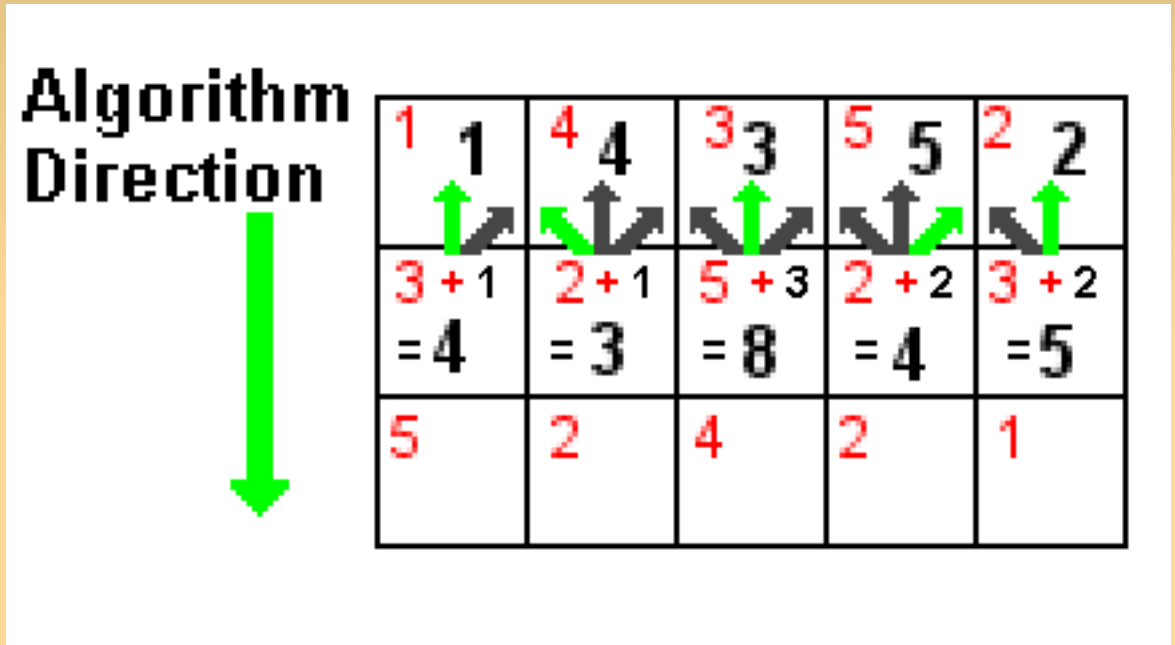
Calculate some energy (gradient, entropy, etc.)
for each pixel

