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SIGNIFICANCE MAP BASED CONTENT AWARE IMAGE RESIZING

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ABSTRACT

Images are displayed in devices with different resolutions with the help of image resizing. Traditional image resizing methods don't pay attention to the content of an image while resizing, thus make the image be seen unnaturally. Content-aware image resizing techniques consider the visual content of images during the resizing process. The basic idea in these algorithms is the removal of vertical and/or horizontal paths of pixels (i.e., seams) having low energy. These low energy pixels contain the low salient information. The proposed method uses gradient vector flow (GVF) of the image to find the pixel paths to be considered for resizing. The relevance of these paths can be directly obtained from an energy map, related to the magnitude of the GVF of the image to be resized. These seams may contain visually important regions. So the proposed method uses a significance map for the final selection of the pixel path. The significance map includes the saliency and depth features of the associated image. Visually important image regions can be better preserved in the final resized image with the help of the significance map.

Keywords: content-aware,image resizing, seam carving, gradient vector flow, saliency map, depth map.

INTRODUCTION

As different devices like Tablet- PCs, Handheld-PCs, PDAs, notebooks or mobile phones are built for different purposes, vary in size and shape. So the display resolutions of these devices may vary, thus these devices does not support fully display or full aspect ratios of the visual media. Hence resizing of images is needed to display the images in these devices. Here image resizing refers to change in the resolution of the image.

Standard image resizing techniques are scaling and cropping. Scaling method is used to change the image size (width and height) without disturbing any contents, shapes and features of the image. Scaling does not consider the visual importance of pixels during image resizing. In cropping, an appropriate rectangle is selected and outer parts of that rectangle are removed. Even-though image cropping does not change the vital content of the image, results in the loss of context information that may still contain salient information.

Several techniques for content-aware image resizing have been proposed over the last years. Preservation of relevant visual information into the resized image is the main aim of a content-aware image resizing. This can be done by removing unnoticeable paths of pixels that blend well with their surroundings, and by retaining the salient pixels which are needed to generate the visual stimuli useful to correctly perceive the visual content. The algorithm should be able to preserve edges, important textured areas belonging to the objects, size and shape of the objects, and other relevant details of the scene. Moreover, they should avoid distortion and changes of perspective of the image.

The proposed method uses Gradient Vector Flow (GVF) for the energy map of the image. The GVF energy map is used to find the connected pixel paths to be considered for removal for image resizing. The vector field produced by GVF helps to preserve the objects by enhancing the edge information during the generation of the possible paths to be removed. The GVF vector field is coupled with significance map for the final selection of the paths to be removed. Significance map denote the visual significance of each pixel with respect to other pixels in the image. Saliency map, which denote the salient regions in an image and depth map, which gives the depth information in a scene together produces the significance map.

BACKGROUND

Image resizing is one of the basic operations for image handling and video editing. It is widely used for image and video display, transmission, analysis.

Seam carving is first introduced in [1], is the most popular content-aware image resizing approach. This method reduces the image by removing the connected path of pixels having low energy in the energy map related to the image to be resized. These connected path of pixels are called seams. Seams can be defined as an optimal 8-connected path of pixels in an image either from top to bottom or from left to right. In seam carving [1] magnitude of the intensity gradient is used as energy map. As the nonadjacent pixels become adjacent after the removal of seam, local gradient may change. It results in the recalculation of the energy map for the selection of the next seam.

Rubinstein, Avidan and Shamir proposed a combination of standard resizing operators (i.e., scaling, cropping) and content-aware based algorithms (i.e., seam carving) [2]. The optimal sequence of operators at each step of resizing determines the visual quality of the final reduced image in this method. Also the computational complexity increases due to the use of different operators.
Saliency is the perceptual quality that makes an object, person, or pixel noticeable relative to its neighbors. The salient regions of an image may include its foreground, parts of the background and other interesting patterns. Low level features like color, intensity and orientation

features in an image can be used to determine the salient regions. Saliency estimation allows processing of images without prior knowledge of their content. The saliency map assigns higher value for more salient pixels in the image. Saliency detection models play a very important role in many computer vision and image processing applications. Applications of saliency detection include the image resizing, regions of interest (ROI) extraction, image classification, and adaptive image compression and so on. For image resizing, not only the dominant objects in the image are essential, but also the contexts of those dominant objects in the image. Thus saliency map helps to detect the visually salient regions and they can be retained while resizing.

The energy map used for seam carving can also be built by using other methods like the entropy energy computed for each pixel into a fixed window or saliency measure of each pixel. Saliency based seam carving are noise robust and computationally efficient [3]. It is because it avoids the recalculation of saliency map after each seam removal, since the saliency of a pixel would not be affected by the saliency of adjacent pixel. The saliency map is obtained from the global saliency of pixels using intensity and color features.

