Improved Seam Carving for Image Resizing Using GrowCut

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Abstract

Seam Carving is an image processing operator for content-aware image resizing. However, it sometimes fails to protect important objects in the image. In this paper, a new interactive image resizing technique is proposed, which combines Seam Carving and GrowCut image segmentation algorithm to perceptually improve the visual effects after image resizing. GrowCut is utilized to select the objects in the image for retaining or removal. An intuitive and easy user interface is also supported because user just needs to draft some trails inside and outside the object to select the Regions of interest (ROIs) automatically for object removal. Simulation results demonstrate that the proposed approach can easily remove or protect the region of interest in the image.

Keywords: Image Processing, Seam Carving, GrowCut, Image Resizing.

1. Introduction

Image Resizing is important for its adaptation to various display terminals including mobile phones and PDAs. Most image resizing methods such as cropping and scaling result in serious loss of information or distortion in the images. Seam Carving is an effective image processing operator for content-aware image resizing[1]. It generates an energy map from gradient intensity of pixels and searches for seams, which are vertical or horizontal continuous paths of pixels that run through local minimum energy areas. Removing or inserting pixels along a seam enables users to shrink or enlarge pictures by a wide range, while still retaining all details of the image.

However, in original Seam Carving, many seams often over-concentrate in a particular low energy area of the image, causing an irregular distortion in the surrounding image. Adverse effects of the distortion are conspicuous if these areas contain straight lines of artificial objects, making the resulting image look unnatural. There are already a few works existed in the literature on the improvement of seam carving [2-4]. They are mainly to speed up the resizing process. Huang H. et al. present a more efficient algorithm for seam based content-aware image resizing[2], which searches seams through establishing the matching relation between adjacent rows or columns. A linear algorithm is used to find the optimal matches within a weighted bipartite graph composed of the pixels in adjacent rows or columns. Dong W. et al. propose an optimized image resizing algorithm using seam carving and scaling[3]. It achieves content-aware image resizing based on optimization of a well-defined image distance function, which preserves both the important regions and the global visual effect (the background or other decorative objects) of an image.

For image resizing, user usually wants to protect or remove specific object in the image. However, automatic image resizing by seam carving is difficult to meet this requirement because the energy function by low-level features is hard to discriminate different object with high-level semantics. If an intuitive and easy user interface is provided to user to define the semantic object to be protected or removed, it will be beneficial to image resizing.

In this paper, an improved Seam Carving algorithm is proposed for image resizing. An image segmentation method, i.e., GrowCut [5] is combined with the original Seam Carving algorithm to automatically select the region of interest by draw one line inside the object and one line outside the object. The benefits are two-folds. First, it does benefit to preserve image content and avoid distortion.
Second, an intuitive and easy user interface is also supported and thus the user can control the resizing process.

The rest paper is organized as follows. In section 2, the original Seam Carving operator and GrowCut are briefly described respectively. In section 3, the proposed approach is discussed in detail. The experimental results are illustrated in Section 4 and Section 5 concludes this paper.

2. Background work

2.1. Seam Carving

The idea behind the seam carving technique is to remove unnoticeable pixels that blend in with their surroundings. An energy function is used to compute the energy of every pixel. Then, the dynamic programming algorithm is used to find and remove the seam of lowest importance. In the original seam carving by Avidan and Shamir, the energy functions are defined by gradient magnitude as follows:

$$ e(I) = \left| \frac{\partial}{\partial x} I \right| + \left| \frac{\partial}{\partial y} I \right| $$

where $I$ is the pixel value of image. A seam is found by tracing the path from one edge of the image to the opposite edge through the path with the least energy defined by the following equation:

$$ S^* = \min_s E(s) = \min_s \sum_{i=1}^{n} e(I(s_i)) $$

In addition to gradient magnitude, Seam Carving can support several types of energy functions such as entropy, visual saliency, eye-gaze movement, and more. The removal or insertion processes are parameter free. However, to allow interactive control, we also provide a scribble-based user interface for adding weights to the energy of an image and guide the desired results. This tool can also be used for authoring multi-size images. However, Seam Carving sometimes fails to protect important objects in images (such as human beings), when either the energy content of the object is low with respect to its surroundings, or, the number of seams removed is very large.

