Report

Seam Carving for Content-Aware Image Resizing

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Contents

Abstract: -

Seam Carving is the most popular algorithm used to solve the problem of content aware image resizing which is proposed by **Shai Avidan and Ariel Shamir**. The main purpose of this report is to study the seam carving algorithm and to implement it but not just to reproducing the same research paper written by Shai Avidan and Ariel Shamir but to implement the paper using our own method to seam carve using content aware image resizing.

Our report takes into consideration the algorithm used for seam carving to find the image reduction, image enlargement, object removal by using the Energy Function used like **Sobel** (**gradient magnitude)** even though there are many other functions like **entropy, visual saliency, eye gaze movement**.

Introduction:

Images are playing a vital role in our day to day life not only to display in one universal device but to fit into different displays such as cell phones, tablets or to print on a given paper size or resolution as well as to use on HTML page layout. Digital Image processing is very significant component in machine vision which is used to improve the pictorial representation of image data using various procedure, methods and algorithm which are sometimes more and sometime less efficient according to content of data.

Resizing of data is very important to extract information from images as variety of display devices are used and each display device has it own display varieties and so without resizing it is not possible to get the actual essence of image. While various methods and algorithm are available for image resizing like scaling and cropping but all these are not content aware resizing.

Very common image resizing such as scaling is not sufficient because this is applied uniformly to the whole content, while cropping can remove pixels unwantedly and most importantly they are not taking image content into consideration.

In this report our main aim is to resize image cleverly which contains a unique feature of content awareness which make it more efficient than scaling and cropping. we termed this as a seam-carving which uses a unique energy function that defines the importance of pixels in an image.

Seam carving has many applications such as aspect ratio change, image retargeting, image content enhancement and object removal.

Related Work:

A lot of research has been done in resizing an image. In most of the setting, finding an image with specific size requires resizing the image manually using cropping and scaling. If we want to reduce the image dimension, an image is usually scaled to the desired dimensions or is cropped from a larger image. However, these two old and traditional methods are not desirable as the contents of the image are distorted.

Either the content loses its original form of appearance or the content loses the surrounding information. Also, when applied to an image with multiple objects, the quality of image degrades, and import information is lost.

C. Fillion, G. Sharma [4] proposed an advanced method named Automatic Image Retargeting aims at segmenting, identifying and removing an image into regions of interests, filling the resulting gaps, resizing the remaining areas and re-inserting important regions to obtain the output.

R Achanta, S. Susstrunk [6] proposed another method such that it warps an image into an arbitrary shape while retaining user-specified features. Using a formulation of the Laplacian editing technique, it can accommodate similarity constraints on parts of the domain. However, not all the constraints can be satisfied at once since the local constraints are propagated by the global optimization.

Methodology:

Seam Carving?

Seam Carving is a highly popular and newly developed technique targeting image resizing based on detection of seams from the energy function of the image. The choice of energy function is the most important criteria to define the content aware resizing image. The method aims at finding vertical and horizontal seam seams(threads) of minimum energy and manipulating the image using the seam.

Seam?

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 like the vertical seam except that the connection being from left to right. The energy function gives the importance to pixel by measuring its contrast with its neighbor pixels and then select the pixel to be included in the seam or not.

Image Retargeting?

To determine the best seam for removal, we first create an energy map for the image. We find that the gradient method using the Sobel filter gives us exceptionally good results in the application. The optimal seam can then be obtained using dynamic programming.

Given an energy function if we want content aware resizing of image we can think of various strategies like optimal strategy to preserve energy that is to remove pixels with lowest energy in ascending order. The optimal seam can be found using Dynamic programming. Dynamic programming (DP), is very simple concept to understand, considering that it just consists of not computing the same operations multiple times. Furthermore, this algorithm works on the energy of the pixels to cut down the least important pixels of the picture. Here, the energy of a pixel is a measure of its importance in the picture. This idea can be captured through various mathematical functions.
We use the Python as the main programming language in which the algorithm is going to be implemented.

