Saliency Improvement by Block Segment Seam Carving

S.K. Kavinmuhil
Department of Computer science and Engineering
Sri Ramakrishna Institute of Technology, Coimbatore, Tamil Nadu, India

P.Kanmani
Department of Computer Science and Engineering
Sri Ramakrishna Institute of Technology, Coimbatore, Tamil Nadu, India

Abstract- Traditional seam carving method discards the color information of the image thereby reduces the visual saliency of the output. Also, image distortion problem is faced in traditional methods when the input image has more number of straight lines in it. In order to overcome this problem the original image is segmented into blocks of equal sized smaller images, and then seam carving is applied individually over each block to increase the energy of interested regions. This enables to detect the foreground of the input image which can be preserved and the content of background alone shall be carved. Preserving the contents of foreground in turn will improve the visual saliency of the image.

Keywords – Block segment Seam-Carving, Distortion, Visual-Saliency

I.INTRODUCTION

Seam carving method of image retargeting proves to be too complex and time consuming for implementing real time applications. Usually, while image is reduced to attain a target image size, the content or information that is found to be less important by the users are removed. The content is applied over an energy function to map the pixels into corresponding energy value (ev). After the energy value is calculated, the minimum energy information is found and deleted at random position. But the problem in deleting the minimum energy value at the random position is that, distorted output is generated. The output loses its shape if entire row or columns of minimum energy pixels are deleted. In order to avoid the drawbacks of deleting pixels at random position, a generalized path is calculated. This path can either be vertical or horizontal. Vertical path covers the top to bottom pixel runs in such a way that the length of the path decides the width of the picture. Therefore, for an element (i,j) the next element in the vertical path will be one of the three possible element suggestions

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

In a similar way horizontal path can be defined. But this way of removing rows or columns of lower energy pixels is again a problem because the ROI may be affected and the entire shape of the output image is spoiled.

fig 1. (a) vertical seam(lower energy pixels:10 are identified) (b) Removal of vertical seams

To overcome the disadvantages of deleting pixels at random position or connecting 8 lower energy pixels from top to bottom and removing the entire column of pixels or 8 connected pixels from left to right to remove row of pixels, the input image is divided into equal number of blocks say 4x4 divisions. This causes the input image to generate 16smaller images

- R4: number of rows/4
- C4: number of columns/4
- (i-1): (i-1)*r4+1
- (j-1): (j-1)*c4+1
- j: j*c4

The energy function is applied to each block ($1/16^{th}$ of the original image)
The block with the minimum energy value among all the blocks is chosen by dynamic programming algorithm starting from the block beneath the first,

ev=ev[i,j]+min(e[i-1,j],e[i,j],e[i+1,j]

The minimum energy of the block by comparing the energy value of neighboring blocks is calculated.
In similar way the energy value of all the blocks are calculated till the last right block at the bottom of the image(say b16).Once the energy value of last block is calculated the pointer is made to traverse to older blocks(b1-b15) to see if other blocks has got values less than that of the minimum. The minimum energy pixel in each block is noted by repeating the above process. The next step is to find the optimal order of deleting the lesser important pixel. In conventional methods one of the dimensions is just found, deleted to reduce the original size into target size. But this causes a distortion in the width or height based on which dimension is removed. Hence the image is divided into blocks to find the lesser important pixel in each block and carved out.

Cost of calculating optimal order:

The cost of calculating the optimal order of deleting lesser energy pixels is- suppose if the images are divided into (nxm) blocks, n'x m' is the transpose matrix of the above, rows of the blocks are calculated using r=n-n' and columns , c=m=m'. Cost is calculated by sum of the costs in rows and columns individually.In each block the pixels with least energy value is removed and it's traversed to next block till the last block is reached. This process is repeated till the target size of the image is reached.

Replacing basic gradient function by entropy:

Instead of applying basic gradient energy function to each block- An entropy filter can be applied on the segments to improve the basic gradient energy map. The entropy value after the filter is been applied for the 4 x 4 blocks is added to the basic gradient energy map. After seams of lesser important value are carved in each block, cumulative energy of overall block is calculated.

