Distortion Sensitive Algorithm to Preserve Line Structure Properties in Image Resampling

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***Abstract*—** In order to remove less important content from image seam carving algorithm is used. In seam carving distortion is very low as compared to other techniques like scaling and cropping. The major drawback of seam carving is when seam intersects with straight line present in the image it distorts line structure; the line may become curve after distortion. This structure distortion not only degrades visual quality of image but also gives artifacts or aliased line structure. This paper presents a content aware seam carving algorithm to resize the image. After applying algorithm discussed the structure of regular objects present in the image can be preserved. In the proposed algorithm first line detection algorithm is applied over the image in order to detect possible straight lines present in the image. After detecting straight lines algorithm tries to find out intersection point of optimal seam with the straight line. Algorithm increases energy of local neighbourhood pixels of intersection point up to a predefined radius, so that no further seam can intersect same pixel again.

Keywords- *seam carving, image retargeting, image adaptation, edge preservation, Content aware*

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I. INTRODUCTION *(HEADING 1)*

Now a day in media distribution digital images are widely used. It may be possible that area available for images is smaller or bigger than size of image. Device used for displaying images such as televisions, LCD monitors or mobile device can have high resolution or low resolution. In order to fit digital image on different device resolution and aspect ratio image retargeting techniques are used. A more efficient technique called seam carving was introduced by Avidan and Shamir [1]. Image retargeting techniques not only resize aspect ratio of image but also preserve visual quality and important components of image. Traditional scaling methods do not produce satisfactory result since they are oblivious to image content. To remove this problem a new resizing technique is required resize the images in a content-aware fashion. Seam carving technique for image resizing not only resize image but also preserve the important image contents of the image. Content aware resizing is a challenging problem. Figure 1 shows an example in which seam carving causes noticeable deformations of objects: straight line become curved or disconnected. Automatic ex post de-wrapping of the distortion nearly impossible due to the large number of parameters and the high complexity of image wrapping algorithms [2]. This technique produce aesthetically pleasing image after resizing for the user. Retargeting techniques can also be useful in photography. Researchers have proposed several techniques for automatic retargeting of images. To detect important area in digital image is an important part of computer vision research. In images, a seam is a connected path of low energy pixels crossing the image from top to bottom (or from left to right), and is monotonic, that is, including one, and only one pixel in each row (or column). In video, a seam is a monotonic and connected low energy 2D manifolds passing through a 3D volume cube defined by stacking the video frames. After successively inserting or deleting seams image size can be increased or decrease in both horizontal or in vertical direction. In size reduction pixels which has low energy value are removed, while in size expansion pixel with high energy are inserted in the image.

For enlarging, the order of seam insertion ensures a balance between the original media content and the artificially inserted pixels. These operators produce, in effect, a content aware reading of media. Other major application of this algorithm is to increase size of image, object removal. To resize the image seam carving not only consider the geometric constraint but also image contents. Conventional image resizing techniques such as cropping down sample image without considering image content as an important part. To detect the optimal seam in this algorithm cumulative energy map is considered such that pixel having lowest value is picked horizontally and vertically and is backtracked to obtain the optimal seam. Errors in seam carving occur if the image presents regular patterns or straight lines. When seam carving algorithm applies on the straight line it become curved or aliased. The proposed algorithm in this paper is used to protect distortion of straight line during image resizing in content aware seam carving technique.

II. RELATED WORK

In order to reduce size of image in content aware fashion there are various approaches. These approaches are divided in to two categories. (1) pixel removing, (2) pixel merging. First category includes method cropping. Seam carving algorithm is a new algorithm which is based on the first category. Scaling is also a method for reducing size of image. This method belongs to second category where size of image can be reduced by merging of pixels present in image.

A. Pixel Removing

Cropping is a common image adaptation technique which removes image content from the borders of an image. Suh et al. [3] proposed a basic cropping approach for the automatic generation of thumbnails. In order to identify the Region –of-Interest (ROI): The first one uses a saliency map [4] and is applicable to all different kinds of images.

Automatic browsing, a method presented by Liu et al. [5], simulates the browsing a user has to do while looking at an image with high resolution on a device with a small display. The drawback of the pixel removing approach is, some image regions are lost in the process of image resizing. After

applying image resizing process object can be truncated. The purpose of all the methods which comes under this category is to eliminate content of image which has lowest information value for the viewer of the image.