Approach

Adding and Removing Seam

Seams can either be removed or added to the image to make image reduction and image reduction. In image reduction (seam removal) the pixels are simply taken out of the image one seam at a time. After every iteration of seam removal, the energy and sum fields of the remaining pixels are reset to create a better final image. For vertical seams, this method is erasing the individual pixels in the seam one at a time, In Horizontal seams we bring the seam of pixels to be removed down to the bottom row of the image before we delete them due to our underlying data structure.

In the case of seam addition, the algorithm work as the lowest energy seam is found, and then a new parallel seam is added to the image directly below it, and to the right of it for vertical seams.

Marking Areas for Deletion

In our implementation, we also give the user the ability to mark areas of the image to be erased named as object removal. It works like that if the user marks an area to be erased, then the special energy field of those pixels will be set artificially low, giving incentive for low energy seams to pass through those areas.

Energy Functions:

Seam carving is basically used for all types of images. The main factor that behaves as the core of algorithm is the energy function as **a good energy function can produce accurate results in the resizing of some pictures, whereas as bad energy function can make the whole algorithm useless**.

Method I (Gradient Magnitude)

A gradient is one of the fundamental concepts in image processing. It can be viewed as the directional change of color or intensity in an image. Numerically, the slope of

an image function at every picture pixel is a 2D vector with the magnitude and an orientation. The gradients are used as an energy function because they detect edges in some sort. Edges have high energy because the color change across an edge is very noticeable, and that is very important for seam carving. One of the main issues of seam carving is when a seam crosses an edge and that creates a distortion as we will see in our analysis of the energy functions. There are various methods to extract the unnoticeable pixel from an image. **First and most basic method is to assign energy to each pixel by using a gradient operator (Sobel, Prewiit, Robert or Laplacian) to compute the gradient in both x and Y direction.**

In Mathematics, we know that the derivative of a function is given by:

$$\frac{df}{dx} = \lim_{\Delta x \to 0} \frac{f(x) - f(x - \Delta x)}{\Delta x} = f'(x)$$

For discrete functions, the smallest Delta x is 1, and since any image function is a discrete function. The derivative of an image at a point x is:

$$\frac{df}{dx} = \lim_{\Delta x \to 0} f(x) - f(x - 1) = f'(x)$$

Furthermore, images are functions of two variables, f (x; y) = k, where x and y are the pixel coordinates and k are the color or intensity of said pixel. Therefore, we must take the partial derivatives in both dimensions to obtain the gradient vector at a certain pixel. Accordingly, the gradient of an image can be given by the formula

$$\bigtriangledown f = \begin{bmatrix} g_x \\ \\ g_y \end{bmatrix} = \begin{bmatrix} \frac{\sigma f}{\sigma x} \\ \\ \frac{\sigma f}{\sigma y} \end{bmatrix}$$

gx is the gradient along the x-direction and gy is the gradient along the y-direction.

$$|\bigtriangledown f(x,y)| = \sqrt{g_x^2 + g_y^2}$$

represents the magnitude according to the L2 norm.

The orientation of the gradient vector is given by:

$$\theta = tan^{-1}(\frac{g_x}{g_y})$$

Considering that we are working with RGB pictures, we will have to deal with three different gradient vectors for each pixel. To have one single magnitude, we can choose to either select the vector with the greatest magnitude or compute a norm for the three gradient vector magnitudes.

Determining the Cumulative Energy Map:

We now use Dynamic Programming to find the cumulative energy of a path taken from the top (in case of a vertical seam carving) and left (in case of horizontal seam carving) till the pixel (i, j).

We can define the cumulative energy function as:

M (i, j) = e (i, j) + min (M (i-1, j-1), M (i-1, j), M (i-1, j+1))

Algorithmic Procedure:

Image size reduction:

Generate the energy map using one of the methods.

