A solution to a defect and details of Integration of color and texture cues in a rough-set–based segmentation method

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Abstract

The purpose of this study is to make a better implementation of an approach of image segmentation proposed by Rocio A. Lizarraga-Morales, Raul E. Sanchez-Yanez, Victor Ayala-Ramirez and Fernando E. Correa-Tome in Integration of color and texture cues in a rough set–based segmentation approach.[1] In this paper, some details and a defect of the approach are discussed and a completed implementation is provided. The implementation solves the defect and segments images better in qualitative comparison compared with the original implement.

1. Introduction

In computer vision, image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super-pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze.[2] Lizarraga-Morales et al. proposed an approach, which is named RCT, to segment images with both color cue and texture cue in a rough set–based segmentation method. In the paper of Lizarraga-Morales et al., a framework and some of the details of algorithm is given and the conclusion states that their method yields better outcomes, outperforming other rough set–based approaches and state-of-the-art segmentation algorithms.[1] Nonetheless, there are details that aren't explained and the experiment result shows a defect as well, which are discussed later in this paper. A specific implementation of the approach is proposed as well. This implement is base on the content of the referred paper, but it's differed from the algorithm described in that paper on framework and details. The qualitative comparison shows that the implementation solved a major defect of the original implementation and has improvement on segmentation.

2. Related work

In this section, some theory and methods related to the approach is introduced, mainly about their advantages and disadvantages for image segmentation. The images used in this paper are from the Berkeley Segmentation Dataset300(BSD)[5], a dataset for image segmentation.

2.1. CIE*Lab* Color Space

The CIE*Lab* color space is used in RCT. The main advantage of the CIELab color representation is that the Euclidean distance between two points is proportional to the difference perceived by a human between the two colors represented by these points. This ability to express color difference of human perception by Euclidean distance is very important because any direct comparison can be performed based on geometric separation.[1] In RCT, this ability is used for extract spatial information.

Using CIE*Lab* also achieved the separation of color and lightness, base on which the approach distinguishes different texture. This benefit the system since color cue and texture cue are processed differently in the approach. But it be noticed that the a and b channel also contain imformation of shadows as showed in figure 1.

Figure 1: Result of segmentation just using a and b channels and the background is showed with a constant L value, 65. Parts of the petals still shows different lightness and segmented from each other.

2.2. Standard Deviation Map as Texture Feature

In RCT, standard deviation map is chosen as the feature for texture. To using texture as a cue for segmentation, the texture should be represented by features. Texture can't be represented as easily as color since texture various much in style, direction, scale and else. For areas with dissimilar texture, their variations of lightness are different so that their standard deviation of lightness are different. The areas with the similar standard deviation may also of different texture. The general way to calculate standard deviation map is included in the referred paper[1].

However, there is a defect of standard deviation map as texture feature that standard deviation would be affected by edges as showed in figure 2. When the detect window contains two different textures, the result would be distorted badly by the difference of average intensity of these two kinds of texture, which cause a significant increase of standard deviation showed as the white stripe in figure 2. There may be worse consequence cause by this defect.

Figure 2: A example of the affection of The upper image shows a segmentation by Lizarraga-Morales et al.[1]. Notice that the border is shrinked compared to original image. This is due to blurred standard deviation map showed downside, which makes it hard to determine accurate border.

2.3. Rough-Set–Based Segmentation Process

The segmentation process of RCT is developed from histogram method, which actually segment the histogram of intensity. However, histogram loses all the spatial information. To make use of spatial information, the rough set[3] is introduced. In the context of image segmentation, Mohabey and Ray[4] have developed the idea of the histon, considered as the upper approximation of a rough set; the regular histogram is considered as the lower approximation. A histon is just like a histogram but the pixels that are similar to their neighbors have double weight. From histogram and histon, roughness index, which indicates the degree of aggregation of pixels of certain intensity, can be calculated. Finally the roughness index of images instead of histogram is segmented, achieving a better unsupervised segmentation. The general way to calculate histogram, histon and roughness index is included in the referred paper[1].

2.4. Original segmentation framework

The segmentation frame work of the refereed paper is showed in figure 3. Amongst the steps, the method to merge the three segmentation results is not detailed. For the final region merging, it determine whether a region should be merged to other region by counting its amount of pixels and decide which region to merge into by compare the similarity of two regions and the number of pixels connect two regions.

