
Lab 12 Seam Carving for Content-Aware Image Resizing

Assigned on Dec 12, 2022

Due by Dec 19, 2022

Overview

The goal of this lab is to understand what “Seam Carving” algorithm is and how to implement it with MATLAB.

Problem definition

When we want to resize an image into different aspect ratio, problems will occur. For example, (b) and (c) resize input (a) with scaling and cropping respectively. Scaling distorts the input image, and cropping removes some part of the input image. Both results are undesirable.



(a) Original image



(b) Scaling



(c) Cropping

The **Seam Carving** algorithm can solve above-mentioned problems. Seam Carving algorithm resizes images by removing less meaningful “seams” only. This approach reduces distortions and preserves important contents in images. (d) is the result using Seam Carving algorithm.



(d) Seam Carving

Procedure (Seam Carving)

I. Defining an energy function that would map a pixel into energy value.

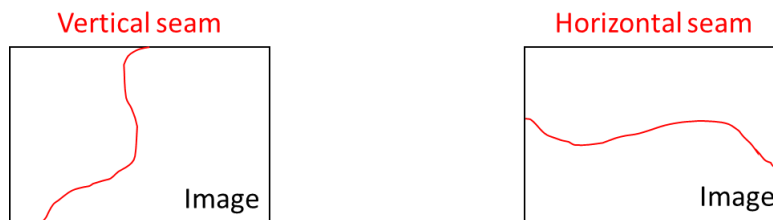
We use the gradient of the pixel as an energy function

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

If the picture has 3 channels, just sum the values of the energy for each channel.

II. Defining the path of pixels (seam)

If we delete pixels with minimum energy directly, we will get a distorted image. The solution is to delete a seam. An example of vertical seam and horizontal seam is shown below



Formally, let I be a $n \times m$ image, then a vertical seam s^x is defined as follow

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

where x is a mapping $x: [1, \dots, n]$ to $[1, \dots, m]$. It means that a vertical seam is path from the top of the image to the bottom such that the length of the path in pixels is the width of the image, and for each seam element (i, j) , the next seam element can only be $(i+1, j-1)$, $(i+1, j)$ or $(i+1, j+1)$.

III. Looking for a seam with the minimum energy among all seams.

We are looking for a seam with the minimum energy among all seams, the minimum s^* is

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

1. Find M , which is minimum energy for all possible seams for each (i, j)
 - ✧ Fill the first row of M with the first row if energy.
 - ✧ Calculate M for all rows starting from second as below

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

2. Find the minimum value in the last row of M and traverse back to choose the pixels with minimum energy.




IV. Reduce image each seam.

Procedure (Seam Insertion)

- I. Duplicate the image.
- II. Perform seam carving on the **duplicated** image and record the position of the seam k times. (Denote the i -th time removed seam as s_i)
- III. Update the recorded positions of seams
- IV. Do the following steps k times:
 1. Take out the s_i from the record. ($i = 1, \dots, k$)
 2. Calculate the inserted seam (s_{insert}):
 $s_{insert} = \text{average of the neighbor of the removed seam } s_i \text{ and itself}$
 3. Insert s_{insert} beside the s_i into the **original** image.

In-class Demo

1. Reduce image by seam carving (30%)
2. Enlarge image by seam insertion (30%)

| | | |
|---|---|--|
|  |  |  |
| Input | Reduce | Enlarge |

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 as mentioned in [1]. Two such applications are **content amplification** and **object removal**. Examples of these two applications are shown below. Try to implement these two applications with provided starter codes **seamCarvingContentAmplification.m** and **seamCarvingObjectRemove.m**. Hints are provided in the starter codes.



Input Image



Content Amplification



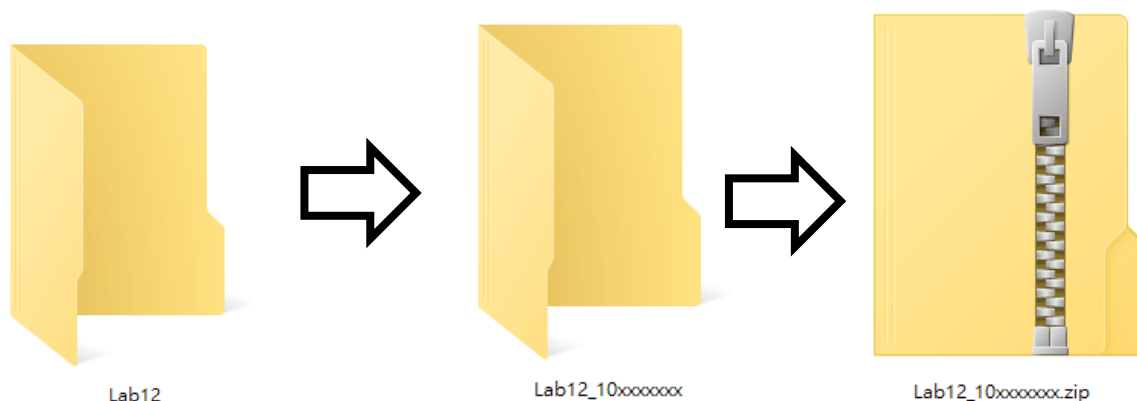
Object Removal

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.

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 change the root name from Lab12 to Lab12_10xxxxxxx. Then compress it as Lab12_10xxxxxxx.zip in ZIP format. (P.S. 10xxxxxxx is your student ID)



Wrong file delivery, wrong file organization or wrong file naming will get up to 5% punishment.

Reference

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