Content-Aware Image Resizing using Seam Carving

Vijayanand Manickam
Computer Vision Project Report
University of Kansas
vijay-am@ku.edu

Abstract

Conventionally image dimension alterations have been done using rigid techniques like cropping or scaling wherein the image content is lost after alterations .Seam carving is a new technique for content aware image dimension alteration. This project deals with implementation and analysis of this algorithm using different energy functions.

1. Introduction

Image resizing is an important demand placed on web developers to accommodate dynamic changes in digital media. We know that web developing tools can support dynamic changes in page layouts or text but the images have always been a rigid part of these dynamic web pages. Image resizing techniques like scaling or cropping cannot be an appropriate solution since dimension alterations will eventually lead to lot of artifacts because of the image content lost during the alterations. Recently, Dr Shai Avidan and Dr. Ariel Shamir [1] have developed an algorithm for content aware image resizing known as seam carving. Seam carving proposes a way of smartly removing the pixels of lesser importance in the image. Seam carving is based on the philosophy that human eye mostly notices only the salient features of an image. So gradual addition or deletion of features those are not salient in an image can be an efficient way of image resizing.

2. Seam Carving

2.1 Seam

Seams are sequence of orthogonally or diagonally adjacent pixels that run through the image either horizontally or vertically. For horizontal seam there will one pixel for each column and for vertical seam there will be one pixel for each row.

For vertical seam calculation we will start with the each pixel in the first row of each column and look for adjacent pixels in the next row with the least energy value then add the energy value of the current pixel with the energy value of the adjacent pixel selected. Now the adjacent pixel being our current pixel we will continue to look for adjacent pixels in the next row with least energy value. Likewise we will calculate the seam till the last row.

Consider the following the matrix with indices as the indices of a section of an image

(i-1, j-1)	(i-1, j)	(i-1, j+1)
(i, j-1)	(i, j)	(i, j+1)
(i+1, j-1)	(i+1, j)	(i+1, j+1)

If the index (i-1, j) is in the first row of the image then for vertical seam calculation we will look for the energy minimum of indices (i, j-1), (i,j), or (i,j+1) . If the index (i, j+1) has the minimum energy then energy (i-1, j) is added with energy (1, j+1). Likewise the seam is calculated till the last row of the image.

Horizontal seam calculation is done in the same manner expect for that we start with the first column and compute the seam till the last column

2.2 Algorithm

The most salient characteristic of the seam carving algorithm is that it is very simple. Following is the algorithm for removing one vertical seam.

First, we calculate all vertical seams for the input image and store it in a seam matrix

Second, incidentally the last row of the seam matrix has energy values of all the seams. The minimum of the last row gives the seam with least energy. Then by backtracking we can find the indices of that seam.

Third, we remove all the pixels in the seam and alter the image size correspondingly.

Now the resultant image will have one column less.

In Fig 2.1 the zigzag red line running through the image vertically is the vertical seam calculated that is to be removed.

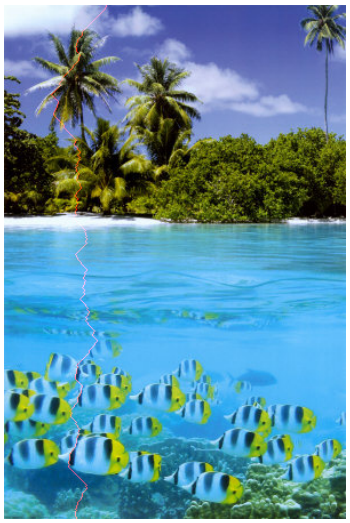

Fig 2.1

In Fig 2.2 the vertical seam seen in Fig 2.1 is removed.

Fig 2.2

The algorithm explained previously is for image shrinking. For image size enlargement after calculating the seam with least energy, the new seam to be inserted will have pixel values averaged from the adjacent pixels. So, the extra pixels will blend into the image

In Fig 2.3 the ten different zigzag red lines running through the image vertically are the vertical seams calculated when image size is increased by adding pixels to the image vertically.