B. Pixel Merging

As pixel removing method discussed in previous section eliminate content of image which is not completely located in a region of interest. To avoid this, Liu et al [6] developed a non photorealistic fisheye-view wrapping method, which emphasizes the ROI and scale down the unimportant parts of an image. Setlur et al [7] propose to protect the important objects of an image by *cutting* them out. They segment an image into regions by using the mean-shift algorithm [14]. The wrapping method proposed by Wolf et al. [8] is mainly designed for video retargeting but is also applicable to image retargeting. Optimized Scale-and-stretch by Wang et al [9] partitions the source image into small regions and determines an optional scaling factor for each of the region. Guo et. al [10] also use a mesh for their image retargeting approach, but instead of using quadratic cells they use triangular cells and formulates the retargeting as a mesh parameterization problem.

III. ALGORITHM OF SEAM CARVING

Seam carving is a technique proposed by Avidan and Shamir [1] for content aware image retargeting. This algorithm is based on pixel removing approach. The main idea of this algorithm is to remove low energy seam from the image either from top to bottom or from left to right. Only those seams are removed from the images which are not useful for understanding the image content. When vertical seam are removed from the image the width of the image will be reduced and when horizontal seams are removed from the image the height of the image will change. Figure 5 (c) shows the reduction of image size after removing seam. The content of image can be distorted while resizing process with this algorithm.

A vertical seam is valid if it satisfies two conditions.

- A vertical seam must contain at least one pixel in each row.
- The horizontal distance between two adjacent seam pixels should not be greater than a certain threshold (T).

$$s = \{s_i\}_{i=1}^{H} = \{(x(i), i)\}_{i=1}^{H}, s.t. \forall i : |x(i) - x(i-1)| \leq T \quad \ldots\ldots (1)$$

The energy of pixels of seam is calculated by using following energy function e.

$$e_1(I) = \left|\frac{\partial}{\partial x} I\right| + \left|\frac{\partial}{\partial y} I\right| \quad \ldots\ldots\ldots (2)$$

To identify optimal seam in the image Dynamic programming is used. An optimal seam is chosen with the minimum cost calculated by energy function.

To overcome limitations of image retargeting algorithm i.e. seam carving, Rubinstein et al [13] proposed multi-operator media retargeting, which combines the three different resizing operators scaling, cropping, and seam carving.

Step 1: Load RGB image and calculate gradient of the image. To calculate gradient of image use sobel or other operators.

Step 2: Calculate energy map

- ***Calculate vertical seam***

For first row of energy map set all the values same as gradient image.

- ***Calculate horizontal seam***

To calculate horizontal energy image can be calculated using the same procedure as calculating vertical seam. To calculate horizontal seam input image must be a transposed image. For each pixel (i, j) in gradient image.

For each row in gradient image calculate Energy of and set the result at P (i, j) in the energy map.

$$P(I, j) + min\left(\text{Energy}\ (i-1, j-1), (i-1, j), (i-1, j+1)\right) \quad \ldots. (3)$$

Step 3:

- Backtrack to (i-1) row and find minimum of the Neighboring pixels of P (i,j). Save this pixel to seam path. Repeat Step 3 until first row is not reached.

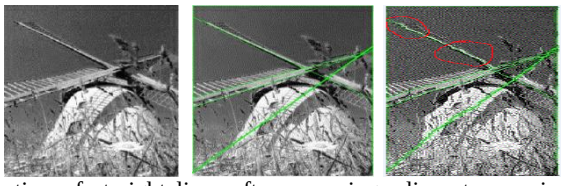
Step 4: Remove the seam from gradient image and shift all the pixels either in right or up direction to get continuous image.

Step 5: To insert seam in a given image to increase size of image. Take average of the two neighboring pixels along the seam can be inserted and then averaged pixels are inserted along each successive seam.

IV. PROBLEM OF SEAM CARVING

When regular objects such as straight lines are present in the image seam carving method will distort lines during resizing process. Straight lines present in the image may be converted in to curve or aliasing effects can be occurred. The distortion on straight lines will occur when seam passes on any non horizontal or non vertical line. Fig (1) in this paper shows the distortion of straight line present in the image during resizing process. When a vertical seam is eliminated from an image, all the pixels which are placed on the right hand side will be shifted to the one pixel left in order to fix the gap. If several seams pass on same intersection point again and again distortion will be visible. (See Figure 1 c). Line detection algorithm is applied on the original image in order to find out the straight lines in the image. To detect straight lines present in the image hough transformation is applied over the image. In figure (2) shows comparison between the images after image resizing with the use of normalized histogram.

Fig 1: (a) Original Image, (b) Image after detecting straight lines (c)



Distortion of straight lines after removing adjacent seam in image during resizing (Red marks shows distortion of straight line).

