EFFICIENT REGION MERGING METHOD BASED ON CLASSIFIED MERGING COST

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1. INTRODUCTION

During image segmentation, region merging is always used to prevent oversegmentation, and region adjacency graph (RAG) is widely used for region merging during image segmentation. The most critical aspect of region merging method is to build, search and sort links storied in the hierarchical queue of RAG, which will affect the efficiency of whole segmentation process.

This paper proposed a new region merging method, its main contributions are as follows: First, several constraint conditions were proposed for inserting links into the queue in order to shorten the queue length; Second, the merging cost of two adjacent regions corresponding to each link was classified so that links with nearly the same cost were put in a same category. Links in the same category were processed using the principle of FIFO, and links sorting was unnecessary and skipped; Third, the MAP class in STL (Standard Template Library of C++) was utilized to build a two-dimensional dynamic queue. With the advantages of MAP class in searching, editing and auto-sorting, the computational and time costs on the queue will be significantly reduced. Experiments on a quickbird test image showed that this method was more efficient than the classical region merging method [1].

2. METHODOLOGY

2.1 Work flow

First, we construct the RAG based on an over-segmented label image. Second, find all links which meets the constraint conditions, and classify their merging costs according to certain rules. Third, these links are inserted into the queue which is built by MAP class. Finally, merging operation is carried out based on RAG and queue, and segmentation result will be obtained subsequently. The whole work flow is given as Figure 1.

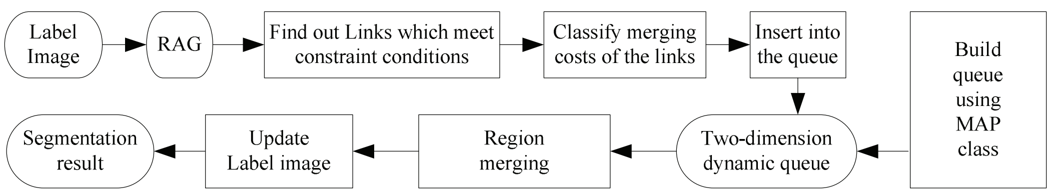


Fig.1 Flow chart of New Region Merging Method

2.2 Constraint conditions for the queue

The queue built by the classical region merging method has a lot of redundant links. In order to remove these links, some constraint conditions are set: (1) It must be Circle-Link [1]. (2) Take A-B and B-A as the same link, thus duplication of insertion can be avoided. (3) The merging cost must be less than the cost-threshold corresponding to the scale of segmentation. These constraints can eliminate invalid links to a great extent.

2.3 Classified merging costs

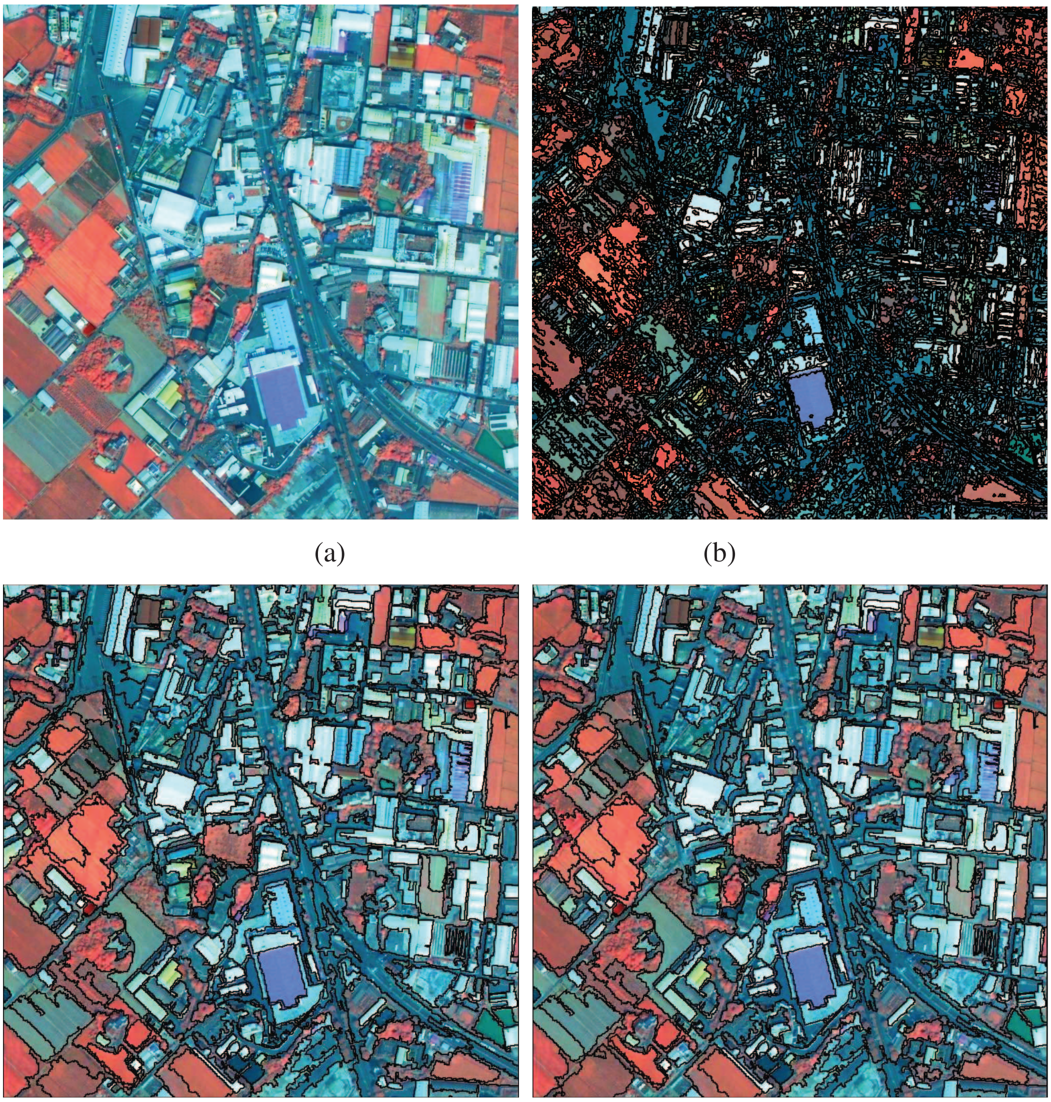
The purpose of classification is to put the links with almost the same cost into the same category, so links sorting is skipped, and the computation cost can be reduced. The rule for classification should be simple and suitable for different range of values because the size and range of merging costs are always changing and unpredictable. Here we proposed an easy rule: [C/N], C is the merging cost which is defined as shown in Formula 1, N denotes the cost interval—the maximum cost variation in each category of merging costs, and [ ] means the value type varying from float-point to integer.

