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Adaptive region growing for unmanned system

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Abstract: Image segmentation is a vital component of the unmanned system visual perception. This paper presents an adaptive region growing for the unmanned system visual perception. The proposed method consists of two sections, adaptive seed pixels selection and merging rules. The procedure of choosing seed pixels adaptively can be divided into three steps. After turning one RGB image to gray image, the position coordinates of one pixel and its gray value can be seemed as XYZ values in space coordinates system. Then, the mesh surface from the gray image is used as a relief map. The most distinct feature points of the relief map, the mountain peak pixles and the valley bottom pixles, can be taken as seed pixels. The procedure of merging starts with calculating the difference of gray values between the seed pixel and the neighbor pixel of seed pixels. According to the principle of similarity, the pixels within the threshold of the difference of gray value can be divided into seed pixel categories. Finally, the proposed method can adaptively implement region growing.

Key Words: Image segmentation, adaptive region growing, unmanned system

1 Introduction

Unmanned system is used extensively, such as unmanned aerial vehicle etc. Almost all kinds of the unmanned system need to sense the environment. Usually, it can sense the environment by radar, ultrasonic or infrared etc. Computer vision is an important way for unmanned system sensing. In the computer vision field, image segmentation is a task of the image processing that consists of partitioning an image into a set of homogenous regions.

For image segmentation, there are mainly four approaches, namely, threshold techniques, boundary-based methods, region-based methods, and hybrid techniques. Threshold techniques are based on the assumption that pixels which are in one region have a certain range of value. Threshold techniques neglect the spatial information of pixels in an image. Besides, this kind of technique is susceptible to noise or blurring at boundaries [1]. Boundary-based methods are based on the postulate that pixel values change fast between different regions. Boundary-based methods usually need to calculate gradient by a gradient operator such as Sobel or Canny filter. The high value of this filter indicates candidates for region boundaries. However, it is difficult to convert the edge pixel candidates to boundaries of the interest region [2]. Region-based methods rely on the hypothesis that pixels within one region have similar value. In general, region-based methods need to locate an initial set of seed pixels. Then, by iteratively merging adjacent pixels, different regions are formatted. Till all pixels in an image are all in corresponding regions, and the region-based methods are complete [3]. The choice of the seed pixels and homogeneity criterion is vital for a good result of image segmentation. Hybrid techniques combine boundary and region criteria. Morphological watershed segmentation is a typical method of hybrid techniques. By thinking gradient image as a topography with the boundary between regions as ridges, segmentation becomes a procedure to flood the topography from seed points. Boundaries are erected to keep water from different seed points from merging. The strength of morphological watershed segmentation is that it can guarantee to produce closed boundaries even if the transitions between regions are of variable strength or sharpness [4].

There are several image segmentation techniques proposed in the literature among which the region growing technique. Most of these region growing techniques focus on the problem that how to define the similarity metric [5-10]. Some of them have only good results for specific pictures[11][12]. One of the main drawbacks of approaches in this group is that seed pixels need to choose manually. The participants of human must will cause some subjective influence for the result of image segmentation. Besides, a non-automatic way of seed pixels choosing needs more time to get a good result.

This paper presents an adaptive region growing for the unmanned system, which consists of adaptive seed pixels selection part and merging rules part. This method combines the region growing and the morphological watershed segmentation. By taking the position coordinates and the gray value of one pixel as XYZ values in spatial coordinates system, a gray image is converted to a topography. Regions in an image should have external differences and internal similarities. On one hand, different regions should be represented by the most different pixels, namely, seed pixels. Thus, choosing the 'mountain peak' and the 'valley bottom' of the topography as seed pixels. On the other hand, region growing criterion, namely, merging rules can guarantee the similarity of pixels in one region. The proposed merging rules is realized by comparing seed pixels with their adjacent pixels.

The rest of this paper is organized as follows: the approach of seed selection is detailed in section 2, the merging rules are detailed in section 3, and its results are presented and discussed in section 4. Section 5 gives conclusions on the presented work.

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2 Adaptive seed pixels selection

The objective of this work is to propose an image segmentation method that does not need to choose seed pixels manually. The proposed adaptive seed pixels selection mainly includes three steps, as in Fig. 1.

