Agenda

- Warping to Mapping
- Seam Carving

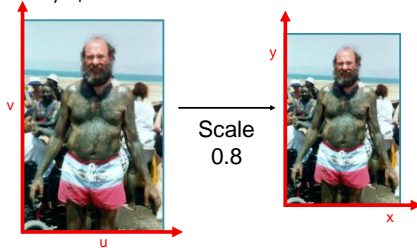2

קורס גרפיקה ממוחשבת
סמסטר ב' 2008

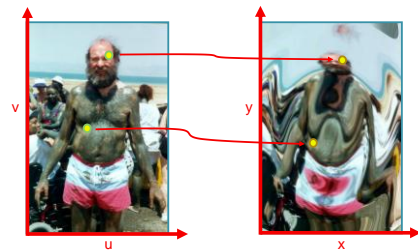## Image Processing II

Example Mappings

- Scale by *factor*:
  - x = *factor* * u
  - y = *factor* * v

Scale 0.8

Mapping

- Last time we started to discuss warping and mapping
- In general, we define a transformation
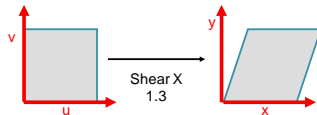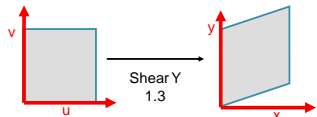 - Destination (x,y) for every source (u,v)

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Example Mappings

- Shear in X by *factor*:
  - x = u + *factor* * v
  - y = v

Shear X 1.3

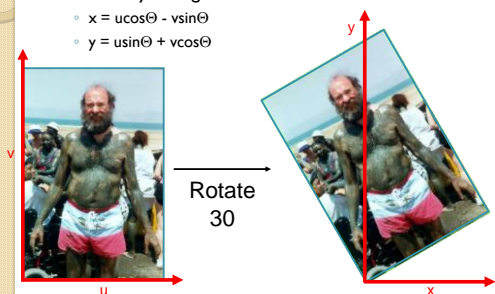- Shear in Y by *factor*:
  - x = u
  - y = v + *factor* * u
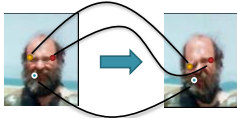
Shear Y 1.3

Example Mappings

- Rotate by Θ degrees:
  - x = ucosΘ - vsinΘ
  - y = usinΘ + vcosΘ

Rotate 30

Point Correspondence

- Another way to define mapping is by correspondences
  - A ←→ A'
  - B ←→ B'
  - C ←→ C'

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Other Mappings

- Any function of u and v:
  - $x = f_x(u,v)$
  - $y = f_y(u,v)$

Fish-eye   "Swirl"   "Rain"
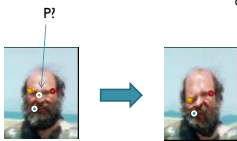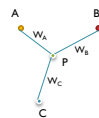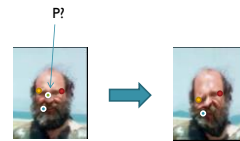
Point Correspondence

- How to compute P'

$$P' = w_A A + w_B B + w_C C$$

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Point Correspondence

- Another way to define mapping is by correspondences
  - A ←→ A'
  - B ←→ B'
  - C ←→ C'

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Possible application: Morphing
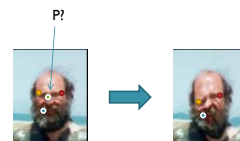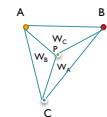
- User specifies corresponding points
- Blend while warping

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Point Correspondence

- How to compute P'
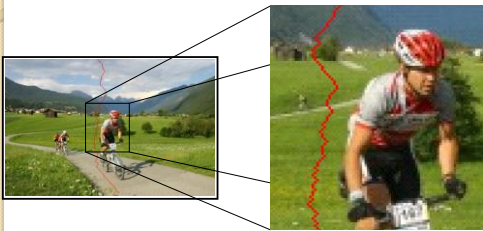
$$P' = w_A A + w_B B + w_C C$$

Barycentric Coordinates

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Seam Carving

- Seam Carving for Content-Aware Image Resizing
- A 2007 SIGGRAPH paper
  ◦ Ariel Shamir (IDC)
  ◦ Shay Avidan (MERL)

(c) ariel shamir

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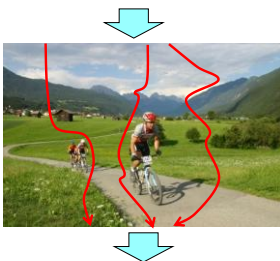
A Seam