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

There may be cases when user's input is not considered. If energy function is simply applied, sometimes the part of image in Region of Interest (ROI) gets distorted. In such a case, the input from user is obtained to know their regions of interest followed by carving of seams not under ROI will protect the ROI.
(Note: even if gradient function results a lesser energy value we consider the ROI)

Detecting the optimal seam:
In order to detect the optimal seam we consider the cumulative energy map such that the Pixel with the lowest value of M(i,j) in the last row (in case of vertical seam carving) or last column (in case of horizontal seam carving) is picked and is backtracked to obtain the optimal seam.

fig 1(c):one seam identified in both directions
fig:1(d):ten seams identified in both directions

Manipulating the Optimal Seam:

For reducing the image size we can remove the optimal seams, to increase the image size we can insert the copy of optimal seams in the image at the appropriate positions.

Object removal:

The areas marked in GREEN have been selected for protection while those marked in RED have been marked for removal. This will protect the region of interest to be preserved which is not in auto seam carving algorithm.

Fig 1(e):green marking for ROI
1(f): object marked green are protected.

II. Proposed Algorithm

A: User input image with ROI marked

The areas marked in GREEN have been selected for protection while those marked in RED have been marked for removal.

B: Block processing of input image

The input image is divided into 4x4 blocks(overlapping or non overlapping) to give 16 images

- R4: number of rows/4
- C4: number of columns/4
- (i-1): (i-1)*r4+1
- (j-1): (j-1)*c4+1
- J: j*c4

The energy function is applied to each block ($1/16^{th}$ of the original image)
The block with the minimum energy value among all the blocks is chosen by dynamic programming algorithm starting from the block beneath the first,

ev=ev[i,j]+min(e[i-1,j],e[I,j],e[i+1,j]

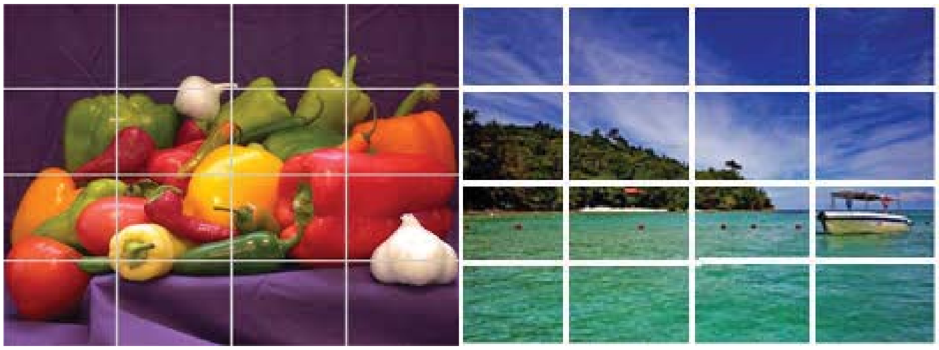

fig 2(a):dividing the input image into equal blocks(4x4)

C: Seam carving application to individual block(entropy filter):

While applying seam carving to individual blocks the seams or lower energy pixels are found at either direction. The least energy pixel is alone noted. But if auto seam carving is trying to carve out the ROI that is marked by the user it is preserved. In short, the least energy pixel that is not in ROI is carved out.

D: Object removal:

The region that is marked red by the user is removed by following these steps:
Generate the energy map using one of the methods.

- Find the cumulative energy map of the image
- Provide the minimum energy values to the M(I,j) if (I,j) is a selected pixel by the user
- 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.

E: Cumulative energy computation:

The entropy value after the filter is been applied for the 4 x 4 blocks is added to the basic gradient energy map. After seams of lesser important value are carved in each block, cumulative energy of overall block is calculated.

- $Ce=\sum e(i,j)+\min(M(i-1,j-1),M(i-1,j),M(i-1,j+1))$

There may be cases when user's input is not considered. If energy function is simply applied, sometimes the part of image in Region of Interest (ROI) gets distorted. In such a case, the input from user is obtained to know their regions of interest followed by carving of seams not under ROI will protect the ROI.

(Note: even if gradient function results a lesser energy value we consider the ROI)

F: Detecting optimal seams:

In order to detect the optimal seam we consider the cumulative energy map such that the Pixel with the lowest value of M(i,j) in the last row (in case of vertical seam carving) or last column (in case of horizontal seam carving) is picked and is backtracked to obtain the optimal seam.