2.2. GrowCut

Image segmentation is an integral part of image processing applications. The existence of reliable and efficient image segmentation techniques can benefit a wide range of computational vision algorithms. Among thousand of image segmentation techniques existed in the literature, GrowCut is an interactive image cutout tool designed to extract solid or opaque objects. Given a small number of user-labelled pixels, the rest of the image is automatically segmented by a Cellular Automaton. The process is iterative, as the automaton labels the image, user can observe the segmentation evolution and guide the algorithm with human input where the segmentation is difficult to compute. For detailed information about GrowCut, please refer to [5][6].

GrowCut is of high degree of interactivity, which allows easy and intuitive correction, and controllable boundary smoothness can be obtained. Other valuable advantages of GrowCut are its simplicity, multi-label assignment, speed and easy extensibility. Therefore, GrowCut can meet the requirement of user control in image resizing so as to remove or protect an object in the image. Thus, we are motivated to use GrowCut in combination with seam carving.
3. Our proposed approach

3.1. Proposed Method

Our approach is to remove pixels in a judicious manner. Therefore, the question is: how to choose the pixels to be removed? Our goal is to remove unnoticeable pixels that blend with their surroundings by using a simple user interface for object removal.

User can specify the importance of individual pixels by draft some trails or points inside and outside the object, thus, selecting all the object on the image.

The block diagram of the proposed approach is illustrated in Figure 1. The input image is firstly processed by GrowCut. In this step, we draw line inside the region of interest (object) and draw line outside it and after that this process will select all the object automatically. The second process is to modify image energy. It is in fact a selection of object removal or object protection. If it is to be protected, the energy of the object by GrowCut is set high. Otherwise, if the object selected by GrowCut is to be removed, its energy is set low. The third process is image resize by Seam Carving. After successively removing seams, the output image will achieve the desired resolution.

![Figure 1. Block diagram of the proposed algorithm](image)

By combining Seam Carving and GrowCut, user can select object or region of interest by just drawing one line inside and outside the object, respectively. These two lines will automatically select or identify the object to be protected or removed by GrowCut. Figure 2 illustrate the process of user intervention in GrowCut. After drawing two lines, the key points along them are determined, and the final object selected by GrowCut is illustrated in Figure 3. Obviously, it is of smooth object boundary,
and the user intervention is quite simple because only two rough lines inside and outside the object are needed.

![Figure 2. shows the line inside and outside the object](image)

After that, user can modify the image energy by choosing "protect selected" or "remove selected" and set the desired image resolution after image resizing. Both step by step mode and batch mode are supported. That is, user can remove just one connected line of pixel, i.e., seam, every time or remove all the seams just in one step until the desired image resolution is achieved.

The Pseudocodes of the implementation of the proposed approach is illustrated as follows:

```plaintext
GET Image, NewHeight, NewWidth
Compute ImageEnergy
Select nodes from inside the object, nodes from outside the object

Define Object           // Using GrowCut algorithm
IF mode = protect THEN  // Update image energy
    Set ImageEnergy = Max. energy for selected object
ELSE
    Set ImageEnergy = Min. energy for selected object
ENDIF

While ImageHeight ≠ NewHeight  // Using seam carving technique
    Remove Horizontal Seam
ENDWHILE

While ImageWidth ≠ NewWidth
    Remove Vertical Seam
ENDWHILE

DISPLAY Final Image
```

![Figure 3. The selected object by GrowCut](image)
4. Experimental results and analysis

We have implemented and tested our image resizing algorithm on a PC with Intel CPU 2.33GHz, 1GB RAM. The programming software is MATLAB 7.0 under Windows XP. The reference codes of GrowCut and Seam Carving are both from the MathWorks file exchange \([7,8]\). The GUI of the proposed approach is illustrated in Figure 2.

