Image Recomposition Using Seam Carving and Insertion Considering the Rule of Thirds

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** Short Paper*

***Abstract*:** In this paper, we present an algorithm for adjusting the position of a user-specified object considering image aesthetics. Specifically, the user-specified object is positioned according to the rule of thirds by inserting or deleting unimportant seam lines from the image. To find such seam lines, a novel weight map is designed using the spatial and color distances from the object. We also design and analyze two approaches to seam carving and insertion. Experimental results show that the proposed method can be used as an effective semi-automatic image recomposition scheme.

***Keywords*:** Photo retargeting, Seam carving, Rule of thirds

1. Introduction

Our subjective impression about a scene is heavily dependent on the spatial arrangement of objects. Finding the proper position for the object to be captured is not straightforward since multiple factors, including line, shape, color, light, and texture, are involved in image aesthetics. However, there is one widely used rule called *the rule of thirds*, which describes a position for an object, as shown in Fig. 1, most suitable for drawing attention or interest [1]. Following the rule of thirds, a photographer can wait a long time for an object to be in the target position, or move to a proper position for a static scene. It is a tedious procedure for experts, so it is also difficult for amateurs to follow such a strict guideline. Therefore, an automatic or semi-automatic post–image composition scheme is clearly desirable. To this end, there have been many publicly available photo editing schemes, including classic cropping or resizing. One interesting approach called *object-based image editing* [2] explicitly extracts the object and applies complicated transformations with extensive user interactions. Meanwhile, an image in-painting scheme [3] is used to crop and move the object region and fill the empty region from background patches. However, the above explicit object manipulation methods need excessive user intervention, or perform correctly only for salient objects.

In this paper, we propose a simple but effective image editing method using a seam carving algorithm [4]. Seam carving has been considered a suitable scheme for content-aware image resizing. In particular, Shafieyan et al. [5] used depth data to define the saliency map, and Dong et al. [6] used a well-defined image distance function. Wu et al. [7] also investigated a speed-up scheme toward seam selection.

The goal of our algorithm differs from the above seam carving–based methods. We attempt to preserve the size of the image but move a specific object toward a specific position. To this end, we perform seam carving and seam insertion by the same amount. We also introduce two different ways of detecting seam lines to be added or deleted, given simple user inputs and target-object position.

2. Proposed Method

The proposed method first receives from user input a rectangle encompassing the object of interest plus the center point of the object of interest. The target position of the object is then determined as the nearest point from among the four intersection points shown in Fig. 1. Comparing the center and target points, the number of seam lines to be added or deleted can be obtained. The following subsections detail the initialization, weight map construction for seam line detection, and seam carving/insertion method, respectively.

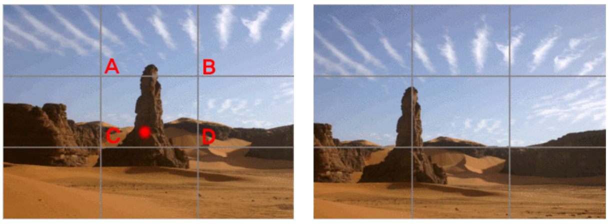


Fig. 1 Example of the rule of thirds. Objects can draw more attention when they are located around the intersection points (A-D).

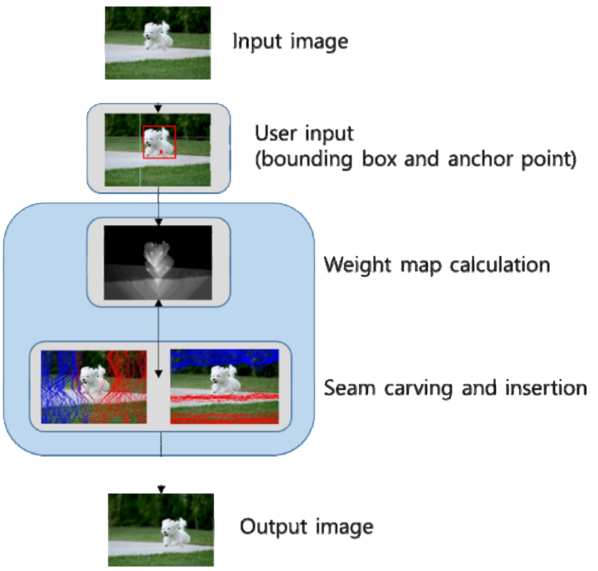


Fig. 2. The flowchart of our photo recomposition method.