Fig 2.3

In Fig 2.4 vertical seams seen in Fig 2.3 are added

Fig 2.4

2.3. Image Energy Functions

In seam carving we can use different energy functions like gradient magnitude, histogram of gradients [2], L1/ L2-norm of gradient, entropy

[5], saliency measurement [3], eye gaze measurement [7], and Harris-Corners measurement [6]. In this project implementation primarily gradient magnitude, histogram of gradients, L1/ L2-norm of gradient have been used. Harris-Corners measurement has also been tested.

3. Implementation

The implementation of the project is exactly same as the algorithm developed by Dr Shai Avidan and Dr. Ariel Shamir. MATLAB implementation of the algorithm was done in two phases. First, the image shrinking and image enlargement for vertical seams and horizontal seams was implemented. Then image resizing for both vertical and horizontal seams were combined.

The energy functions mentioned in section 2.3 were all used. Histogram of gradient function was enhanced to improve the results of image resizing. Harris-Corners measurement has been tested but sophisticated energy functions like saliency measurement and eye gaze measurement have not yet been test.

3. 1. Experiments and Inferences

The following experiments were conducted with two different images to test the quality of energy functions. Two images can be broadly classified as ones with human presence and one without human presence. Ones with human presence the algorithm has to make sure that the less salient features are removed first. It is very hard for an energy function to perform well over the entire image sets but still gradient magnitude and histogram of gradients provide good results over broader set of images.

3. 1. 1. Gradient Magnitude

Gradient magnitude is summation of the horizontal and vertical gradients of the image.

In Fig 3.1 All the seams that are be removed in both vertical and horizontal direction can be seen can be seen

Fig 3.2 is the output image after shrinking the image in both directions.

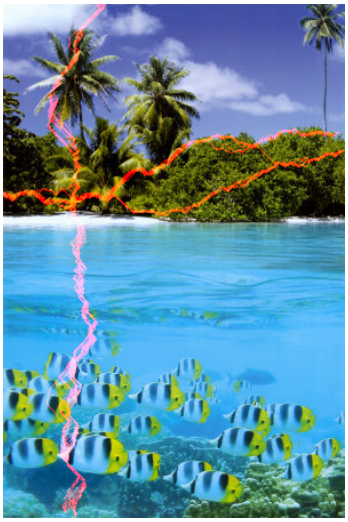

Fig 3.1

Fig 3.2

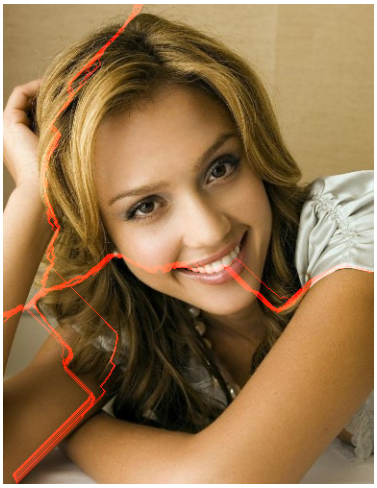

Fig 3.3

In Fig 3.3 seams to be removed can be seen. Horizontal seams pass through some of facial features.

Fig 3.4

In Fig 3.3 it is obvious some of the salient features are lost very early.

3. 1. 2. Histogram of Gradients

Characteristic of Histogram of gradient function is to attract the seams to the edge. The seams will run parallel to edges and mostly will not cross the edges.

