Lab12
Seam Carving for Content-Aware Image Resizing

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Lab 12

- Demo
  - Seam Carving
  - Seam Insertion
- Report
- Submission

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Image Resizing

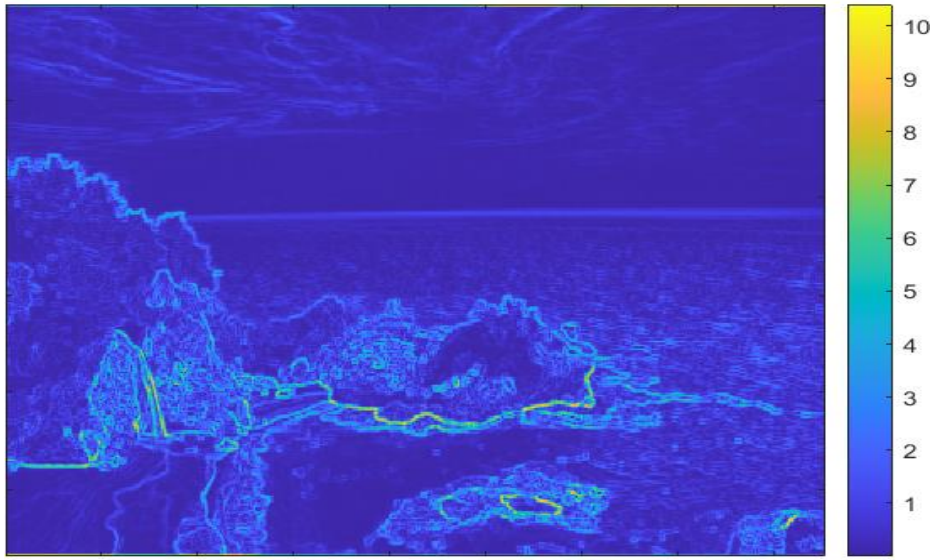
Scaling

Cropping

Seam Carving

Seam Carving

Energy of the image



Seam with minimum energy

$$e = \left|\frac{dI}{dx}\right| + \left|\frac{dI}{dy}\right|$$

$$s^* = \min_s E(s) = \min_s \sum_{i=1}^{n} e(I(S_i))$$

Seam Carving

```
for reduceCnt = 1:reduceSize
    energy = calcEnergy(image)
    optSeamIndex = findOptSeam(energy)
    image = reduceImageByIndex(image, optSeamIndex)
end
```

Calculate Energy

$$e = \left|\frac{dI}{dx}\right| + \left|\frac{dI}{dy}\right|$$

Filter

-1	0	1
-1	0	1
-1	0	1

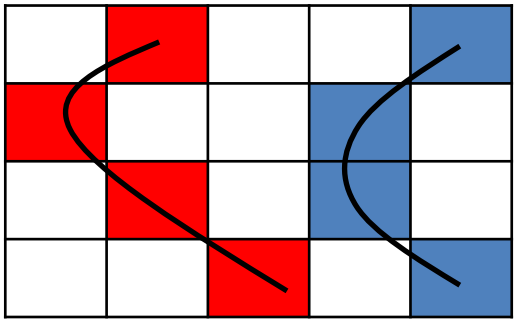
-1	-1	-1
0	0	0
1	1	1

- For RGB image, sum up all three channels

$$e = \left|\frac{dI_R}{dx}\right| + \left|\frac{dI_R}{dy}\right| + \left|\frac{dI_G}{dx}\right| + \left|\frac{dI_G}{dy}\right| + \left|\frac{dI_B}{dx}\right| + \left|\frac{dI_B}{dy}\right|$$

