

# Digital Image Processing (CSE 478)

## Lecture 19: Content aware image resizing

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# Image resizing



We want to perform  $1/3^{\text{rd}}$  reduction in width

Image source: wikipedia

# Image resizing: Cropping



## Image resizing (cropping in videos): Pan and scan



source: <http://forum.videohelp.com/threads/300336-What-is-Pan-and-Scan>

# Image resizing: Scaling



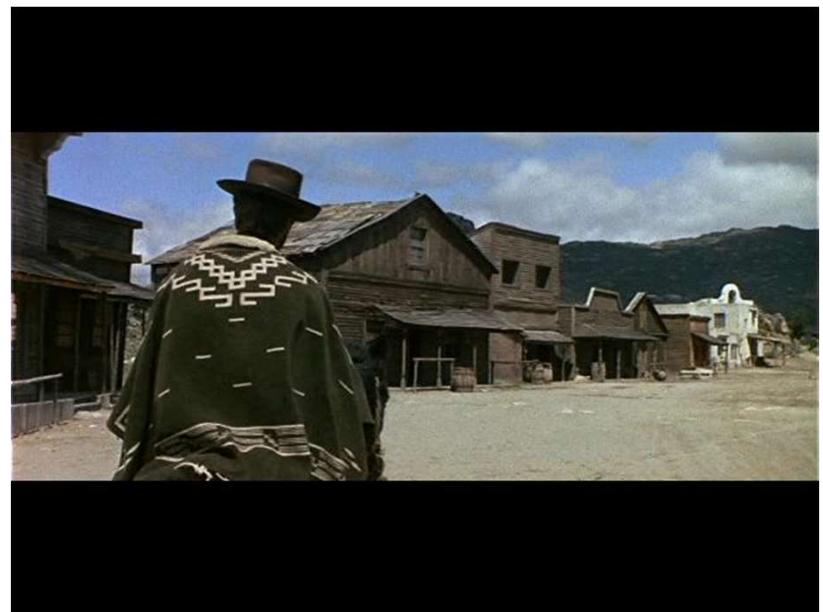
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# Image resizing: Letterboxing



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## Image resizing: Letterboxing

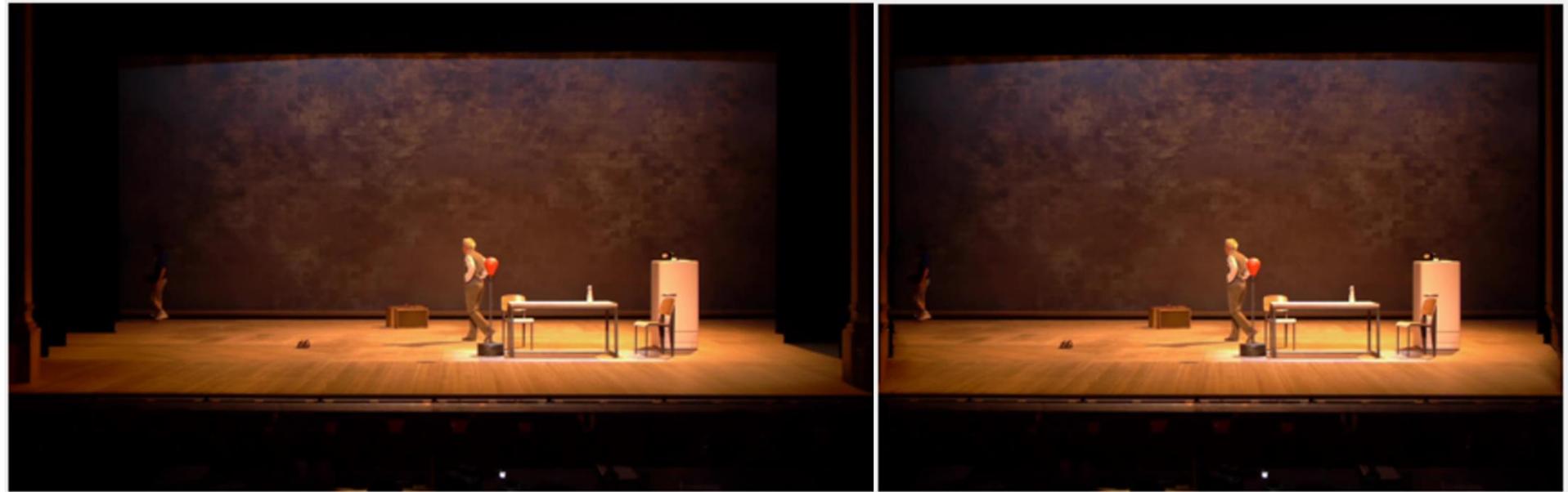


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## Image resizing: content aware



## Image resizing: content aware



## Image resizing: content aware



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## Image resizing: content aware



## How do we do it?

Many algorithms.....