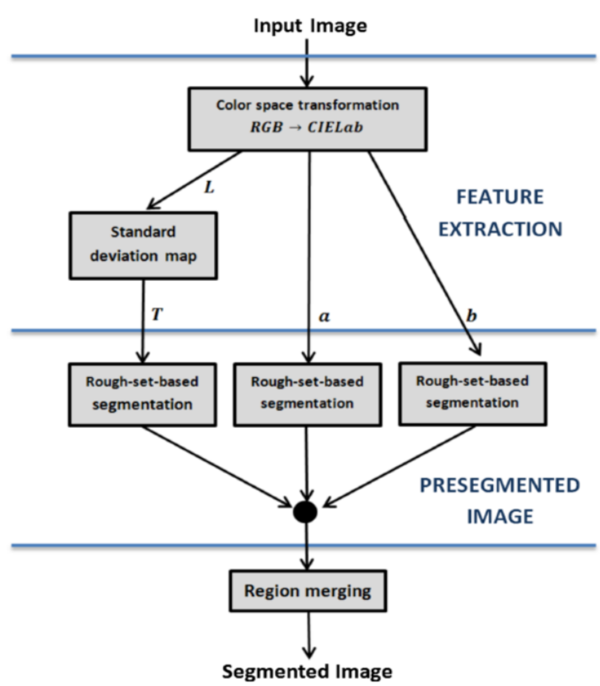

Figure 3[1]: Original segmentation framework

3. Proposed Segmentation Framework and details

To solve the defect pointed out in section 2.2, a modified framework, as showed in figure 4, is proposed. The idea is based on a phenomenon that the segmentation using only color channels is not bad for images that is not hard to segment. The key point is to segment using texture cue after segmenting using color cue. When calculate standard deviation of one pixel, the pixels in another region or with extreme intensity aren't took as its neighbor so that the standard deviation not be distorted by obvious edges and the system can still segment the regions with similar color. As a result, the regions that have been segmented by using color cue would not be affect by the defect and have correct border. This idea is illustrated in figure 5.

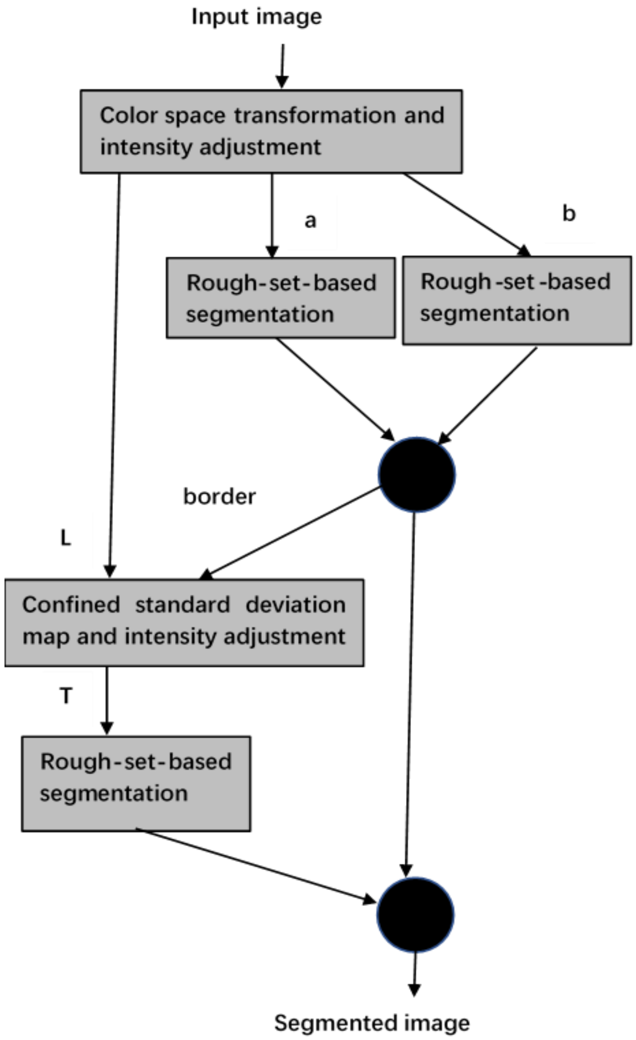

Figure 4: Proposed segmentation framework. The "L", "a" and "b" refers channels of the Lab image. The "T" refers to the standard deviation map. The black circle refers to merge different segmentation results.

The intensity adjustment is to adjust the intensity of an image channel to a proper range. On one hand, this control the weight of channels. More variation a channel has, more weight it given so that the segmentation tends to use obvious information. On the other hand, this process maps the float intensity to integer, making the fellow processed more convenient.

The way to merge segment results of different channels is to overlapping the borders of the results and then label pixels according to the border. Since which of the region that the pixels on borders belong to is unknow. The labeled pixels are propagated to fill the pixels without label.

Figure 5: The segmentation just using color channels, the confined standard deviation map and the final result of a segmentation of a image.

