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# Saliency Based Content-Aware Image Retargeting

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**Abstract:** ***Imaging technology is increasing very rapidly with the advent and development of digital image processing. Evolution and popularity of Internet and various display devices have further given an additive hand for this enrichment. Different display sizes and different resolutions of display devices have made image resizing with content preservation i.e. content-aware image resizing, a challenging task. Image Retargeting aims at resizing the image to a target aspect ratio. To enhance content-aware image retargeting, many techniques have been proposed till now, but it cannot be worked out with one single operator/method. Multi-operator approach is best suited and considered for resizing. This project aims at enhancing the quality of content-aware image retargeting approach by finding out saliency of each pixel while retargeting. Spatial domain is selected to achieve better results, as it works on each pixel.***

**Keywords:** Content-aware image retargeting, GVF, saliency, seam carving, seam vector.

## 1. Introduction

Imaging technology has always been a trending topic for researchers since early ages and more since the development of internet. Images are frequently used in news, stories, and people post their pictures online to be seen by their family and friends. Dynamically changing the layout of web pages in browser should take into account the distribution of text and images, resizing them if necessary. But, the ever increasing diversity of display devices and availability of images has made effective utilization of display space, a challenging task. Wide applications of multimedia technologies has led to significant need of convenient image displays using portable devices such as mobile phones and digital cameras. With recent advances in image technology, digital images have become an important component of media distribution. Digital images taken by digital cameras, generally have higher resolution and fixed aspect ratio. On the other hand, although mobile phones and Personal Digital Assistants (PDAs) typically have increased in popularity in recent years. This makes the image resizing problem to be very relevant, due to their limited resolutions and the need to convert high resolution images for displaying on small screen. However, the resolution and the aspect ratio of the existing image may not match the target display screen. Images typically authored once, need to be adapted for consumption in varied conditions. This crops up the necessity to resize image to a 'target' size according to the display size of the end device.

Only retargeting the image may not take into consideration the important regions, objects in the original image. Also, the features of important objects won't be preserved, which will surely degrade the quality of the retargeted image. Hence, just retargeting isn't at all sufficient for faithful representation of the original image. Salient regions or objects, with their basic features should be represented as the same in the retargeted image. Solutions have been contributed by the computer vision, computer graphics, and human-computer interaction communities. The detection of interesting or salient areas in an image is an important part of computer vision research.

Motivated by the compelling applications and the challenges related to the resizing problem, comes down the necessity for content-aware image retargeting. A considerable body of work in graphics focuses on creating more compelling pictures, and the human-computer interaction community has an interest in exploring novel types of interaction for retargeting images, as well as evaluating the effectiveness of retargeting algorithms in different tasks. It is not about just resizing the image, but the prime necessity of efficient retargeting is to retain the contents in the original image faithfully and effectively in its retargeted version, in terms of visually pleasant image retargeting.

Image retargeting has emerged to be an evergreen topic for researchers since images are dealt by digital cameras and internet. Instead of working on image as whole by segmenting it in mesh, grid or patches, it proved to be beneficial to work on raster scale image i.e on each pixel. This approach has two major advantages over those that work on whole image: 1) It works on each pixel and hence each pixel is given due justice in terms of intensity and position. 2) Important pixels are treated than lesser important pixels to preserve the overall saliency of image.