Seam carving

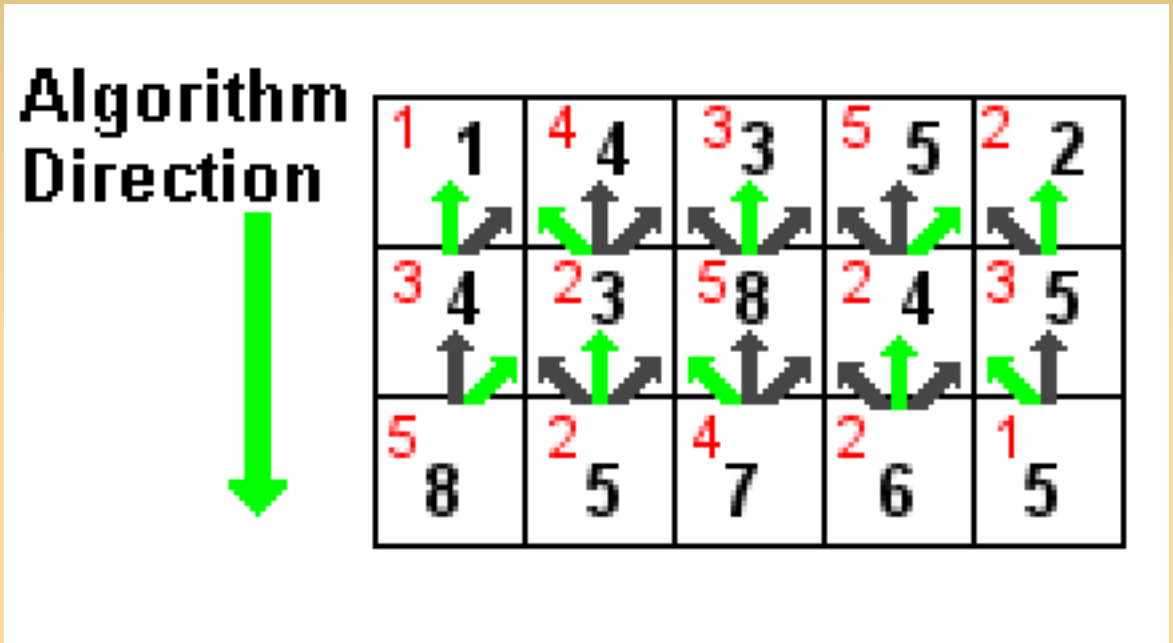


Calculate the seams
with lowest energy

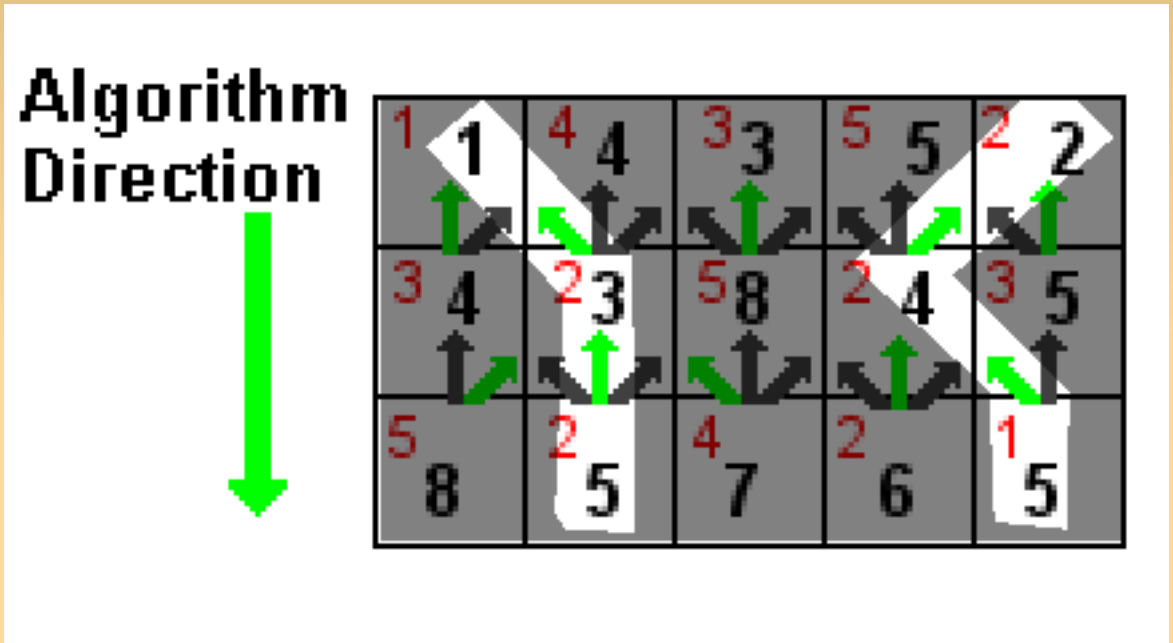
Seam carving: DP



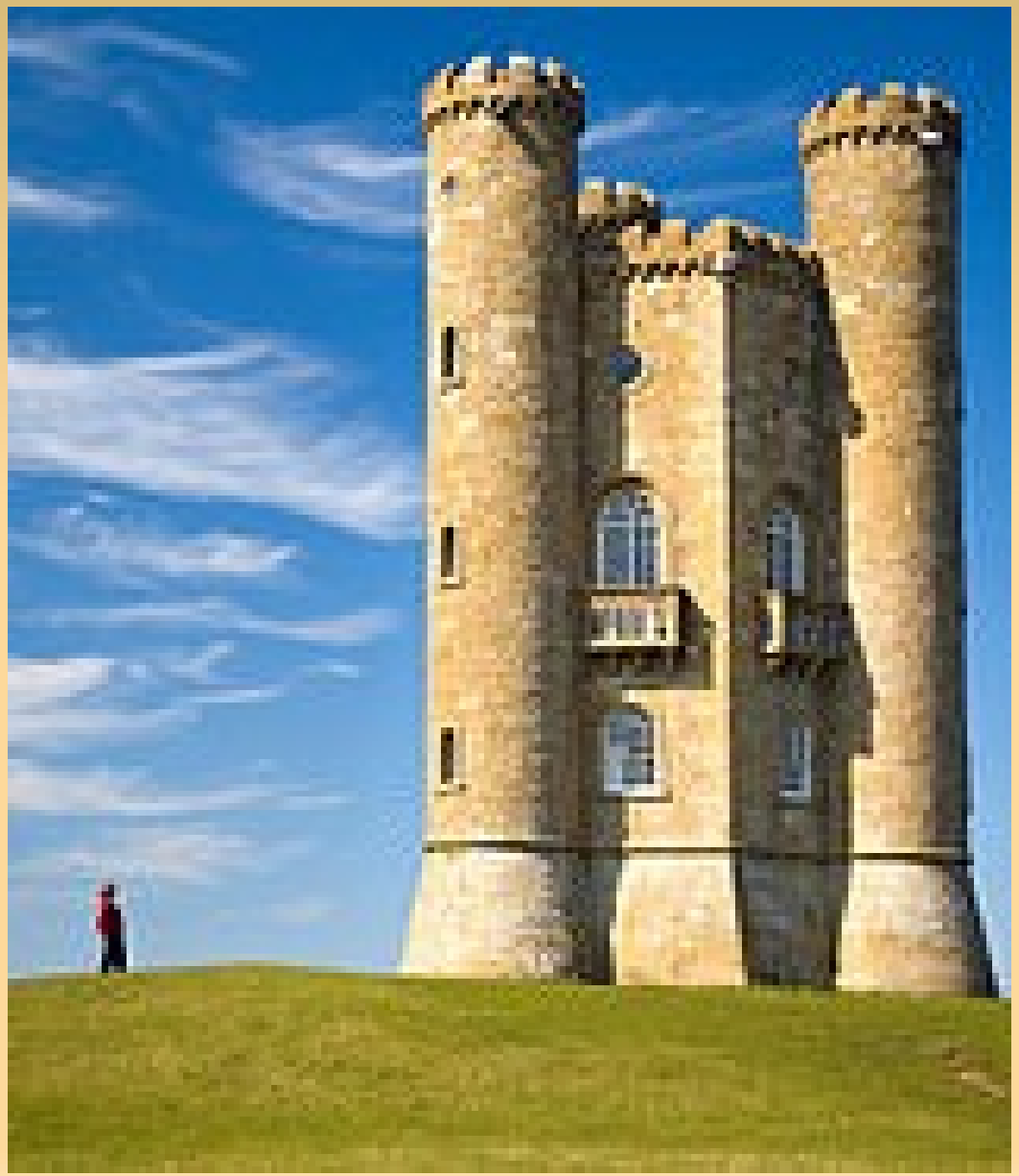
Seam carving: DP



Seam carving: DP



Seam carving: Result



Examples of DP in CV

- Active contours
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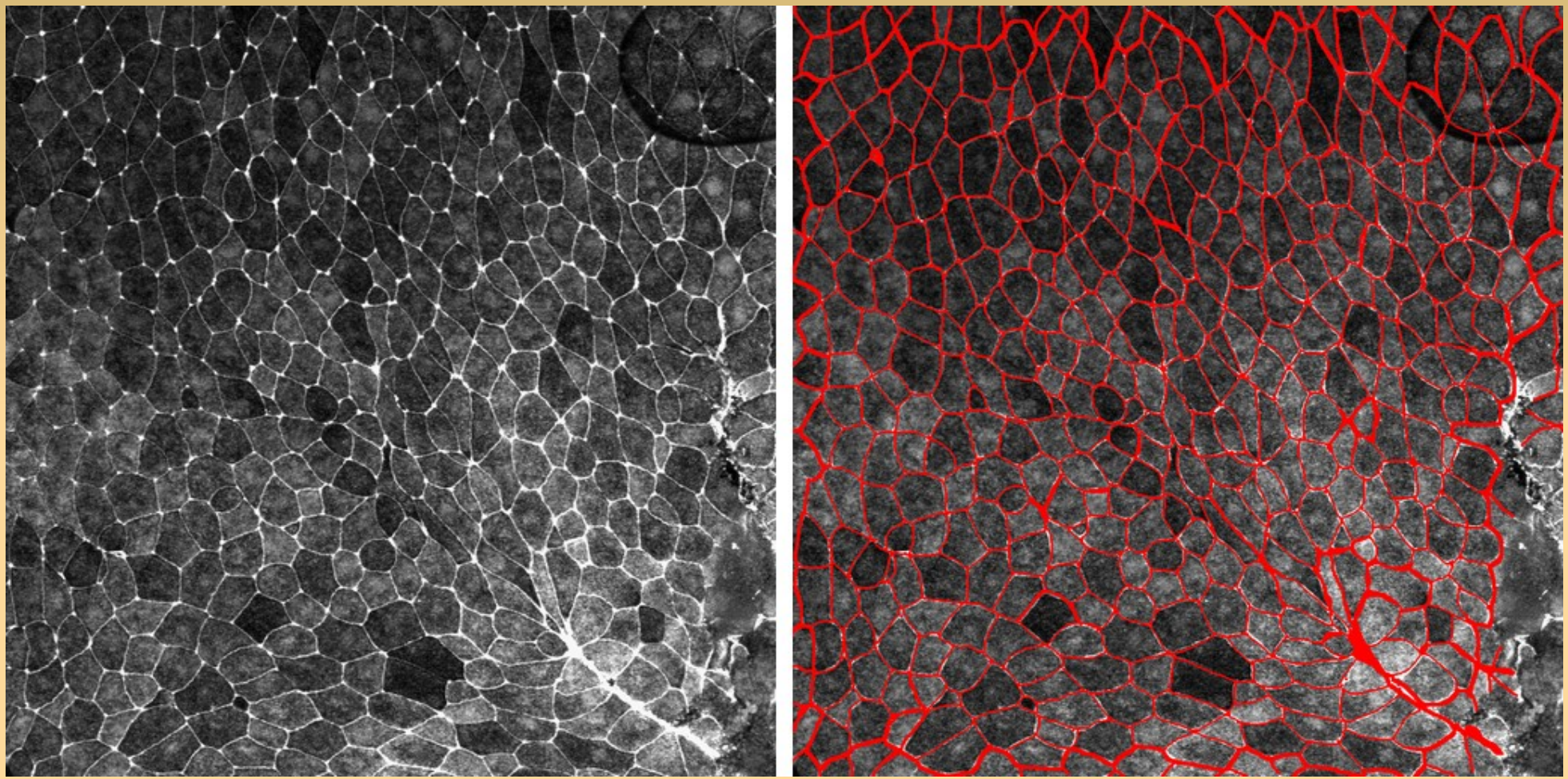
- **Cell analysis**
- Stereo Correspondence
- Trajectory approximation
- Inpainting and quilting

