CS 4116: Computer Vision
HW2 Background

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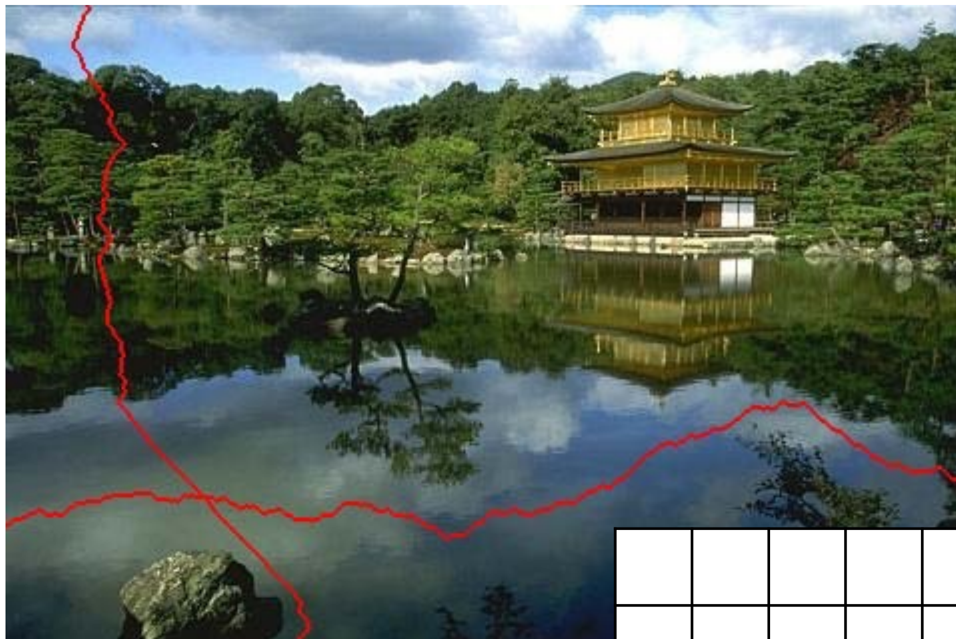
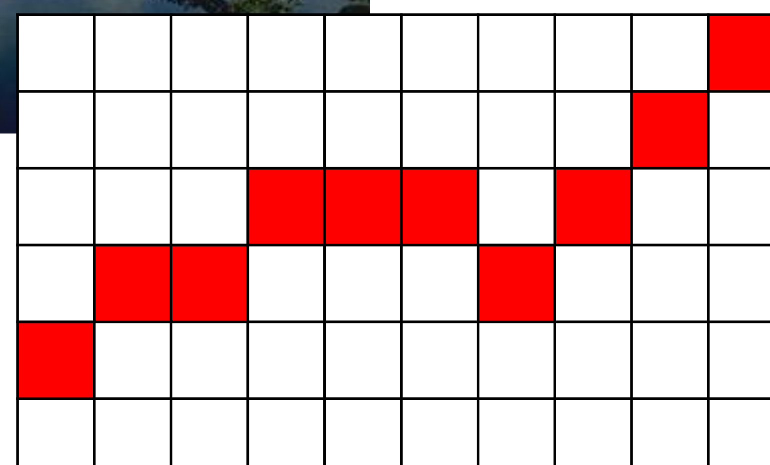
Slides from Kristen Grauman and Adriana Kovashka

Seam carving: main idea



Resize effect:
6x10 → 5x10



[Shai & Avidan, SIGGRAPH 2007]

Seam carving: main idea

Content-aware resizing

Traditional resizing

[Shai & Avidan, SIGGRAPH 2007]

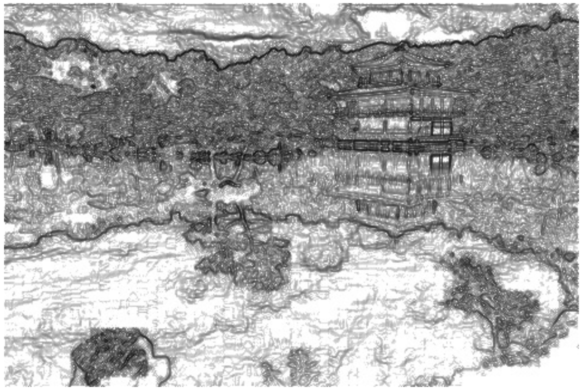
Seam carving: main idea

Content-aware resizing

Intuition:

- Preserve the most “interesting” content
  → Prefer to remove pixels with low gradient energy
- To reduce or increase size in one dimension, remove irregularly shaped (non-straight) “seams”
  → Optimal solution via dynamic programming.