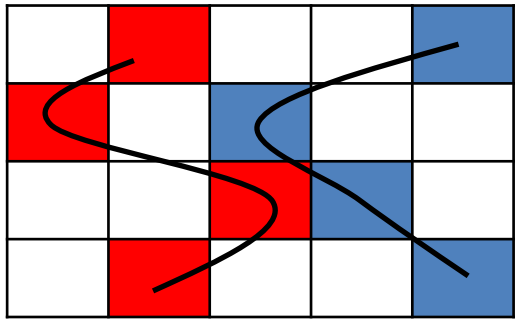
Find Optimal Seam (1/3)

energy



Seams

energy



Not seams

$$s^x = \{s_i^x\}_{i=1}^n = \{(x(i), i)\}_{i=1}^n, s.t. \forall i, |x(i) - x(i-1)| \leq 1$$

- Find a seam with minimum energy

$$s^* = \min_s E(s) = \min_s \sum_{i=1}^n e(I(S_i))$$

Find Optimal Seam (2/3)

energy

3	2	5	0
8	6	8	4
2	3	5	6
0	2	5	3

∞	3	2	5	0	∞
∞	8	6	8	4	∞
∞	2	3	5	6	∞
∞	0	2	5	3	∞

$$M[i,j] = e[i,j] + min\left(M[i-1,j-1], M[i-1,j], M[i-1,j+1]\right)$$

∞	3	2	5	0	∞
∞					∞
∞					∞
∞					∞

∞	3	2	5	0	∞
∞	10	8	8	4	∞
∞					∞
∞					∞

∞	3	2	5	0	∞
∞	10	8	8	4	∞
∞	10	11	9	10	∞
∞					∞

∞	3	2	5	0	∞
∞	10	8	8	4	∞
∞	10	11	9	10	∞
∞	**10**	11	14	12	∞

Find Optimal Seam (3/3)

M

∞	3	2	5	0	∞
∞	10	8	8	4	∞
∞	10	11	9	10	∞
∞	**10**	11	14	12	∞

∞	3	2	5	0	∞
∞	10	8	8	4	∞
∞	**10**	11	9	10	∞
∞	**10**	11	14	12	∞

∞	3	2	5	0	∞
∞	10	**8**	8	4	∞
∞	**10**	11	9	10	∞
∞	**10**	11	14	12	∞

∞	3	**2**	5	0	∞
∞	10	**8**	8	4	∞
∞	**10**	11	9	10	∞
∞	**10**	11	14	12	∞

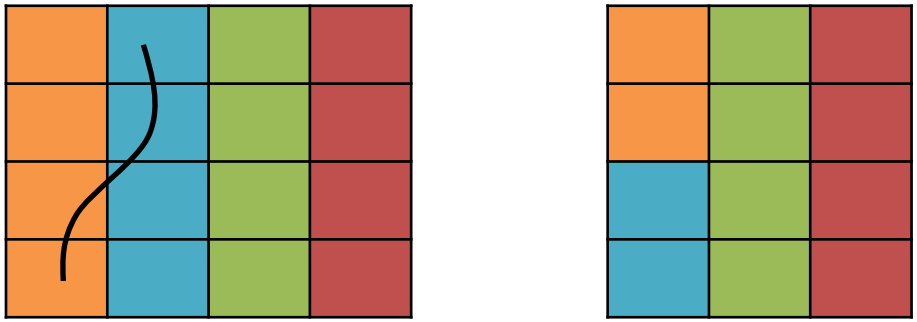
Seam index

[?, ?, ?, 2] [?,?,2,2] [?,3,2,2] [3,3,2,2]

Seam index without padding

[2,2,1,1]

Remove Seam



Seam index: [2,2,1,1]

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Seam Insertion

Before seam insertion

After seam insertion

Key idea:
Insert seams at locations with low energy
-> Seam Carving

Record Seam Index by Seam Carving

- Insert four seams for example
- Perform seam carving four times
- Record seam indexes

seam index

52	8	78	57
52	8	78	57
53	8	79	58
54	8	79	59

1st carving

52	8		
52	8		
53	8		
54	8		

2nd carving

52	8	78	
52	8	78	
53	8	79	
54	8	79	

3rd carving

52	8	78	57
52	8	78	57
53	8	79	58
54	8	79	59

4th carving

Update Index (1/2)