**We will discuss a particular one today, called seam carving!**



## Overview: step 1



Compute some sort of importance characteristic: gradient magnitude, entropy, visual saliency, eye-gaze movement

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## Overview: step 2



Find the path of minimum cost in the importance image

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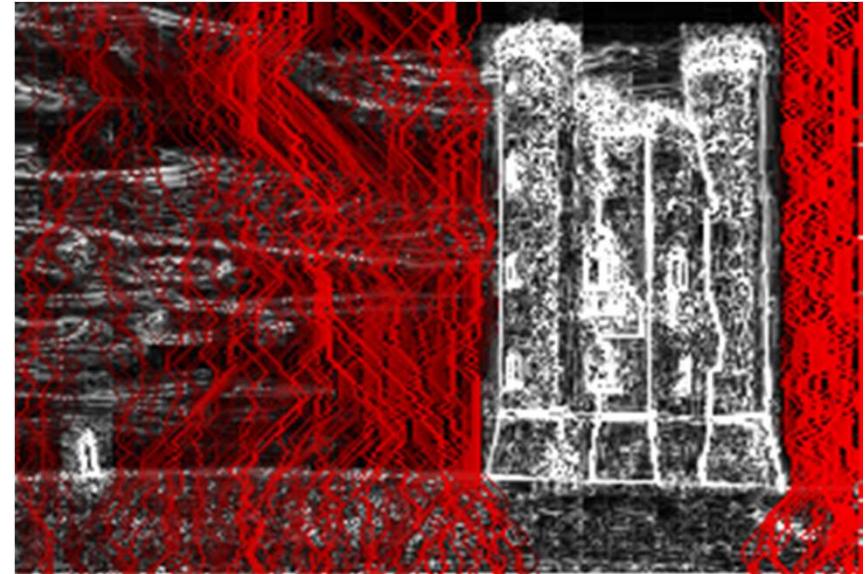
## Overview: step 3



Delete the minimum cost seam

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## Overview: step 4



Repeat step 1, 2 and 3 until reaching the desired size

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## Overview: step 4



Repeat step 1, 2 and 3 until reaching the desired size

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# Video Illustration



Source: <http://blogs.techsmith.com/>

# How to find the minimum cost seam?



## How to find the minimum cost seam?

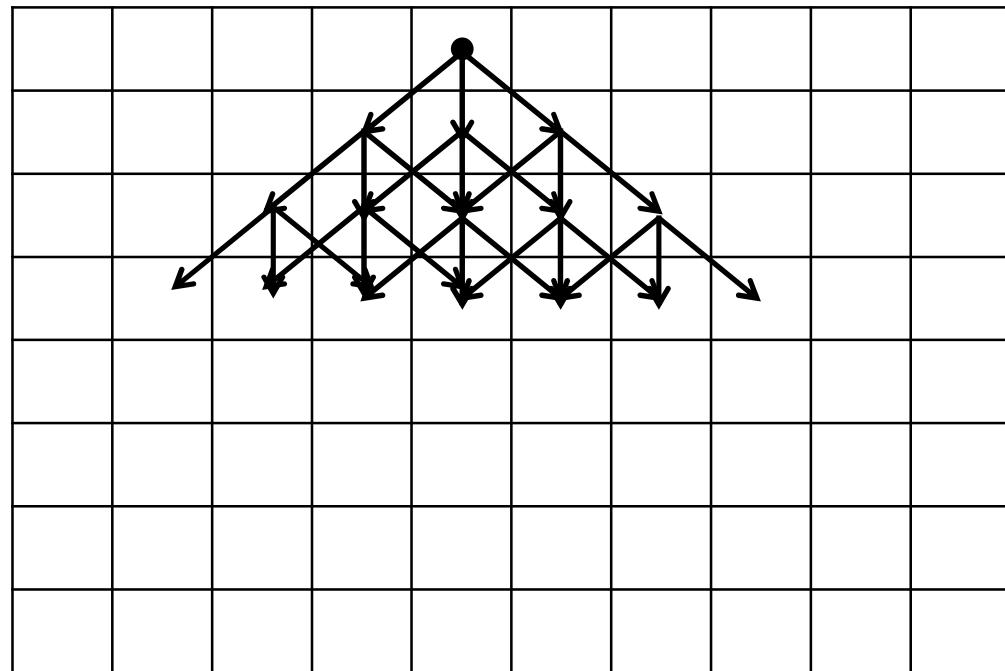
- Find minimum cost **connected** path from top to bottom (width reduction)



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## Naïve algorithm

- Check all possible paths
  - foolish and infeasible



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# Dynamic programming

1	4	3	5	2
3	2	5	2	3
5	2	4	2	1
1	7	3	9	4

Importance image (M)

1	4	3	5	2
4	3	8	4	5
8	5	7	6	5
6	12	8	14	9

Cost matrix (C)

$$C(i, j) = M(i, j) + \min \begin{cases} C(i - 1, j - 1) \\ C(i - 1, j) \\ C(i - 1, j + 1) \end{cases}$$