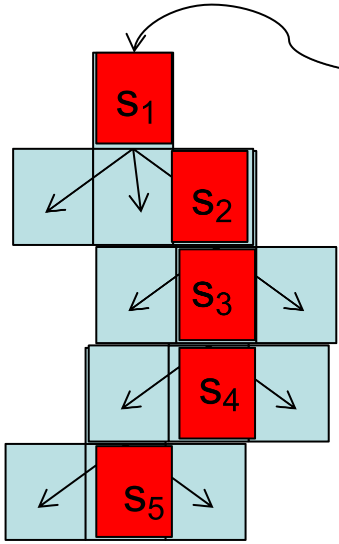
Seam carving: main idea

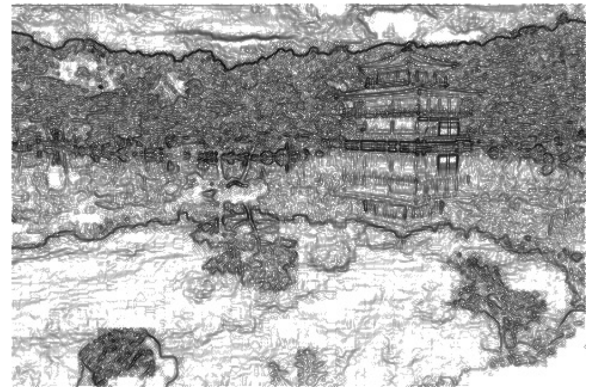


$$Energy(f) = \sqrt{\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2}$$

- Want to remove seams where they won't be very noticeable:
  - Measure "energy" as gradient magnitude (horizontal/vertical change)
- Choose seam based on **minimum total energy path** across image, subject to 8-connectedness.

Seam carving: algorithm





$$Energy(f) = \sqrt{\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2}$$

Let a vertical seam **s** consist of *h* positions that form an 8-connected path.

Let the cost of a seam be: $Cost(\mathbf{s}) = \sum_{i=1}^{h} Energy(f(s_i))$

Optimal seam minimizes this cost: $\mathbf{s}^* = \min_{\mathbf{s}} Cost(\mathbf{s})$

Compute it efficiently with dynamic programming.

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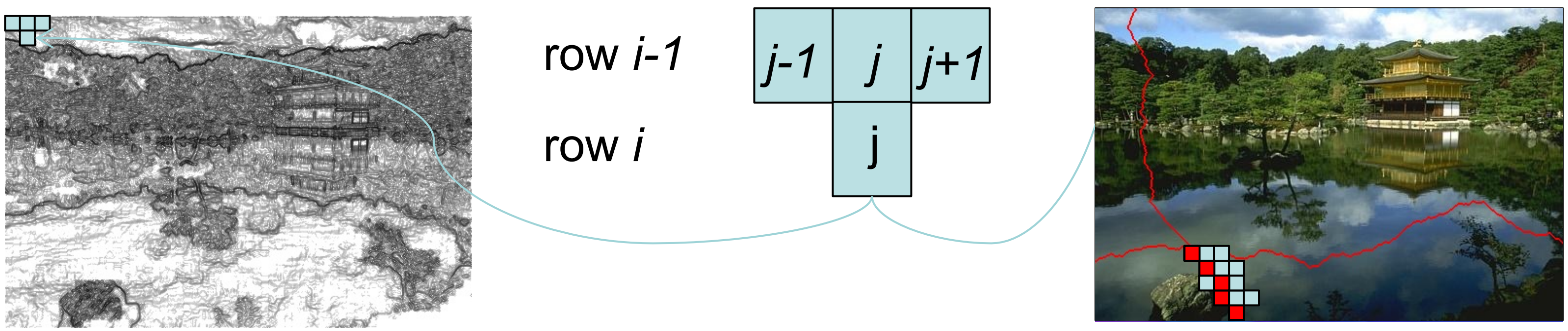
Seam carving: algorithm