2.1 Initialization

In the proposed method, the object to be moved is first selected by the user, who draws a bounding box and locates the anchor point of the object. The anchor point is used to determine the position to be designated as the target point. That target position of the object is then determined as the nearest intersection point. Specifically, the center position of the object is moved to the selected nearest intersection point. In this way, the number of seam lines to be deleted and inserted can easily be computed.

2.2 Weight map construction

When inserting or carving the required number of seam lines, it is necessary to find seam lines that are not visually important and not close to the object of interest. To this end, we define two weighting functions. First, the spatial distance to the center location is used to give a high weight to the pixels close to the object. Let G_S denote the spatial distance, defined as

$$G_S(i,j) = \exp\left(\frac{-\left((i-i_c)^2+(j-j_c)^2\right)}{2\sigma_S^{\;2}}\right) \tag{1}$$

where (i_c, j_c) denotes the center coordinates of the object. The standard deviation σ_S is empirically chosen as 0.91 x D, where D is the diagonal length of the image. In addition, the color distance to the median color of the object is used to assign a high weight to pixels with a similar color. Let G_C denote the color distance, defined as

$$G_C(i,j) = \exp\left(\frac{-c_{i,j}^{\;2}}{2\sigma_c^{\;2}}\right) \qquad c_{i,j} = \sqrt{(\bar{r}-r_{i,j})^2+(\bar{g}-g_{i,j})^2+(\bar{b}-b_{i,j})^2} \tag{2}$$

where $r_{i,j}$, $g_{i,j}$, and $b_{i,j}$ denote the red, green, and blue color channel values at (i, j), respectively, and $[\,\bar{r}\ \bar{g}\ \bar{b}\,]$ is the median color vector of the object. The standard deviation σ_C is empirically set as a large value of 5.47 x 70 because of the ambiguity at selecting the anchor point during the user initialization.

Finally, weight map $W(i, j)$ is obtained by multiplying the spatial and color distances:

$$W(i,j) = G_S\left(i,j\right) \times G_C(i,j) \tag{3}$$

2.3 Seam Carving and Insertion

Given the weight map, we perform seam carving and insertion. We use the conventional seam carving algorithm [4] using a modified weight map. Specifically, energy value $E(i,j)$ is defined as

$$E(i,j) = e(i,j) \times W(i,j) \tag{4}$$

where $e(i, j)$ represents local energy computed from the gradient magnitude [4]. To give a high weight to spatially close and color-similar pixels, the weight map in (3) is multiplied with the conventional energy value.

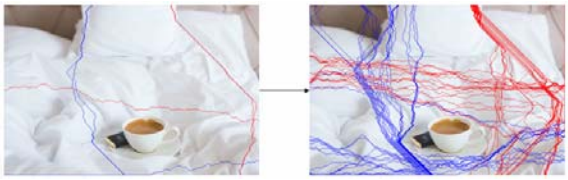
We then use the same seam line detection method by accumulating energy values as follows:

$$\begin{aligned} M(i,j) &= E(i,j) \\ &+ \min(M(i-1,j-1), M(i-1,j), M(i-1,j+1)) \end{aligned} \tag{5}$$

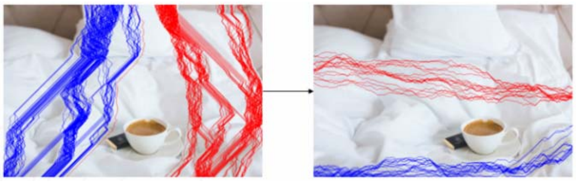
where $M(i,j)$ represents accumulated energy at (i, j). Since seam carving simply deletes visually unimportant seams from the image, we can follow the conventional method without modification. However, a problem occurs when seam insertion is performed.