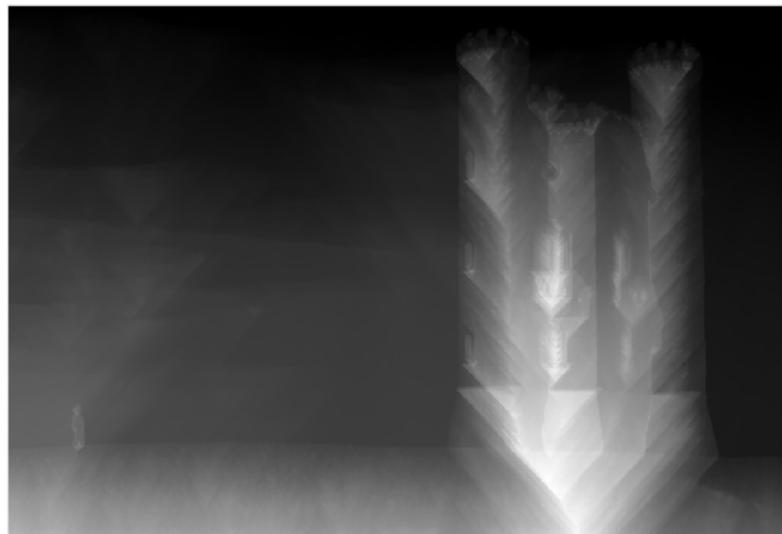


## Deleting a column

67	87	255	88	24
69	65	59	221	23
74	72	70	222	190
77	78	90	94	49



## Example cost matrix

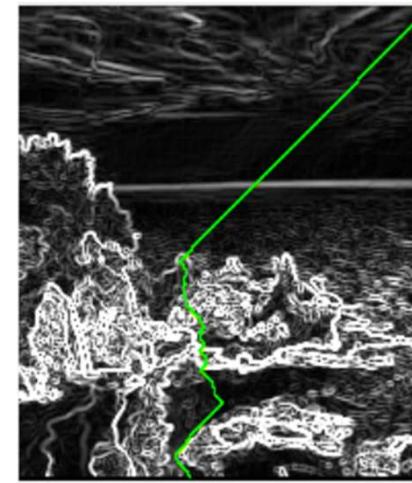
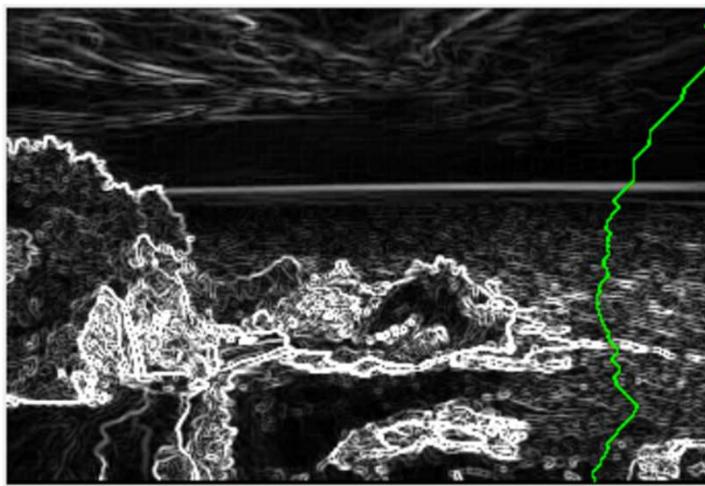


## Image resizing: content aware





First  
seam



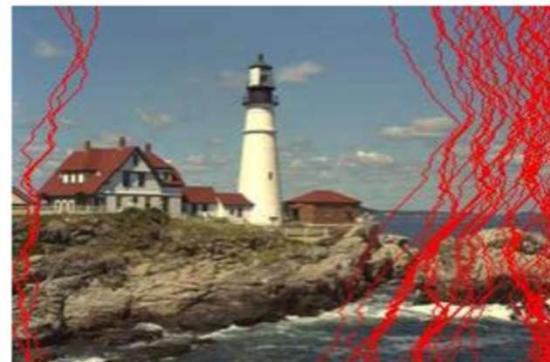
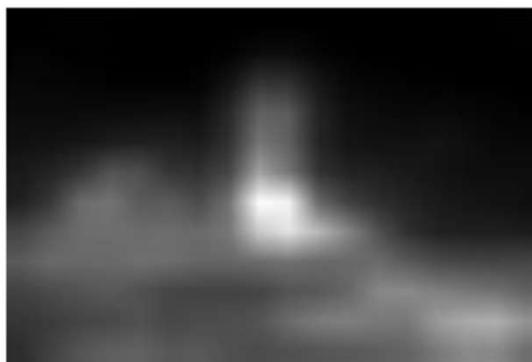
Last  
seam

