A HEIGHT ANDTEXTURE INFORMATION INTERGRATED APPROCH FOR OBJECT EXTRACTION APPLIED TO AUTOMATIC AERIAL TRIANGULATION

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Abstract:

This paper proposes a method of objects extraction based high and color texture features. Trees or forests are interested objects in this paper, which are higher than their surroundings. According to the disparity image processed, at first, the original color aerial images are segmented into the high and low objects, next, on the basis of preliminary results, the trees are refined by Fuzzy C-Mean with the texture and color features from the high and low areas. With above results, in this paper, an architecture is presented that observed points on forest and on non-forest are divided into two different groups in automatic aerial triangulation. This is because the matching accuracy and reliability of observed points on trees is lower than on non-trees. To decrease the negative influence of the observed points on trees, the observed points in two different groups are given the different a'priori standard deviation of photo coordination measurement and weights. The experiment results have proved that the method of observed points grouped can improve the accuracy of automatic aerial triangulation in forest-covered regions..

1. Introduction

The analysis of texture has proven to be an important tool for image segmentation. A lots of approaches were presented by the researchers who were in different fields. Those methods are divided into the three major branches: thresholding or clustering, edge detection, and region extraction. Traditionally, the analysis of texture models is on the images of two dimension, while the height feature belonged to the information of third dimension has received much less attention. Among the approaches that have been examined, T. Dang (1994) proposed the algorithm that was to directly use height information for detection and reconstruction of buildings in aerial images. The other method (N.Haala, 1994) that was via stereo reconstruction process to obtain height information for detection of buildings. The above two algorithms assume only the case that there are simple houses and little trees or no trees on flat ground and the quality of the images is very good. In this paper, trees or forests are interested objects. In contrast to artificial objects, such as houses and roads, trees or forests are a kind of natural scenes which are not structured and cannot be represented easily by regular rules. In addition, trees or forests do not obey strict position rules. Hence, texture and color features are important cues for trees or forests extraction in color aerial images. In practice, if only texture and color features are used, sometimes the results of trees or forests extraction are inaccurate. There are two reasons: (1) The non-tree objects have the similar texture features to trees; (2) Usually different tree type has different texture features. But, it is the fact that trees are the objects that are higher than their surroundings. In this paper, an approach is descried for the recognition of various forest and trees in low resolution aerial images. Our method combines texture features, color and height information to overcome those disadvantages. A technique similar to ours was discussed in (W.Eckstein, 1996). Their method has the advantage that can dealt with realistic and complex scenes. But it needed high resolution aerial images and DTM, and assumed that the range of the highest building was from 20m to 30m. Hence, it was able to extract the huge buildings and forests. Our method is to first use the parallaxes data to provide the preliminary segmentation of the image and, given this results, perform Fuzzy C-Mean to refine and produce the final segmentation. At first, the stereo models are created by the digital photogrammetry system (Virtuozo), the parallaxes data are obtained. Second, the image that parallaxes are represented by 256 grey levels is divided into different regions and the edges are detected by Sobel algorithm. Third, according to the parallaxes image processed, the original color aerial images are segmented into the high and low objects. Generally , in the areas covered by forest, high objects mainly include trees or forest, less houses and bridges and more non-trees objects are took in the low region. In order to refine trees or forest, the high and low objects are classified by Fuzzy C-Mean respectively. With above results, in this paper, an architecture is presented that observed points on forest and on non-forest are divided into two different groups in automatic aerial triangulation, because the matching accuracy of observed points on trees is lower than the observed points on non-trees. To decrease the negative influence of the observed points on forest, the observed points in two different groups are given the different pre-variances and weights. The experiment results have proved that the method of observed points divided into two different groups can improve the accuracy of automatic aerial triangulation.

This paper is organized as follows: Section 2 describes the method of the objects extraction based on the high and color texture features and is divided into two subsection. In section 3, experimental results are discussed and the conclusion is given in Section 4.

2. The objects extraction based high and color texture features

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In this session, we describe our segmentation algorithms, including preliminary segmentation based on disparity image, the texture features and final trees of extraction using fuzzy c-mean.

2.1 High and low objects distinguishing

We start with DEM data an automatically generated by the digital photogrammetry system --Virtuozo. The resolution of the images by which DEM data are obtained may be lower than original images. According to following algorithm high and low objects are obtained.