- Compute the cumulative minimum energy for all possible connected seams at each entry *(i,j)*:

$$\mathbf{M}(i,j) = Energy(i,j) + \min\big(\mathbf{M}(i-1,j-1), \mathbf{M}(i-1,j), \mathbf{M}(i-1,j+1)\big)$$



Energy matrix (gradient magnitude)

M matrix: cumulative min energy (for vertical seams)

- Then, min value in last row of **M** indicates end of the minimal connected vertical seam.
- Backtrack up from there, selecting min of 3 above in **M**.
- Computing horizontal seams is analogous.

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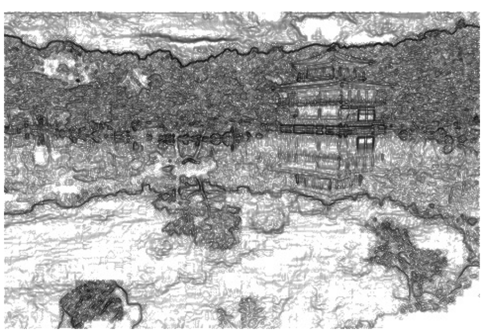
Example

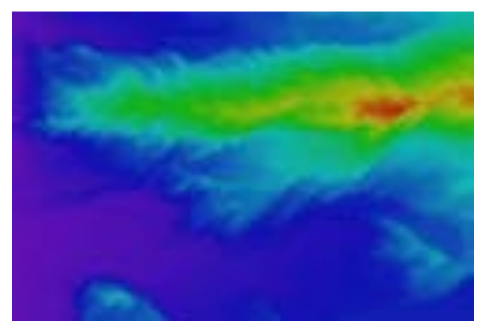
$$\mathbf{M}(i,j) = Energy(i,j) + \min\big(\mathbf{M}(i-1,j-1), \mathbf{M}(i-1,j), \mathbf{M}(i-1,j+1)\big)$$

1	3	0
2	8	9
5	2	6

First, compute cumulative energy from raw energy



Energy matrix (gradient magnitude)



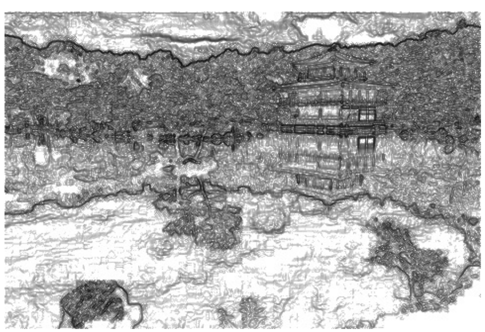
M matrix (for vertical seams)

Example

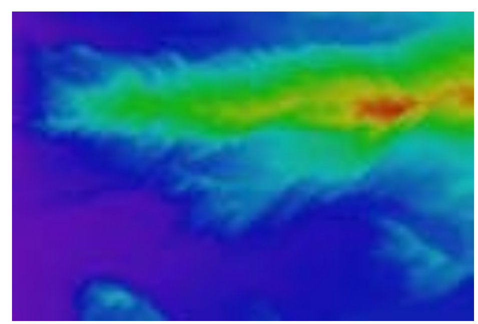
$$\mathbf{M}(i,j) = Energy(i,j) + \min\big(\mathbf{M}(i-1,j-1), \mathbf{M}(i-1,j), \mathbf{M}(i-1,j+1)\big)$$

$$\begin{matrix} \boxed{1} & 3 & 0 \\ \boxed{2} & 8 & 9 \\ 5 & \boxed{2} & 6 \end{matrix} \qquad \begin{matrix} \boxed{1} & 3 & 0 \\ \boxed{3} & 8 & 9 \\ 8 & \boxed{5} & 14 \end{matrix}$$

Now backtrack



Energy matrix (gradient magnitude)



M matrix (for vertical seams)

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