Rosin [4] uses edge to compute saliency. As edge is easy to compute and requires simple or no parameters, edge density is used as a measure of saliency. Distance transform is used to measure edge density.

Saliency of an image is calculated by retaining more frequency content from the original image [5]. Difference of Gaussian filters is used to retain the frequency contents in the image. This frequency tuned approach is used to estimate center surround contrast using color and luminance features. Saliency map resulted from this approach have advantages of uniformly highlighted salient regions with well defined boundaries, full resolution map and computational efficiency.

Content-aware image resizing can be done with Gradient Vector Flow; the relevance of the identified seam can be obtained from the magnitude of the GVF [6]. The saliency map can be used instead of GVF magnitude to avoid the presence of visually salient regions in the seam considered for removal [7].

Depth map gives the depth information in a scene. Depth information of an image can be obtained in different ways from the scene. Depth can be captured by a depth camera such as the Kinect sensor. Disparity map can give an estimation of depth information from stereo images.

THE METHODOLOGY

A novel algorithm for content aware image resizing is introduced in this paper which uses Gradient Vector Flow (GVF), Saliency and Depth map of the image. The GVF energy map is used to find the connected pixel paths to be considered for image resizing. The vector field produced by GVF helps to preserve the objects by enhancing the edge information during the generation of the possible paths to be removed. The GVF vector field is coupled with significance map for the final selection of the paths to be removed. Significance map denote the significance of each pixel with respect to other pixels in the image. Saliency map and depth map together produces the significance map. Saliency map specify the salient regions in an image and depth map gives the depth information in a scene.

Framework of the proposed project is shown below:

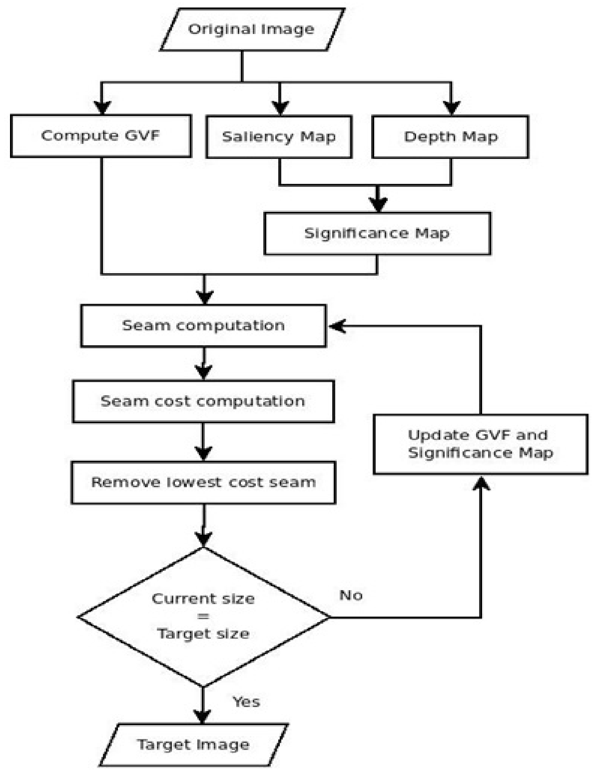

Figure-1. Framework of the proposed solution.

The proposed work involves the following steps:

- Gradient Vector Flow (GVF) computation: It is a vector field which avoids the classical problems that affect snakes. This vector field is used to find the candidate seams that need to be considered for the resizing process.

- Seam computation: In each of the iteration of the seam computation algorithm a fixed number of seams are calculated and returned [7]. Seam computation algorithm uses the properties of GVF. Out of these calculated seams the final selection of the seam for resizing is done by considering the significance map.

- Significance map calculation: Significance map gives the visual importance of each pixel in the image. This is calculated by using the saliency map and the depth map of the image. Saliency map gives saliency value

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of each pixel and depth map specify the depth information in an image.

- Minimum cost seam removal: The cost of each of the identified seams is calculated using significance map. The minimum cost seam from the identified seams is suitable to remove for image resizing.

- Updation of GVF and Significance map: After the removal of minimum cost seam the vector field and significance map are updated. This is done by removing the vector field and significance values corresponding to the removed seam. After the removal of vector field values corresponding to the last removed seam, the GVF is corrected by using the diffusion equations.

Gradient Vector Flow Computation

Gradient Vector Flow (GVF) is a dense force field, solves the classical problems that affect snakes, sensitivity to initialization and poor convergence to boundary concavity. Gradient Vector Flow is the vector field, $V = [u, v]$ that minimizes the following energy function:

$$E = \iint \mu(u_x^2 + u_y^2 + v_x^2 + v_y^2) + |\nabla f|^2 |V - \nabla f|^2 dxdy$$

GVF is calculated from the gradient of an image with the help of diffusion equations.