# Changing the importance criteria

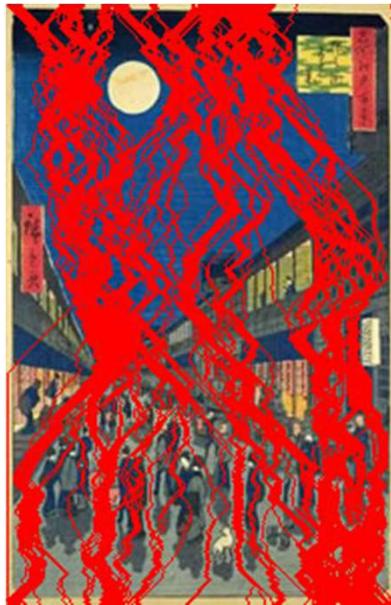
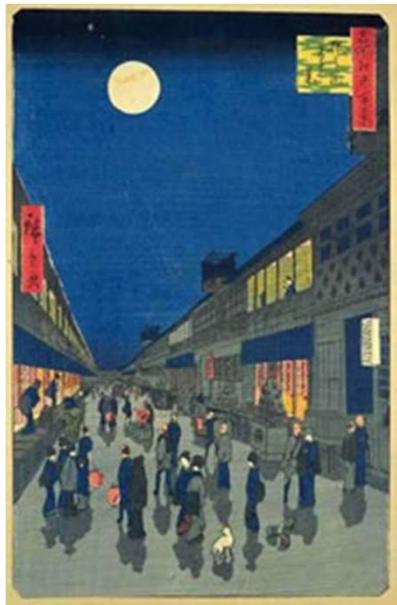
**Gradient  
magnitude**



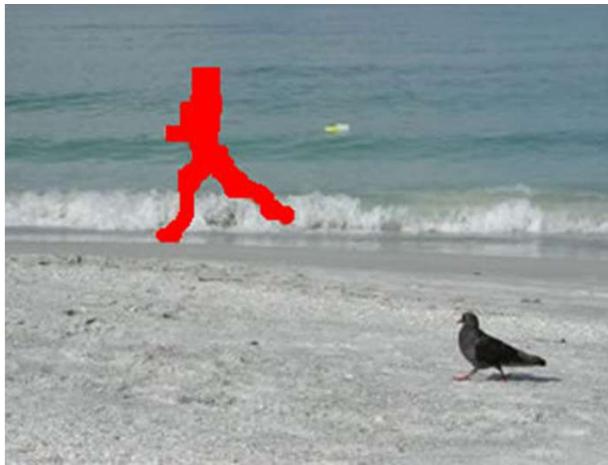
**Saliency**



Can we do more?



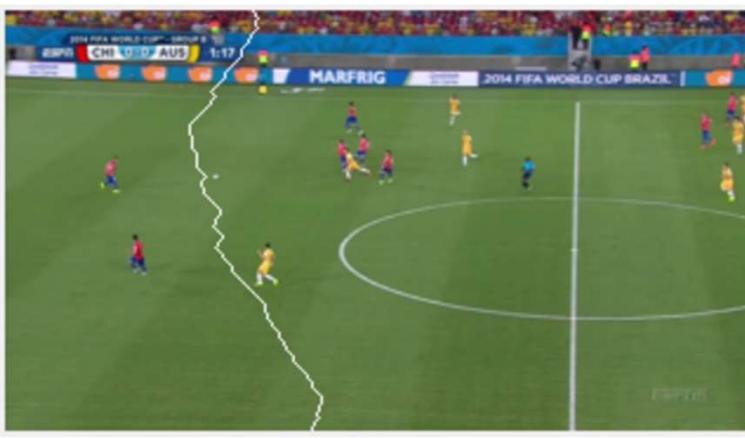
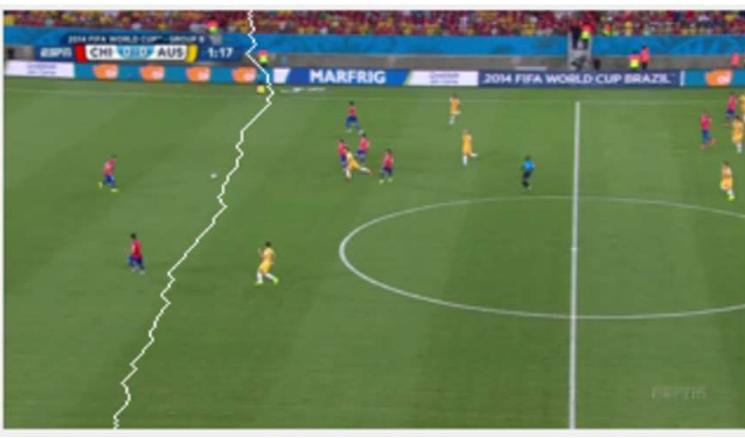
Can we do more?



Can we do more?



