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A Survey on Image Retargeting Techniques

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Abstract— *The technique of adapting images to display devices with various aspect ratios and sizes is called image retargeting. The key requirement behind content aware retargeting is to minimize visual distortion. Several image retargeting techniques have been developed to fit images to devices of different sizes. This work reviews different techniques for content aware retargeting i.e., retargeting an image while taking its content into consideration to preserve important regions and minimize distortions. Only selected works are included in the survey. The advantages and disadvantages of the different techniques are also included.*

Keywords— *Image retargeting, mesh, salient object, patch*

I. INTRODUCTION

With the rapid advancement in the growth of display devices, image retargeting has become an interesting topic in the present arena of image processing. Retargeting is the technique of altering image size to fit to the target display devices for effective reading. They include simple methods like scaling to complex methods like warping. Earlier naïve methods like scaling to arbitrary aspect ratios result in stretching or squashing of significant regions. Cropping results in the loss of necessary details of the image.

Seam carving in [1] and image warping in [2] are recent techniques of content aware retargeting. Reference [2] proposes an optimized scale-and-stretch warping using a quad mesh as a control mesh. This approach can preserve the aspect ratios of local objects. However, for an object occupying many quads, an inconsistent deformation may occur because of the inconsistent scaling factors of quads as in [3]. Visually salient objects are forced to undergo similarity transformations during resizing in [3-5]. The methods in [6-8] are patch based image retargeting techniques.

II. OPTIMIZED SCALE AND STRETCH FOR IMAGE RESIZING

A. System Overview

A “scale-and-stretch” warping method that allows resizing images into arbitrary aspect ratios while preserving visually prominent features is presented in [2]. The method operates by iteratively computing optimal local scaling factors as closely as possible. The amount of deformation of the image content

is guided by a significance map that characterizes the visual attractiveness of each pixel; this significance map is computed automatically using a novel combination of gradient and salience-based measures. This technique allows diverting the distortion due to resizing to image regions with homogeneous content, such that the impact on perceptually important features is minimized. This method distributes the distortion in all spatial directions, even when the resizing operation is only applied horizontally or vertically, thus fully utilizing the available homogeneous regions to absorb the distortion. An efficient formulation for the nonlinear optimization involved in the warping function computation is developed allowing interactive image resizing.

The work presents a warping method that, instead of enforcing the size of salient image regions to remain unchanged, determines an optimal scaling factor for each local region. The scaling factors are iteratively optimized, and the amount of deformation to each region is guided by a significance map that characterizes the visual attractiveness of each pixel. This strategy is called optimized scale-and-stretch since it allows regions with importance to scale uniformly and regions with homogeneous content to be distorted. The grid mesh that represents the image is warped such that it fits the new image dimensions, and each quad’s deformation matches the local scaling factor. The scaling transformations and the positions of the grid vertices are both variables in the global optimization process. The key aspect of the method is that the distortion due to image resizing is optimally distributed over the image, irrespective of the direction of the resizing operation (horizontal, vertical or both). This gives the

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technique full freedom to utilize homogeneous image regions to hide the distortion.

B. Advantages and Disadvantages

The main advantage is that the structures within the retargeting images are well preserved. This method can be used in video resizing. The main disadvantage is that the method may contract a quad into a line or even a point, removing the quad content and introducing discontinuities. The method may fail to preserve the shapes of prominent image lines of arbitrary orientations due to the quads not being aligned with the feature.

III. A SHAPE PRESERVING APPROACH TO IMAGE RESIZING

A. System Overview

The work in [3] presents a novel image resizing method that attempts to ensure that important regions undergo a geometric similarity transformation, and at the same time, to preserve image edge structure. To accomplish this, handles are defined to describe both local regions and image edges, and assign a weight for each handle based on an importance map for the source image. Inspired by conformal energy, which is widely used in geometry processing, novel quadratic distortion energy is constructed to measure the shape distortion for each handle. The resulting result is obtained by minimizing the weighted sum of the quadratic distortion energies of all handles. The method attempts to ensure that the new shapes of prominent objects are geometrically similar to their original shapes both locally and globally. This uses a grid mesh and optimally diffuse distortion into less important regions in all directions. The method allows quads to undergo a similarity transformation and preserves important edge features. As a result, distortion is better diffused, and large prominent objects are better preserved by edge similarity constraints.

First associate an image with the vertices of a grid mesh, and additional points sampled from the image edges. Next, all of these points are automatically grouped into local or larger-scale control point sets, called handles. A handle can describe a local region (a mesh quad) or an extended feature (an image edge) in the original image. Using a novel definition for distortion energy for handles, similarity constraints are used to preserve the geometric similarity of the handles in an energy minimization process and are able to keep important handles

similar to their shapes during resizing. Thus, shapes of important objects are thus also well preserved.