G: Calculating cost of removing optimal seam:

The cost of calculating the optimal order of deleting lesser energy pixels is- suppose if the images are divided into (nxm) blocks, n'x m' is the transpose matrix of the above, rows of the blocks are calculated using r=n-n' and columns , c=m=m'. cost is calculated by sum of the costs in rows and columns individually.

H: Improving visual saliency:

Normal gradient method just defines energy at edges. It does not include information regarding color of the image and causes unwanted distortions as well as loss of useful data.
Visual saliency method takes into account the color information of the image. Salient regions and objects stand-out with respect to their neighborhood. The goal is to compute the degree of standing out or saliency of each pixel with respect to its neighborhood in terms of its color and lightness properties.
Saliency detection methods take a centre-versus-surround approach. One of the key decisions to make is the size of the neighborhood used for computing saliency. We use the entire image as the neighborhood (global saliency) as well as smaller block sizes and combination of them (local saliency). This allows us to exploit more spatial frequencies resulting in uniformly highlighted salient regions with well-defined borders

- 3x3 or 5x5 Gaussian smoothing on the image is performed.
- color Lab transform of the image or a block of the image is done.
- In the lab color transform every pixel is defined as vector with coordinates as L*, a* and b*.
- The centroid of the image or block in the L*, a*, b* coordinate system is calculated
- For every pixel the distance from the centroid is calculated.
- Multiple distance matrixes pertaining to different block sizes used.
- Compression of range on lower value and expansion for higher value for all distance matrices except the global distance matrix.
- Summations of all the distance matrices give the new energy map.

III. Experiment and Result

A: Problems with traditional Seam carving

Problem1: The traditional method discards the color information of the image and focuses on the edges to determine the energy map.
Problem2: The distortions in the Images are mainly visible in traditional method since a regular line when deformed gives the impression of distortion. *Problem3*: No clear distinction between the background and foreground. That results in some part of the fore ground to be removed.

B: Overcoming problems faced in traditional methods

- A method that can be used to solve problem 1 is to combine the seam carving method with saliency detection. We can use Visual Saliency detection to take the color content into consideration and then apply seam carving on the new energy map created.
- Proposed system assures that no other seams pass the line in the nearby area of some radius. This will overcome the image distortion problem faced in traditional seam carving.
- Proposed algorithm segments out different regions by dividing into blocks therefore, we increase the energy of the interested regions to protect them. This will result in the detection of the foreground and only the background will be reduced using seam carving.

C: Result Analysis:

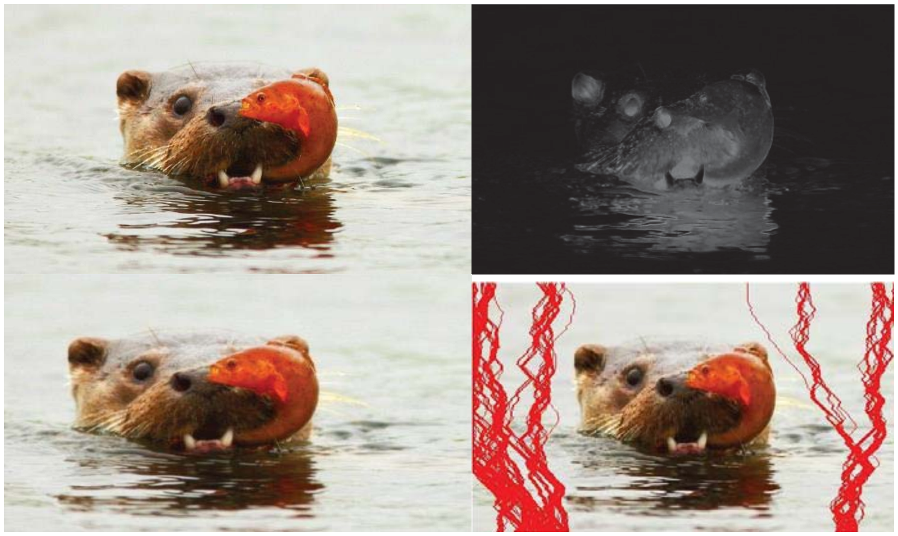

Fig 3(a):original image 3(b): energy map result 3(c) : seams applied 3(d): saliency preserved