- The recoded indexes are about indexes after seam carving
- Update to indexes before seam carving

```
for column_ref = n-1:-1:1
    for column = column_ref+1:n
```

seam index

52	8	78	57
52	8	78	57
53	8	79	58
54	8	79	59

…

52	8	78	57
52	8	78	57
53	8	79	58
54	8	79	59

52	8	78	57
52	8	78	57
53	8	79	58
54	8	79	59

52	8	79	58
52	8	79	58
53	8	80	59
54	8	80	60

52	8	80	59
52	8	80	59
53	8	81	60
54	8	81	61

Smaller ->
No change

Larger ->
Add one

Add one to
those larger

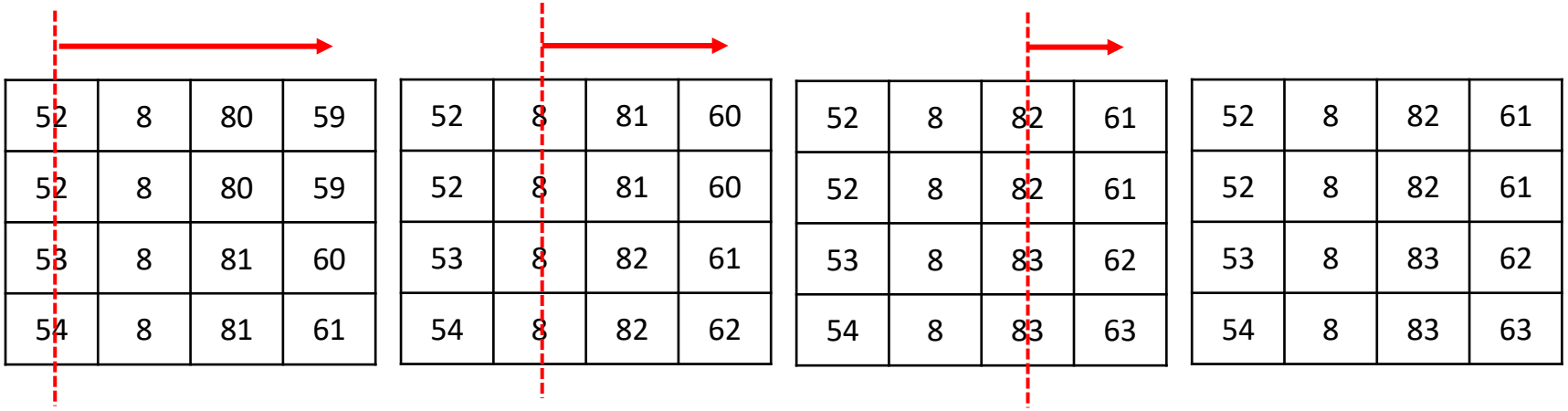
Update Index (2/2)

- Update to indexes after seam insertion

```
for column_ref = 1:n-1
    for column = column_ref+1:n
        …
```

