Content Aware Media Retargeting for still images using Seam Carving

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ABSTRACT

When changing height and width of image traditional techniques for image resizing are oblivious to the content of image. A simple operator seam carving is used for image and video retargeting. This seam carving operator is used for content aware image resizing to reduce or expand image size. According to seam carving method every object in the image must be scaled down proportionally. Pixels in image which are belonging to most interesting parts of image are preserving and pixels which are belonging to most uninteresting parts of image are removed. By repeatedly inserting seams in vertical and horizontal directions we can increase size of image or the aspect ratio of image can be changed. Seam carving technique can also be used for enhancing the content of image and removal of object from the image by applying successive operation of the seam carving operator. This paper discuss problem in object removal with seam carving and distortion of image contents when inserting excessive seams in image.

General Terms

Seam carving, energy function, aliasing, backward and forward energy criterion, dynamic programming, automatic cropping, saliency measures, content aware resizing, Energy map, importance map.

Keywords

ROI- Region of interest, HTML- Hypertext Markup language.

1. INTRODUCTION

The versatility of display devices and advancement in image processing techniques content aware resizing of images is required to fit images into different display devices of varying resolutions. For example the size of image or aspect ratio of image must change so that image can fit into different displays such as cell phones or PDAs. Traditional methods cropping and resampling can introduce undesirable losses in information. Seam carving, a content aware image resizing technique has greatly gained popularity in this scenario. The seam carving algorithm is introduced and discussed by Avidan and Shamir [1]. Later solutions by Wolf et al. [2], Simakov et al. [3] and Guo et al. [4] produce good results by using global optimization techniques. These techniques are more computationally expensive. It proves to be superior to other resizing methods like scaling, cropping and warping. Several researches are in progress to optimize seam carving. More effective resizing can only be achieved by considering the image content and not only geometric constraints. Seam carving uses an energy function defining the importance of pixels. A seam is a connected path of low energy pixels

crossing the image from top to bottom, or from left to right. In image seam should be of two types (1) monotonic because it includes one and only one pixel from each row and each column of image. (2) 8 connected – Being found a pixel on the seam, the next pixel that constitute the seam [5] is one of its three neighbors on the next row/column. By successively removing or inserting seams in image, image can be reduced, as well as enlarged, in both directions either in horizontal direction or vertical direction. To preserve structure of image Seam selection procedure ensures that low energy pixels within the image must be removed instead of removing high energy pixels. Seam carving at extreme level can leads to distortion of ROIs. Seam insertion procedure to enlarge image insures a balance between the original image content and the pixels which are artificially inserted. The applications of seam carving are to change aspect ratio of image, image retargeting, enhancement of contents present in image, and removal of objects from the image. Seam carving not only preserve the important content present in image but also global visual effect of image. Seam carving can support several types of

energy functions such as entropy, visual saliency, gradient magnitude, eye-gaze movement, and more. Energy image E is an important component of the seam carving algorithm because the primary aim of seam carving algorithm is to shrink an image by removing only those pixels that don't have a much amount of energy. Changing the size of the image is extremely required in texture synthesis. In texture synthesis the goal is to generate a large texture image from a small one. The main drawbacks of seam carving are that it only considers the pixel information to make the image resizing unperceivable causing discontinuity artifacts. The optimality of pixels is defined by an image energy function. There are various techniques are available for image resizing such as cropping, column removal, pixel removal, seam carving. Seam carving approach is hybridized with other resizing methods to efficiently use the positive aspects and minimize the negative impact of each other [6]. Seam carving techniques typically start by computing an importance map which represents the relevance of every pixel, and then apply an operator that resizes the image while taking into account the importance map and additional constraints. We intend this review to be useful to researchers and practitioners interested in image retargeting [7]. Researchers have been proposed so many techniques for image resizing and the solution of this has been contributed by human computer interaction, computer graphics and computer vision. The importance map is typically a saliency map, which describes that region of image which draw human attention. Various saliency detection approaches are available. A popular saliency measure approach is suggested by [17] which are based on low level feature of image. Some methods are also available for Computing saliency based on dissimilarities between neighborhoods in the image [18].