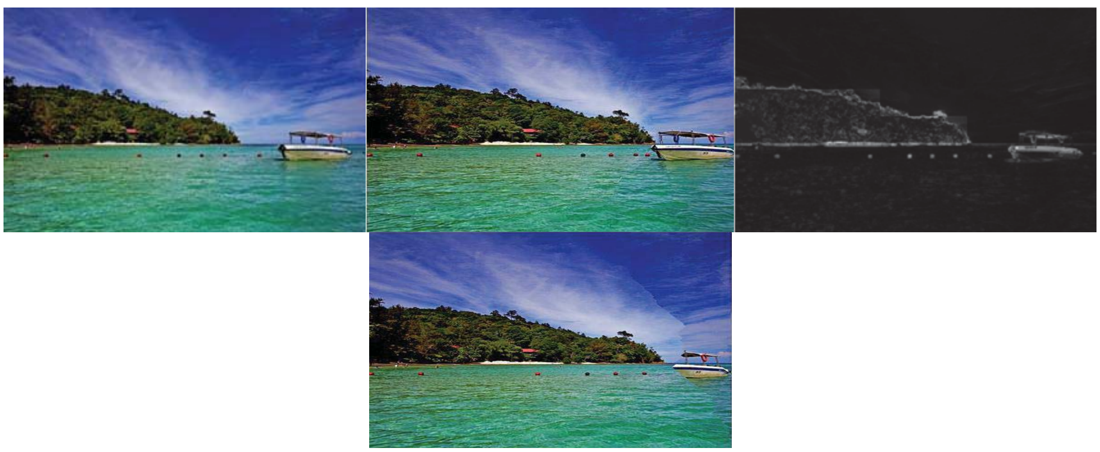

Fig 3(e):original image 3(f): traditional seam carving 3(g) : improved energy map 3(h): output of proposed system

PSNR (Peak Signal to Noise Ratio)

PSNR is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Higher the PSNR worse is the output attained. Low PSNR determines good outputs.

Structural similarity analysis

The structural similarity (SSIM) index is a method for measuring the similarity between two images. The SSIM index is a full reference metric, in other words, the measuring of image quality based on an initial uncompressed or distortion-free image as reference.

Fig 3(i): correlation value: 0.6993, PSNR- 18.0659, SSIM- 0.4437(traditional seam carving)

3(j): correlation value: 0.7325, PSNR- 17.8124, SSIM- 0.4240 (proposed algorithm)

Fig 3(k): correlation value: 0.4119 , PSNR-13.8444, SSIM-0.2139 (traditional seam carving)

3(l): correlation value:0.4020 , PSNR-13.7729 , SSIM-0.2205 (proposed algorithm)

IV.CONCLUSION

The above method overcomes the problems faced in traditional seam carving. Also the PSNR value is reduced and SSIM value is increased when compared with traditional seam carving method. The same algorithm can be applied for carving out videos and improve the saliency of videos which is not solved in the above algorithm.

REFERENCES

[1] S.Avidanand A.Shamir,Seam carving for content-aware image resizing. ACM Trans. Graph., 26(3):10, 2007

[2] P.Zarghanand S.Nassipour, Content-aware image resizing. Stanford 2012

[3] M. Rubinstein, A. Shamir and S.Avidan, Improved Seam Carving for Video Retargeting ACM Trans. Graph., 27(3):16, 2008

[4] M.Grundmann, V.Kwatra, M Han, I.Essa, Discontinuous Seam-Carving for Video Retargeting, IEEECVPR, 2010

[5] Mansfield, P.Gehler, L.V.Gooland C. Rother, Scene Carving: Scene Consistent Image Retargeting, Microsoft Research

[6] J.Kiess, S. Kopf, B,Guthierand W.Effelsberg, Seam Carving with Improved Edge Preservation , Proc. of IS&T/SPIE Electronic Imaging (EI), 2010

[7] S. Cho, H. Choi, Y. Matsushita and S.Lee, Image retargeting using importance diffusion, Intl. Conf. on Image Processing, 2009

[8] R.Achantaand S.Susstrunk, Saliency detection for content-aware image resizing, IEEE ICIP, 2009