1. Find the cumulative energy map of the image
2. For each iteration:
    - Detect the optimal seam (in the desired direction-horizontal, vertical)
    - Remove the Seam from the image thereby reducing the size of the image.

Image Size Expansion:

1. Generate the energy map using one of the methods.
2. Find the cumulative energy map of the image
3. For each iteration:
    - Detect the optimal seam (in the desired direction-horizontal, vertical)
    - Copy the optimal seam and extend the image at the point of the optimal seam.

Object Removal:

1. Generate the energy map using one of the methods.
2. Find the cumulative energy map of the image
3. Provide the minimum energy values to the M (i, j) if (i, j) is a selected pixel by the user
4. For each Iteration:
    - Detect the optimal seam (in the desired direction-horizontal, vertical)
    - Remove the Seam from the image thereby reducing the size of the image

Results: -

We obtained the following results by implementing seam carving software.

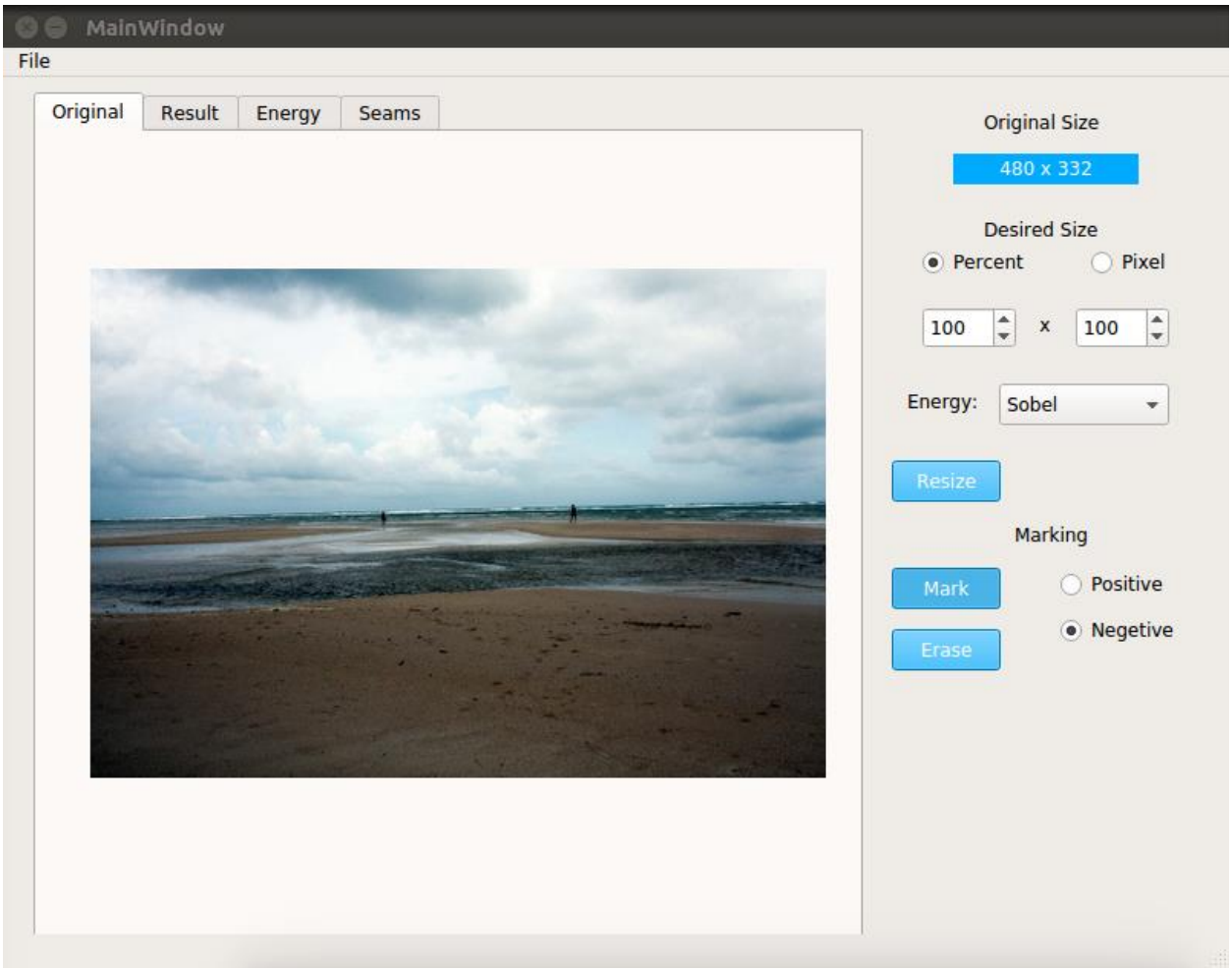

Figure 1- Graphical User Interface for Seam Carving.