2. RELATED WORK

Image resizing approaches are useful for those applications where different screen resolution and aspect ratio is required to represent image. Traditional methods are only pay attention for resizing image without considering image content. These methods produce image distortion. To overcome this shortcoming, many approaches attempt to remove the unimportant information from the image periphery [13][14][15][16]. Now a days various seam carving algorithms are available which pay more attention on important region of image which can easily recognized by human eye after removing low energy pixels of image. Automatic resizing operators such as scaling, letterboxing, cropping does not produced better quality of image as desirable. Scaling can distort aspect ratio of image and can produce artifacts in image such as aliasing effects, fixed window cropping and letterboxing also do not prevent important region of image. This section introduces various methods of content aware image retargeting methods which pay more attention for important content of image. Researchers has been proposed automatically cropping images before scaling them to create thumbnails, with the objective to avoid important image contents from being scaled beyond recognition [15]. Amrutha find the best crop based on regions of interest obtained from the combination of Itti's and Stentiford's saliency models [19]. Nishiyama propose a brute-force search of subwindows for the window that maximizes the output of a quality classifier, which measures the aesthetic value of a crop [20]. Golub describes a system for semi-automatic image cropping, where the user selects a point of interest in an image and the system suggests a few cropping candidates that place the point of interest according to photography rules-of-thumb [21]. Traditional operator for scaling often lost detail of image in resizing process. In order to overcome this problem Mu˜noz introduce an optimal spline-based algorithm for image resizing with arbitrary scale factors [22]. Samadani deal with the problem of creating thumbnails from images, where typically a large image is scaled to generate a small image [23]. Due to limited area of display of current mobile phones visualizing large image is a challenging task. To overcome this problem few approaches have been suggested by Rapid Serial Visual Presentation (RSVP) methodology. Researchers estimate interesting regions by bottom-up (saliency map) and top-down analysis and then determine a path for browsing through the image contents [24]. Liu extends the work to determine an optimal path to maximize the information displayed in the minimum amount of time [25]. Liu detect regions of interest (ROIs) and sequentially display them, either cropped or rescaled to fit the size of the device [26]. When one operator does not perform well, it is natural to extend it to a multi-operator. Rubinstein presented an image resizing algorithm to combine different operators in an optimal manner [27]. Wang present a ”scale-and stretch” warping method. The method iteratively updates a warped image that matches optimal local scaling factors [28]. Patch-based methods are also presented for image retargeting or image summarization. Cho chose patch arrangements that fit well together to change the size of an image. The main drawback of this method is that it cannot preserve the completeness of the image [29].

3. PROBLEM IN IMAGE RETARGETING

A digital image on 2D discrete grid is a collection of pixels having n rows and n columns. Each pixel in image has some intensity which represents color depth on a pixel. A digital image can have RGB components. Problem of image retargeting states that how retargeting operation on an image I, with size M x N can produce better results.

The resultant image must be close approximation of original image.

There are three main objective of retargeting.

- The important components of image I must remain intact in I'.
- The original structure of image should be preserved in resultant image.
- I' i.e. resultant image should not have any aliasing effects.

Current algorithms of seam carving are not capable to automatically find out important regions in image when scenes in image are complex and crowded. Different algorithms for computing the important maps are applied on image on the basis of image category. Important map quantifies the importance of every pixel in the image. The computation of importance measures may involve the extraction of several features and the use of complex object detection schemes [7]. In seam carving finding out important regions in the image is a typical process. This process may be error prone hence much human interaction is required to determine the saliency map in some cases, which gives important part of image.

4. REGION PROTECTION IN SEAM CARVING

(a)

(b)

(c)

Fig 1: (a) Original Image with resolution 338x 600, (b) Image after applying protective layer on selected portion of image. (c) Output image with resolution 192x600 by removing 1 vertical seam in each iteration.

Traditional methods of seam carving distort image after resizing. After applying protective layer on the image image can be protected and better result can be produced.

4. PROCESS OF SEAM CARVING

The process of Seam carving can be described by 3- steps.