## Image resizing: content aware



## Failure: regular structures

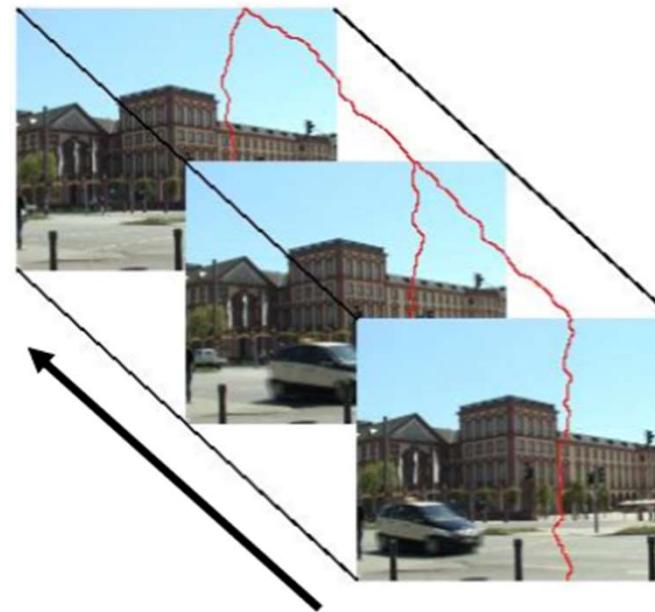


## Failure: regular structures



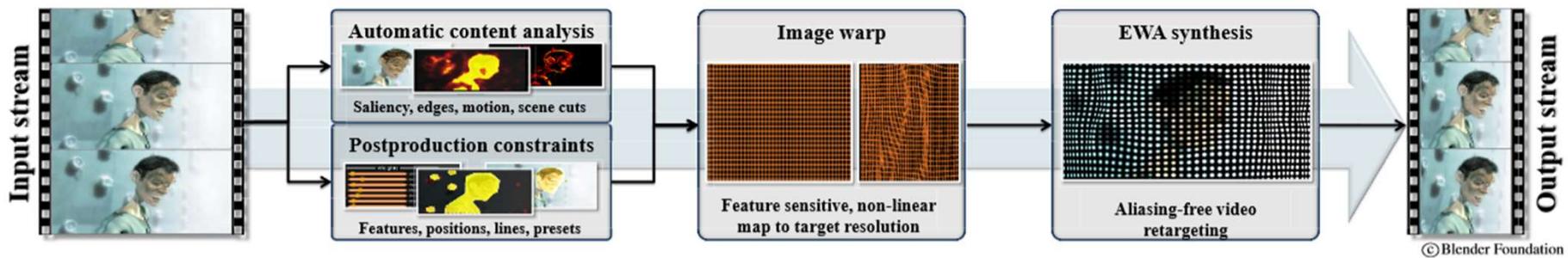
## Seam carving for videos

- Also need to compensate for temporal coherency



# Other methods for content aware image resizing

- Shift map image editing (Pritch et al. ICCV 2009)
- Patch match (Barnes et al. SIGGRAPH 2009)
- Content aware warping (Krahenbuhl et al. SIGGRAPH ASIA 2009)
- A comparative study (Rubinstein et al. SIGGRAPH ASIA 2010)



## More



<https://www.youtube.com/watch?v=ixCroJfzM6U>

## Application to texture synthesis

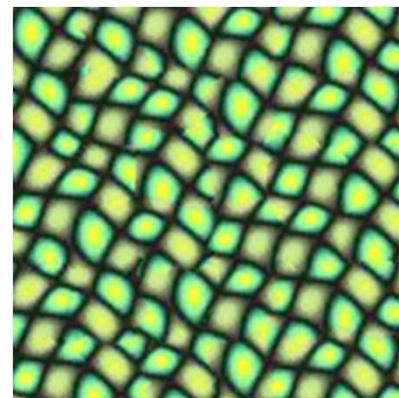
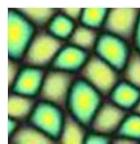
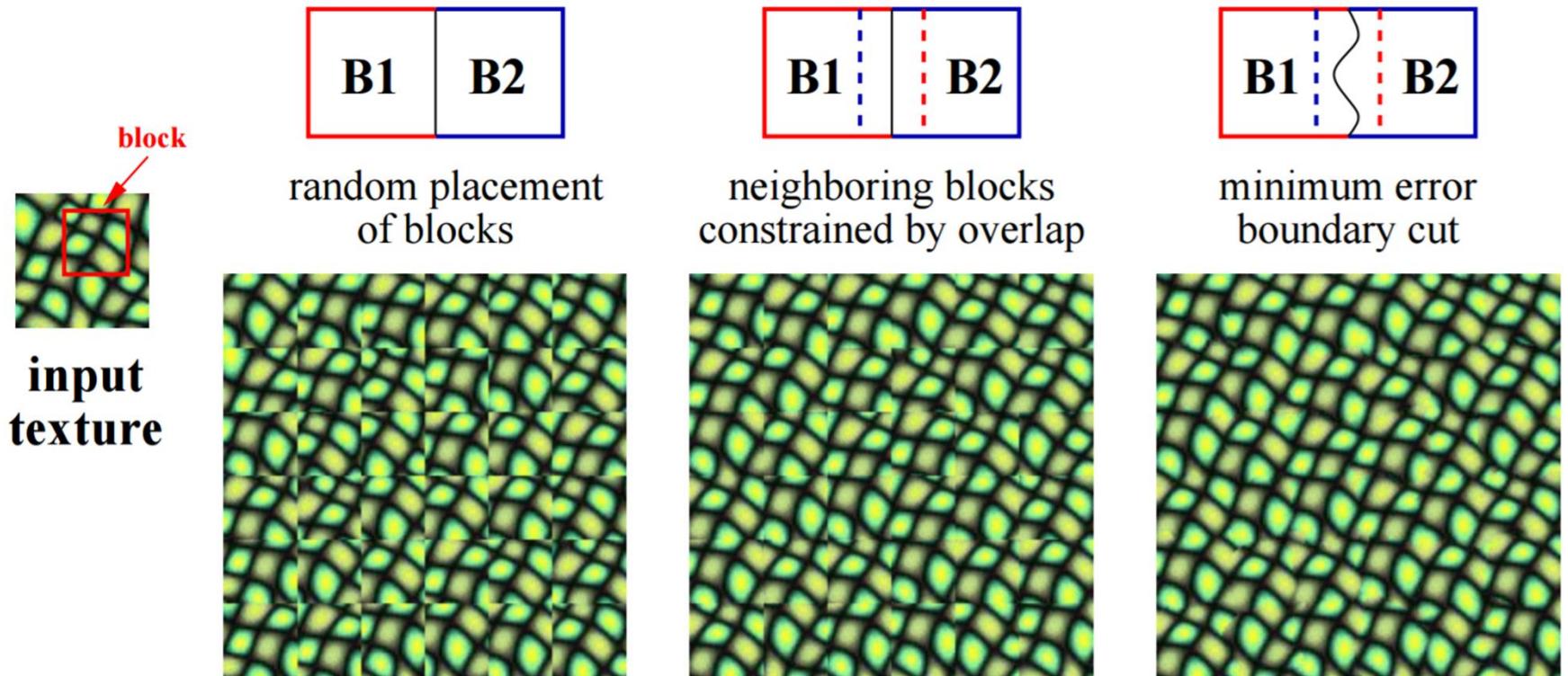