Figure 2- Input Image

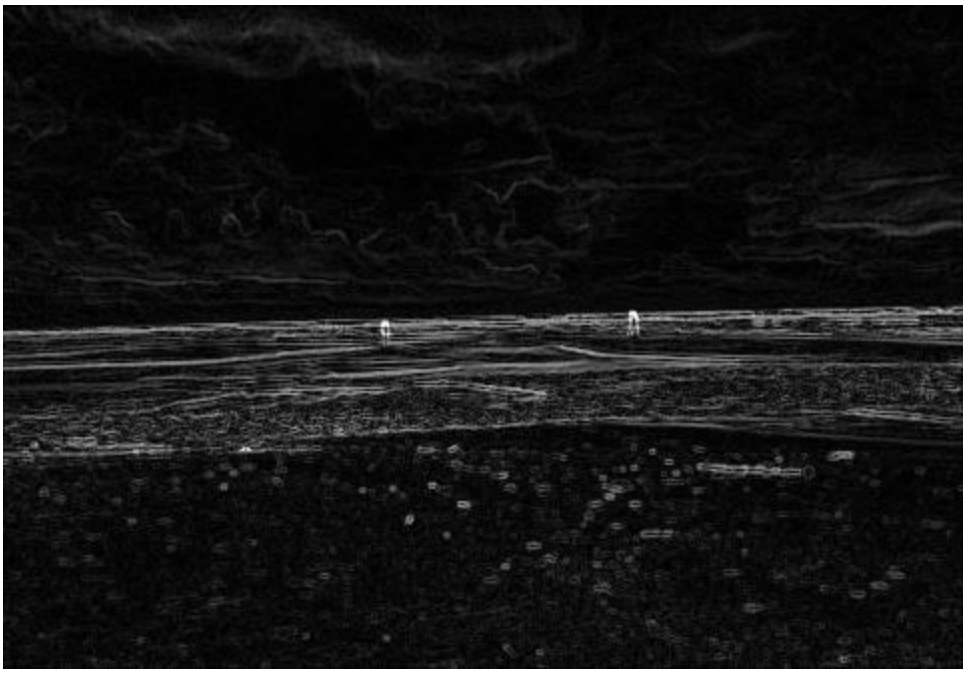

Figure 2-Energy Image

Figure 3-Output Image enlargement

Figure 4-Seam Carved Output Image

Figure 5- Seams Image Enlargement with horizontal seams

Figure 6- Seams Image reduction with vertical seams

Figure 7-Output image with Object Removed.

Conclusion and Future Work:

Even after choosing a very good energy function, the effectiveness of seam carving can be questioned. For some reasons, it is just the nature of the picture that causes irregularities. As a solution we can increase the energy value of every pixel in that region. At a point when many seams removed, and the pixels outside gain more energy, the algorithm might need to cut down from that region to preserve the content outside the region.

This project is very interesting to come up with varies interest fact. According to improvement we can also try the seam carving and image enlargement with different energy function to order to enhance the performance.

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