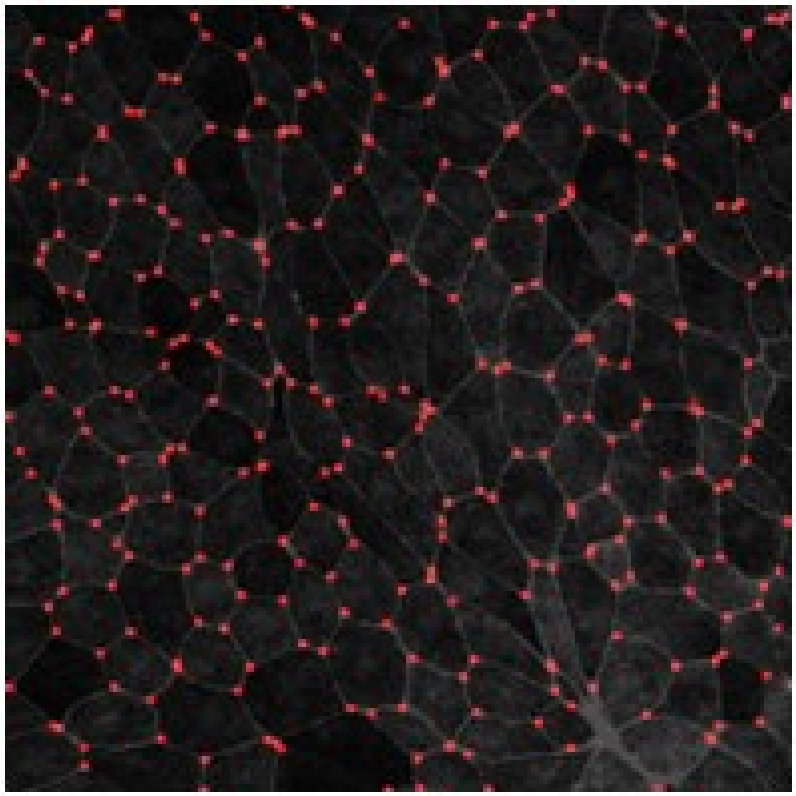
Cell analysis: The aim

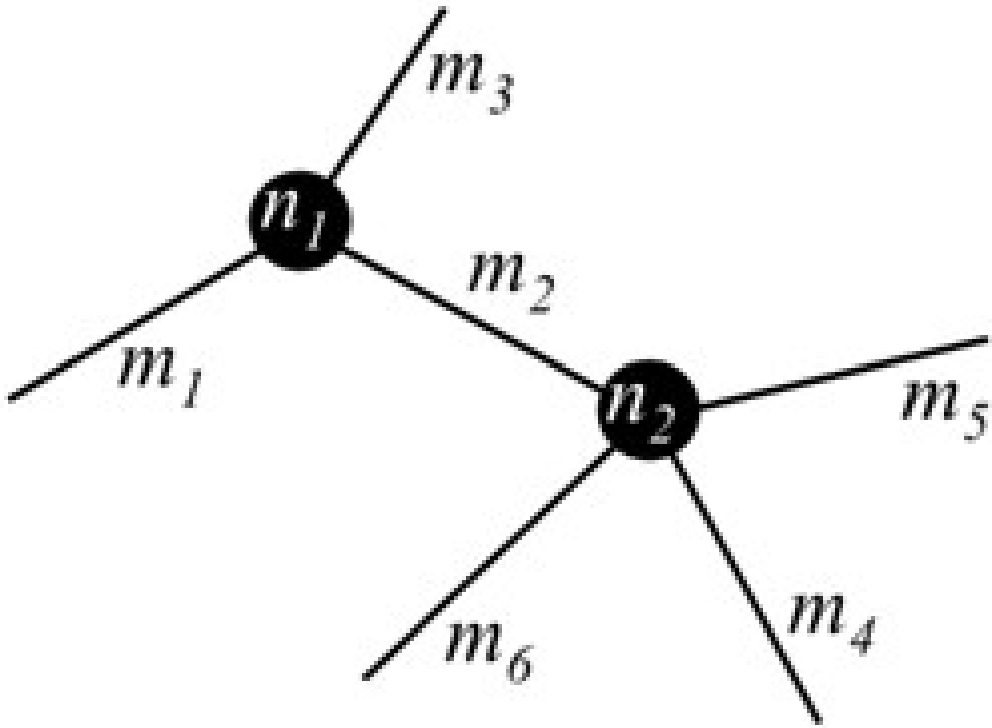


Given a tissue picture.
The cells have to be segmented

(Nekrasov K., Laptev D., Vetrov D.)

Cell analysis: The approach

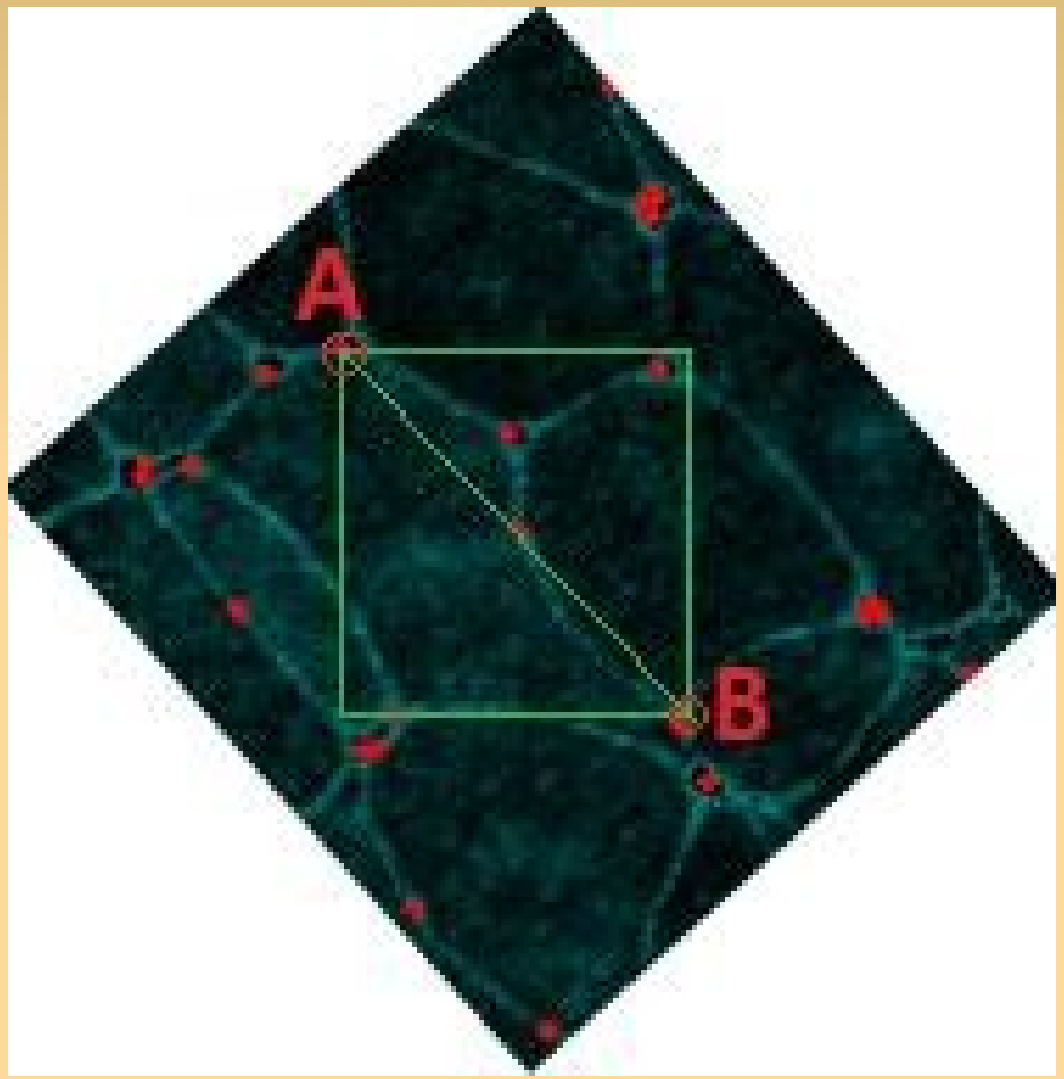




(Nekrasov K., Laptev D., Vetrov D.)

Enough bright corner points of the cells are thresholded
but the connections between them are unclear

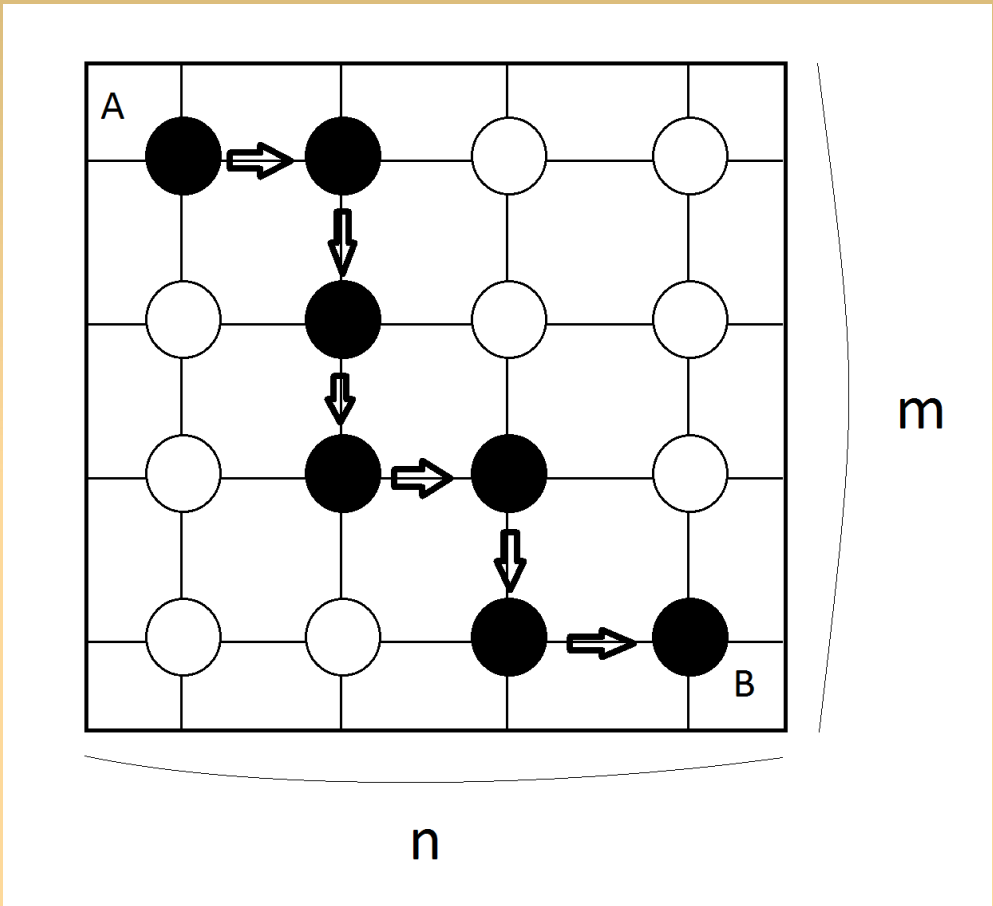
Cell analysis: The approach



Try to find a path for each pair of near points

(Nekrasov K., Laptev D., Vetrov D.)