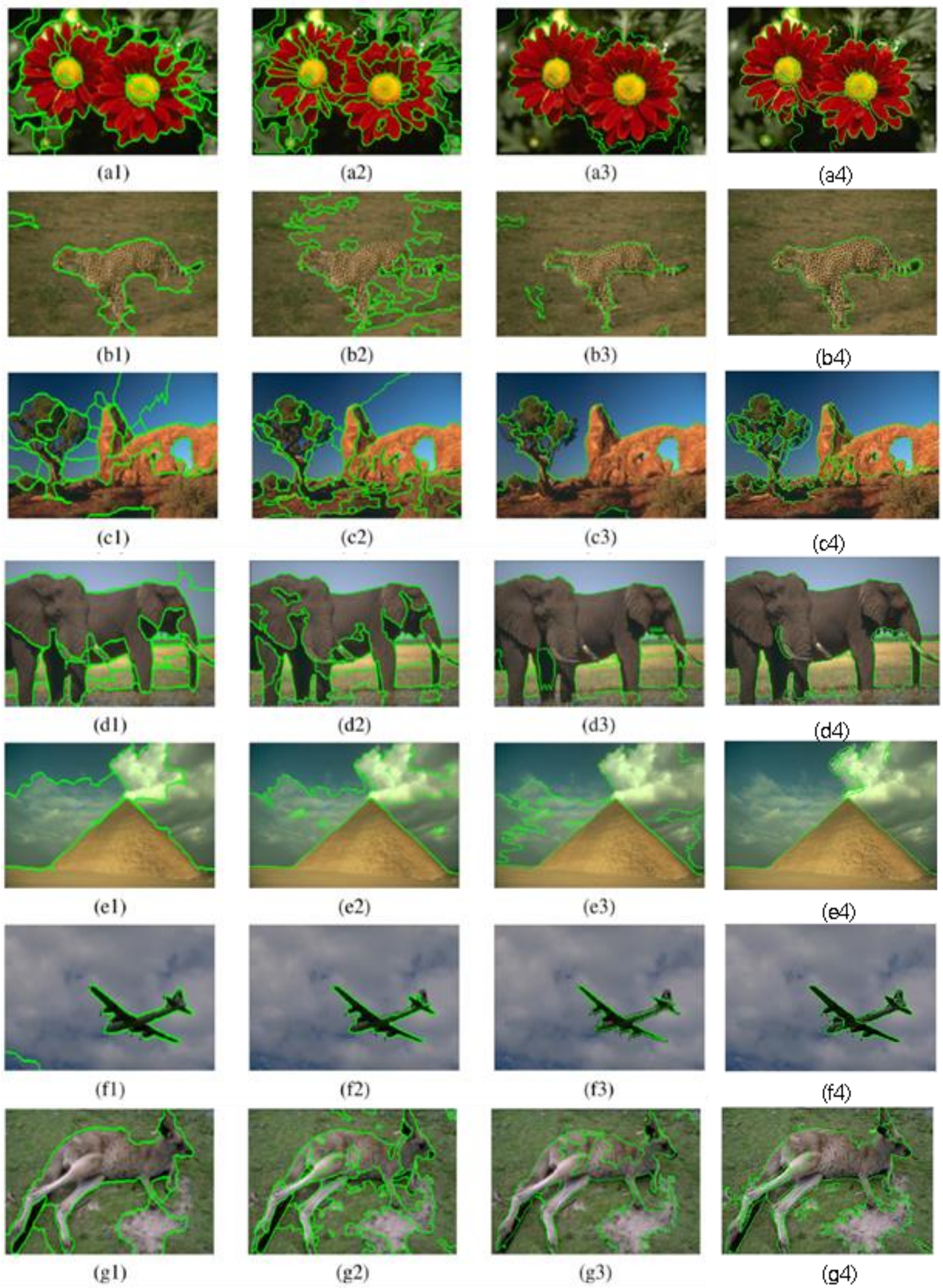

Figure 6: A qualitative comparison of seven out of 300 segmentation outcomes between the CTM (first column), JSEG (second column), RCT (third column) [1] and RCT proposed in this paper (forth column). The segmentation borders are overlaid on the original image.

There are region merging processes after every segmentation and result merging process, which is not showed in figure 4. It determines a region whether to merge into another region by counting its number of pixels and ratio of pixels that similar to its neighbors on its border. It chooses which region to merge into by calculating the feature similarity and connection strength between two regions.

Some other details are explained in the referred paper[1]. For calculation in practice and more details, see the MATLAB code.

4. Experimental results

As showed in figure 6, there are results of four segmentation method. The first two segmentation is too sensitive to color, which cause some over-segmentation. The third segmentation can't detect accurate border in some cases like image b, image c and image f. Generally speaking, RCT of this paper segment images more properly compared to other segmentations.

5. Conclusions and future work

In this paper, the integration of color and visual texture cues in a rough-set–based segmentation approach is improved. A defect of the original approach is almost solved. Some of the details is discussed. A qualitative comparison shows that the implementation proposed in this paper can segment images more properly.

However, the parameters of the implementation aren't adjusted exhaustively and quantitative evaluation is absent. This implementation isn't hierarchical, which mean it somewhat lack the ability to adapt different scales. The implementation hasn't been optimized for speed.

References

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