B. Advantages and Disadvantages

The method has the main advantage that it allows distortion to be diffused better in all directions, and important image edges are well preserved. The method is efficient and offers a closed form solution. The disadvantage is that it cannot guarantee to strictly preserve edges.

IV. IMAGE RETARGETING USING MESH PARAMETRIZATION

A. System Overview

An effective image retargeting method using saliency-based mesh parametrization is presented in [4]. This method first constructs a mesh image representation that is consistent with the underlying image structures. Such a mesh representation enables easy preservation of image structures during retargeting since it captures underlying image structures. Based on this mesh representation, the problem of retargeting an image to a desired size is formulated as a constrained image mesh parametrization problem that aims at finding a homomorphous target mesh with a desired size. To emphasize salient objects and minimize visual distortion, image saliency is associated into the image mesh and regard image structure as constraints for mesh parametrization. Through a stretch-based mesh parametrization process the homomorphous target mesh is obtained, which is then used to render the target image by texture mapping.

Image retargeting is formulated as a mesh parametrization problem that emphasizes the important content while retaining the surrounding background with slight distortion. To emphasize salient objects in an image, first calculate a saliency map of the source image. Then build a controlling mesh of the input image that is consistent with the underlying image structures, and associate the saliency information with the source mesh. In this way, retargeting is transformed into a parametrization problem of finding a target mesh with the desired resolution. In order to improve visual quality of the target image, preservation of saliency and image structure information are interpreted as constraints of parametrization. Afterwards, the target mesh is solved by a constrained stretch-based mesh parametrization scheme. Retargeting result is finally rendered using the standard texture mapping algorithm as in [11].

B. Advantages and Disadvantages

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This method has the advantage that it emphasizes the important image content while retaining the surrounding context with minimal visual distortion. Images with multiple salient objects can be easily retargeted by mesh parametrization. This method fails to capture some important human bodies with varied face poses or illumination. The emphasis on relative scale of salient object will inevitably distort its nearby objects.

V. NONHOMOGENEOUS SCALING OPTIMIZATION FOR REAL-TIME IMAGE RESIZING

A. System Overview

A novel approach for interactive content aware image resizing is presented in [5]. The resizing is performed on warping a triangular mesh over the image, which captures the image saliency information as well as the underlying image features. The warped triangular mesh and the horizontal and vertical scales of all triangles are simultaneously obtained by a quadratic optimization which can be achieved by solving a sparse linear system. This approach can preserve the shapes of curved features in the resized images. The resizing operation can be performed in an interactive rate which makes the proposed approach practically useful for real-time image resizing. To guarantee a fold over free result, the optimization is modified to a standard quadratic programming.

As the first step build a triangular mesh over the original image that is consistent with the existing features which include sharp edges, feature curves and image boundaries. Instead of using quad mesh; which was generally used in content aware image resizing, triangular mesh is used as it is more flexible to adapt feature constraints than quad mesh does. The triangular mesh is generated so that its edges capture the image saliency information as well as the underlying image geometric features. Then a global nonhomogeneous scale optimization is performed to warp the triangular mesh. The resizing problem is then formulated as a nonhomogeneous warping problem which finds a target mesh with same topology and respecting the salient features. The result image can be obtained by texture mapping. The algorithm is as follows. A saliency map is computed for the given input image. The Canny edges and the feature line are then detected. Some feature points are sampled from Canny edges, feature line and image boundaries respectively. A triangular mesh is constructed over the feature points in which the important triangles are determined and marked. The triangular mesh is warped to fit the target image dimensions

while preserving the salient content and the result image is then obtained by texture mapping.

B. Advantages and Disadvantages

The method preserves salient line features as well as curved features efficiently. The algorithm emphasizes important image content whose aspect ratios can be specified by the user. It produces pleasing results and outperforms the previous approaches. The main limitation is that inconsistent deformations may occur on structure lines. Triangle mesh as a control mesh in warping may have the problem of inconsistency in triangle orientations.

VI. PATCHWISE SCALING METHOD FOR CONTENT AWARE RESIZING

A. System Overview

The work in [6] presents a new content aware resizing method by patchwise deformation of the source image with different scaling factors. The main idea of the method is to divide the original image into small patches and to compute the most suitable scaling factor for each patch to preserve important objects and avoid distortions. The method can preserve important objects, and can keep the smoothness and coherence of the resizing result.

First compute the important map of the original image and normalize it to identify its important areas. The important map is computed by a novel combination of image edge and saliency measures. The image is automatically divided into small important patches and unimportant patches based on the important map. Then cover each important area by a rectangle and its edges are parallel to the boundaries of image. Then, divide the image into small rectangles based on the rectangles of important areas such that any important area is covered by one small rectangle patch. Still, the edges of each small rectangle patch are parallel to the boundaries of the image. Thus it is possible to patchwise assign a scaling factor for each small rectangle patch. An image distance measurement is defined for computing the most suitable scaling factors to measure the quality of the resizing output. After each patch is assigned a scaling factor, shrink or enlarge the patch by some interpolation methods like bilinear interpolation. By this way, one can preserve the important objects by assigning suitable scaling factors for their covering rectangles. Then, the important areas will be proportionally deformed since each of them is applied by only one scaling factor while other resizing methods cannot consistently deform them. Additionally, one

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can control the discontinuity and distortion as little as possible by introducing a new image distance. The final resizing result, which has the most suitable scaling factors for each patch is obtained by minimizing the image distance.