1. Calculating the energy of each pixel. This is done by smoothing the image and then computing the first x- and y-derivative at each point using a 3x3 Sobel filter.

$$\text{ENERGY} = |I_x| + |I_y|$$

2. Using dynamic programming to find a seam from top to bottom (or left to right) with the least total energy. A seam is defined as a continuous series of pixels. Thus, if you have a vertical seam, it consists of one pixel per row, with pixels in adjacent rows in either the same or an adjacent column.
3. Removing the pixels along the lowest-energy seam to create a smaller image. This will remove a less-interesting part of the image, while still preserving continuity in the image.

These steps are repeated until the image has shrunk to the desired size.

(a)

(b)

(c)

Fig2: (a) Original Image with resolution 800 x 450 (b) Image after horizontal seam carving with resolution 719 x 450, (c) Image after vertical seam carving with resolution 800 x 329.

5. FINDING SEAM IN IMAGE

The purpose of content aware resizing is to recognize unnoticeable pixels which are mixed with their surroundings. Because human eye are very sensitive to boundaries or edges present in the image so it is require to give high value to edges by using following energy function.

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

The process of removal of low energy pixels and preventing high energy pixels should to perform in very effective manner. Equal number of low energy pixels should be removed from each row and column of image. This prevents not only image breaking and visual coherence but also rectangular shape of the image. Even after applying this low energy pixel removal process astutely some artifact still may appear in image. Vertical seam eq (1) and horizontal seam eq (2) can be defined by following equations.

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

$$s^y = \{s_j^y\}_{j=1}^m = \{(j, y(j))\}_{j=1}^m, s.t. \forall j, |y(j) - y(j-1)| \leq 1 \quad \ldots (2)$$

Cost of the seam can be measured by the sum of energy of its pixels.

$$E(s) = E(I_s) = \sum_{i=1}^{n} e(I(s_i)) \quad \ldots (3)$$

A seam is said to be optimal if minimizes this cost.

$$S^x = \min_S E(S) = \min_S \sum_{i=1}^{n} e(I(S_i)) \quad \ldots (4)$$

There can be exponential number of seam are available in the image but to find out optimal seam dynamic programming is used in linear complexity. In seam carving image is traverse in all possible direction (left, right, and vertical) to find out seam which is optimal or which gives minimum energy of its pixel (i,j).

$$M(i,j) = e(i,j) + \min(M(i-1,j-1), M(i-1,j), M(i-1,j+1) \ldots (5)$$

Removal of left seam:

$$C_L(i,j) = |(I(i,j+1) - I(i,j-1)| + |I(i-1,j) - I(i,j-1)| \quad \ldots (6)$$

Removal of right seam:

$$C_R(i,j) = |(I(i,j+1) - I(i,j-1)| + |I(i-1,j) - I(i,j+1)| \quad \ldots (7)$$

Removal of vertical seam:

$$C_V(i,j) = |(I(i,j+1) - I(i,j-1)| \quad \ldots (8)$$

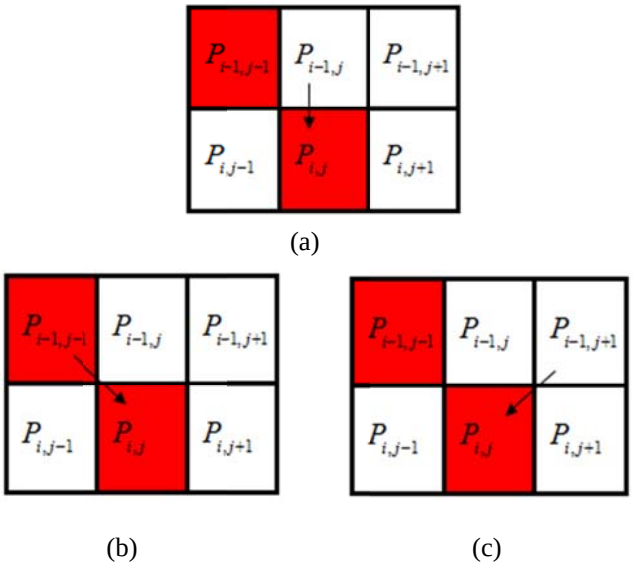


Fig 3: Removal of seam carving (a) Removal of left seam (b) Removal of right seam (c) Removal of vertical seam.