Cell analysis: South-Eestern movement



$$F(x,y) = \max\{F(x,y-1), F(x-1,y)\} + I(x,y)$$

(Nekrasov K., Laptev D., Vetrov D.)

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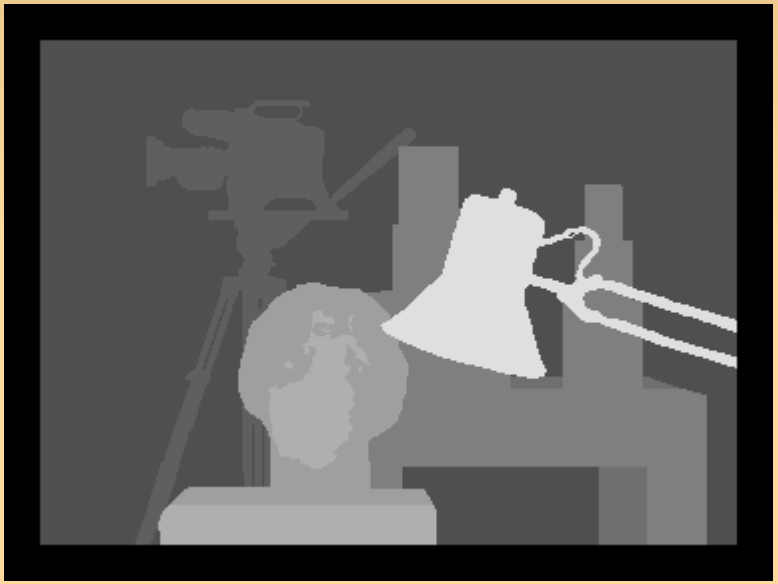
Stereo Correspondence

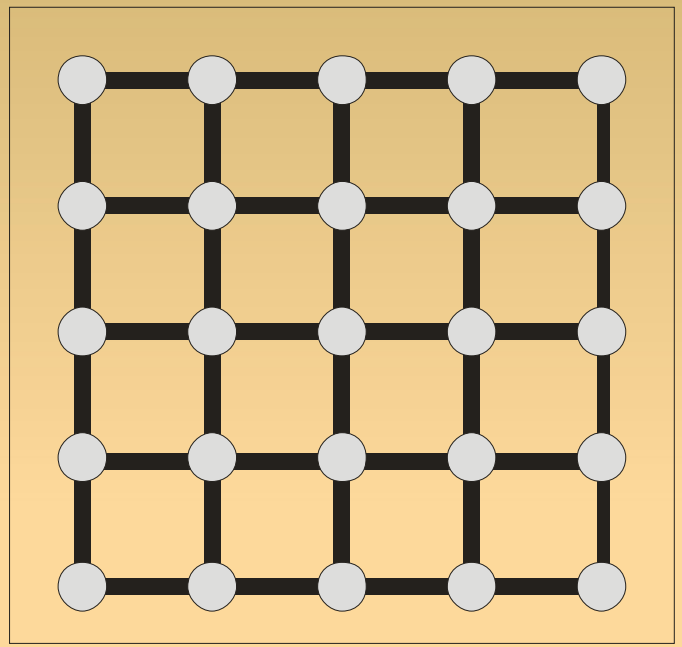
Left image

Right image



Depth map

Stereo Correspondence

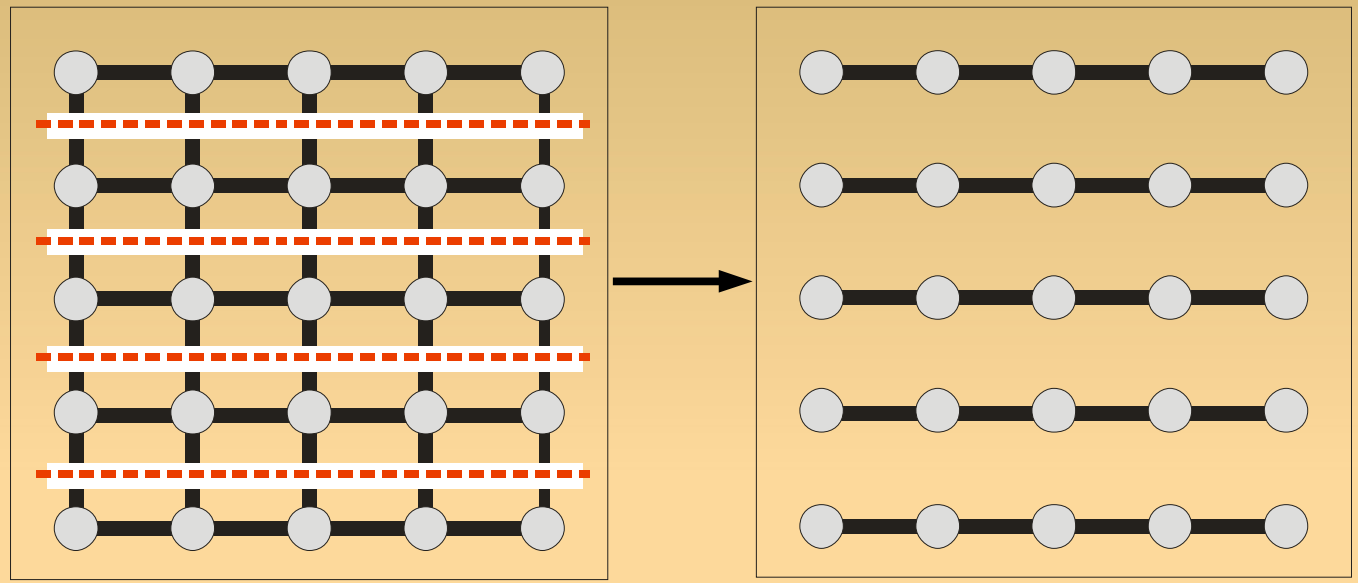


$$E(D) = E_{data}(D) + E_{smooth}(D)$$

Unary potential
(color similarity)

Pair potential
(smooth edges)

