Computational Photography

Assignment 4 - Seam Carving
Winter 2024

Introduction

For this assignment we are going to implement seam carving.

Grading

Theory Questions	15pts
Energy Matrix	20pts
Optimal Seam Discovery	30pts
Optimal Seam Removal	15pts
Full Removal	20pts
TOTAL	100pts

Table 1: Grading Rubric

1 Theory Questions

1. If the matrix below is the gradient magnitude image

$$G = \begin{bmatrix} 2 & 3 & 4 & 5 & 1 \\ 1 & 0 & 2 & 2 & 1 \\ 4 & 3 & 5 & 1 & 2 \\ 4 & 4 & 4 & 4 & 6 \\ 4 & 5 & 2 & 0 & 2 \\ 2 & 3 & 3 & 0 & 3 \end{bmatrix}$$

   (a) Construct the cost matrix if we assume vertical seams (10pts).

   (b) The cost matrix C calculated from the gradient magnitude image is given by:

$$C = \begin{bmatrix} 2 & 3 & 4 & 5 & 1 \\ 3 & 2 & 5 & 3 & 2 \\ 6 & 5 & 7 & 3 & 4 \\ 9 & 9 & 7 & 7 & 9 \\ 13 & 12 & 9 & 7 & 9 \\ 14 & 12 & 10 & 7 & 10 \end{bmatrix}$$

   (c) What is the optimal seam (5pts)?

   (d) The optimal seam, representing the path of minimum cumulative energy from the top to the bottom of the image, is found to traverse the following columns in each row (using 1-based indexing):

$$\text{seam} = \begin{bmatrix} 6 \\ 6 \\ 5 \\ 5 \\ 5 \\ 4 \end{bmatrix}$$

   This path indicates a traversal from the bottom row, moving from the 4th column to the 5th column in the middle rows, and finally to the 6th column at the top, effectively identifying the path of least energy through the image.

2 Energy Function

First grab two images of interest to you so that we can multiple example I/O. To do seam carving we'll first need to compute the energy functions of your images.

For each of your images, compute its energy and visualize this as an image.

Some implementation details:

- Do this in grayscale
- First smooth your grayscale image using a Guassian kernel prior to getting the gradients (or do this in one step). Choose parameters that make sense for you (and report them!).

Since you already demonstrated in prior assignments your to implement RGB to Gray, Gaussian and Gradient kernels and convolution, for this assignment **may** use Matlab functions like $conv2$, $rgb2gray$. In addition, for this and subsequent parts, you **may** use Matlab's *imgradxy* to compute the gradients, since we've already implemented it ourselves in prior assignments.

3 Optimal Seam

Now that you have your energy images, we must find the optimal seam in it.

Using the technique discussed in class, for each of your images,

- Use its energy image to compute a seam matrix.
- Find the optimal seam in this seam matrix via backtracing.
- Superimpose on your color image the optimal seam in red.

Additional Details:

- We will do vertical seam carving, starting at the top of the image.
- You'll likely have to think about how to handle the edge cases.

4 Remove a Seam

Now, in each image, remove its optimal seam, thereby reducing the width of the images by one pixel.

5 Remove all the Seams!

Finally, let's use seam carving to reduce down to a width of zero, and show the process via a video!

For each of your images, create a **video** showing the seam removal process. Each frame of the video should depict the current color image with the current optimal seam superimposed (like in the previous part). Subsequent frames should have the previous seam removed (thus be one pixel narrower).

Note:

- When writing your image as a frame to your video, you'll have to place its contect on a "padded" image so that all the frames have the same size.
- To create a movie in Matlab use the *VideoWriter* class. In addition, to keep the movies relatively small in file size, use the *MPEG-4* profile for your VideoWriter object.

Submission

For your submission, upload to Blackboard a single zip file containing:

1. PDF writeup that includes:
   (a) Your answer to the theory question(s).
   (b) Your two original images.
   (c) Your two energy function images for Part 2.
   (d) Your two optimal seam images for Part 3.
   (e) Your two images with the optimal seam removed, for Part 4.
2. A README text file (not Word or PDF) that explains
   - Features of your program
   - Name of your entry-point script
   - Any useful instructions to run your script.
3. Your source files
4. The chosen images that you are processing.
5. The videos generated for Part 5.

Figure 1: ORIGINAL IMAGE 'fabric.png'

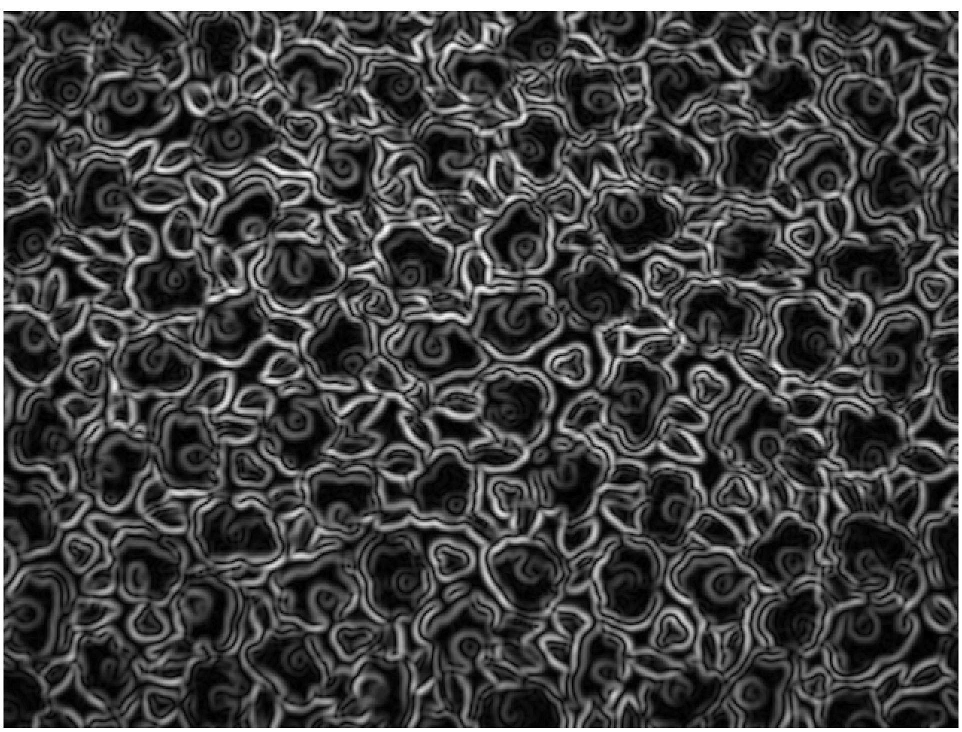

Figure 2: ENERGY FUNCTION IMAGE

Figure 3: OPTIMAL SEAM IMAGE

Figure 4: OPTIMAL SEAM REMOVED

Figure 5: ORIGINAL IMAGE 'cameraman.tiff'

Figure 6: ENERGY FUNCTION IMAGE

Figure 7: OPTIMAL SEAM IMAGE

Figure 8: OPTIMAL SEAM REMOVED