## 2. Previous Work

Previously, many resizing techniques have been proposed for image retargeting. Cropping refers to removing unwanted part of image to improve framing, enhance subject matter, or to change the aspect ratio. Cropping discards those trimmed pixels, making the image dimensions smaller, but primarily, it changes the scene included, and often the shape too[1]. Scaling performs a geometric transformation which either shrinks an image or a part, or zooms it. But, if the aspect ratio between the input and the output image is different, scaling causes large distortions and introduce shape deformation in the retargeted image[2]. Setlur et al. [3] introduced a segmentation based approach that crops foreground objects from the background and scale the extracted foreground and background differently. But their method heavily depends on the segmentation quality. Warping-based methods, also referred to as continuous methods, perform non-linear distortion to obtain the resized image. The basic idea of this method is to constraint the local distortion of important areas in the image as small as possible, while the unimportant regions are allowed to distort more. Hence, this results in preserving both important and unimportant areas in the final image, which are useful for preserving context for the relevant objects[4]. Methods based on image patches achieve retargeting through the manipulation of patches. These algorithms use distances between image patches, aiming to minimize a distance measure between the input image and the retargeted image. Patches are then rearranged to form the final image[5]. Seam carving technique by Avidan and Shamir[6] is a popular Image Retargeting method which removes seams from an image, which are classified as insignificant i.e this method decreases image width or height, one pixel at a time, thus removing out areas of less importance. Seam carving works by finding the lowest-energy connected path of pixels from either left to right (*horizontal seam*) or top to bottom (*vertical seam*), removing those pixels, and repeating the process until the desired image size is achieved. Pritch et al [7] introduced geometric rearrangement of images for operations such as image retargeting, object removal or object rearrangement. All these operations are characterized by shift map which means relatively shifting every pixel in the output image from its source in an input image. Rubinstein et al.[8] present a user study that concludes that users generally prefer to combine different retargeting operators (such as cropping, scaling and seam carving) to obtain more pleasing results, rather than relying on the use of a single operator.

## 3. Proposed Methodology

Image retargeting becomes a challenging problem due to some of the following reasons:

1. Real-world scenes exhibit tremendous variability, and the techniques are expected to handle different kinds of imagery, such as barren landscapes, complex scenes with no clear foreground-background segmentation.
2. Images taken out door have different overall characteristics from that of the images taken indoor.
3. The definition of important can depend on the application being considered. Crowded and complex scenes prove to be a typical failure, due to automatically determining what is considered important in the image.

Considering the above problems, it is clear that some factors have to be considered before retargeting an image. Subjective analysis or user interaction should be carried out for deciding the 'important' parts of the image. Although subjective analysis plays a crucial role for replicating the output image as that of original ones, there should definitely be some common criteria which forms a basis for an acceptable form of 'content-aware retargeted' version of original image. The basic criteria here, build with some mathematical formulations is called **Saliency Map.** Visual saliency refers to the properties of visual stimuli that are exploited by the human visual system in the task of visual attention and rapid scene analysis. Saliency map aims at preserving these 'salient' regions in the image. In our project we have given priority to the basic structure of object i.e. shape, which is provided by GVF algorithm and also the visual saliency of each pixel in terms of content retention. Hence our saliency map will aim at preserving the edges of objects derived from the gradient flow of the image and saliency from cost of each pixel[9].

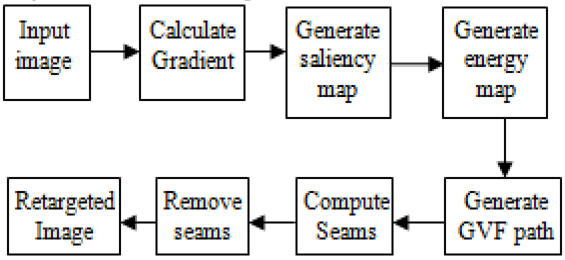



**Figure 1:** Block Diagram for saliency-based content-aware image retargeting

The generalized description can be termed as follows: The image to be retargeted and resized is taken as input. Images of various file formats (.bmp, .jpg, .png) and from various sources (standard database, internet images, etc.) serve good as inputs to operate upon, for retargeting application. Firstly we will calculate gradient flow, so that we come to know the important objects in the image. Here, Sobel operator/mask is operated on the original image to detect the edges determining the objects in image. Performing masking operation is simply convolution of the mask with underneath image intensity values. Two different kernels are used for detection of horizontal as well as vertical edges. When important objects in the image are determined, saliency map is built aiming to preserve the important objects in the retargeted image. Saliency map aims at preserving these visually important regions in the image. Saliency map is constructed first by blurring the original image using 3x3 Guassian filter, instead of constructing directly from the original image [10]. Energy map is generated and energy of pixels is calculated by calculating cost of each pixel. A seam is 8-connected path of pixels (from top to bottom or from right to left, depending on which dimension is to be reduced) that contains only one pixel per row or per column.

