6.815/6.865 Digital & Computational Photography

Problem Set 5: Seam Carving

Due Friday, March 18 at 7:00pm

Seam Carving

We often need to resize images or to change their aspect ratios to fit them into different page layouts or display devices. However, changing the aspect ratio using image scaling distorts the image *content*, and cropping removes objects from the periphery.

A recent SIGGRAPH paper, "Seam Carving for Content-Aware Image Resizing", by Shai Avidan and Ariel Shamir introduces a smart image resizing method, *seam-carving*, that changes the image size by removing unnoticeable seams first. A seam is a connected vertical or horizontal line with low energy. This is done as follows:

- Define an energy function E(I) for each pixel in the gray scale. As discussed in the lecture, the L1 energy based on gradients, ($E(I) = |I_x| + |I_y|$), is easy to compute and works well.
- Remove seams. Remove the same number pixels in every row or column. The removed pixels should be connected. This is achieved using dynamic programming which is described in the paper and lecture notes. To find a vertical seam, you accumulate the minimum seam cost from the top to the bottom. The minimum seam cost for the current pixel is (the current pixel's energy value + the minimum seam cost in the upper row which is connected to the current pixel). As you track back the minimum seam cost from bottom to top, you can find the optimal vertical seam.

Problem 1 (6.815/6.865)

Implement the seam carving technique, as described in Section 3 of Avidan and Shamir's paper. For this assignment, you only need to implement shrinking in one dimension. The paper discusses multiple energy functions. You can implement any energy function in the paper, however you're free to use MATLAB `sobel` filter (`help fspecial`).

Here is a pseudocode of the algorithm.

```
while (I is not of desired size)
e = compute_energy_function(I)
M = compute_cumulative_minimum_energy(e)
s = find_optimal_seam(M)
I = carve_seam(I,s)
```

```
end
```

Given an input image `I`, your code should be able to shrink an output image by a given number of pixels either in width or in height. You only need to implement for one dimension, and you can transpose the input image for the other dimension.

In your writeup: Show the results of your code for resizing `parkstreet.png` to 512 x 300 and for resizing `copley.png` to 480 x 340, and plot the removed seams in the original images like the left figure in Figure 1 of the seam carving paper.

Problem 2 (6.865 only)

The seam carving paper has more advanced techniques than what you implemented in Problem 1: optimal seams-order for diagonal resizing (Section 4.2), image enlarging (Section 4.3), object removal (Section 4.6), and so on. Implement one of these extensions.

In your writeup: State the extension that you chose to implement, and show great examples of your implementation.

Submission

Like the previous assignment, you should assemble a ZIP file that is named after your Athena login. Make sure this file contains:

- A PDF file with answers to your written questions and your results. *In general, you should try to make this file as self-sufficient as possible.* In other words, we shouldn't have to look at your code to evaluate your results. Please don't tell us to run something unless it's absolutely necessary. We will look at your code to make sure you did the work and assign partial credit if you did something wrong.
- Your MATLAB code (we've provided stub methods with the method signatures we expect for grading):
  - `seam_carving.m`
  - Code for Problem 2 (6.865 only)
- Any images (other than the provided ones) that might be necessary to run your code.

All electronic submissions are due on the Stellar website by March 18 at 7pm.