3D Image Retargeting

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ABSTRACT

Advancement in 3D imaging technology has increased the capture and display of 3D images. 3D images can be viewed over many devices, ranging from high-resolution computer monitors, cinema screens to low-resolution mobile devices. These images are also processed by many computer vision algorithms. Stereoscopic images often have to experience changes in size as well as aspect ratio in order to adapt to different display screens. Displaying and printing documents with embedded images often involve resizing of the images to fulfill the general layout. Image resizing by cropping, scaling or stretching often do not generate satisfactory and pleasing results, distorting image structure and 3D depth. This work focuses on reviewing and categorizing algorithms for content aware 3D image retargeting which means resizing an image while taking its important content into concern to preserve its salient regions and minimizes the visual and depth distortion. Also modified stereo seam carving method is proposed for retargeting 3D images into required aspect ratio. There are many challenges in 3D image retargeting as compared to 2D because focus is to maintain stereo consistency as well as relevant information in the image. The proposed technique work by computing energy function for every pixel or group of pixels in order to find their importance and then apply an operator that retarget the image taking into consideration the importance map, depth map and additional constraints.

Keywords: Depth map, Depth distortion, Stereoscopic 3D images, Salient regions

1. INTRODUCTION

Recently, 3D stereoscopic images and videos have become popular due to the rapid increase in contents as well as advances in hardware capability. Stereoscopic images and video contents are widely available in 3D cinemas and 3D broadcasting. They can be created and displayed using latest developed hardware such as 3D camera rigs, 3D televisions and 3D smartphones. Stereoscopic media processing methods present two offset images independently to the left and right eye of the observer. These 2D offset images are then merged in the brain to give the insight of 3D depth. It can be expected that stereo images will be widely available in the near future, and it would be interesting to take advantage of these contents to develop virtual reality applications. Due to the attractiveness of stereo (or 3D) images/videos, techniques for producing and editing stereo media are attracting a lot of research attention in recent years. Various techniques for stereoscopic postproduction image processing are available. However, many of these applications rely on existing 2D image processing techniques, which may not always produce good results on stereo images, mainly due to issues related to the additional depth information arising from stereo images. Stereoscopic media delivers not only an additional dimension and added enjoyment, but also additional challenges and constraints in creating a comfortable and enjoyable 3D experience. Because they do not address these constraints, naive extensions of existing 2D media manipulation algorithms usually fail to deliver a comfortable 3D viewing experience. Thus, nontrivial adjustments are often required to accommodate new constraints and take advantage of new opportunities.
The diversity of image consumption conditions for example in 3D photography, web browsers, smartphones, printing documents, virtual reality introduces a new problem: images must be resized for optimal display or use in different applications. The process, also known as image retargeting or image resizing in Figure 1, consists of modifying the image's aspect ratio and size in order to best satisfy the new requirements. However, straightforward image resizing operators, such as scaling, cropping often do not produce pleasing results, since they are unaware of image content. To overcome this limitation, various techniques attempt to resize the images in a content aware fashion, i.e., taking the image content into consideration to preserve salient regions and minimize visual and depth distortions. This problem is challenging, as it needs preserving the crucial information while maintaining an aesthetically enjoyable image for the user.

Figure 1 An example of image retargeting. From left to right: original image, resized using seam carving [3], scaling, and cropping

Motivated by the persuasive applications and the challenges related to the problem, researchers have proposed several techniques for automatic retargeting of images, and the topic is still a subject of ongoing research. Solutions have been contributed by the computer vision, computer graphics, and human-computer interaction communities. Main two classes of algorithms for retargeting have emerged. Discrete methods for single image retargeting, such as seam carving [3] or shift map [6], remove and shift pixels in the image. Continuous methods [7], [8] warp a quad mesh based on image content. The seam carving algorithm works by iteratively computing a seam with minimal visual distortion in the image and removing it. A seam is defined to be a connected path in the image from top to bottom or left to right. An energy function is used to evaluate the importance of each pixel in the image and the optimal seam is chosen which contains the pixels with the lowest overall energy. Each seam can then be removed or duplicated to reduce or extend the size of the image by one column or row. This paper introduces the basics of image retargeting in section 1. Section 2 emphasizes summarizing and categorizing recent work from the image retargeting literature. This review mainly refers to techniques that are applicable to the retargeting of 3D images while some approaches related to 2D images are also highlighted. Modified stereo seam carving methods for 3D image retargeting is proposed in section 3 which will reduce the limitations of existing seam carving methods and will produce better quality results. Section 4 is based on 3D image datasets and section 5 gives conclusion.