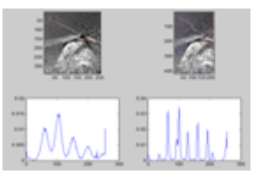


Fig 2: Comparison of two images with the use of normalized histogram

V. STEPS OF ALGORITHM TO PROTECT DISTORTION

Objects which have regular patterns will be distorted when optimal seam crosses the object in order to protect distortion of straight line each time there is need to change the energy map when any intersection will occur with optimal seam and straight line. When an intersection will be occur the energy map needs to modify in all local neighborhood of pixels over the straight line. Main objective of our algorithm is to increase the energy of pixels in a certain distance or radius so that the probability of intersection of other seams with adjacent pixel position at some predefined radius will be minimized. Working of our algorithm is divided in to two parts in first part line detection algorithm is applied over the image and other one is to resize image using seam carving.

Step 1: Load RGB image and calculate gradient of the image. To calculate gradient of image use sobel or other operators.

Step 2: if the size of image is not the desired size, calculate energy map

- Calculate vertical seam

For first row of energy map set all the values same as gradient image.

- Calculate horizontal seam

To calculate horizontal energy image can be calculated using the same procedure as calculating vertical seam. To calculate horizontal seam input image must be a transposed image.

For each pixel (i, j) in gradient image, calculate

For each row in gradient image calculate Energy of P(i, j)+ *min*(Energy (i-1,j-1),(i-1,j),(i-1,j+1)) and set the result at P(i, j) in the energy map.

Step 3:

- In order to find the optimal seam first find the minimum value in the last row and save the pixel location the pixel location for use in removal.
- Backtrack to (i-1) row and find minimum of the 3 neighboring pixels of P (i, j). Save this pixel to seam path.

Repeat Step 3 until first row is not reached.

Step 4: Remove the seam from gradient image and shift all the pixels either in right or up direction to get continuous image.

Step 5: To insert seam in a given image to increase size of image. Take average of the two neighboring pixels along the seam can be inserted and then averaged pixels are inserted along each successive seam.

Step 6: Detect edges in the image using canny edge detector [11] operator and use hough transformation [12] to detect straight lines present in the image.

Step 7: Execute steps 1 to 5 to resize image after detecting straight line present in the image.

Step 8: To preserve geometry of regular objects present in the image find the intersection of optimal seam with the straight line and modify the energy of pixels in a predefined radius which are local neighborhood of that pixel which has intersected by optimal seam.

Step 9: Find next optimal seam in the image and repeat step 8 until desired size of image does not found.

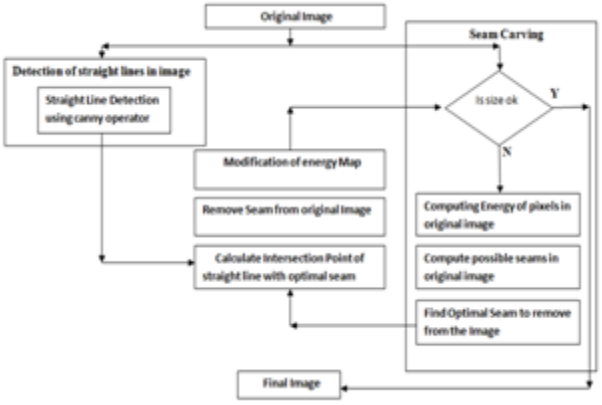


Fig 3: Process of Modified Seam carving algorithm

VI. MODIFICATION OF ENERGY MAP

The main concept of the algorithm present in the paper is to modify energy map when an optimal seam intersect the straight line detected by using hough transformation [12]. The energy of pixels which are neighborhood of this intersection point is increased up to a certain predefined radius. This guarantees that no other optimal seam will pass over the intersection point in next iteration. When seam gives first intersection over straight line the energy of local neighborhood pixels up to predefine radius is increased by a value of 150. After increasing energy of pixels up to a predefined radius no optimal seam intersect the point over straight line which lies under the predefined radius. The algorithm stops after eliminating sufficient number of seams from image in order to get desired size of image.

VII. COMPARISION AND DISSCUSSION

This section compares result of algorithm discussed in this paper with the traditional seam carving algorithm. Quality of image generated by algorithm discussed in this paper generates better results. Identical result will be generated when an image does not contain any straight line.