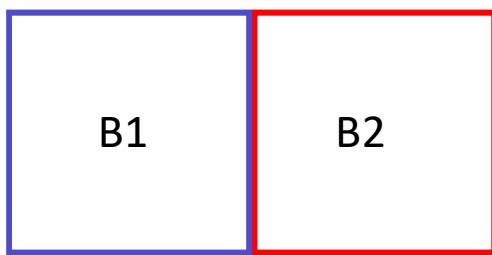
Image Quilting for Texture Synthesis & Transfer, SIGGRAPH 2001

Slides from A. Efros

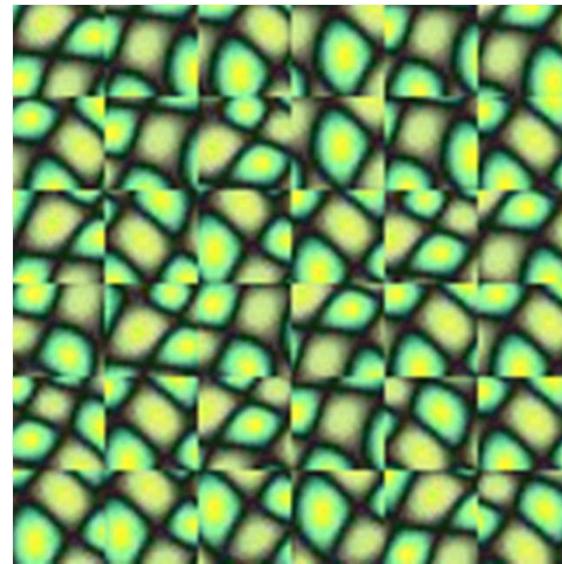
## Application to texture synthesis



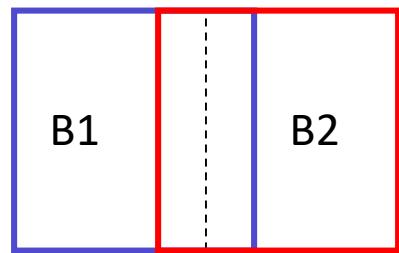
## Application to texture synthesis



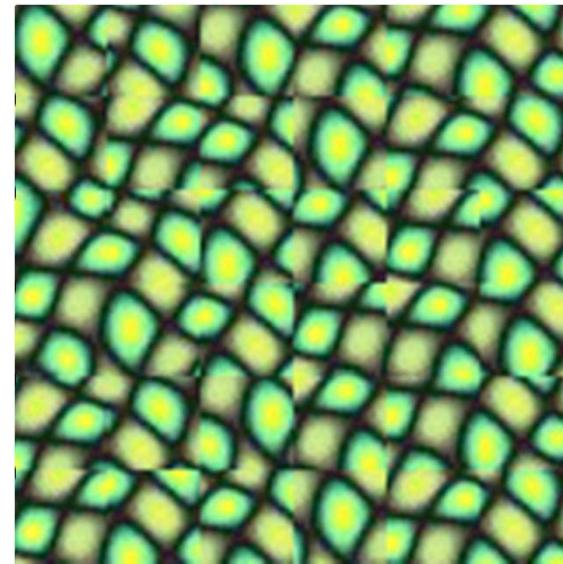
Random placement  
of blocks



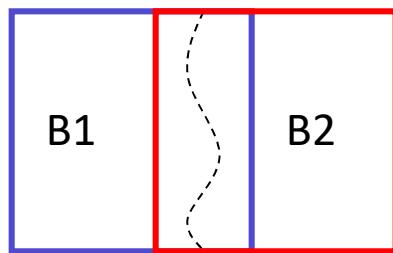
## Application to texture synthesis



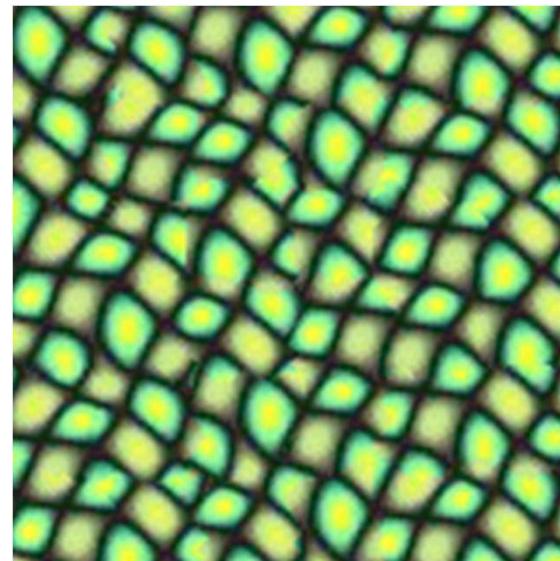
Neighboring blocks  
constrained by overlap



