National Tsing Hua University
Department of Electrical Engineering
EE3662 Digital Signal Processing Laboratory, Fall 2021

Lab 8 Seam Carving for Content-Aware Image Resizing

Assigned on Nov 23, 2021
Due by Nov 30, 2021

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 the image and the aspect ratio which is different from original image, some problems will occur. The image (a) is original image. And the (b) and (c) are resized image by scaling and cropping. As you can see, the result in (b) is distorted and the part of input is removed in (c). Both results are undesirable.

(a) Original image

(b) Scaling

(c) Cropping

Solution

The Seam Carving algorithm can solve previous problem. It can remove pixels which are less meaning while saving more important ones, i.e., preserving the important contents and delete the less meaning contents in the picture to resize the image. (d) is the result of Seam Carving.

(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), which length is width/height of the image.**

If we delete pixels with minimum energy but random positions, we will get distorted picture. The solution is to introduce a generalization of column/row (called seam). Formally, let I is n x 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,...,n] to [1,...,m]. It means that a vertical seam is path from the top of the picture to the bottom such that the length of the path in pixels is width of the image, and for each seam element (i, j), the next seam element can be only (i+1, j-1), (i+1, j), (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 energy in the first row.
   - ✧ 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. Do the following steps k times:

1. Take out the s_i from the record in reverse order. ($i = k, \dots, 1$)

2. Calculate the inserted seam (s_{insert}):
   s_{insert} = average of the neighbor of the removed seam s_i and itself

3. Insert s_{insert} beside the s_i into the **original** image.

4. Update the position of the affected seam after inserting s_{insert}.

In-class Demo

1. Reduce image by seam carving (40%)
2. Enlarge image by seam insertion (20%)

		
Input	Reduce	Enlarge

Report

1. (5%) Describe the goals of this lab and approach (algorithm).
2. (10%) Show two more other results of Seam Carving and Seam Insertion algorithm.
3. (10%) Show the **horizontal** result of scaling, cropping, and Seam Carving for one of your input images.
4. (5%) Discuss the limitation of Seam Carving algorithm.
5. (5%) If we enlarge the image by inserting the minimum energy seam directly, the result will be better or worse than the result of the method in this handout? Why?
6. (5%) Conclusion

Deliverable and file organization

Directory	Filename	Description
LAB8/code/	*.m	All MATLAB codes
LAB8/data/	*.png / *.jpg	Your own source image
LAB8/report/	report.pdf	Your report
LAB8/results/	*.png / *.jpg	Your results

Please organize your files according to the above table and compress it as LAB8_10xxxxxxx.zip in ZIP format. (P.S. 10xxxxxxx is your student ID)

Reference

[1] Paper by Shai Avidan and Ariel Shamir, title is Seam carving for content-aware image resizing, which is published in SIGGRAPH, ACM 2007.