Stereo Correspondence



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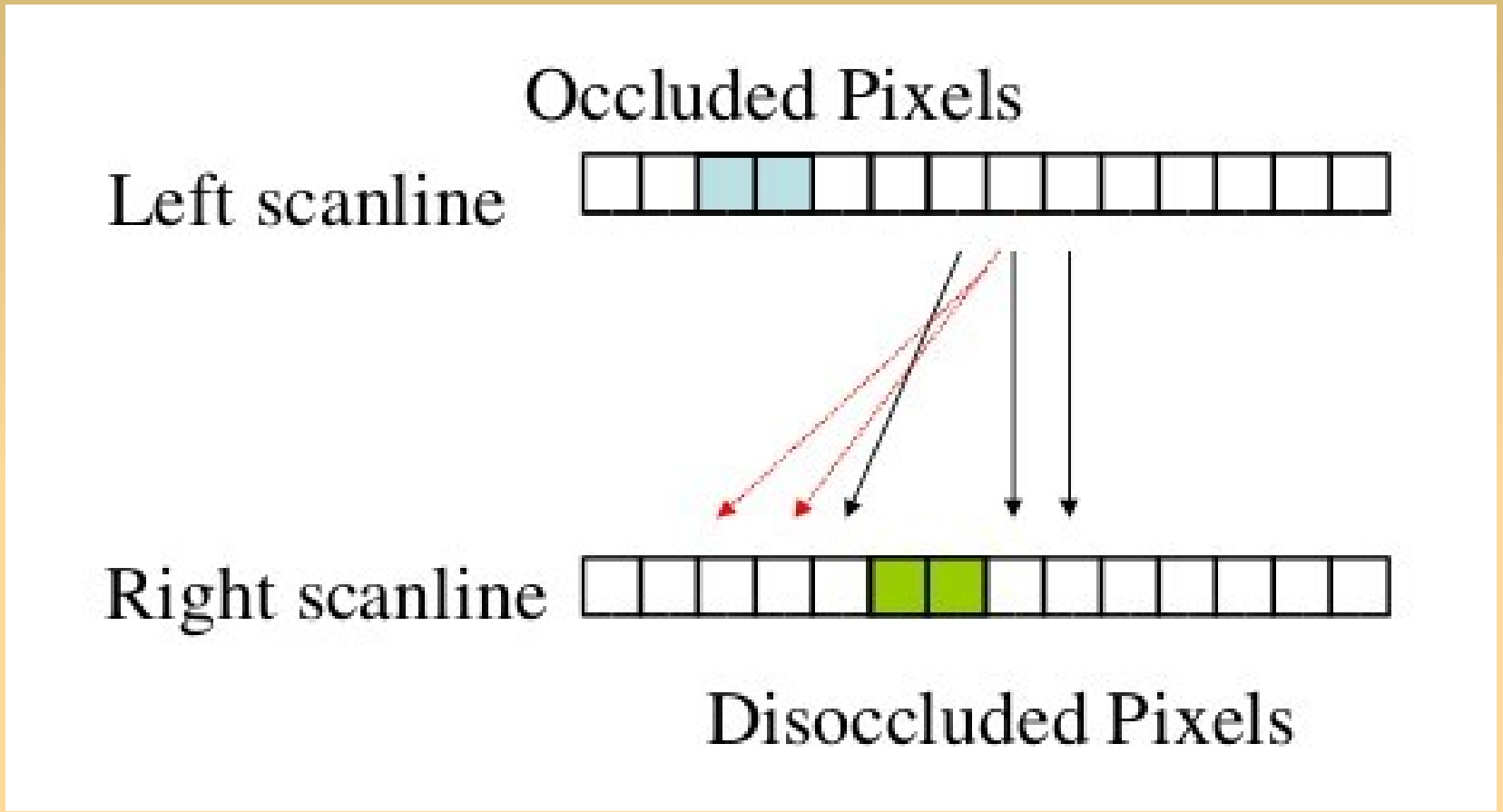
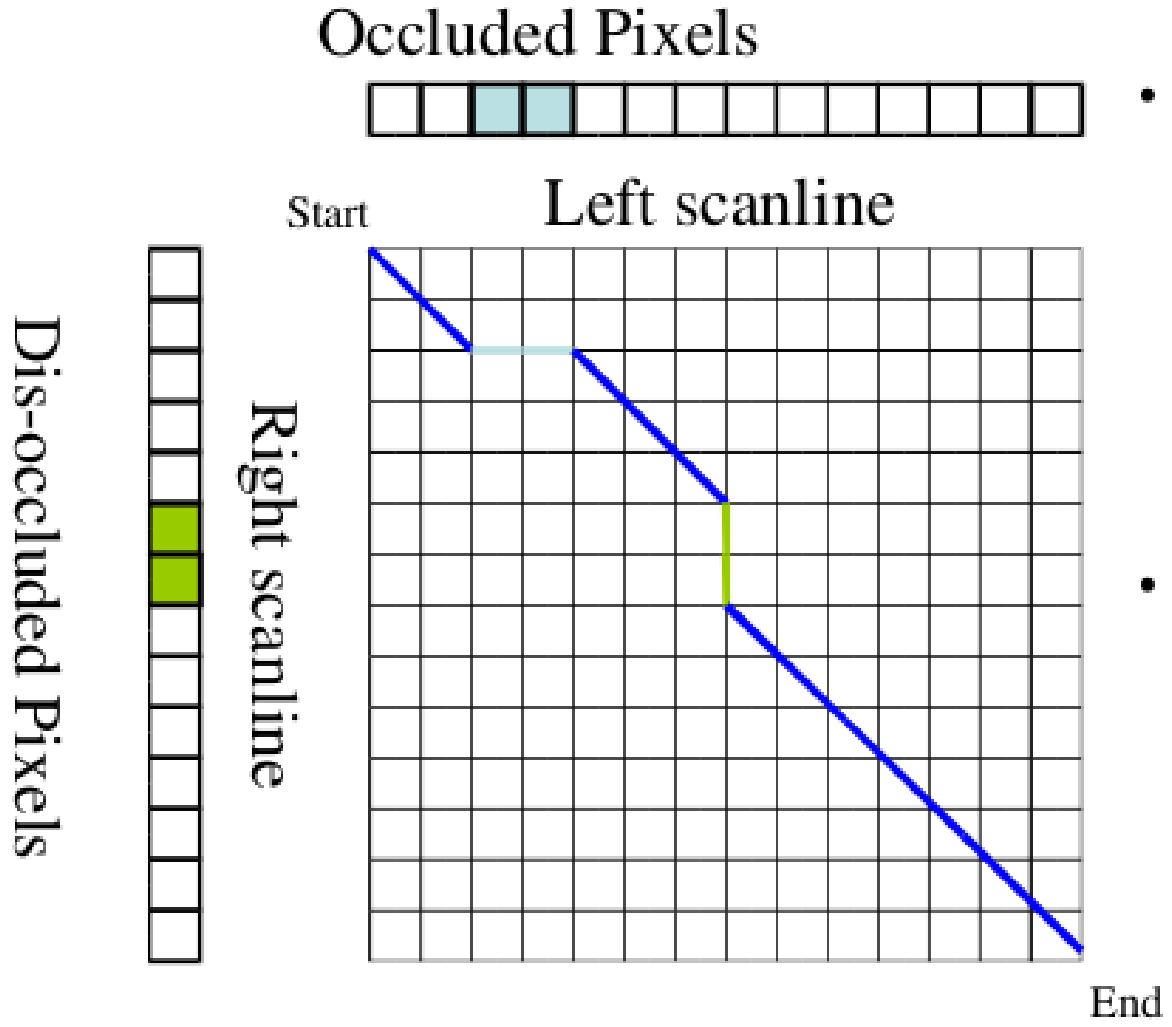
Stereo Correspondence



(Rehg)