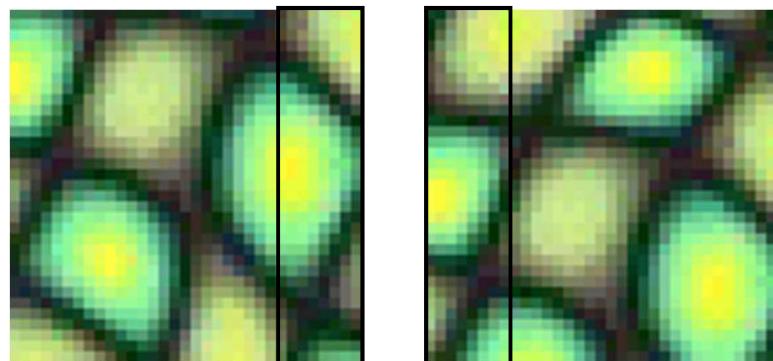
## Application to texture synthesis



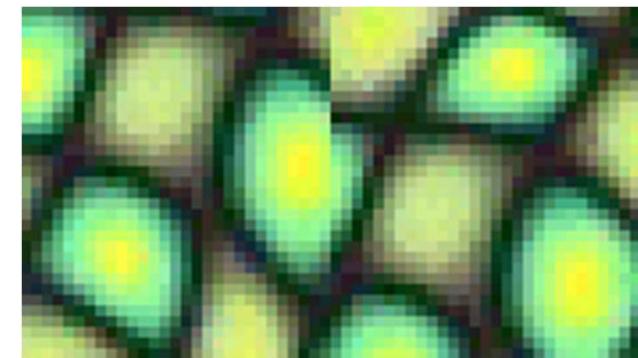
Minimal error  
boundary cut



overlapping blocks

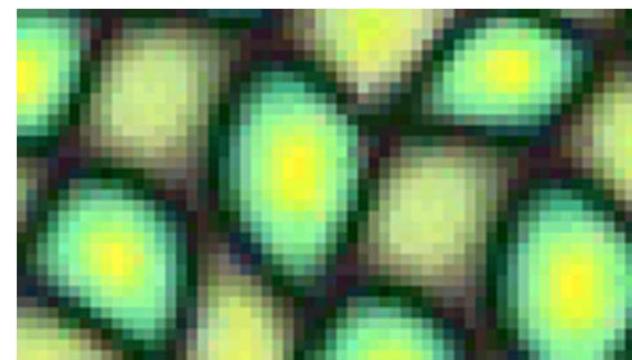


vertical boundary

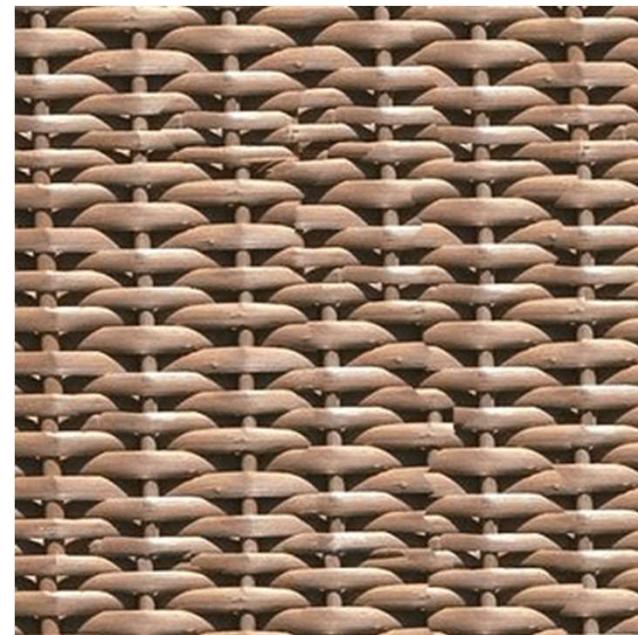
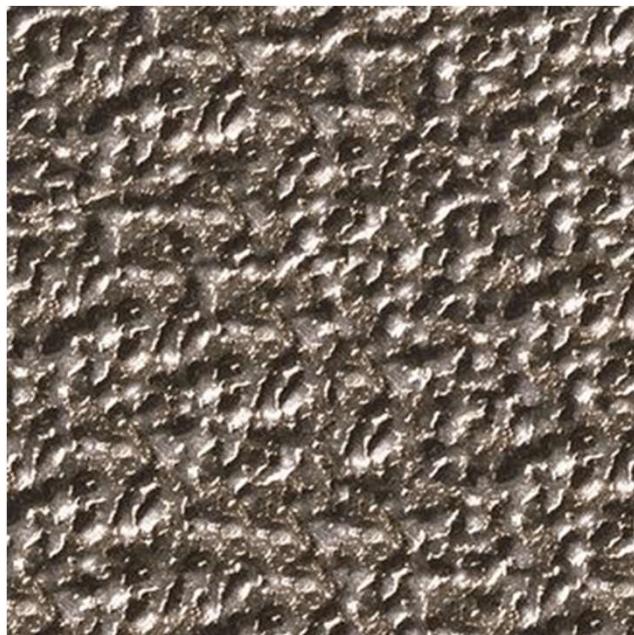
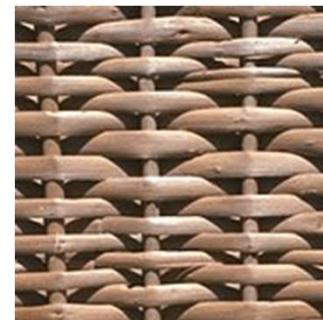


$$\left( \text{block}_1 - \text{block}_2 \right)^2 = \text{overlap error}$$

A diagram illustrating the calculation of overlap error. It shows two overlapping blocks of a heatmap. A bracket groups the two blocks