(c) ariel shamir

Seam Carving

Cropping

Scaling
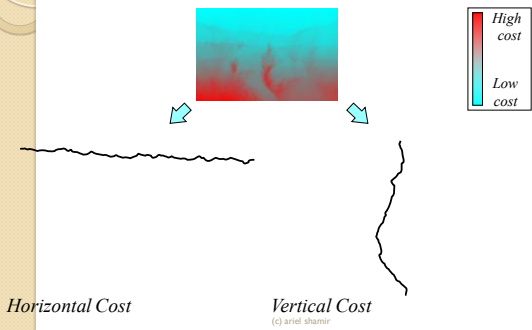
(c) ariel shamir

Finding the Seam?

(c) ariel shamir

Seam Carving

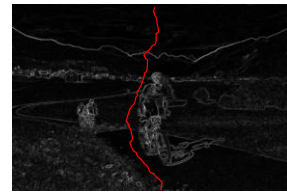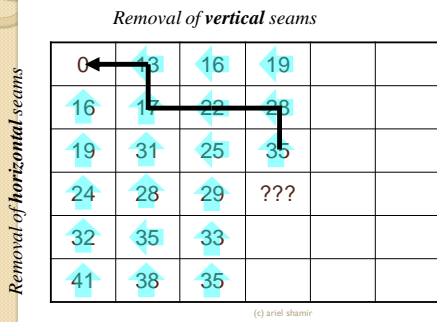(c) ariel shamir

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Dynamic Programming

High cost	
Low cost	

Horizontal Cost   *Vertical Cost*

(c) ariel shamir

Finding the Optimal Seam

$$s^* = \arg\min_{s} E(s)$$

(c) ariel shamir

Optimal Order Map

*Removal of **vertical** seams*

0	8	16	19		
16	1	22	28		
19	31	25	35		
24	28	29	???		
32	35	33			
41	38	35			

*Removal of **horizontal** seams*

(c) ariel shamir

Dynamic Programming

M(i,

5	8	12	3
9	2	3	9
7	3	4	2
4	5	7	8
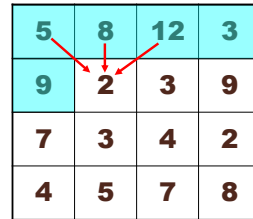
(c) ariel shamir

Aspect Ratio Change

(c) ariel shamir

A Local Operator!

(c) ariel shamir

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Aspect Ratio Change

Cropping   *Seams*   *Scaling*

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Aspect Ratio Change

Original

Seam Carving

Scaling

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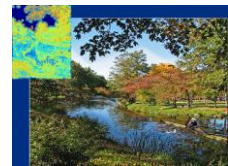## Energy Preservation

Energy

10%   30%   40%   75%
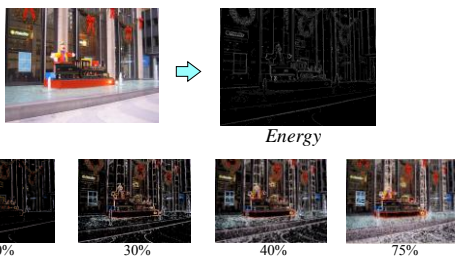
While resizing: remove *as many* low energy pixels and *as few* high energy pixels!
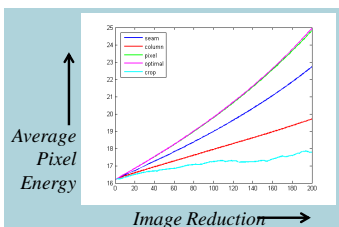
(c) ariel shamir

Different Energy Functions

- *Histogram of Gradient*
- *Entropy*
- E_1
- *Mean shift & E_1*

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Reduce Width

Average Pixel Energy

Image Reduction
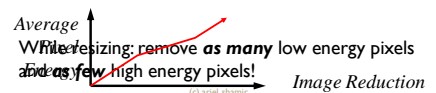
crop   **column**   **pixel**   **optimal**

(c) ariel shamir

Energy Preservation

If we measure the average energy of pixels in the image after applying a resizing operator…

…the average should increase!

Average

While resizing: remove *as many* low energy pixels and *as few* high energy pixels!

Image Reduction

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Exercise #1 – Image retargeting

- See definition on course website
- Submission: on 18/6/2008
- Headsup:
  - Exercise #2 will be published 11/6/2008 (week overlap)
  - Exercise #3 will be published (I hope) beginning of July

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