2.4 Hierarchical queue based on MAP class

The key of the first dimension MAP queue represents the category, and its value contains another MAP queue which is used to store all links belonging to the category. Due to the characteristics of the MAP class, we do not have to resort queue while adding links, neither traverse the entire queue while search one link. It greatly improves the merging rate.

3. EXPERIMENTS

In this study, a quickbird subset image with spatial resolution as 0.6 meter was selected as the test image. It consists three bands--blue, green, red band, and near-infrared band was not used. The classical region merging method was selected for comparison. Before region merging, mean shift segmentation method was used to produce an over-segmentation image. Then, region merging methods were applied to obtain the final segmentation results.



(a) (b) (c) (d)

Fig.2 Region merging results
(a. A false composition of the 1000×1000 test image;
b. Over-segmentation image before region merging;
c. Using classical method with cost threshold as 500;
d. Using proposed method with cost interval as 10 and cost threshold as 500)

From the comparison experiment, we learned that with the increase of region number in the image, the efficiency advantage of the proposed method became more obvious (see chart 1). In Chart 2, the relationship between cost interval and relative segmentation accuracy (RAS) was revealed. Assuming segmentation results using classical region merging method are accurate，RAS is obtained by calculating the fraction of correctly segmented pixels of the proposed method when compared with the classical one. When the cost interval is less than 10, RAS maintains a high level (see chart 2), which, in most cases, can meet the requirement for post-processing. However, with the increase of cost interval, RAS decline rapidly.

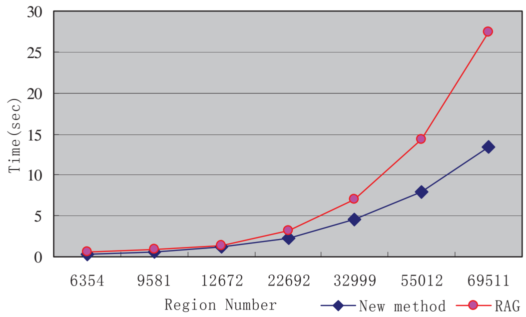


Chart.1 Efficiency Comparison of Two Methods

(for algorithm parameters, please see Fig.2)

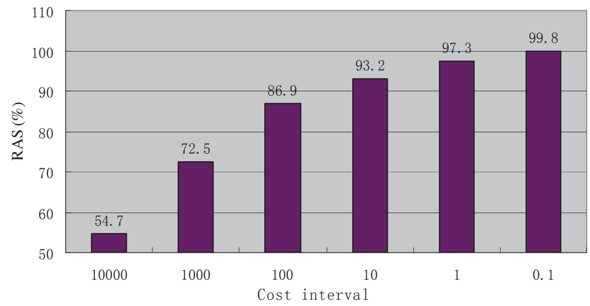


Chart.2 Relationship between Interval and Accuracy

4. CONCLUSIONS

This paper proposes a new region merging method based on classified merging costs. Experiments showed that it can obviously improve merging speed, especially when there are a large number of links in the queue. However, it should be pointed out that if the cost interval is too big (i.e. the number of categories is too small), the segmentation result is probably not guaranteed. Further study should be conducted to find the best balance between the cost interval, speed, and the segmentation result.

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Appendix

$$Cost = c \cdot \sum_b w_b \left(n_{meg} \cdot \delta_b^{meg} - \left(n_{rgn1} \cdot \delta_b^{rgn1} + n_{rgn2} \cdot \delta_b^{rgn2} \right) \right) / S \qquad (1)$$

Here, $cost$ is merging cost, w_b and δ_b represent the weight and the region's standard deviation of band b, n is the number of pixels in the region, $rgn1$ and $rgn2$ are the couple of region to be merged, and meg is the new region formed by the previous two. S denotes the total amount of pixels in the image. c is a constant, used to control the magnitude of the merging cost. In all experiments of this paper, c is 100000, and each band takes the same weight.