Extract each pair of horizontal lines and
Search for the corresponding pixels

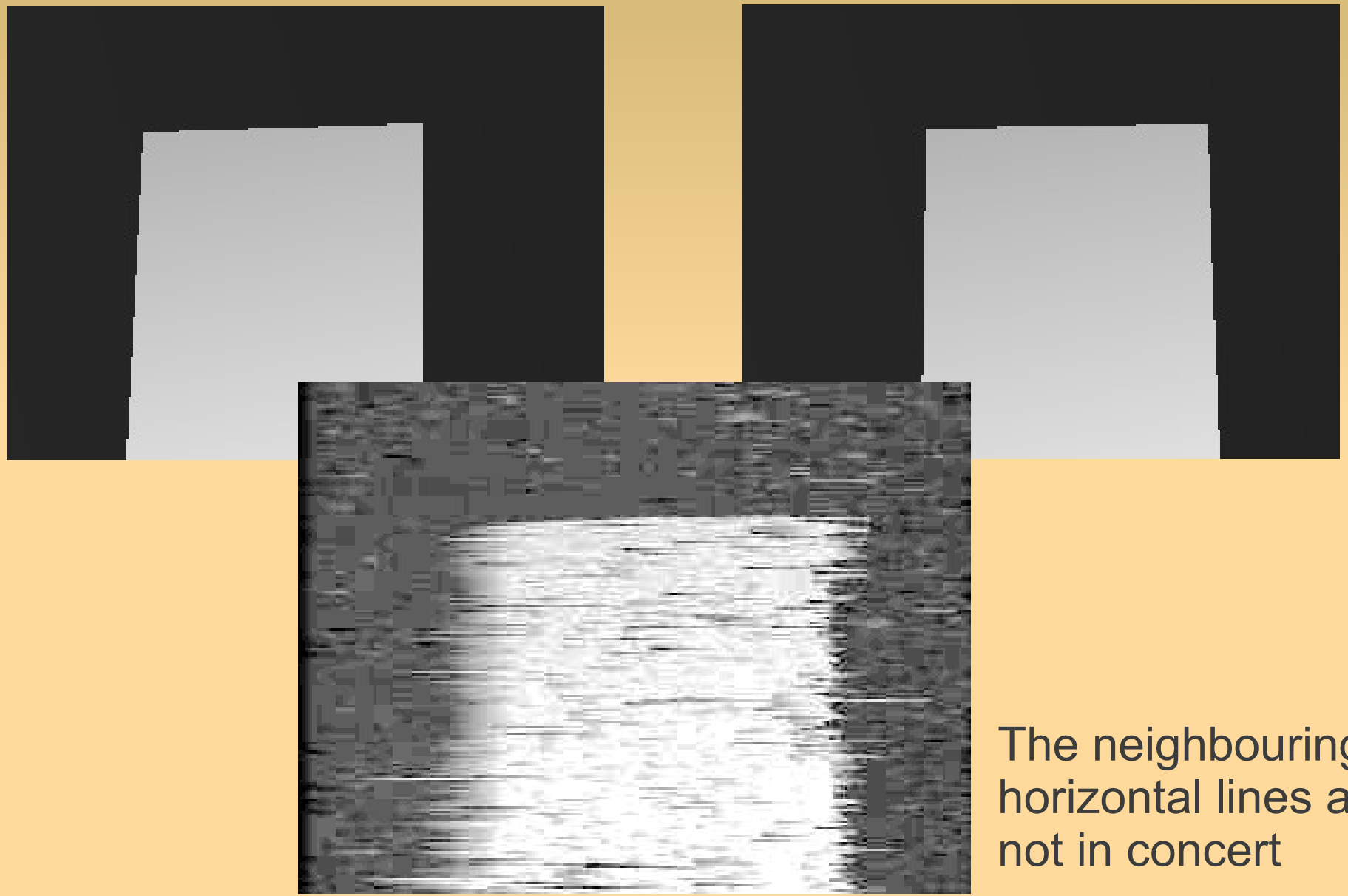
Stereo Correspondence



- Key idea: The lowest cost path for the rest of any sequence can only depend on what state you start from and not how you got to that state.
- Objective: Find the optimal path through grid. This is the best set of matches that satisfy the ordering constraint

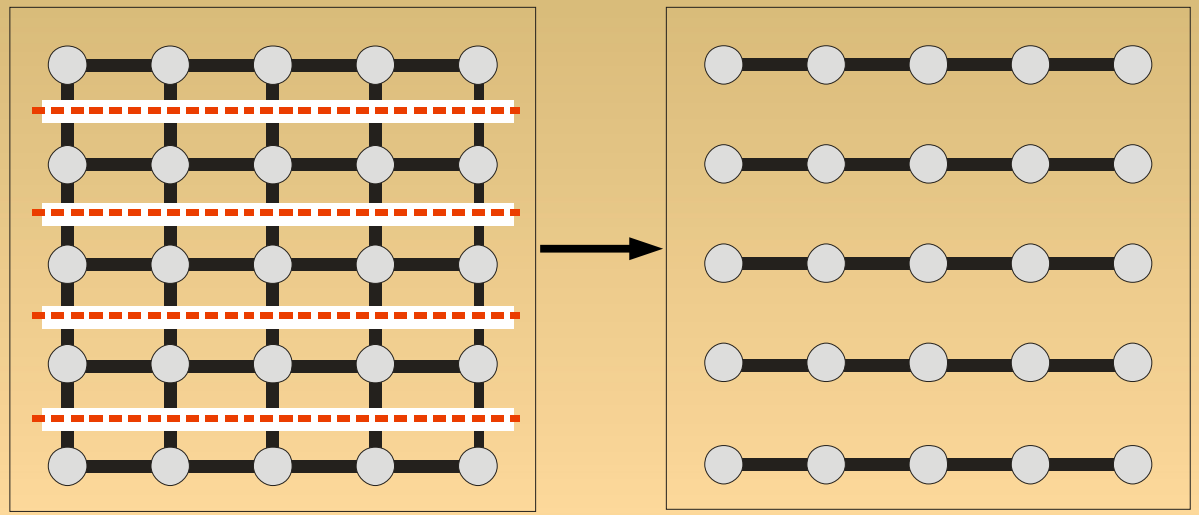
(Rehg)

Stereo Correspondence



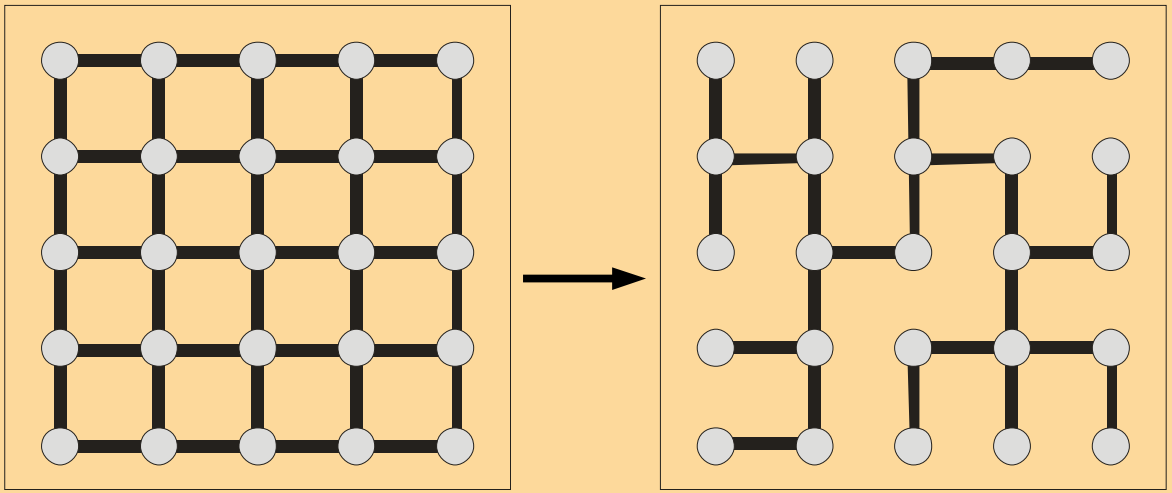
The neighbouring horizontal lines are not in concert

Stereo Correspondence



LIne by line

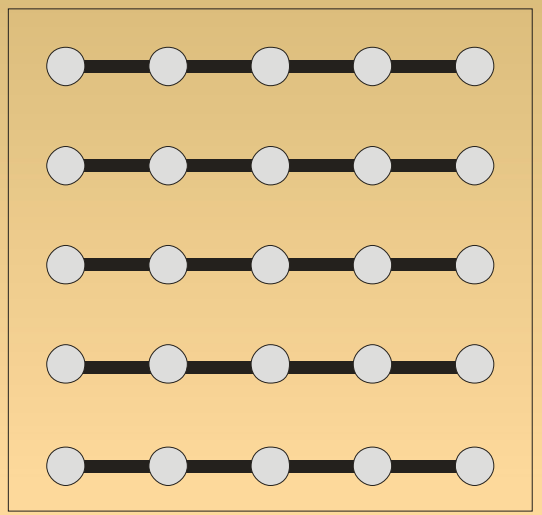
Different ways

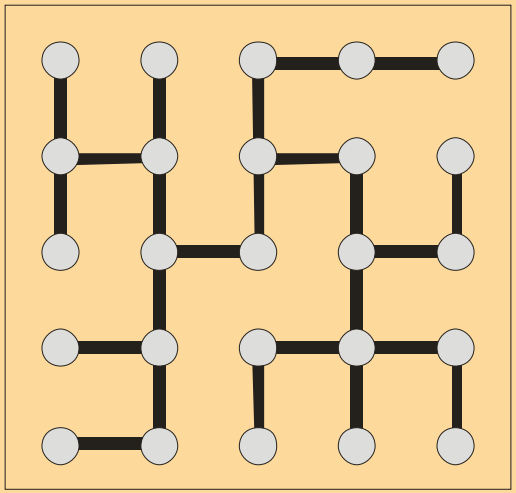


Minimum Spanning Tree

(M. Bleyer)