There are two primary criteria for describing the energy of a seam: backward-energy and forward-energy. The backward-energy criterion uses an energy map defined as:

$$E_g(x, y) = \left| \frac{\partial}{\partial x} I \right| + \left| \frac{\partial}{\partial y} I \right| \quad (1.1)$$

where, $E_g(x, y)$ is the resulting importance value of a pixel at column $x$ and row $y$. $I$ is the gray scale intensity image.

GVF is a dense force field, useful to solve the classical problems that affect snakes: sensitivity to initialization and poor convergence to boundary concavity. Starting from the gradient of an image, this field is computed through diffusion equations. GVF is defined as a vector field **F** of vectors **v(x,y) =** [u(x,y),v(x,y)] that minimizes the following energy function:

$$E = \iint \mu(u_x^2+u_y^2+v_x^2+v_y^2) + |\nabla f|^2 |\mathbf{v}-\nabla f|^2 \, dxdy \quad (1.2)$$

This method exploits the gradient vector flow of the image to establish the paths to be considered during resizing. Thus, this technique exploits the properties of Gradient Vector Flow (GVF) to properly detect the seams to be removed, without introducing artefacts in the resized image. The relevance of each GVF path is derived from an energy map related to the magnitude of the GVF associated to the image to be resized. GVF generates a vector field useful to preserve objects by enhancing edges information during the generation of the possible paths to be removed. The vector field produced by GVF is also coupled with a visual saliency map, in order contents of the image during the content-aware resizing, GVF paths are selected based on their visual saliency properties.

A path of pixels with minimum cost is evaluated and removed in retargeting operation. After computing the set of candidate seams $\{s_1, s_2, . . . , s_k\}$, a cost is associated to each seam by considering the sum of the GVF magnitude $|GV F|$ of the pixels belonging to the seam. Specifically the cost $c_k$ of a seam $s_k$ is computed as follows:

$$c_k = \sum_{(i,j) \in sk} |GVF\ (i,j)| \quad (1.3)$$

But with saliency based approach, cost function will be:

$$c_k = \sum_{(i,j) \in sk} Saliency(i,j) \quad (1.4)$$

Seam is defined as an 8-connected path of low energy pixels in the image, either from top to bottom, or from left to right; containing one and only one pixel in each row or column of the image. This helps in maintaining the rectangular shape of the image while resizing.

For calculation of seams, first traverse the image from the second row to the last row and compute the cumulative minimum energy $M$ for all possible connected seams for each entry as:

$$M(i,j) = e(i,j) + min\ (m(i-1,j-1),M(i-1,j),M(i-1,j+1) \quad (1.5)$$

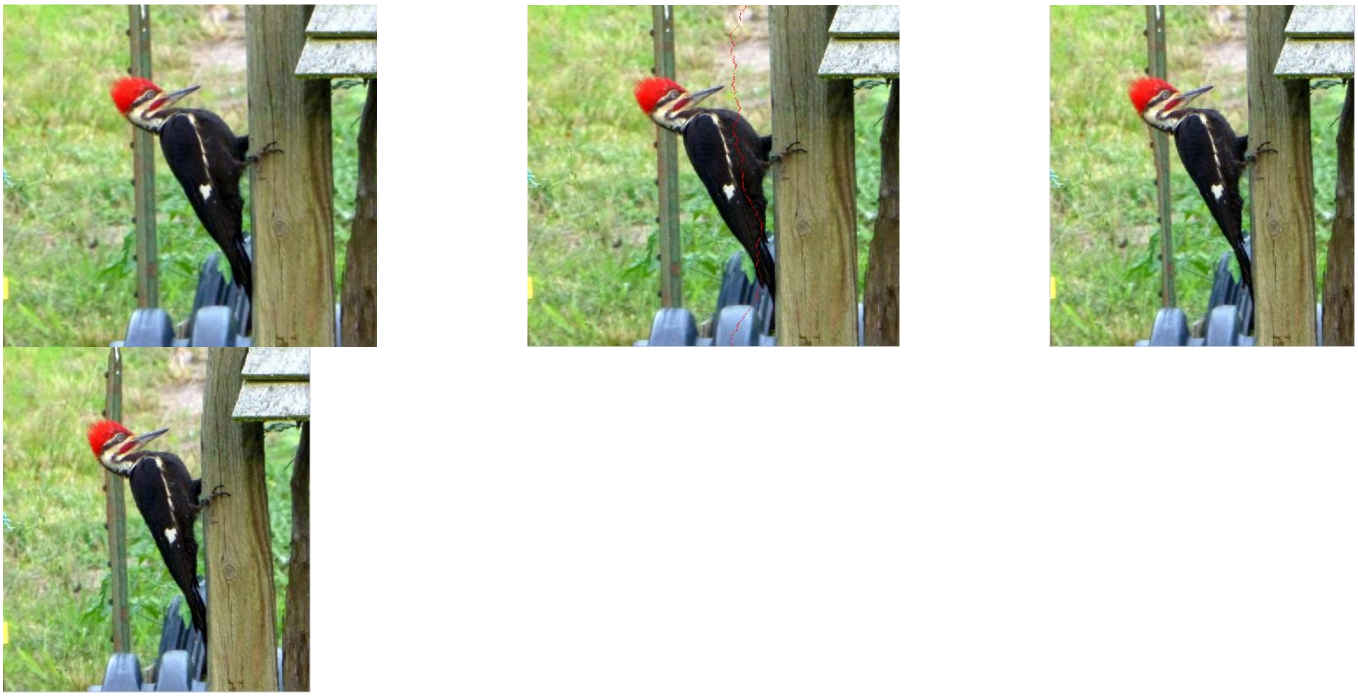
At the end of this process, the minimum value of the last row in $M$ will indicate the end of minimal connected vertical seam. Next, backtracking from this minimum entry on M is done, to find the path of optimal seam[11].

The seam with the lower cost $C_k$ is removed from the image at each iteration. The GVF map is then updated and a new iteration of the seam removal algorithm is performed for each seam to be removed. Thus, removing a vertical/horizontal seam reduces width/height by one pixel. By finding the global minimum energy seam, removes the least salient content. Hence, along with finding backward energy, forward energy criteria was also considered during energy map generation, which results in an improved version of finding out the seams to be removed. Remove the seams along the seam path till target aspect ratio is achieved.

Retargeted image appears in the form of targeted size which is predefined by the user. Images with different file formats, with different sizes are considered for retargeting according to application chosen.

## 4. Experimental Results

The performance of a content-aware image resizing algorithm strongly depends on the adopted energy map which captures the salient regions of an image. We propose to use GVF to build the seams during the resizing. The selection of the seams to be removed is then driven by GVF magnitude or by the saliency map. As estimation approach to build the visual saliency map we used the one proposed in [10]. In order to evaluate the results of our approach we have compared it with respect to approach without considering saliency (eqn (1.3)) and considering saliency (eqn(1.4)). In order to objectively assess the performances of the aforementioned methods, we have found tested the method on the basis of Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR). Four datasets are considered, two of them with standard image retargeting database, one with standard database for natural images and other containing images randomly from the internet. Almost 130 images are considered for evaluating results. The dataset contains enough varieties of scenes and objects which also appear in multiple instances and in different locations (not only centered).



