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Survey of Seam Carving Techniques

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Abstract- Development of novel mobile devices in the electronic world, built the need for developing display unit with appropriate aspect ratio. Image of various size and resolution undergo several modifications to get displayed in varying display size. This modification which is image resizing leads to important detail or content of the image to be lost. Image retargeting considered as the content-aware image resizing become very challenging to achieve visually better image while resizing. In this paper, the various forms of Seam Carving (SC) which indeed referred as a dazzling image retargeting technique are discussed precisely as a survey. For better accomplishments on image retargeting, the seam carving that undergone huge changes for the past is emphasized upon to impart a concise understanding of various models of contemporary seam carving techniques. This paper also provides significant insights into the seam carving technique by exploring its various methodologies and includes a comprehensive survey of the relatively new ground-breaking seam carving models for comparing with the state-of–the-art seam carving models.

General Terms

Digital Image Processing, Computer graphics, Computer Vision, Pattern Recognition

Keywords

Image Resizing, Content-Aware, Image Retargeting, Seam Carving, Region of interest, Discrete wavelet transform, Spatial orientation tree.

1. Introduction

Frequent progress in novel display devices with discriminate aspect ratio and resolution is demanding the display of multimedia contents. Some standards like HTML allow dynamic changes in text and page layouts but the images remain inflexible in size and cannot distort to fit different layouts automatically. So versatility of the images on different display sizes is challenging. As the display device varies in the display screen size, the content of the image is not displayed effectively by visually distorting the Region of Interest (ROI) which is referred to contain sub-images. Image resizing thus has to face many challenges to display the image with high quality. Conventional image resizing methods such as scaling and cropping are used for resizing ROI. However they are ineffective when used on content-aware resizing of overall image.

When images from high-resolution display are displayed in low-resolution display it then leads to distortions of important contents in the displayed image. To avoid the loss of important image features a better method introduced to remove uninterested pixels while preserving the region of interest of the image. This leads to the development of image retargeting [1] techniques. The major retargeting objectives are to preserve content, preserve structure and prevent artifacts. Image retargeting resizes the image to utilize the full screen size of the display device without the quality and content decrease. Scaling and cropping are the standard content unaware image retargeting techniques. Scaling can be applied only uniformly to retain the image without the loss of any pixels but oblivious to the image content. Cropping or re-sampling can only remove pixels which lead to visual distortion and artifacts. This method does not produce satisfactory results and introduces significant visual distortions. This situation emphasizes to induce novel operators for image retargeting. Conventional methods for image resizing like scaling and cropping introduces distortions when the aspect ratio changes, can generate artifacts due to aliasing, and can make important objects unrecognizable due to the change in size. To address these issues, techniques are taken into account the images content while resizing attempt to preserve important regions while maintaining an aesthetically pleasing image. Seam carving (SC) [2] is referred as content-aware image resizing technique that results in better image quality by preserving the details.

2. Seam Carving

Seams which are considered as the 8 connected paths of pixels is inserted or removed iteratively to accomplish the target display size. This technique is robust for any kind of images and it provides satisfactory results by considering the contents of the image and

removes image distortion and visual artifacts. Beyond traditional sampling theory, image resizing not only considers on geometric constraints but on image content as well. Content aware image retargeting, image feature enhancement, object insertion and object removal, object preservation, image resizing like image shrinking and image enlarging are the main scope of applications of Seam carving technique.

2.1 Seam Carving Techniques

In this dissertation the seam carving which is one of the content aware images retargeting technique is presented as a survey.

- **Multi-view Image Seam Carving:** Multi-view image [3] resized to display in a single liquid-crystal display (LCD) unit using the pixel intensity and the depth information. The combination of 2D image and depth map gives inter and intra object boundaries very precisely when used with L1 norm to generate the energy function that provides improved seam carving algorithm. Authors proved that the proposed SC would provide better result than the Vanilla SC which concentrated only on the pixel intensity. And concluded that the idea can be extended to 3D multi-view video streams.