Stereo Correspondence





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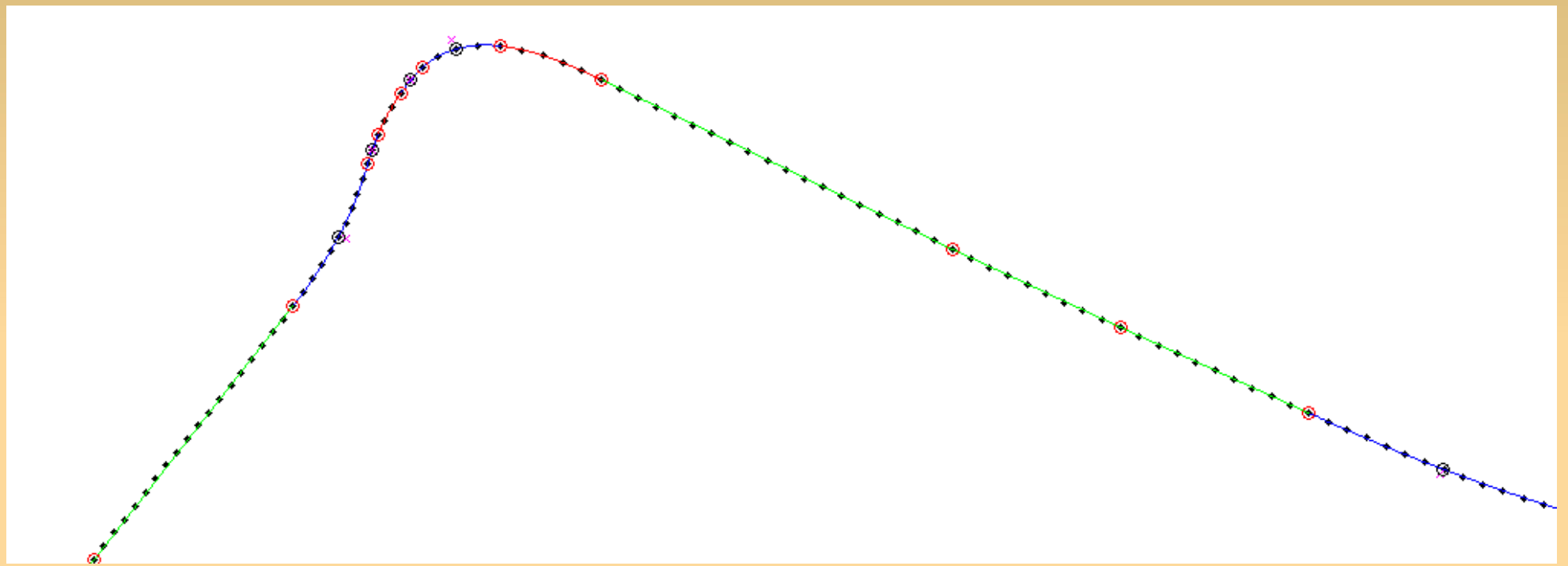
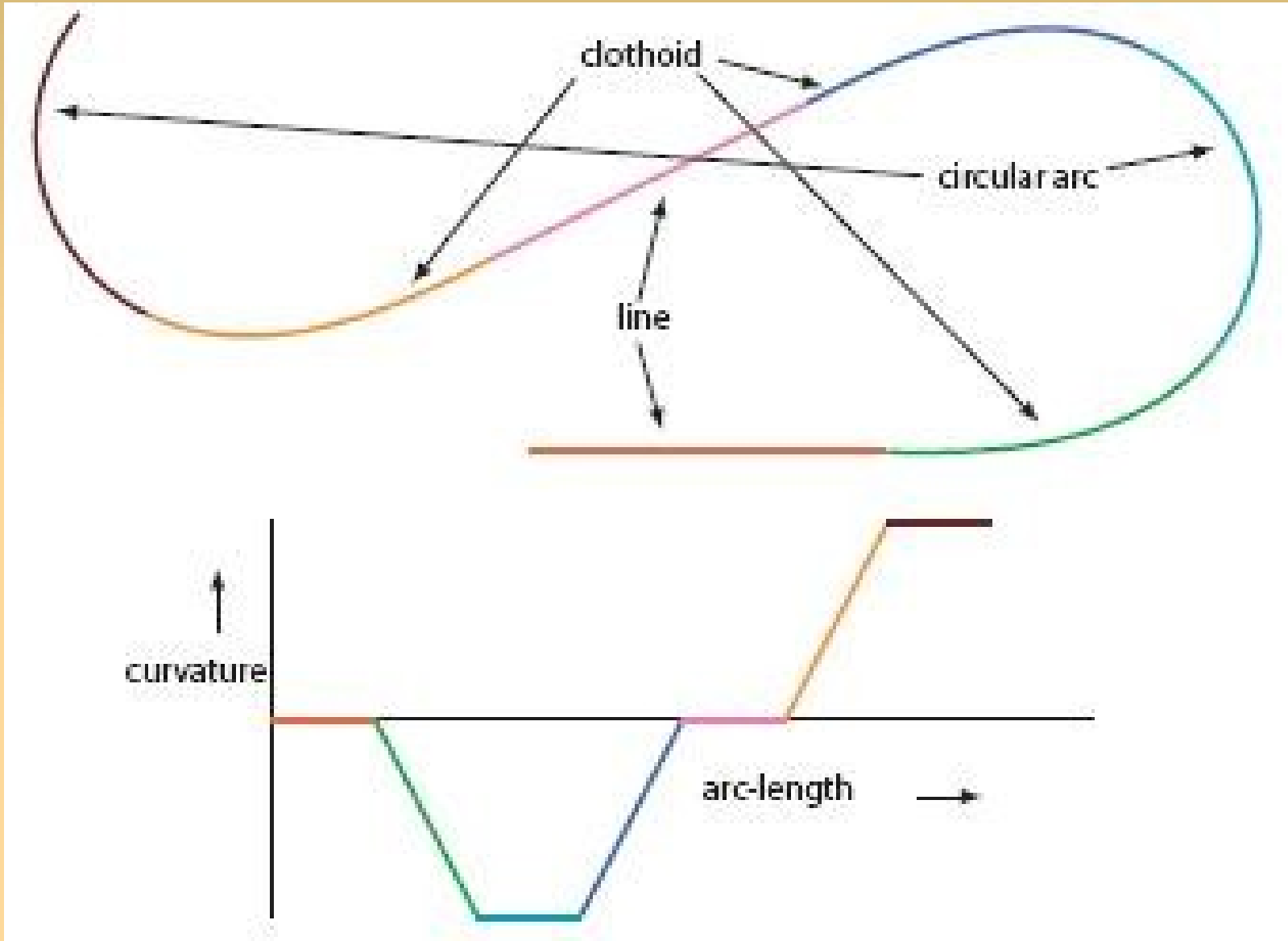
Trajectory approximation



Given N points on the plane. Curve approximation using **segments**, **circles** and **clothoids** (kind of a spiral)

Trajectory approximation



(J. McCrae and K. Singh)