Algorithm 1: Preliminary segmentation based on high features

Given: original color aerial images

Step 1. DEM are mapped to range (0—255 gray level) in order to form the image of DEM. As a result, different gray levels denote different elevation.
Step 2. With the DEM image, original image is divided into many regions with same size .
Step 3. The edges in the DEM image are extracted by Sobel algorithm. These edges reflect the local changes of elevations of objects.
Step 4. According to the edge image, we compute the segment threshold for each region according to following rules:

Mean clustering based the color texture features.

2.2 The classification based on Fuzzy c-mean

Fuzzy c-mean clustering algorithm (FCM) was introduced by J. C. Bezdek (J. C. Bezdek, 1987). In this paper, FCM is used to refine the trees from the high and low objects. The algorithm is described as following.

Algorithm 2: The classification based on Fuzzy c-means clustering.

Given : The images including the high and low objects.

Step 1: Calculating the texture and color features values of every pixel in the images(.

Step 2 : Computing the fuzzy membership of the pixels of images.

$$U_{ik} = \left(\sum_{j=1}^{c}\left(\frac{D_{ik}}{Djk}\right)^{\frac{2}{m-1}}\right)^{-1} \forall i,k$$

$$v_i = \frac{\sum_{k=1}^{n} U_{ik}{}^{m} X_k}{\sum_{k=1}^{n} U_{ik}{}^{m}} \forall i \qquad (1)$$

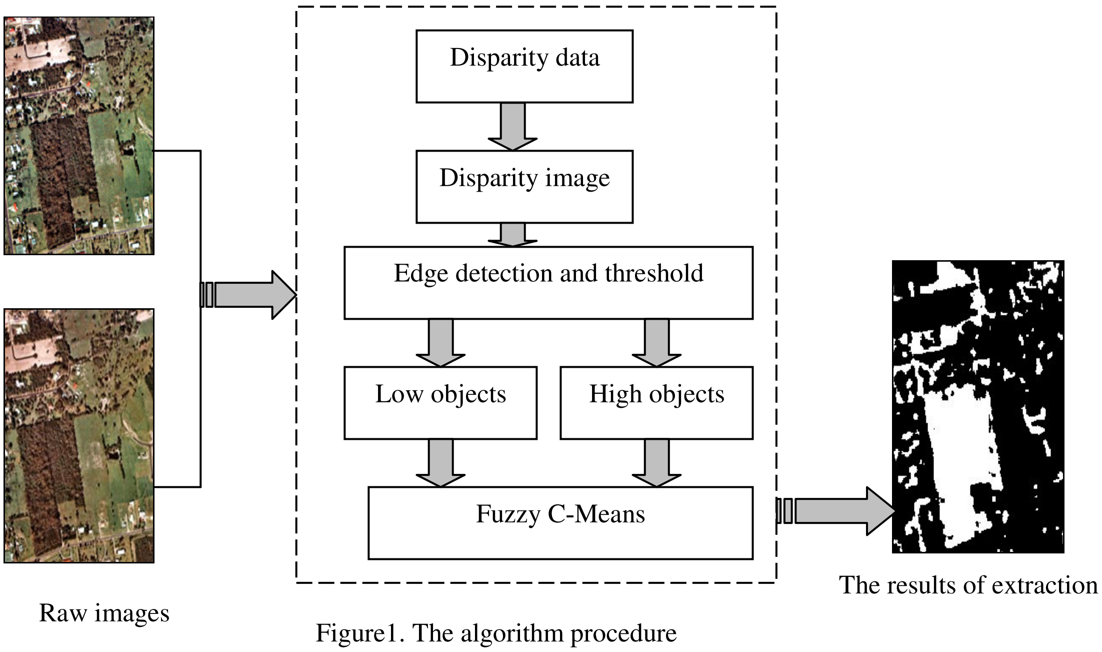


Figure1. The algorithm procedure

(1) If there is any edge in a region, the average gray level value of pixels on edges is to set to the threshold;
(2) If there is no edge in a region, the threshold can be obtained by the bilinear interpolation method of thresholds of its neighbor regions.

Step 5. According to the threshold of region, the original image is segmented into a binary image, in which 1 represents high objects and 0 represents low objects. The high objects include trees, houses ,bridges and so on.