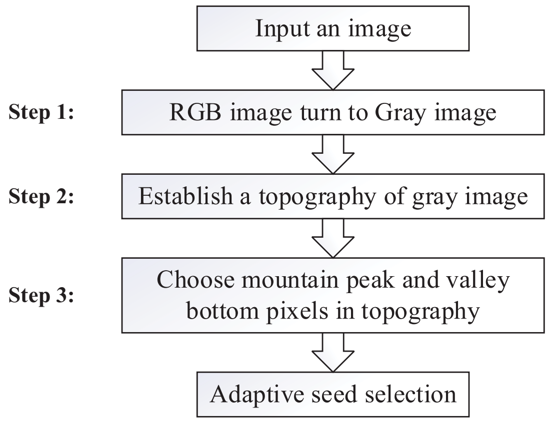

Fig. 1: The process of adaptive seed seletion

2.1 RGB image turn to Gray image

There are some ways which can turn RGB image to Gray image, such as average method, maximum and minimum average method and weighted averaging method.

Average method is to calculate the average value of one pixel's RGB values, as equation (1).

$$Gray = \frac{R+G+B}{3} \tag{1}$$

Maximum and minimum average method is to choose the maximum and the minimum value of the values of one pixel. Then the average of the maximum and the minimum values are calculated, as equation (2).

$$Gray = \frac{\max(R,G,B)+\min(R,G,B)}{2} \tag{2}$$

Weighted averaging method is that RGB values of one pixel are multiplied by different weighting coefficients, as equation (3).

$$Gray = 0.299 * R + 0.587 * G + 0.114 * B \tag{3}$$

The weighting coefficients are set according to human luminance sensing system. Thus, the RGB image is turned to the Gray image by equation (3). The result of this step is shown in Fig. 2. The left image is original image. The right image is gray image of source image.

Fig. 2 RGB image turn to Gray image

2.2 Establish a topography of gray image

After turning a source image to gray image, each pixel in the gray image has a two-dimension coordinate location and one gray value. By taking the two-dimension coordinate location as XY value and taking the gray value of the pixel as Z value, the gray image is turned to a topography, as shown in Fig. 3.

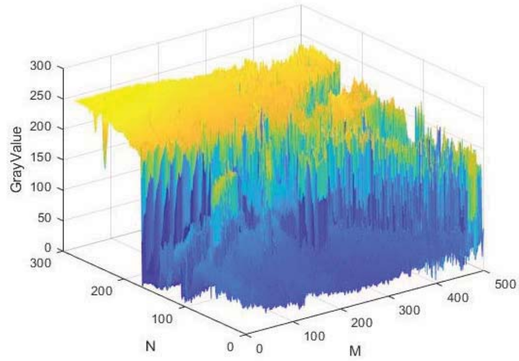

Fig. 3: Establish a topography of the gray image

2.3 Choose seed pixels in the topography

Mountain peak and valley bottom are a kind of feature points which can represent its neighboring area in topography. By comparing with adjacent pixels, the mountain peak and valley bottom as seed pixels are chosen. This procedure is described in Fig. 4. In Fig. 4, p(i, j) is one pixel in gray image. The value of m and n are the scale of gray image.

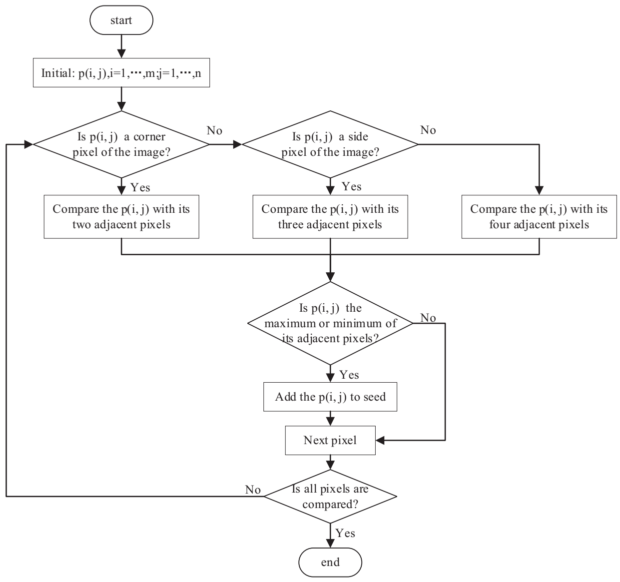

Fig. 4: adaptive seed choose procedure

3 Merging rules

The growing phase is completed according to the merging rules. Merging rules determine whether the adjacent pixel of the seed pixel should be added to the region the seed pixel belongs to. Then, by repeating this procedure to the new seed pixel, till all pixels are distributed to corresponding regions, region growing is finished. Different merging rules always consist of computing of feature value and selection of threshold.