2. RETARGETING TECHNIQUES

Many algorithms have been proposed in the last decade for retargeting digital images. These algorithms attempt to change the aspect ratio of an image or a video in a way that does not distort the proportions of the important objects in the image. The various algorithms differ in how they determine the importance of different pixels in the image and in how they use this information.

2.1 2D Image Retargeting

Currently, various image retargeting algorithms have been proposed for image resizing. Traditional scaling and cropping methods can easily cause significant distortions or information loss in images. Due to this many content aware retargeting methods such as Segmentation, Non-homogeneous warping, Seam-Carving, Scale-and-Stretch, Multi-operator, Shift-maps, Streaming and Energy-based deformation gained attention in recent years. These algorithms can be applied to each left and right 3D stereoscopic images in order to resize them in appropriate aspect ratio. But retargeting each image independently will distort the geometric structure and hence will harm the perception of the 3D structure of the scene. Hence modified retargeting algorithms are needed to process stereoscopic images preserving their geometric structure and depth information.

2.2 3D Image Retargeting

Image retargeting algorithms can be classified as discrete or continuous. Discrete approaches remove or insert pixels (or patches) judiciously to preserve content, while continuous solutions optimize a mapping (warp) from the source media size to the target size, constrained on its important regions and acceptable deformations. All 3D retargeting techniques proposed in literature generalizes available 2D retargeting techniques. But there are many challenges in extending 2D techniques over 3D images due to their complex nature and requirement of consistency between the stereo views to preserve the depth information.

2.2.1 Discrete Methods

In the discrete methods, a stereoscopic image is resized mainly by cropping or seam carving. Niu *et al.* [16] proposed an esthetics-based cropping method in which an input image pair is optimally cropped and then rescaled such that the aesthetic value defined according to the principles of stereoscopic photography is maximized. Although this method performs well in most cases, it is unsuitable for the case in which visually salient contents are located near the borders of images. Mansfield et al. [2] extended seam carving to scene carving and showed that scene carving is definitely scene consistent. They resized images with the additional information of a relative depth map provided by the user.

With this depth map, the image is segmented into several depth layers containing either the background or the objects of the image. In the result, the objects keep their depth ordering, but may be rearranged with regard to the scene consistency. This also includes the introduction of occlusions into the image, as the salient objects are not allowed to be distorted. Utsugi *et al.* [14] also extended the 2D image seam-carving technique [3] to 3D stereoscopic images. In these methods, a pair of one pixel-wide seam with minimal significance in the left and right images is iteratively and simultaneously removed to resize the input images to the desired aspect ratio. However, preserving the geometric consistency of the output image pair is not discussed in their work. Birklbauer and Bimber [15] proposed a method for light-field retargeting that preserves the angular consistency in images. Their algorithm converts a stack of images into a light-field representation in which seam carving is performed. The retargeted light field is then mapped back to retargeted individual images. They avoid the need to recover explicit 3D information, but it is not specified how they deal with occlusions. Most recently, another seam carving algorithm for reducing the width of stereo images was presented by Basha et al. [1]. It together uses the information provided by both left and right stereo views and disparity map for the computation of the energy map. A pair of one pixel wide seams with minimum importance in the left and right images is iteratively and simultaneously carved to resize the input images to the preferred aspect ratio. Errors in the disparity map affect the depth distortion scores as well as the visual appearance of the images. The effect of these errors becomes more significant as more seams are removed.

2.2.2 Continuous Methods

Continuous methods optimizes warping using several deformation and smoothness constraints work better for images containing dense information. Chang et al. [12] proposed a content-aware display adaptation method that simultaneously resizes a stereoscopic 3D image to the target resolution and adapts its depth to the comfort zone of the display while maintaining the perceived shapes of important objects. This is done by detecting and matching a sparse set of feature points which are then used to define a warping field according to the target display parameters. Here the disparities and shapes of object in the high-significance layers are preserved, whereas the low-significance regions are squeezed or stretched out. Scene-warping method proposed by Lee et al. [13] combine the layer based approach [2] and the warping-based approach [12]. Each of the input stereo images is decomposed into multiple layers according to color and depth information. Each layer is then warped by its own mesh deformation, and the warped layers are composed together to form the resized images. Both methods [12], [13] do not discuss the geometric consistency of their method. Also how they deal with occlusions between the left and right views is not specified. Niu *et al.* [17] and Zhang *et al.* [18] proposed to extract and preserve foreground objects in warping. The assumption was based on the fact that users are more interested in foreground objects. These two methods can preserve the shapes of foreground objects properly. However, the problem of over constraining may make the methods incompatible for images/videos that contain visually salient content in the background.