6. CHANGE IN IMAGE SIZE AND ASPECT RATIO

The process of inserting and deleting seam from an image is time consuming process. In order to increase and decrease size of image optimal seam (S) is calculated and duplicates this optimal seam on image (I).

To produce better output image after seam carving process it is require balancing between original image contents and part of image where artificial seams have been inserted. Duplicating seams in the image is same as performing standard scaling. Insertion process of seam in the original image enlarge size of image only fraction of its size. The main aim of seam caring algorithm is to guard important contents of image and alter those parts of image where pixels have low energy. Insertion of seam at extreme level produced aliasing effect and can destroy global visual effect of image.

Fig 4: (a) Aliasing effect in output image after inserting horizontal seam in original image. After duplicating seams in original image aspect ratio of image has also been changed.

7. APPLICATIONS OF SEAM CARVING

7.1 Change in Aspect Ratio

Aspect ratio of an image can be changed by successively deleting seam from the image in vertical or horizontal direction. This operation does not change important part of image. Image resizing or change in aspect ratio can also achieved by inserting seam or row in the image either in horizontal direction or in vertical direction.

7.2 Object Removal using Seam carving

To remove target object from the image seam related to the objects are removed. In this protective region method for image size reduction user provide minimum energy values to the M (I, J), here (I, J) is selected pixel location by the user. This process of removing seam is successively applied over the object until all the pixels related to that target object are gone. In order to do this, system automatically calculates optimal seams of low energy and removes it. After removing the object from the image the size of original image will be reduced. Seam insertion can be applied on resulting image to convert its size as original image.

(a)

(b)

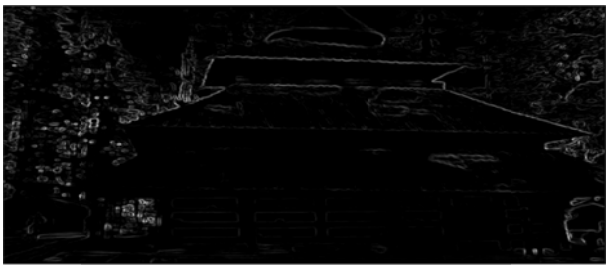
(c)

Fig 5: (a) Original image: (b) Red region in image represent object to be removed (c) Image after removing vertical seam by width until whole red pixel does not remove.

7.2.1 Problem in object removal

When a large object is removed from the image, all the seams pass from that region is almost equivalent to cropping [7]. This object removing technique [10][11][12] alters the whole image. This is because both the removed and inserted seams may pass anywhere in the image. This can improve seam carving algorithm by modifying the energy function used to incorporate methods such as Line detection, segmentation, saliency detection etc.

(a)



(b)

(c)

(d)

Fig 6: (a) Original image, (b) Image after applying edge detection algorithm, (c) Image after removing selected portion of image, (d) Image after applying edge detection algorithm on resized image width wise.

7.3 Multi Size Images

It may be possible that user knows size of image in advance but in some case it may not be possible. For example a web site designer does not know at client side on what resolution the image contents will be displayed in such case it is not good to generate a single target image. In this case web site designer must generate different target image and use most suitable image according to requirement. Dynamically changing the layout of web pages in browsers should take into account the distribution of text and images, resizing them if necessary [7]. Although resolution of various display devices has been improved but still their physical area is small. Hence, rearranging the relative sizes of different objects in the image could still provide an improved viewing experience, despite the availability of more pixels [7].

8. GENERATING ENERGY MAP USING GRADIENT MAGNITUDE

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.

(a)

(b)

(c)

(d)

Fig 7: (a) Original Image, (b) Edge detection after applying prewitt edge detector, (c) Edge detection after applying Sobel edge detector, (d) Edge detection after applying Laplacian operator.

