A Noise-Robust and Adaptive Image Segmentation Method based on Splitting and Merging method

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Abstract. This paper proposes a new image segmentation algorithm that involves local area splitting and merging based on intensity change. The proposed method adaptively changes pixel intensity during the process of region segmentation to the representative intensity of the adjacent sub-area of high homogeneity. In addition, this method preserves the edges of segmented objects and reduces the phenomenon of excessive region merger by determining the direction of the next merger upon splitting a local area into small sub-areas. Our experimental results demonstrated that the proposed method accurately segments images higher credibility than the existing image segmentation algorithms.

Keywords: Image processing, Segmentation, Local Area Splitting, Intensity Change.

1 Introduction

Image segmentation techniques allow distinction between many areas of an object image based on the features of the image data. They have also been utilized in the pre-process stage for image analysis and object recognition in diverse fields where image is used as input data. Image segmentation techniques process data based on the similarity and discontinuity to the grouping of input image data, which segments an image into many regions, each having a unique homogeneous feature compared to the adjacent regions[1][2]. The efficiency of image segmentation depends on standard conditions, such as the kind of feature information used for grouping, the credibility of feature extraction and merging of feature information. Existing image segmentation techniques can be categorized into 3 general groups by method : (a) a method based on the threshold of histogram,(b) based on the edge present in image, and (c) based on region[3][4]. The threshold based method shows low credibility in region classification when the object image has unclear edges between regions or has numerous complicated regions. The edge based method classifies regions by extracting the edges between the regions with different features. If the extracted edges are not connected to each other, post-processes such as edge tracking and gap filling are required to connect them together. The region based method presumes that pixels in the same region are similar in such features as brightness, texture and color. Based on the latter presumption, this method segments an image by merging or splitting adjacent pixels of homogeneous feature[5][6]. Besides, there are combined methods for to improve region classification through region expansion by modifying or removing the edges of regions that have a homogeneous feature, or by taking advantage of the geometric feature and watershed method.

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2 Proposed Method

As shown in Figure 1, the proposed region segmentation method can be divided into 2 steps: the first step is the segmentation of an image into many regions, and for the second is re-merging very small regions. In the proposed region segmentation method, A local area of a fixed size is generated around the pixel under consideration. The local area is then divided into sub-areas, and the representative intensity of each sub-area is calculated. Then, in order to set the direction of a new search, measurement is made as to the homogeneity of the calculated representative intensity in comparison with the intensity of the pixel under consideration. Such a process is repeated, and each of the resulting regions is subjected to the re-merging of extremely small areas.

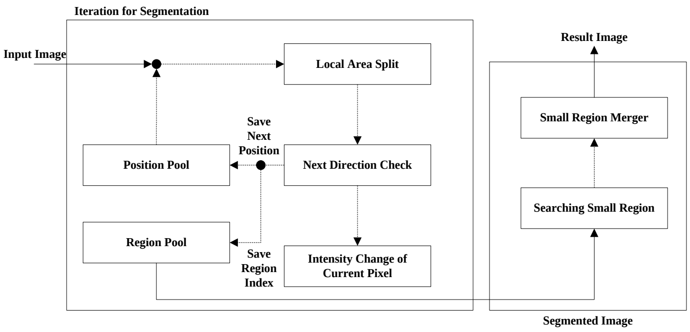

Fig. 1. Block diagram of the proposed region segmentation

2.1 Local Area Splitting

The proposed local area splitting method set a local area of fixed size around the pixel under consideration for merger. Then, the pixels making up the local area are subjected to measurement to find out the similarity of intensity between them and, based on the result, to generate sub-areas each having unique homogeneous features. The proposed algorithm was designed to operate as follows. Decision on whether or not a local area should be split is made based on the distribution of intensity among the pixels in that local area. If the coefficient of variation is large in the area, then the area is recognized as having diverse boundary shapes and an attempt is thus made to split the area. However, if the value is small, then splitting does not occur because the pixels have similar intensities.