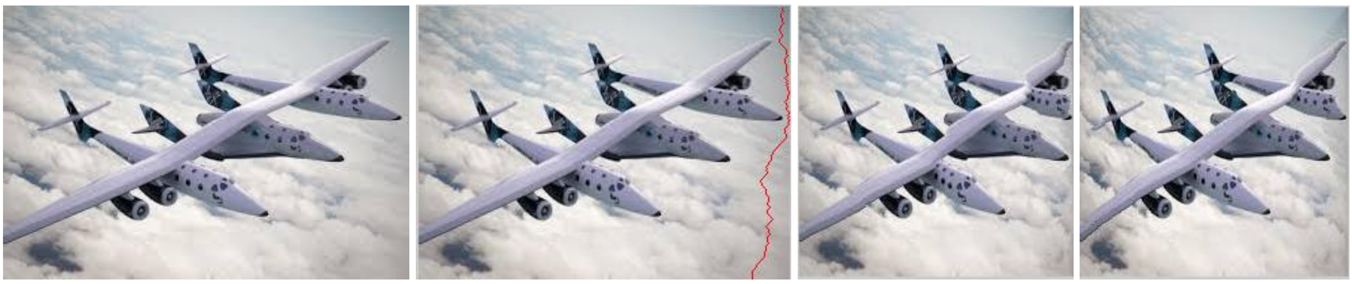


Fig 2: Above all images are retargeted to 80% of the original image. Column 1: Original Image Column 2: Image with seam path Column 3: Seam removed image Column 4: saliency based seam removal(proposed method). Maximum images considered have important objects spread out on full dimension of image, and not concentrated in any specific area. Results show that proposed method works for all types and formats of images and is not restricted to any specific image. Proposed method also works well with animated and HD images(row8).

The MSE and PSNR values for the considered four datasets are evaluated in table given.

**Table 1**

| Images | MSE | PSNR(dB) |
|---|---|---|
| Standard image retargeting database (.jpg) format | 0.0481 | 61.68 |
| Standard image retargeting database (.png) format | 0.111 | 57.93 |
| NRID database for natural images | 0.067 | 60.133 |
| Images from internet | 0.0936 | 58.701 |

Above table shows MSE and PSNR values for four different database.

Higher PSNR values indicate that retargeted image is quite efficient to preserve all the contents with good visual quality that as the original image.

The graph of MSE and PSNR values for the considered four datasets are evaluated.

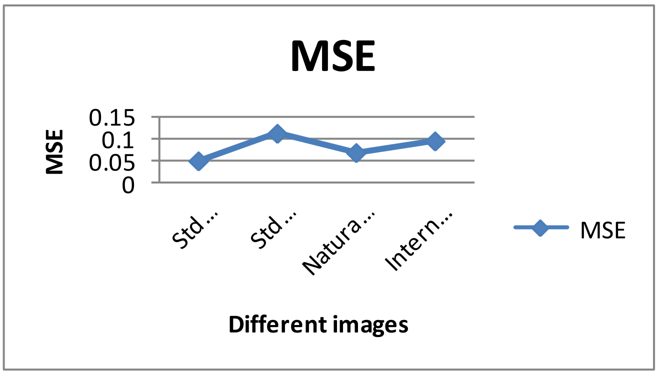



**Figure 3:** Graph for MSE for four database considered. Error for (.png) format image is highest.

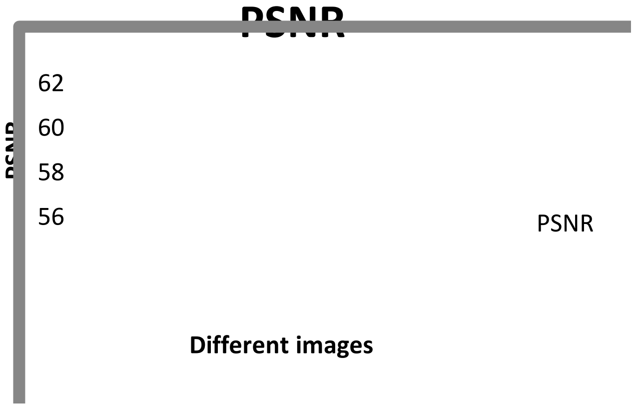



**Figure 4:** Graph for PSNR for four database considered. PSNR for standard retargeting database (.jpg) images is highest.

## 5. Conclusions

Image retargeting is emerging as an important necessity with the evolution of new digital devices and displays. This method can be further extended to enhance the visual quality of retargeted image by considering saliency of each pixel. More than one operators i.e. multi-operator approach works best for good image retargeting. GVF method helps to briefly select the seam paths in plain regions and keeping the important contents and objects in the image unharmed and also reduces the time computations and calculations. Hence proposed method proves better results as it exploits characteristics and advantages of more methods.

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