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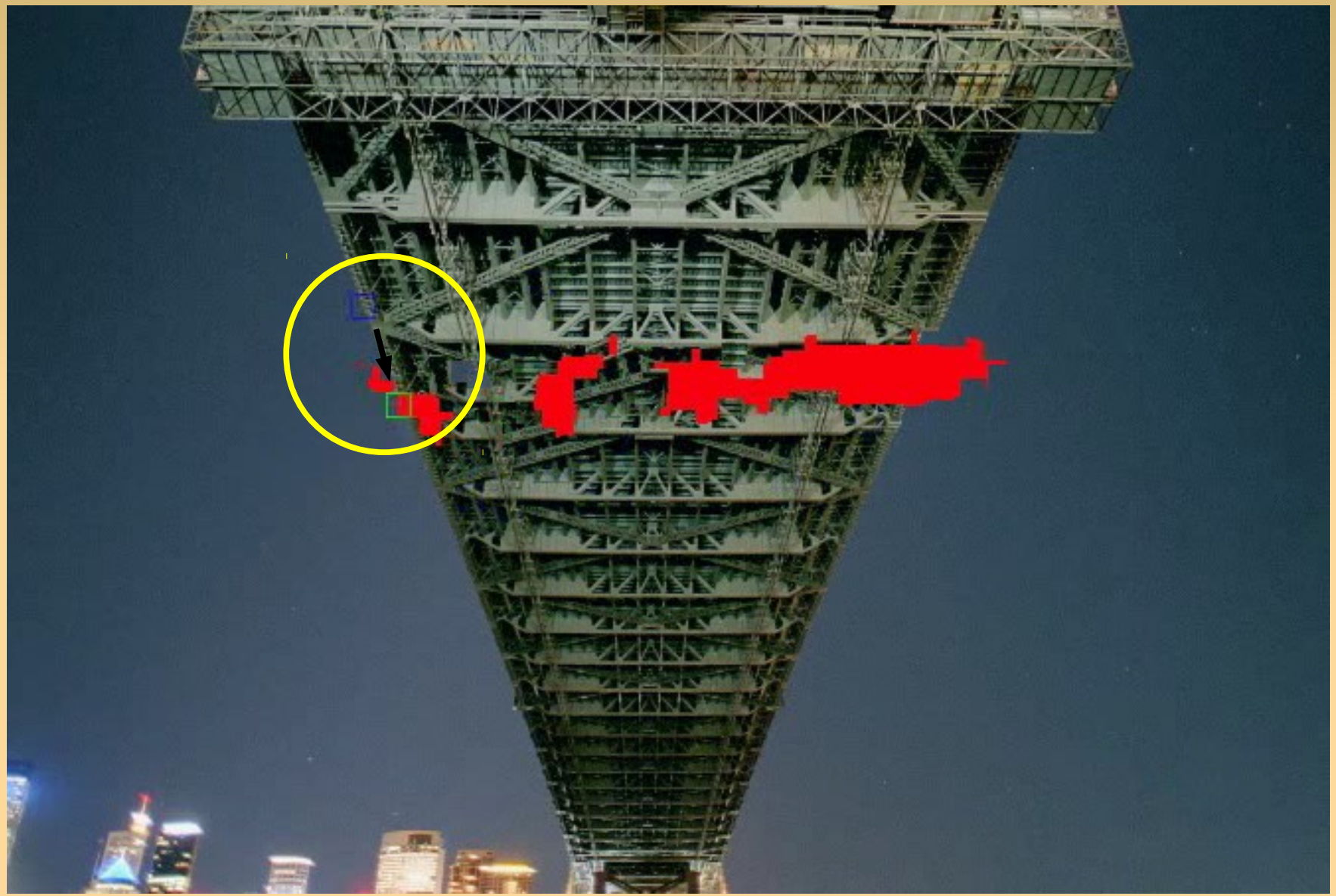
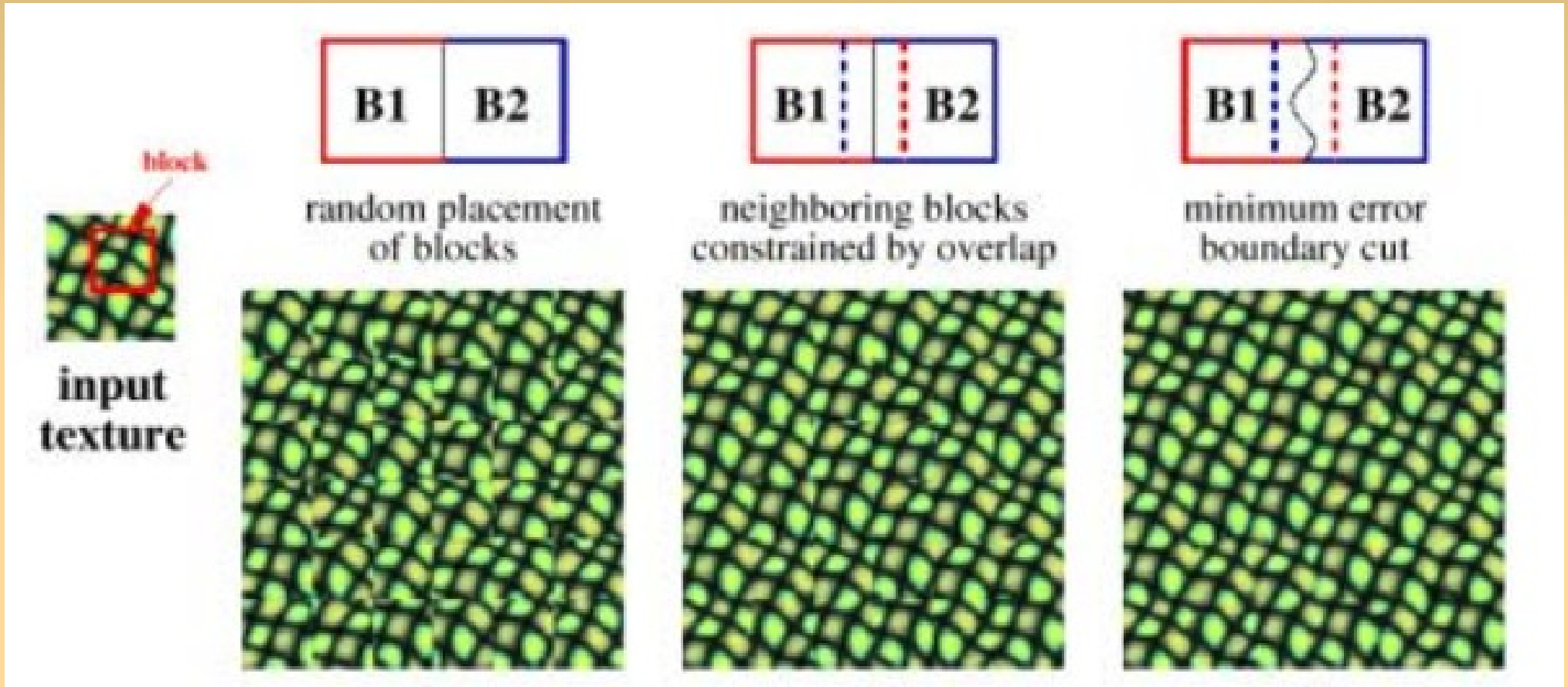
- **Inpainting and quilting**

Image inpainting



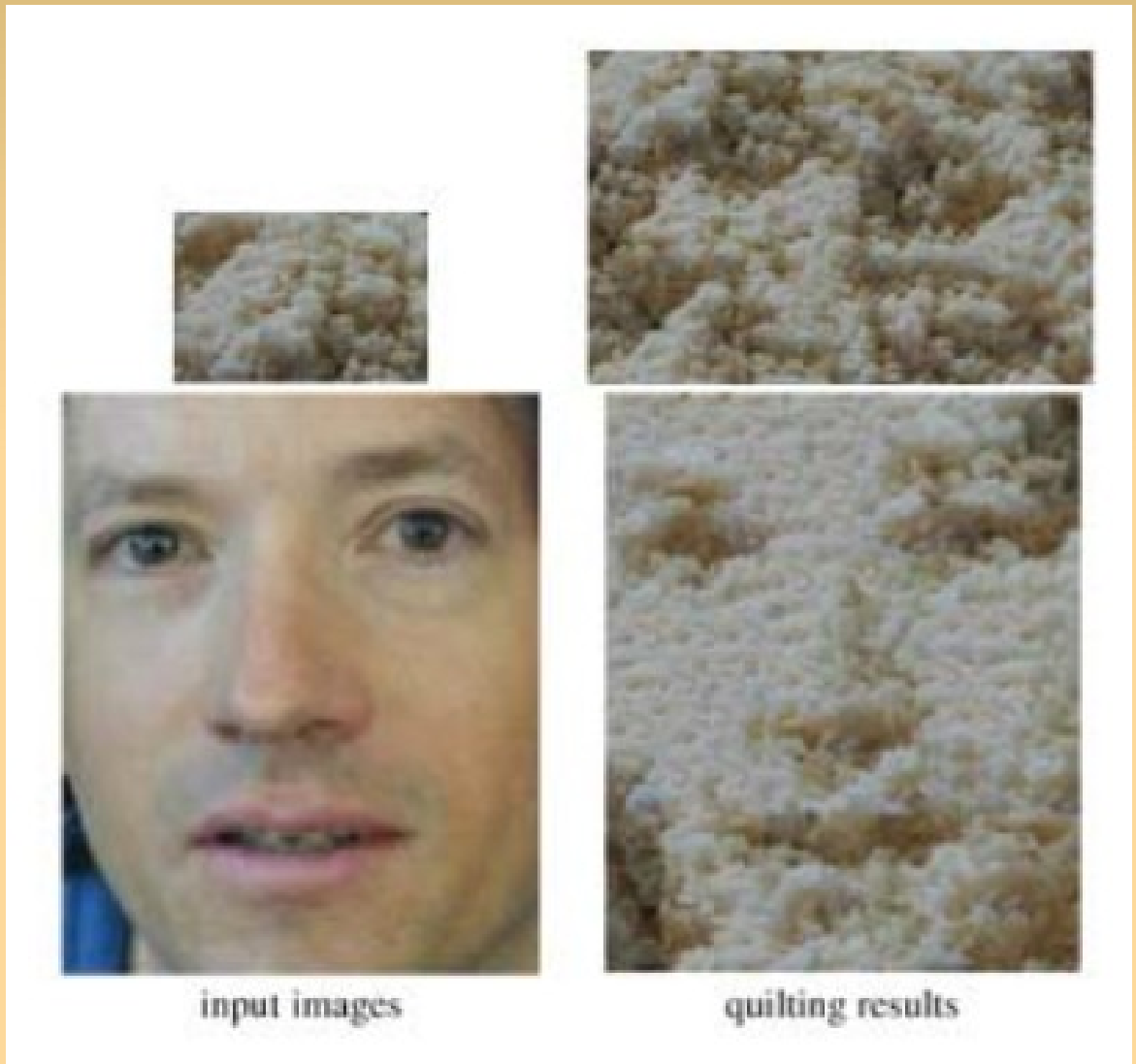
(Yury Gitman)

Image inpainting



(Efros)

Image quilting



(Efros)

Let the DP be with you

Presentation destination:
http://pesho.me/share