In the above equation the subscripts represent partial derivatives along x and y axes respectively, is called regularization parameter or blending factor, and $|\nabla f|$ is the gradient of the edge map of the input image. GVF field values are close to $|\nabla f|$ values in areas where this quantity is large and are slowly varying in homogeneous regions. Thus GVF values are stronger close to the edges of objects in the image. Thus it preserves the strong edges and propagates the information related to the presence of strong edges in the neighboring pixels. These properties of GVF vector field is exploited to effectively build the set of pixel paths (i.e., the seams) to be considered for the removal process. The relevance of each GVF path can be derived from the energy map obtained by the GVF magnitude associated to the image under consideration.

Figure-2. (a) Input image (b) GVF.

Saliency

Perceptual quality that makes an object, person, or pixel noticeable relative to its neighbors is called visual saliency. The distinction between noticeable/importance regions and other regions can be done by the saliency. Color, intensity and orientation features in an image can be used to determine the salient regions. The saliency map assigns higher value for more salient pixels in the image. Thus it helps to detect the visually silent objects in the image and can be removed for resizing.

As most images over Internet are stored in the compressed domain of Joint Photographic Experts Group (JPEG), saliency method based on the compressed domain is employed in the proposed method [8]. The Discrete Cosine Transform (DCT) coefficients in the JPEG bit-stream of the image are used to extract the intensity, color and texture features and saliency map is calculated from the extracted features.

Steps in the saliency map calculation are:

- Feature Extraction - Intensity, color and texture features are extracted from the DCT coefficients. DCT coefficients are obtained in the YC_bC_r color space by dividing the image in to 8 x 8 blocks, as color images are encoded in the YC_bC_r color space in JPEG standard. DCT coefficients consist of one DC coefficient and 63 AC coefficients. The DC coefficients are transferred from the YC_bC_r color space to RGB color space. This is used to extract the intensity and color features for JPEG images. Texture information is extracted from the AC coefficients in the Y component of YC_bC_r color space.

- Saliency detection - Feature differences between DCT blocks are calculated for intensity, color and texture features. Feature maps are calculated by finding the weighing for the block differences. Gaussian model of the Euclidean distances between the DCT blocks is used as weighting of the block differences. Saliency value for the block will be larger for larger block differences.

- Final saliency map - The obtained feature maps are integrated to obtain the final saliency map.

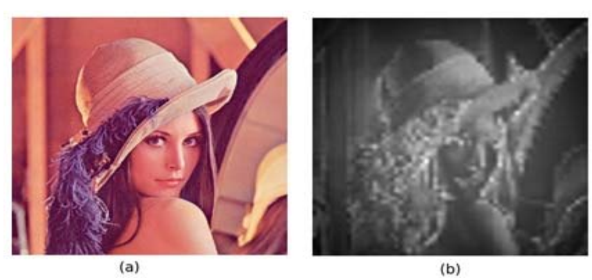

Figure-3. (a) Input image (b) Saliency map.

Depth Map

The depth map of image can get useful information for image resizing. Usually in a scene people pay more attention to the closer objects than distant one. Thus distant pixels are good candidates to be removed in the resizing process. Depth map is an image or image channel that contains information relating to the distance of the surfaces of scene objects from a viewpoint. In a

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depth map the largest depth energy is assigned to the pixels of closer objects and smallest depth energy is assigned to the pixels of far objects in the scene. Depth map for the proposed can be obtained by using the method of single defocused image [9].

Significance Map

The significance map is obtained by combining both the saliency map and the depth map of the image. In this paper the visual significance of each pixel is taken as the largest of the saliency value and the depth value for that pixel. Visually important objects in the seams are identified by considering the significance map of the image used for resizing.

CONCLUSIONS

A novel algorithm for content aware image resizing is introduced in this paper which uses Gradient Vector Flow (GVF), saliency and depth map of the image. Gradient Vector Flow field preserves strong edges by propagating the information about their presence to the neighboring pixels. Seam computation algorithm uses these properties and calculates the seams as far as possible from the edges of the objects. So the shape of the objects present in the image can be preserved. The method also considers the visual significance of each seam that is being considered for removal, to compute the seam cost. The minimum cost seam is removed to resize the image to the target size. Significance map denote the significance of each pixel with respect to other pixels in the image. The visual significance of the image is obtained from the saliency map and the depth map. Saliency map specify the salient regions in an image and depth map gives the depth information in a scene. Final selection of the seam for resizing is based on the combined feature of Gradient Vector Flow field and significance map of the image considering for resizing. Thus an effective resizing of the image based on the content of the image is possible.

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