Master MAIA Image Processing Project

Seam Carving for Content-Aware Image Resizing

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1 Introduction

Image re-sizing is being used very frequently nowadays such as cropping and scaling. Many designers encounter with difficulties to save content aware of images that have an exactly specified size. Both of these solutions are not sufficient. In this project we considered the most effective re-sizing method called seam-carving which pays attention to the contents of the image. This method is capable of removing those belonging to more uninteresting objects in the image would be given preference, while interesting parts of the image are saved.

2 Problem Statement

The problem is to locate the images optimal seams, connected pixel paths going from top to bottom or left to right, to remove or insert while preserving the photorealism of the image. Seam Carving method is targeted on image resizing based on detection of seams from the energy function of the image. The method aims at finding seams of minimum energy and manipulating the image using them. By successively removing seams we can reduce the size of an image. Seams can be either vertical or horizontal. A vertical seam is a path of 8 connected pixels from top to bottom in an image with one pixel in each row. A horizontal seam is similar with the exception of the connection being from left to right. For image reduction, seam selection ensures that while preserving the image structure, we remove more of the low energy pixels and fewer of the high energy ones.

Figure 1: Original image

Seam carving can support several types of energy functions such as gradient magnitude, entropy, visual saliency, eye-gaze movement, and more. We assigned energy to each pixel by using a gradient operator (Sobel, Prewiit, Robert or Laplacian) to compute the gradient in both x and y direction and then finding the path across the image that minimizes total energy. The energy function is defined as follows:

$$e_1(I) = |\frac{\partial}{\partial x} I| + |\frac{\partial}{\partial y} I| \tag{1}$$

After we have the energy of the image, we generate a list of seams. Seams are ranked by energy, with low energy seams being of least importance to the content of the image. The optimal seam can be found using dynamic programming. The first step is to traverse the image from the second row to the last row and compute the cumulative minimum energy M for all possible connected seams for each entry (i; j):

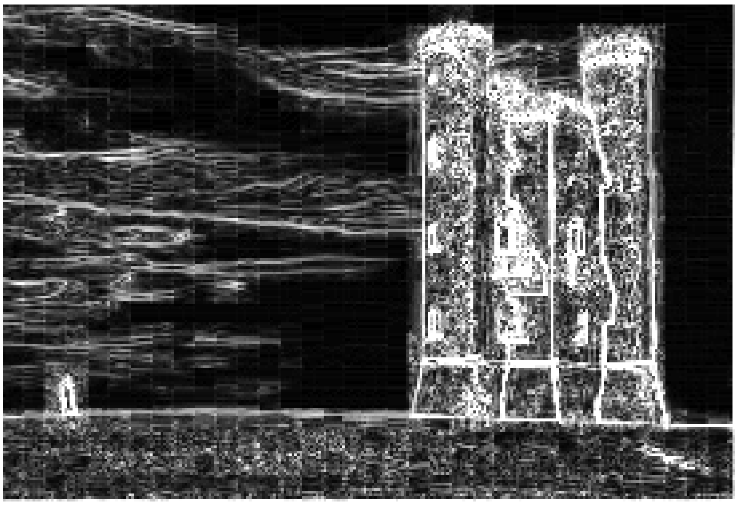

Figure 2: Gradient magnitude of the image

$$M(i;j) = e(i,j) + min(M(i-1;j-1), M(i-1,j), M(i-1,j+1)) \tag{2}$$

Figure 3: Seams of the original image

To understand the calculation, it is better to describe as follows:

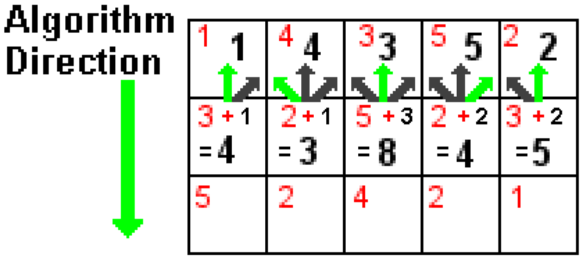

Figure 4: Algorithm direction 1

Each square represents a pixel, with the top-left value in red representing the energy value of that said pixel. The value in black represents the cumulative sum of energies leading up to and including that pixel.

The first row has no rows above it, so the sum (black) is just the energy value of the current pixel (red).

The second row, if we look at the second pixel for example, we see its energy value is 2 (red). If we look above it, it has a choice of either 1, 4, or 3 (black). Since 1 is the minimum number of the three values, we ignore the other two and set the sum of the pixel to its energy value which is 2 (red) plus 1 (black).

After the above operation is carried out for every pixel in the second row, we go to the third row:

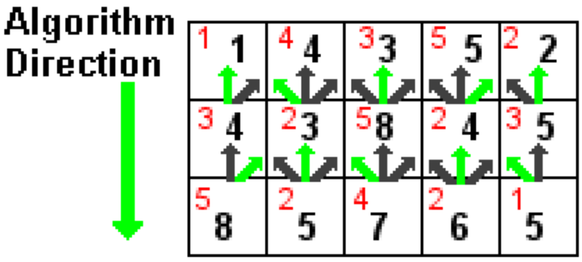

Figure 5: Algorithm direction 2

We repeat the process from row two in row three to end up with the final cumulative sums for the seams/paths. The lowest value or values are the seams with the lowest energy, which would be in this example the seams with '5' in the last row.

To trace the seam/path, it is worked from the last row and follow the green arrows:

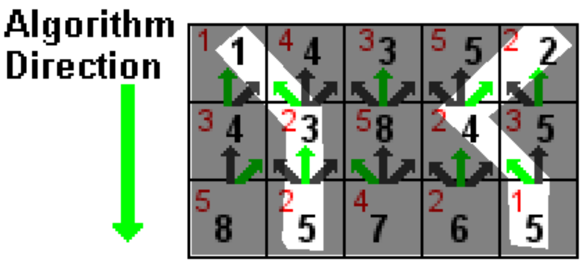

Figure 6: Algorithm direction 3

More specifically, we find the pixel on the last row with the minimum cumulative energy and use this as the starting pixel. Then from the three pixels above it choose the one with the minimum cumulative energy and so on. The definition of M for horizontal seams is similar.

After finding the regions of an image that have low total energy we removed all of the pixels in the column and row. When resizing an image all the pixels are shifted left or up to compensate for the missing path.

Figure 7: Reduced image

3 Methodology

1. Get RGB image.
2. Get conversion to gray scale image.
3. Calculate energy map.
4. Find minimum seam from top to bottom edge.
5. Remove minimum seam from top to bottom edge.

4 Results

Finding an appropriate energy function was affect the results. One problem with this energy function was that it does not take into account vertical lines in the image. A minimum path may not cross through a vertical line directly, but if part of the path is on one side of a line and part of the path is on the other, then the end result may be a skew in the vertical line with deformation.

5 Conclusion

This project was implemented on Matlab programming. During this project I learned to work with pixels, gradient magnitude, energy of the image, dynamic programming and most important thing I learned that the results of seam carving really depends on energy function.

6 References

1. S. Avidan and A. Shamir, "Seam carving for content-aware image resizing," ACM Trans. Graph., vol. 26, July 2007.
2. Z. He, M. Gao, H. Yu, X. Ye, L. Zhang, and G. Ma, "A new improved seam carving content aware image resizing method," in 2013 IEEE 8th Conference on Industrial Electronics and Applications (ICIEA), pp. 738– 741, June 2013.