3.1 Related merging rules

There are several merging rules mentioned in references. These merging rules can be separate three kinds, which are the change of threshold, the change of feature type and the hybrid of them. In change of threshold kind, the simplest one is to compare the gray value between seed pixels and its adjacent pixels. When the difference value between the gray value of a seed pixel and the gray values of each of its eight neighborhood pixels is in the range of the global threshold value, the adjacent pixel can be joint into the region of the seed pixel. In contrast, another technique utilizes a local threshold value to determine whether pixels should be joint seed region. However, this method needs to adjust the threshold for getting a good result. Besides, the threshold of new image may be readjusted.

For change of feature type, one of this kind needs input an initial contour-constrained over-segmentation image. Instead of choosing seed pixels, it needs to choose seed regions. Then, the similarity between regions is measured by their content and common border. The lack of this kind fashion is that it needs preprocessing and preprocessing can influence heavily experiment result.

For hybrid of change threshold and feature type, one of this kind needs to calculate threshold by the Firefly algorithm and compare texture feature value. It is a quite complex way because of too many steps need to be implemented.

3.2 Adopted merging rules

In order to improve the computational efficiency and test the influence of adaptive seed pixels selection conveniently, the proposed method adopts global threshold and take gray value of pixels as feature value. The global threshold is picked up by experience. The region growing phase is depicted in Fig. 5.

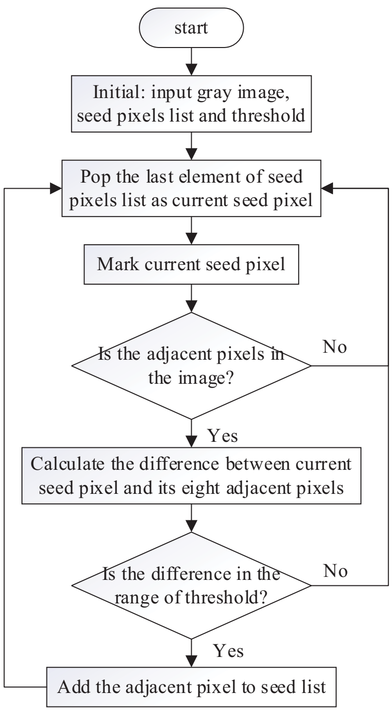

Fig. 5: the procedure of merging

In the initial phase, three things should be prepared, namely, a gray image, seed pixels list from adaptive seed pixels selection and threshold from experience. As all known, a digital image is represented by matrices. For obtaining segmentation result, a blank image with same scale as the original image needs to be created. Then, assign the last element of seed pixels list to current seed pixel and mark the seed pixel in the blank image. Then, assign the eight adjacent pixels to temporary seed pixel. If the temporary seed pixel is not in the blank image, assign the next adjacent pixel to temporary seed pixel. Otherwise, calculate the difference between the current seed pixel and the temporary seed pixel. If the difference is in the threshold, add the temporary seed pixel to seed pixel list. Finally, repeat assigning the seed pixel list to the current seed pixel.

4 Results and discussion

In order to simulate the perspective of unmanned vehicle, this method is tested with several images from tachograph. The proposed work is done in the platform, Pycharm. The code is written in accordance with the process shown in Fig. 4 and Fig. 5.

4.1 Results of adaptive seed selection

In this part, three photos form tachograph are tested by the adaptive seed selection for region growing. The results are shown in Fig. 6, Fig. 7 and Fig. 8.