- **Balanced Seam Carving:** A novel energy called as balanced energy map [4] is introduced by combining the merits of edge map and saliency map. Edge map which is considered as a governing map spreads energy more smoothly and proved to be robust. Whereas, the saliency map which is considered as a complement allocates visually prominent regions with higher energy and detects pixel saliency values from the low-level features rather than the intensity values. New insight in to forward energy is introduced by 8-connected energy measurement that accurately measures the vertical, horizontal and diagonal artifacts. Later they used dynamic programming and graph cut to carve out the seams. However limitations like more user interactions to reset the weight parameter for saliency map is required and the straight edges are distorted in the structure dominant image.

- **Multi-scale Seam Carving:** Authors, improved SC technique by providing general filter bank frame work [5]. Multiple scales of image structures are enebled by designing novel filters that worked for variety of images irrespective of their types. Authors introduced guidance vectors in cumulative energy map that designate which pixels are to be selected for driving the seam. Experiments done by redefining backward energy seam carving filters and forward energy seam carving filters bank by passing each level of image through the designed novel filters. It has been shown that the importance of a pixel not only lies in the energy at a particular scale but also in the number of scales as shown in Fig.1 and the coarser scales are preferred for resizing. Authors conducted various experiments and concluded that Roberts filters at 5 levels and forward-energy filters at 3 to 4 levels produced desired results and one of the results is shown in Fig.2.

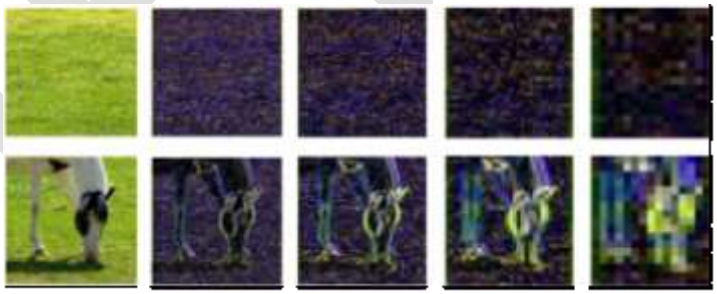

Fig.1: (Top) Grassy Image and its 4 Levels of High Pass Coefficients from Fine to Coarse. (Bottom) Part of Horse Head and its 4 Levels of High Pass Coefficients.

(a) (b)

Fig.2: (a) Original Image. (b) 30% Width Reduction of the Original Image Using $\mathcal{B}$fwd Filter Bank and Scale Depth N=4.

(c) **Reverse Seam Carving:** Authors found that there is an affiliation between the two processes of seam insertion and seam deletion [6]. To and fro usage of these two processes resulted in aliasing which means removing seam and inserting seam lead to artifacts and distortions as shown in Fig. 3 where the original image and the expanded image are slightly different. The authors proposed energy functional composed of two parts to determine the importance of the pixels. The first part is the straight one that defines the unimportant pixels. The second part is the inverse one that defines the perceptible space in seam insertion process. The forward energy is expanded using virtual points for determining the cost for seam Insertion. And for examining the similarities between two images, Scale-invariant feature transform (SIFT) based method is used. As the limitation the proposed system works better only for resizing the image in a small scale. Any retargeting techniques other than the seam carving can be implemented using reverse idea.

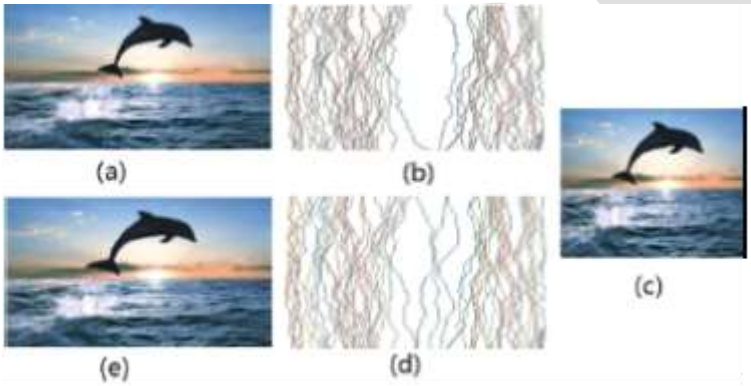

Fig.3: Seam Removing and Inserting Process To and Fro. (a) Original Image. (b) Optimal Seams for Removal. (c) Reduced Image. (d) Optimal Seams for Insertion. (e) Expanded Image.