3. PROPOSED WORK

Proposed work extends the seam carving technique proposed by Basha et al. [1]. In that the main limitation was related to using inappropriate disparity map for stereoscopic images which produces erroneous results with occluded pixels.

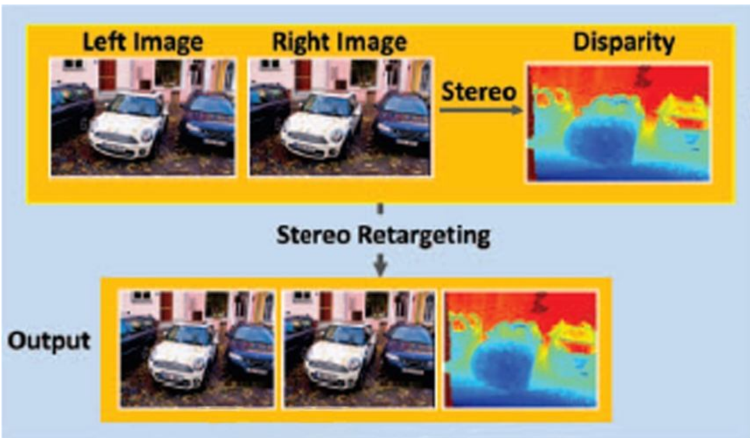

Figure2 Block Diagram of Proposed Work

To overcome this modified disparity map [5] will be used. The idea of proposed work is shown in Figure 2 in which modified disparity map is considered which will detect and handle occlusions. Stereo seam carving will be performed over stereoscopic images using modified disparity map which will simultaneously carve a pair of seams in both images while minimizing distortion in appearance and depth to obtain retargeted stereo images.

3.1 Stereo Seam Carving Energy Function

The energy function of the stereo seam carving method consists of an intensity term and a 3D geometry term. Removing a seam's pixel from each image in the stereo pair has the local effect of creating new neighboring pixels in the target image. The resulting gradients in the retargeted left and right images depend on the seam pixel in the previous row, denoted by $j^{\pm}{}_{L}$ and $j^{\pm}{}_{R}$, respectively. The energy function is defined (w.r.t. the left image) in accordance with the seam pixel in the previous row, $j^{\pm}$ (which is short for $j^{\pm}{}_{L}$).

$$E_{total}(i,j,j^{\pm}) = E_{intensity}(i,j,j^{\pm}) + \alpha E_{3D}(i,j,j^{\pm}) \qquad (1)$$

Here α control the relative impact of each of the terms.

3.1.1 Appearance Energy

The appearance distortion $E_{intensity}(i, j, j^{\pm})$ is taken to be the sum of the energy terms, E_L and E_R, for removing a pair of coupled pixels from the left and right images. That is,

$$E_{intensity}(i,j,j^{\pm}) = E_L(i,j,j^{\pm}) + E_R(i,j_R,j^{\pm}{}_R) \qquad (2)$$

3.1.2 Depth Energy

The computed depth map provides valuable cues for seam selection, and a 3D forward energy term E_D is used to minimize the disparity distortion. The total forward 3D energy is a weighted sum of three components:

$$E_{3D}(i,j,j^{\pm}) = E_D(i,j,j^{\pm}) + \beta |D_n(i,j)| + \gamma G(i,j) \qquad (3)$$

4. DATASETS

The stereo datasets which will be considered in proposed work are *Middlebury* and *Flickr*. These datasets are challenging because the scenes are highly textured and contain objects at different depths. Also in most of these datasets, about 20 percent of the pixels in the original reference images are either occluding or occluded which will evaluate the proposed work to its fullest.

5. CONCLUSION

Various approaches to image retargeting have been proposed, but no single operator completely solves the retargeting problem completely, and automatic retargeting is still a subject of active research. The choice of methods depends on the requirements posed by the application at hand. Discrete methods allow high flexibility in cropping and seam removal and can, therefore, be applied to resizing media. However, carving seams sometimes produces discontinuous artifacts in the visually salient content, thereby causing visual distortion in stereoscopic 3D images. Seam carving techniques also suffers from occlusions in 3D images due to disparities. Continuous methods optimize warping using several deformation and smoothness constraints potentially perform better in images containing dense information. But they suffer from preserving regions with fine edges. Seam carving method can be enhanced using refined disparity map taking occlusions into consideration. This will minimize visual and depth distortion present in existing seam carving method.

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