4.1. Comparison between Seam Carving and other methods

Using Seam Carving for image resizing is the best method by comparison with the previous methods. First, in Cropping we can protect only one region of interest; If an input image has two ROIs on opposite corners of image so in order to include both of the ROIs in Cropped result, the bounding box will be the same size as the original image, to solve this problem we must lose important part of the image, and this is illustrated in Figure 4, but by using Seam Carving we can protect all the regions of interest because it can change the size of an image by removing the low energy pixel without need to lose any important part and this result is very clear in figure 4.

![Figure 4](image)

**Figure 4.** shows two images: the first one (in the left) using Seam Carving to resize the image and the second one (in the right) using Cropping for resizing the same image with the same size and we lose one object from the image.

Second, in Exaggerating and Cut & paste, both techniques have also disadvantages as by warping the back-ground to emphasize the ROIs, the context of the original image is lost. It becomes impossible to tell how big the ROI is in comparison to the rest of the image. Also, these techniques are limited to a single ROI. If the image contains multiple ROIs, the most important region is selected to be emphasized while all others are de-emphasized, but in the seam carving we solve this problem by resize the image without need to lose any ROI.

4.2. Comparison between object removal and our method

Object Removal is done for resizing images by painting all the object but our method is using GrowCut method. By this method we do not need to paint all the object, but just make points or lines for selecting the object because Grow Cut algorithm can treat pixel labeling process as growth for domination of bacteria. This bacteria start to spread (grow) from the seed pixels and occupy the ROI, by using this method we can protect the important objects in images.

This will be done automatically, thus, the selection will be more efficient while the old painting way is manually, thus, the selection is not efficient and in figure 5, 6 and 7 we illustrate the deferent between our method and the painting one.
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Figure 5. shows our method (in the left) where the object is selected automatically and in Efficient way (we just draw two lines), while in the painting way (in the right), the object is selected manually and not efficient.

Figure 6. (a) the original (b) the map of points white is selected object the black is outside the object (c) the selected object (d) the white part show us the selected area.

Figure 7. In the top images we show the protected object and in the down images we show the removed object.

By using our method the execution time is not the same, it takes less time than the painting one.
4.3. Comparison between "Interactive Region Growing" and our method "GrowCut"

"Region Growing" is a basic image segmentation method, where a user can select a whole region of pixels by clicking on some seed point inside some object of interest. The basic idea of the method is to "grow" the region (from a single seed) by adding neighboring pixels when the difference of intensity between the neighbors is smaller than some fixed threshold.

In our method we use GrowCut, by our experiment we illustrate that the GrowCut is the best method for selecting objects because GrowCut is high degree of interactivity, which allows easy and intuitive correction, and controllable boundary smoothness can be obtained. Other valuable advantages of GrowCut are its simplicity, multi-label assignment, speed and easy extensibility. But in the "Region Growing", the main problem is the ‘leaking’ of the growing region through ‘weak’ boundaries and more suitable for medical images and the leaking is very clear in figure 8 and 9.

![Figure 8](image1.png)

**Figure 8.** shows "Region growing" and it is leaking of the growing region through ‘weak’ boundaries.

![Figure 9](image2.png)

**Figure 9.** shows "Region growing" and it is leaking of the growing region through ‘weak’ boundaries.

Therefore, GrowCut can meet the requirement of user control in image resizing so as to remove or protect an object in the image. Thus, we are motivated to use GrowCut in combination with Seam Carving.
5. Conclusion

We present a new Seam Carving algorithm for image resizing that supports content-aware image resizing for both reduction and expansion. A seam is an optimal 8-connected path of pixels on a single image from top to bottom, or left to right. By combining Seam Carving and GrowCut (cute segmentation), we protect or remove the region of interest by telling the image energy function to make new map of energy to guide the seam to be an optimal seam and improve the visual effects after image resizing.

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7. References