 Improved Seam Carving: The authors addressed the retaining of both image content and image structure in the reduction and enlargement processes by using improved seam merging [7]. For image reduction new pixel is obtained by merging a 2 pixel-width seam and for image enlargement a new pixel is inserted between the 2 pixels. A cumulative seam merging history is used in the resizing process. The pixel importance is used to generate the importance energy and the pixel context. Cartoon image of an original image is used to calculate the structure energies. To obtain excessive resizing and suppressive distortions the authors introduced additional new energies in the interactive merging or inserting process. The result of the proposed system showed in Fig.4 for image reduction and for image enlargement.

(a) (b) (c)

(d)

Fig.4 (a) Original Image. (b) Cartoon Image of (a). (c) Reduced Image. (d) Enlarged Image.

 Adaptive Seam Carving: Novel design of saliency detection algorithm and adaptive image retargeting algorithm are implemented in the compressed domain [8]. The features of the joint photographic experts group (JPEG) images are extracted using discrete cosine transform (DCT) coefficients for the saliency detection. The performance of saliency map is evaluated using receiver operating characteristic (ROC). The obtained saliency map is used to determine the visual significance map which is one of the performance factors of image retargeting algorithm. The multi-operators such as block based SC and image scaling are used as the another performance factor of the image retargeting algorithm in an adaptive manner for the JPEG images. Fig.5 shows the original image, saliency map and retargeted image of 75% reduced width. Adaptive seam carving method assumed to be out performed the state-of-the-art saliency detection algorithm and the width of the retargeted image is reduced by 75% to 80% of the original image by preserving regions of interest (ROI).

 (b) (c)

Fig. 5: (a) Original Image, (b) Saliency Map of (a), (c) Retargeted Image of 75% Reduced Width.

 Enhanced Seam Carving: Authors provided enhanced SC [9] by using non-8-connected seams and proved to have better computational performance and quality. To punish the temporal artifacts the video frames are processed dependently. Spatial and temporal energy map generated for the current frame from which they determined spatial cost and temporal cost for each pixel. The cumulative cost of each pixel is determined by summing up the spatial and temporal cost in an adaptive search window size that depends on the video contents and temporal weight so as to reduce the computational time. Using dynamic programming the seam with minimum cumulative cost is carved out to the desired video frame size.

 Seam Carving Principle: The authors introduced a novel image coding scheme that provided content based spatial scalability [10] of the image. At the encoder side the original image undergoes discrete wavelet transform (DWT) with the resultant spatial orientation tree (SOT) of ordered coefficients. Even at the encoder side the block-based seam used to generate the energy map which directs the DWT coefficients scanning and encoding orders in a content-based manner. At the decoder side the side information and bit-streams of the DWT coefficients are decoded to obtain the content-aware image in arbitrary display unit. Seam based SPIHT scheme is used which differs from the conventional scanning and coding order in low frequency sub-band. The side information which constitutes SOTs roots, ROI size, etc. are also encoded using SPIHT and then the bit-streams are transmitted in a content-aware fashion. As the encoder was implemented in the cloud, the computational complexity became less in the mobile devices. Thus the proposed novel codec resulted in a better compression technique for transmission.

- **Video Seam Carving:** Image SC is transformed into video SC by accomplishing both temporal and spatial coherence than any other methods for video retargeting [11]. Video seam carving method explained that the seam from the previous frame is used to compute the key point in the current frame. The energy map of the current frame is adjusted to determine reward and punish regions and then SC is applied on newly generated energy map.

- **Depth Seam Carving**: Authors proposed a new method by extending the SC approach for single image to a pair of stereo images [12] to retain geometric consistency in the pair of image. In their approach they considered the disparity energy map, occluded and occluding pixels relationship visually in the image pair. The resulted pair of the images are geometrically intact with 3D scene and had high percentage of similarity with the original image. However it has limitation on the amount of occluded and occluding pixels and on the quality of input disparity map.

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4.Conclusion

Many seam carving techniques are not mutually exclusive. A combined method of various retargeting technique may result in a better image since various attributes of image can affect the performance of any seam carving techniques. Many authors dissertations mentioned in this paper as a survey is considered to be the best methods for image re-sizing by optimally selecting the seams that may result in undistorted image.

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