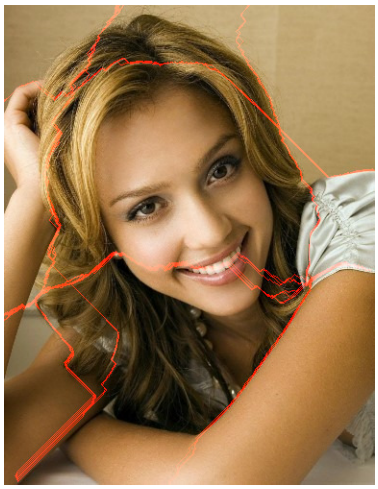

Fig 3.5

Fig 3.5 we can see that the seams run parallel to the edges but still some of the seams cross edges.

In this project histogram of gradients is enhanced by simple technique of increasing pixels with higher energy value so that salient features are maintained.

Fig 3.6

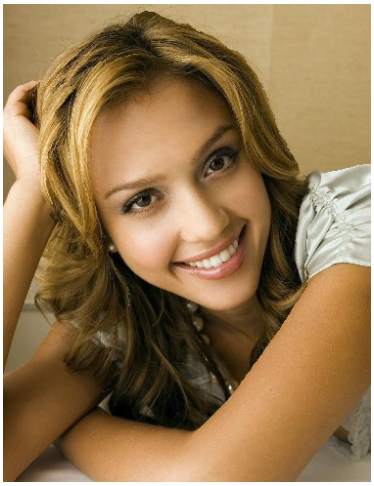

Fig 3.7

In fig 3.7 the seams that can be seen in fig 3.6 are removed. The salient features of the image are sustained.

3. 1. 3. Other Energy Functions.

Other energy functions like Harris-Corners and L1/L2 norm were tested but these functions did not provide satisfactory results yet. For example as seen in the Fig 3.8 the energy function used is Harris-Corners, the seams for first cut through salient features. Sophisticated functions like eye

gaze measurement could provide with better quality results for these problems.

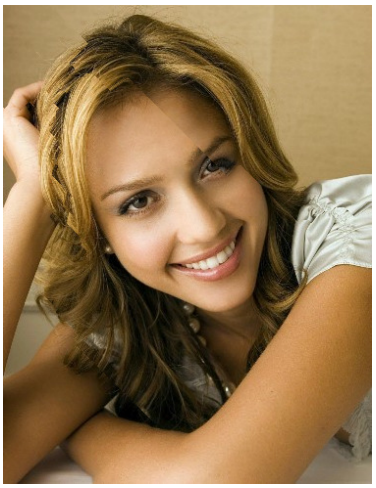

Fig 3.8

4. Conclusion and Future Work

Seam carving algorithm has been used not only for content-aware image resizing but other interesting prospects like content amplification and object removal.

The objective was to implement seam carving algorithm using an efficient algorithm. During the course of the implementation of I sought after the implementation of saliency measurement and eye gaze measurement. But the gradient magnitude and histogram of gradients gave good results for large set images.

The implementation of the algorithm was not difficult but choosing the energy functions was highly interesting.

Future works of the project is developing a graphical user interface for this algorithm and also test better energy functions to enhance the quality of the results.

5. References

1) Shai Avidan and Ariel Shamir, Seam Carving for Content-Aware Image Resizing**,** *ACM Transactions on Graphics, Volume 26, Number 3, SIGGRAPH 2007*

2) Dalal and Triggs 2005, Histogram of oriented gradients for human detection. In International Conference on Computer Vision and patter recognition

3) Nitin Dhavale and Laurent Itti, Saliency-based multi-foveated MPEG compression,Computer Science Department - University of Southern California

4) Michael Rubinstein, Ariel Ahamir, Shai Avidan,Improved Seam Carving for Video Retargeting *ACM Transactions on Graphics, Volume 27, Number 3 SIGGRAPH 2008*

5) Willis, M.; Jeffs, B.D.; Long, D.G, Maximum entropy image restoration revisited, Image Processing, 2000. Proceedings. 2000 International Conference on

6) Harris-Corners measurement, http://www.roborealm.com/help/Harris.php

7) Eye Gaze measurement, http://www.eyegaze.com/content/papers-and-presentations-research-done-using-eyegaze-analysis-system