Fig. 6: car1 after adaptive region growing

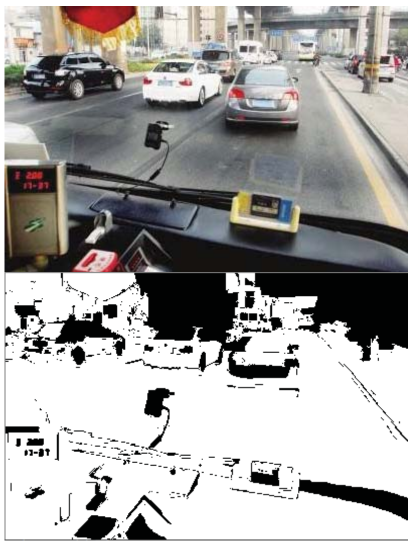

Fig. 7: car2 after adaptive region growing

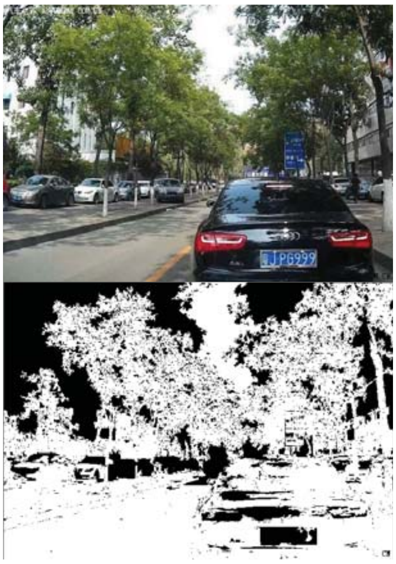

Fig. 8: car3 after adaptive region growing

4.2 Results of manual seed selection

In order to compare the difference between adaptive seed selection and manual seed selection, manual seed selection is tested. In manual seed selection method, it is needed to pick up seed pixels by human. The merging rules of manual region growing is not changed. The results are shown in Fig. 9, Fig. 10 and Fig. 11.

Fig. 9: car1 after manual region growing

Fig. 10: car2 after manual region growing

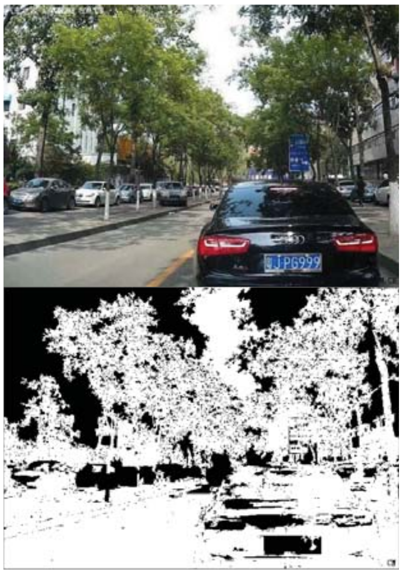

Fig. 11: car3 after manual region growing

4.3 Comparison of adaptive seed selection and manual seed selection

The results of adaptive seed selection and manual seed selection are shown in Fig. 12. The left part of Fig. 12 are the results of adaptive region growing. The right part of Fig. 12 are the results of manual region growing. For image car1 in Fig. 12, the middle car in left results have more details than the right results do. For image car2 in Fig.12, the bottom of left results shows more particulars than the right results do. For image car3 in Fig. 12, the left road side of the left results present more specifics than the right results do. The results of the comparison of adaptive region growing and manual region growing indicate that the adaptive region growing can obtain the interest target effectively.

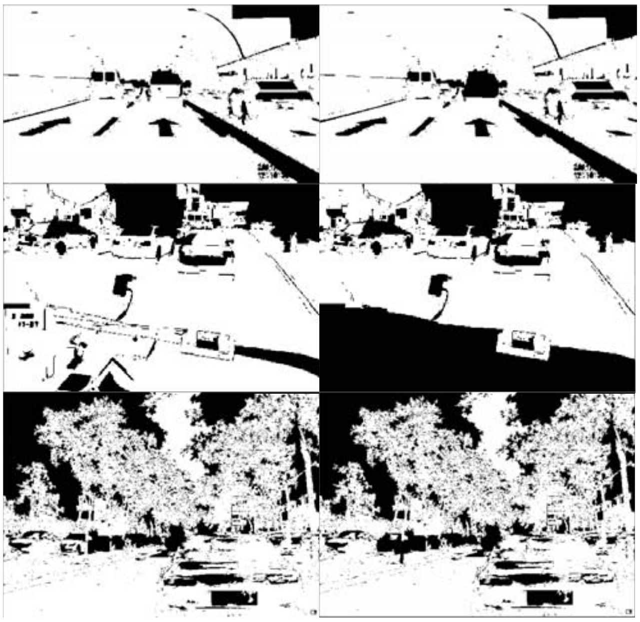

Fig. 12: comparison between adaptive region growing and manual seed selection

5 Conclusions

This paper describes an adaptive region growing for unmanned system. The experiment results indicate that there is almost not difference between adaptive seed selection and manually seed selection. The adaptive seed selection method can replace manually seed selection in region growing. The excellent segmentation effect can make a vast improvement for object recognition or target tracking or other tasks in unmanned system. Although this method can automatically select seed pixels for region growing, it would be improved in future work, where reducing the influence of noise points could be considered.

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