National Tsing Hua University

Department of Electrical Engineering

EE3662 Digital Signal Processing Laboratory, Fall 2018

Lab #8 Seam Carving for Content-Aware Image Resizing

Assigned on Nov 5, 2018

Due by Nov 12, 2018

Overview

The goal of this lab is to understand what "Seam Carving" algorithm is and how to implement it with Matlab. Here is the contribution of Seam Carving algorithm.

- **Problem defining**

  When we want to resize the image and the aspect ratio 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 castle in (b) is distorted and the part of castle in (c) is removed. Both of these results are undesirable.

(a) Original image

(b) Scaling

(c) Cropping

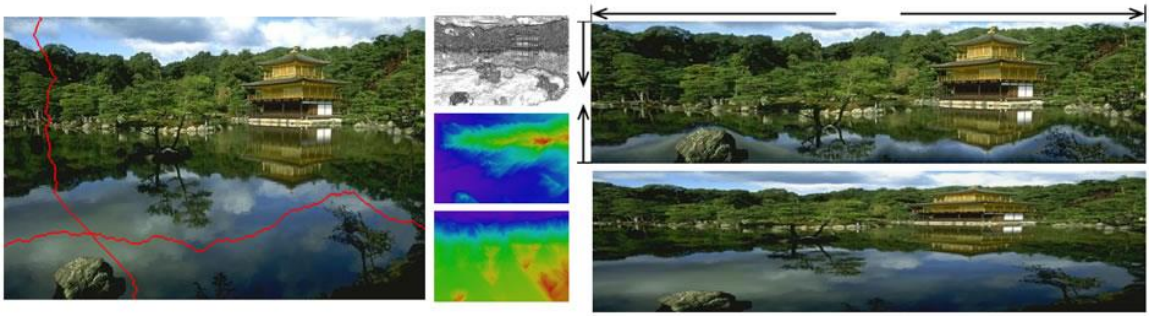
- **Problem solving**

  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

- **Others**

  Actually, the Seam Carving algorithm can not only reduce pixel of image like previous example but also extend the image like (e). In general, Seam Carving algorithm can apply when you want to display images without distortion on different device with various sizes (projector, TV, cellphone…). **But in this lab, we only focus on how to reduce image size by Seam Carving algorithm.**



(e) On the left is the original image with one horizontal and one vertical seam. The example on the top right shows the result of extending in one dimension and reducing in the other, compared to standard scaling on the bottom right.

Implementation part of Seam Carving Algorithm in this lab

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

We use gradient of the pixel as an energy function: "e=|dI/dx|+|dI/dy|". If the picture has 3 channels, just sum 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 is defined as follow:

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

where x is a mapping x: [1,..,n] -> [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

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

1. Find M, which is minimum energy for all possible seams for each (i, j)
   - Filling in the first row by energy
   - For all rows starting from second:

     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 choosing pixels with minimum energy.

IV. Finding optimal order of deleting seams. [Already Finish]

Let n' x m' are desirable size of the image (n' < n, m' < m). We introduce a transport matrix T which defines for every n' x m' the cost of the optimal sequence of horizontal and vertical seam removal operations. It is more suitable to introduce r = n - n' and c = m - m' which defines number of horizontal and vertical removal operations.

V. Reducing an image by a given mask.

Score Details

I. In-class Demo (80%, 20% for each)

- Working implementation of gradient of pixel in **energyRGB.m**
- Working implementation of finding optimal seam in **findOptSeam.m**
- Working implementation of reduce pixels by input mask in **reduceImageByMask.m**
- Using the image in "**data"** folder to show the result of Seam Carving algorithm.

II. Report (20%)

- Showing some examples of Seam Carving algorithm **(4%)**
- Explain the Seam Carving algorithm (procedure detail and physical meaning) **(5%)**
- Explain code (Correspondence between code and algorithm) **(5%)**
- Discuss the limitation of Seam Carving algorithm **(6%)**

III. Bonus (5%)

- Implement image enlargement with Seam Carving algorithm (show your result and code)

IV. Deliverable and file organization

Directory	Filename	Description
LAB8/code/	*.m	All matlab script
LAB8/results/	*.png / *jpg	Your result
LAB8/report/	report.pdf	Your report
LAB8/data/	*.png / *jpg	Your other input images

When you submit your file, please organize your files according to the above table and compress your files to LAB8_10xxxxxxx.zip in ZIP format. (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.