3. Two approaches to Seam Carving and Insertion

Our method performs both seam carving and insertion. Since implementation of seam carving and insertion is not straightforward, we consider two approaches. The first is to proceed with seam carving and insertion in the vertical

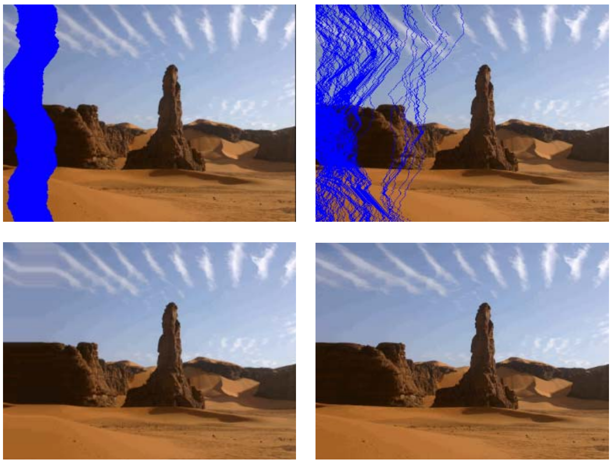


(a)



(b)

Fig. 3. Two approaches to seam carving and insertion: (a) repetition of one-pair seam carving and insertion, and (b) all-at-once seam carving and insertion.



(a) **(b)**

Fig. 4. The inserted seam lines (above) and recomposition results (below) for (a) the first and (b) the second seam carving and insertion approaches, respectively.

and horizontal directions alternately, as shown in Fig. 3(a). A pair of seam lines to be deleted and to be inserted is found in one direction. Then, another pair of seam lines is found in another direction. The iterations are finished when the required number of seam lines are carved and inserted. The second approach is to find all seam lines to be deleted and inserted in one direction, and then to repeat the process in another direction, as shown in Fig. 3(b). In the second approach, the algorithm performs seam carving and insertion in one direction until the end.

The main difference between the two approaches is that the first approach finds two seam lines to be inserted and deleted, turn by turn, and the second approach finds all seam lines at one time. The first approach iterates seam carving and insertion in both the horizontal and the vertical directions. The second approach finds the required number of seam lines in one direction first and then proceeds with the seam carving and insertion at one time. The first approach is sometimes problematic, as shown in Fig. 4(a), when the same seam line is repeatedly inserted. The second approach is free from this problem since all the required seam lines are found together.

Table 1. Processing time of the two approaches.

Image	Size(pixel)	Time(sec)	
People	600×449	**Approach 1**	**210**
		Approach 2	349
Tree1	700×437	Approach 1	360
		Approach 2	483
Butterfly	900×562	Approach 1	815
		Approach 2	1248
Tree2	960×635	Approach 1	989
		Approach 2	1550