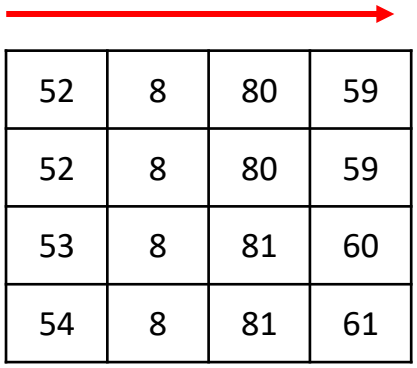
seam index

52	8	80	59
52	8	80	59
53	8	81	60
54	8	81	61



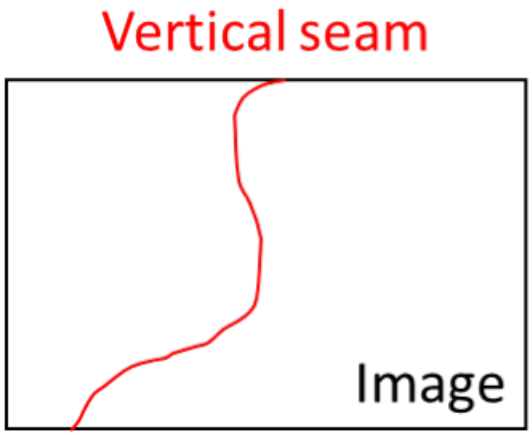
Seam Insertion

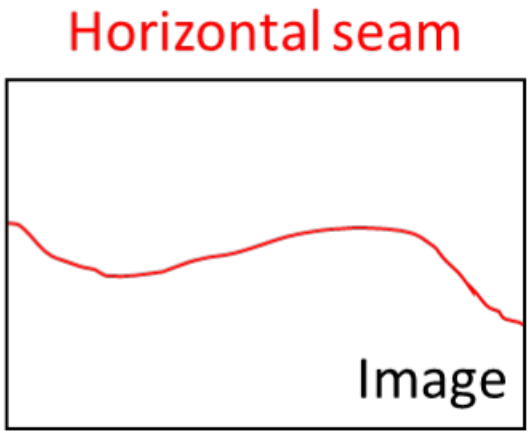
- Insert seams from the location of the first recorded seam to the last
- What values should be inserted
  - May copy from the left, from the right, interpolate with pixels from the left or from the right



Seam Direction

- Vertical seam only for demo
- Complete horizontal seam in report





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Report

1. (5%) In the process of seam insertion, what will happen if we insert the seam with minimum energy directly. Is it better than what we did in the demo section? Why?
2. (10%) Finish the **horizontal** seams part in **`reduceImageByIndexArray.m`** and **`findOptSeam.m`**. What if we remove horizontal seams from the image **`sea.jpg`**. Is there any problem?
3. (10%) Besides image resizing, Seam Carving algorithm can be used for other applications such as **content amplification** and **object removal** as mentioned in [1]. Try to implement these two applications with provided starter codes **`seamCarvingContentAmplification.m`** and **`seamCarvingObjectRemove.m`**. Hints are provided in the starter codes.
4. (10%) In the object removal part, what is the difference between removing vertical seams and removing horizontal seams. Which one removes object with less seams? Provide one example with images to explain your idea.
5. (5%) Conclusion.

Object Removal & Content Amplification

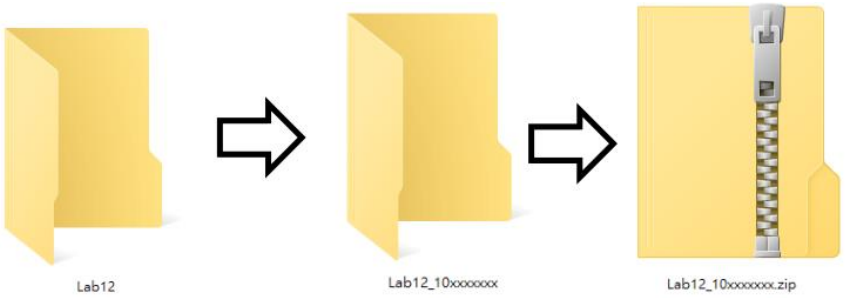
Submission

- Due 12/19 23:59

Deliverable and file organization

Directory	Filename	Description
Lab12/code/	*.m	All MATLAB codes
Lab12/data/	*.png / *.jpg	Your own source image
Lab12/report/	report_10xxxxxxx.pdf	Your report
Lab12/results/	*.png / *.jpg	Your results

Please organize your files according to the above table and compress it as Lab12_10xxxxxxx.zip in ZIP format. (P.S. 10xxxxxxx is your student ID)



Reference

S. Avidan and A. Shamir, "Seam Carving for Content-Aware Image Resizing", ACM Trans. Graphics, vol. 26, no. 3, pp. 10, 2007.