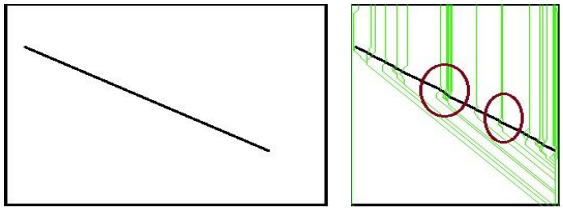


Figure 4: (a) Image with straight line without distortion and resizing operation. (b) Image after applying traditional seam carving method without improvement. Multiple seams are intersected over a same intersection point due to this straight line become distorted (Red circle are shown in the figure which show multiple seams intersection over a same intersection point).

The black circles mark distorted lines in the images after applying traditional seam carving approach. After applying traditional seam carving method over the image present in fig 4 (b) the straight line may convert in to curve. Aliasing effects over line will also occur when traditional seam carving method apply over the image. Finally over method discussed in this paper gives better result and higher visual quality of image can achieve. If there is large number of straight line present in the image this algorithm cannot work. If an image contains high number of straight line the prevention cannot be done with

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disturbing others.

Fig 5: (a) Original Image with resolution 800 x 600, (b) Image after applying seam carving algorithm with improvement (Dark black circle represent intersection of multiple seam over a single point on straight line (c) image after applying seam carving algorithm without showing seam over the image, This image shows the distortion of straight line.

Fig 6: (a) Original Image with resolution 800 x 600 pixels, (b) Image with distortion of straight line using traditional seam carving method. (c) Image with prevention of straight lines by increasing energy of pixels which are local neighborhood of that pixels which is intersected by optimal seam. Result in image (C) is significantly better than result generated by traditional seam carving method

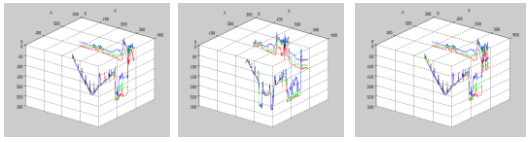

Fig 7: (a) Intensity profile of Original Image, Fig 7: (a), (b) Intensity profile of Image without improving energy of pixels when intersection between straight line and seam will occur, Fig 7: (c) Intensity profile of Image after improving energy of pixels when intersection of straight lines with seam will occur.

TABLE I in this paper presents entropy of different images after applying seam carving method and method which is present in this paper. Images in Fig 8 shows seam carving methods destroy geometry of objects. Geometry of important objects can be preserve after applying algorithm presented in this paper.

Fig 8: (a) Original Image (b) Image generated using seam carving algorithm (c) Image generated after applying image resizing method describe in this paper.

TABLE-I
ENTROPY COMPARISION OF IMAGE IN FIG 6 WITH DIFFERENT RESIZING METHODS

Frame	Original	Seam Carving Method	Our Method
Image of Badminton Court	7.5278	6.3515	6.3335
Image of University	7.1078	5.7563	5.7712

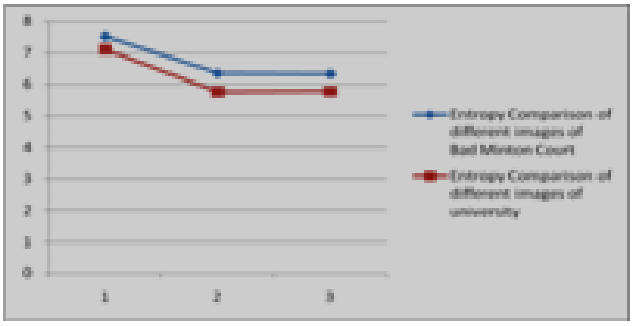

Fig 9: Entropy Comparison graph generated from data shown in Table 1.

VIII. CONCLUSION

This paper focuses preservation of straight lines when content aware resizing process is applied over the image. This paper takes general concept of seam carving in order to resize image but include line detection and preservation methods in order to prevent distortion of regular objects in the image. This algorithm is actually divided in to two major parts; first one is detection of edges and straight lines using canny edge detector operator and hough transformation respectively. Algorithm present in this paper increase energy of local neighborhood of pixel which is intersected by optimal seam. By increasing the energy of pixel in to a predefined radius the distortion of straight line can be prevent. Algorithm present in this paper gives better result when it is applied over various images. Image in figure 10 (a) contains lots of straight lines. Algorithm present in the paper will not work if straight line present in the image is very nearer to each other. If algorithm will applied over such type of image then the straight line will blend with each other or get distorted.

Fig 10: Drawback of the algorithm; Red circles in fig 6 (b) shows distortion of straight lines even after applying our modified algorithm.

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