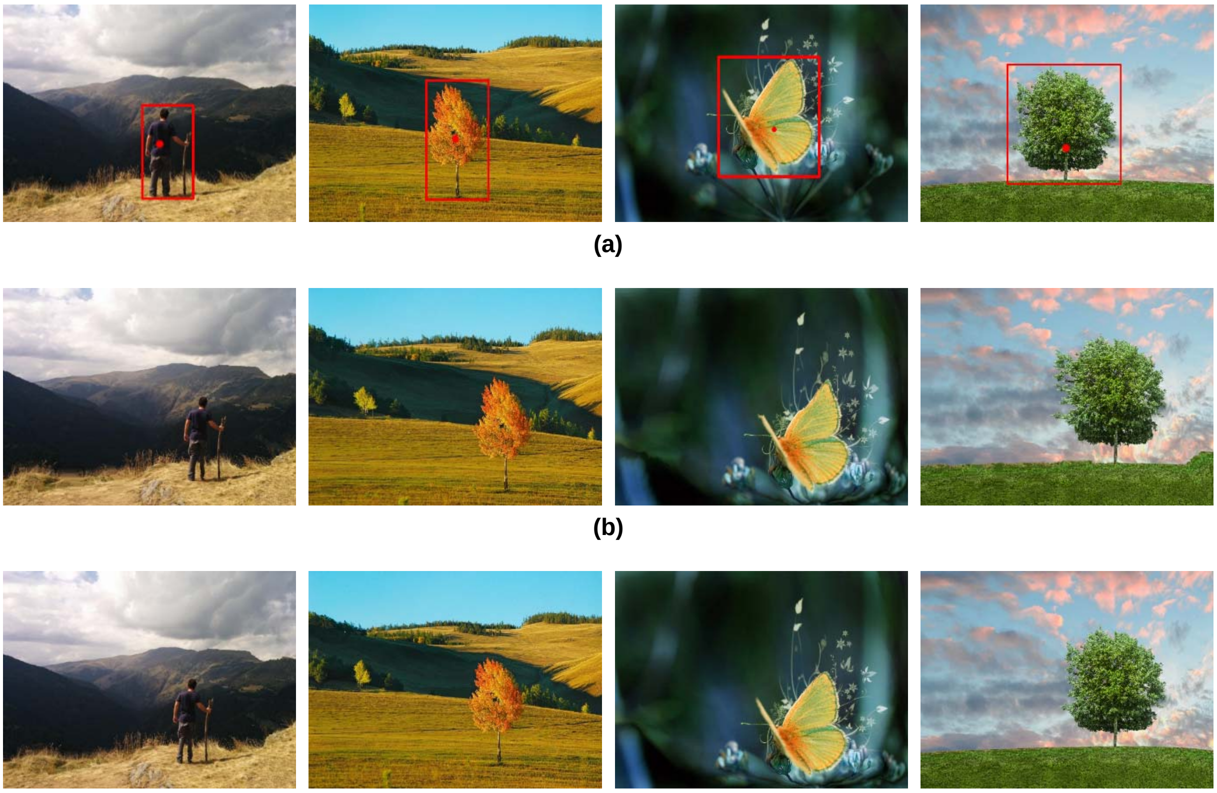
4. Experimental Result

Fig. 5 shows our experimental results. We can see that the object of interest is successfully moved to the position satisfying the rule of thirds. Each algorithm was executed on a PC with an i5-4670 CPU and 8GB memory. The source code is unoptimized, and was mainly developed to examine the quality of recomposition in the images. Table 1 compares the processing time of the two methods. The second approach finds the all seam lines together, but the same number of seam lines for seam carving and insertion should be found. Therefore, it is possible to perform unnecessary seam line searches when only enough seam lines are found for either carving or insertion. Instead, the image size is sequentially reduced during seam line selection. On the other hand, the first approach finds seam lines with the same size from the image. However, a wasteful seam line search problem is not severe in the first approach. Thus, the first approach is found to be faster than the second. Although it is difficult to evaluate the quality of recomposition results, because the reference image is not available, the second approach produces fewer artifacts because the detected seam lines are more diversely distributed.

Fig. 6 shows a failure in our method. The proposed method may not work properly when the object to be moved is located around the image boundary or it is too large. Finally, although the proposed methods require minimal user input, we plan to exclude user intervention to make a fully automated algorithm.

5. Conclusion

In this paper, we proposed a simple but effective photo recomposition technique that moves the object of interest in a given photo in accordance with the rule of thirds. Seam carving and insertion operations are applied to move the object, and two effective implementation schemes of seam line detection are also studied and experimentally



(a)

(b)

(c)

Fig. 5. Experimental results. (a) Input image, (b) the result of pair-wise seam carving and insertion, and (c) the result of all-at-once seam carving and insertion.

(a) (b) (c)

Fig. 6. A failure. (a) Input image, (b)-(c) output image of the first and second approaches.

compared. Experimental results show that the proposed method can be used as an effective semi-automatic image recomposition scheme.

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