9. LIMITATION OF SEAM CARVING

There are some limitations of seam carving algorithm. The purpose of seam carving algorithm is to remove seam which is a path in image containing low energy pixels. Seam removal from image results down sampling, which may produce aliasing effects. If seams are removed from smooth area of image it does not produce any staircase effect. Jagged edges always produce in non-smooth area of the image. To remove these aliasing effect from the image low pass filter can be used. Seam carving cannot preserve ROIs to be carved out. Seam carving in which optimal seam is calculated by pixel by pixel computation. Hence seam carving is time consuming process.

10. SIMULATION AND RESULT

This section represents experiments and result of content aware resizing after applying traditional approach i.e. scaling and seam carving approach on various images. In this section results are shown for width resizing of image, height resizing of image, image enlarging.

10.1 Images after resizing width and height using scaling and seam carving (Compression and Expansion)

Fig 8: Original Image with resolution 450x600 for resizing by using Cropping and seam carving.

Fig 9: Original image with resolution 800x600 for resizing by using scaling and seam carving operation.

Fig 10: Image with resolution 200x350 after resizing using seam carving approach.This result shows after applying seam carving approach up to high level image contents may be distroyed.

Fig 11: Image with resolution 200x350 after applying scaling over image in fig 8.

Fig 12: Image with resolution 200x300 after applying seam carving approach over image in Fig 9. Image will distort after apply seam carving approach up to high level.

Fig 13: Image with resolution 200x300 after applying scaling over image in Fig 9.

(a)

(b)

(c)

Fig 14: (a) original Image (b) Image after inserting 799 seams in image (in vertical direction, Now image resolution is 1599x800) (c) Image with resolution 1599x800 after resizing with scaling.

11. ACKNOWLEDGMENTS

I thank my guide Dr. Ashish Negi, Associate professor in Department of Computer Science and Engineering, Govind Ballabh pant Engineering College, Pauri Garhwal for providing me an opportunity and resource to carry out this work. I am also thankful to NPTEL funded by ministry of HRD government of india to carry out this work which provides E-learning through online Web and Video courses in Engineering, Science and humanities streams. I am also thankful to my wife Ayushi Garg for giving me support to carry out this work.

12. CONCLUSION

As the number of different devices is used for displaying media are increasing day by day image retargeting and resizing techniques is required to display images in mobile phone, PDAs and HTML that supports dynamic displaying and changing of image sizes. Seam carving is a method to resize image by removing path of low energy pixels from image either in vertical and horizontal direction. By removing low energy pixels from the image aspect ratio of image can be change. Seam of low energy pixels are removed only from the smooth area of image to remove aliasing effect. The purpose of seam carving is not only resizing the image but also in object removal from image. Seam carving is also use full for the applications where many different sizes of the same image or video are required without the need for reprocessing the image for each size request. Various approaches have been proposed by researchers but still not a single operator for image retargeting is capable to solve the entire problem. Now a days automatic image retargeting is a valid and active research area. Cropping method of image retargeting does not retain all the important components of the objects hence image

composition can be damaged. Scaling can distort image by introducing artifacts such as aliasing and blockiness. The better idea of improving cropping is seam carving where all the important region of the image remains intact. Here results in section-11 shows that excessive seam carving process when apply over image either after inserting seam horizontally and vertically important image contents may be destroyed.

13. FUTURE WORK

After successively remove seam having low energy pixels it may be possible that image contents distort. In order to protect important image contents stopping criteria must be set which must decide up to what level seam carving does not produce artifacts such as blockiness and aliasing. But the algorithm of seam carving does not always work well. It may be possible that after applying seam carving algorithm up to a higher level all the image contents may destroy. In order to solve this problem some further preprocessing image techniques must be developed. Seam carving algorithm can be improved by investigating different energy functions to find a better way to select optimal seam. Finding operators and algorithms which not only take less time to search optimal seam but also less time to record dynamic path and energy map. A better approach for multi-seam carving algorithm for content-aware image resizing can be suggested, which enables multiple seam reduction at each step as opposed to prior seam carving methods that only remove one seam at a time. This provides a clear advantage by requiring less iteration to achieve the desired image size. Seam carving is well suited for the image without straight line or regular patterns like landscape images but may cause distortion if used otherwise, hence better algorithm must be suggested for this purpose.

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