2.2 Setting the direction of merger and intensity change

The representative intensity of each of the sub-areas that had been generated from the index mask achieved via local area splitting was obtained by calculating the average intensity of the pixels belonging to each sub-area. Then, the direction of merger was decided toward the sub-area that showed the minimum intensity difference when compared to the pixel under current consideration. The intensity difference was calculated using equation(1):

$$DR_S = \begin{cases} 1 & if\ \min(\left|R_S - CP\right| < IL), \forall S \\ 0 & otherwise \end{cases} \tag{1}$$

Here DR_s is the sub-area containing the pixels with the highest similarity to the pixel under current consideration(CP). In order to eliminate excessive merging with other sub-areas containing pixels of high similarity to the pixel under current consideration, the threshold of intensity difference(IL) was set. Thus, the direction of the next merger was set toward the sub-area of the smallest intensity difference among the sub-areas whose intensity did not exceed the threshold. In the mean time, in order to increase homogeneity, intensity of the pixel under current consideration was updated with the representative intensity of the sub-area to be merged. Such an intensity change has the effect of removing the noise present in the image without a separate pre-process.

2.3 Region Merger

Among the regions generated by the region segmentation of an input image, there are regions whose sizes are relatively compared to other regions. An attempt was made to merge such small regions into adjacent regions to reduce the number of the finally generated regions.

$$CD_j = \frac{1}{C_n^j} \sum_{i=1}^{C_n^j} C_i^j \tag{2}$$

$$CR_k = \frac{1}{R_n^k} \sum_{i=1}^{R_n^k} R_i^k \tag{3}$$

$$CRN_j = \begin{cases} k\ if\ \min(\left|CR_k - CD_j\right| < IL), \forall k \\ j \quad otherwise \end{cases} \tag{4}$$

In these equations, CD_j is the average intensity of the candidate region with which merger will be attempted; C_n^j is the number of pixels belonging to the candidate region; and C_i^j is the i^{th} pixel. CR_k is the average intensity of the region adjacent to the candidate region; R_n^k is the number of pixels belonging to the adjacent region; R_i^k is the i^{th} pixel; and CRN_j is the index number of region segmentation.

3 Experimental Result

In order to verity the suitability of the proposed method, a comparative analysis was carried out between the proposed algorithm and the image segmentation algorithms based on K-mean and Mean-Shift. Table 1 shows Information about the images and original images used for experiment. Figures 2 shows that the proposed algorithm achieved better results than the one based on K-mean and mean-shift. According to the result achieved by the region segmentation based on mean-shift with “camera man” image, the accuracy of image segmentation was low for the regions of uneven intensity distribution, although image segmentation result was always good for the regions of even intensity distribution. On the contrary, the result showed that the proposed method was not affected at all by intensity distribution and showed that the proposed algorithm performed accurate segmentation to reproduce the regions of the original images.

Images / Items	Bookshelf	Camera
Image size	256×256	256×256
Noise	10%	10%
IL	5	5
WT	0.15	0.15

(a)K-mean (b)mean-shift (c)proposed method

Fig. 2. Information about Images and the results of region segmentation

Conclusion

This paper proposed a new image segmentation algorithm was designed to split a local area into sub-areas and then determine the direction of merger direction by examining this sub-area. In addition, this method adaptively updates a pixel's intensity with the representative intensities of the region to which it belongs, in order that a new intensity is used for next merger. In this way the feature of initial information is stabilized, and the homogeneity within the region is increased. Thus, the proposed method involves the merging of both pixel units and block units in a combined manner in order to preserve the edge. Therefore, the proposed method shows the effect of removing noise present in the image, as well as excellent performance in splitting small regions. Our experimental results also showed that the proposed method reduced the phenomenon of excessive region merger, demonstrating that it is a simpler and more accurate segmentation method than existing image segmentation algorithms.

References

1. N. R. Pal and S. K. Pal, [1993], A review on Image segmentation techniques, Pattern Recognition, [29], 1277-1294.
2. H. D. Cheng, et al., [2001], Color Image Segmentation: advances and prospects, Pattern Recongition, [34], 2259-2281.
3. J. Fan and D. K. Yau, [2001], Automatic Image segmentation by Integrating Color-Edge Extraction and Seeded Region Growing, IEEE Transactions on Image Processing, [10], 1454-1466.
4. Haralick, R. and L. Shapiro, [1985], Image segmentation techniques, CVGIP, [29], 100-132.
5. S. A. Hijjatoleslami and J. Kittler, [1998], Region Growing: A New Approach, IEEE Transactions on Image Processing, [7], 1079-1084.

6. Wan, S.-Y and W. E. Higgins, [2003], Symmetric region growing, IEEE Transaction on Image Processing, [12], 1007-1015.