with a minus sign between them, followed by a squared symbol (^2) and an equals sign (=). To the right of the equals sign is a small heatmap showing a red zigzag boundary, labeled "overlap error".



min. error boundary



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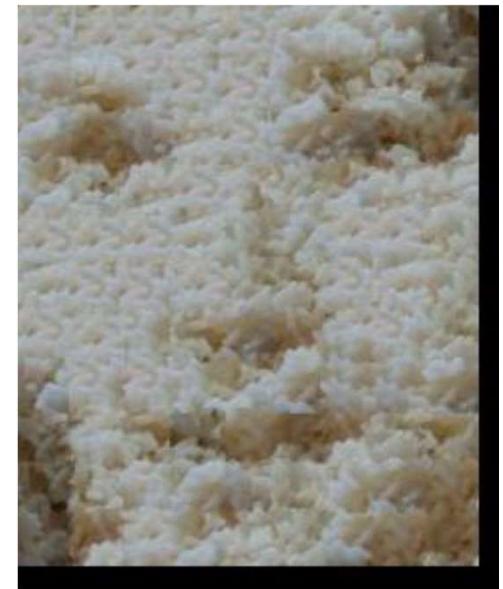


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rice

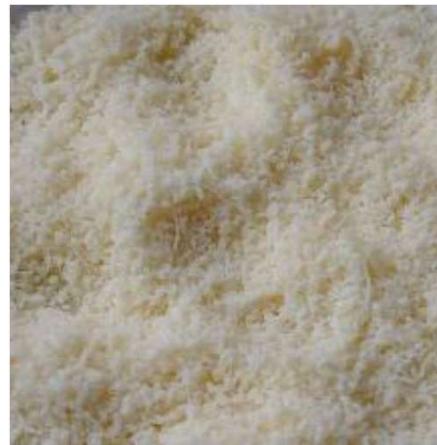


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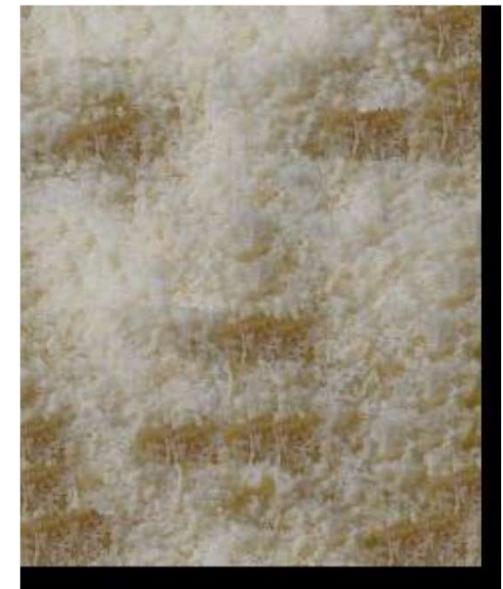




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