B. Advantages and Disadvantages

The main advantage of the method is that it can preserve the main details in the resized resultant image. This method can simultaneously shrink and/or enlarge different parts of the image with less distortion and discontinuity. The limitation is that it produces shearing around the boundary of important and unimportant objects if the patches covering a characteristic of the input are divided into different columns.

VII. PATCH BASED WARPING FOR CONTENT AWARE RETARGETING

A. System Overview

The aim of the work in [7] is to preserve the visually salient objects and structure lines while minimizing visual distortions. For this the method includes a patch based retargeting scheme with an extended significance measurement. A patch based significance measurement is adopted instead of pixel based method. The main steps are preprocessing and image warping.

As the first step, the input image is partitioned into various homogenous patches using graph based segmentation in [9]. Since many patches are generated a merge process is adopted to prevent over segmentation. In order to represent each patch an average color is assigned to it. Then the neighboring patches are merged based on the following criteria. Initially, small patches are merged with their neighboring patches. If the area (number of pixels) of patch is smaller than a defined threshold (0.01% of the image area), the patch is merged to its neighboring patch that has similar representative color. Finally, if the adjacent patches have similar representative color, they are merged together. Color similarity is defined as the Euclidean distance in RGB color space, and the merge threshold is set to 20. After segmentation, saliency detection is performed by context-aware saliency detection in [10]. Then a significance map is generated from the segmented patches and the saliency map. Each segmented patch is assigned a significance value by averaging the saliency values of pixels in the patch. By using the significance map, this method can avoid inconsistent deformation and can generate satisfactory retargeting results. The patches with high significance value are forced to undergo as-rigid-as-possible deformation by

similarity transformation constraints while an optimization process is applied to smoothly propagate distortions.

B. Advantages and Disadvantages

The main advantage of the method is that it can preserve shapes of both visually salient objects and structure lines while minimizing visual distortions. The method can be efficiently applied in images containing dense information and structure lines. This approach has the limitation that it cannot work well for images containing objects with similar significance values. The retargeting results produced are similar to those generated by linear scaling.

VIII. OPTIMAL SCALING FACTOR ASSIGNMENT FOR PATCHWISE IMAGE RETARGETING

A. System Overview

The framework in [8] aims to improve a patchwise scaling method for image retargeting at an object level. The image retargeting problem is formulated as an optimal patch-wise scaling factor assignment problem. The patches used in this method are adaptive to the number of salient objects in an image. Compared to the previously patch-based methods that use fixed resolutions, the important patches correspond to salient objects in the image and have adaptive sizes. The improved patch-wise scaling method first takes the overall image structure into consideration by partitioning the image into rectangle patches of adaptive sizes, which are comparable to the sizes of salient objects in the image. This partitioning is based on a visual saliency map and the partitioned patches are labelled important and non-important. Then an optimal patchwise scaling method is applied that scales the important patches as uniform as possible and stretches or squeezes the non-important patches to fit the target size. To find an optimal set of scaling factors, a patch-based image similarity measure is proposed to guide the optimization process.

Identify the important objects in the given an input image and use them to divide the image into patches for later scaling. The meaning of important object is based on visual perception, and in this work, is defined as a visually conspicuous, continuous and homogenous content of the image that attracts human attention. A binarized important map of the original image is computed by combining an edge detector and a saliency map. The important objects in the image are identified by its importance map and bound the important objects using axis-aligned bounding boxes. Then

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extend the edges of the bounding boxes to form a partitioning of the whole image. Given the partitioning, the original image is regarded as consisting of important and non-important patches. Once the target size is given, the retargeting problem becomes assigning optimal scaling factors to each patch in the original image. For each patch column containing important objects, its scaling factor should be as close to 1 as possible and the width change in the retargeting image should be compensated by scaling patch columns which do not contain any important object. The scaling factors of adjacent patch columns should be also as close as possible to reduce the distortion along the patch boundaries. Thus there is a trade-off between scaling factors of important and unimportant patch columns.

B. Advantages

The main advantage of the method is that there is no inconsistent classification of important patches containing salient object. By applying the optimal scaling-factor assignment, the method achieves better retargeting effects. The line features are better preserved in the resultant image.

IX. CONCLUSIONS

Image retargeting has emerged as an interesting topic due to the increase in diversity of display devices. Many types image retargeting techniques have been developed by various researchers. This work is a survey of some of the selected recent image retargeting techniques. A brief overview of the different methods, their advantages and disadvantages are included as part of the survey.

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