The next step is to refine trees from high objects by Fuzzy C-

where D_{ik} is some measure of similarity between v_i and x_k or the attribute vectors, and the cluster centre of each region $v = (v_1, v_2, \ldots, v_c)$ is geometric cluster prototypes. U denotes the fuzzy membership matrix of pixel block k in cluster i, c denotes the number of cluster.

$$U = [u_{ik}], 1 \le i \le c, 1 \le k \le n \qquad (2)$$

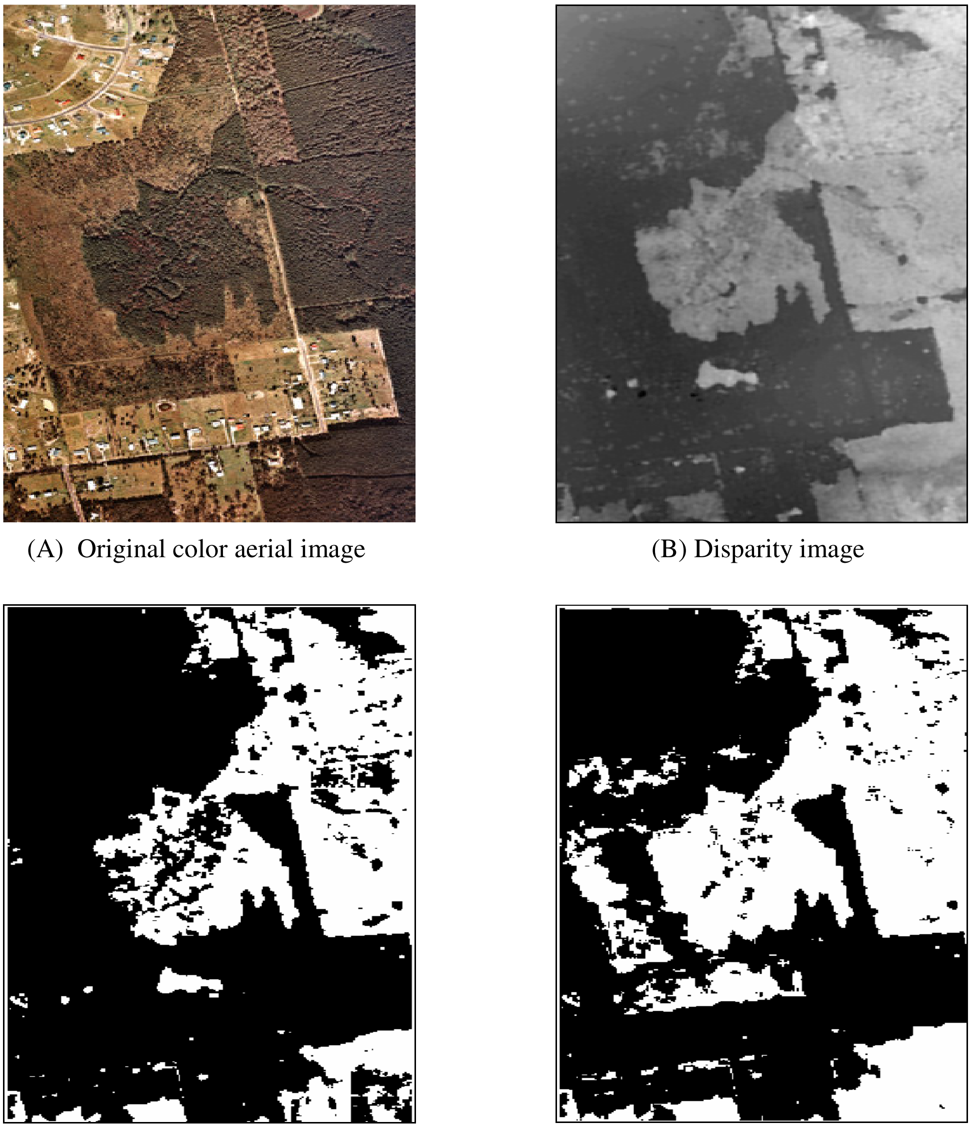
Step 3: To determine the pixels of images membership as follows:

$$J_m(U, v, X) = \sum_{i=1}^{c}\sum_{k=1}^{n}(\mu_{ik})^m D_{ik} \qquad (3)$$

where the real number $m \in [0, \propto]$ is a weighting exponent on each fuzzy membership. As J_m is iteratively minimized, v_i became more stable. Iteration terminated when $u_{ik(\alpha)} - u_{ik(\alpha-1)} < \beta$ or the maximum number of iterations is reached, where α is the number of iteration and β is predefined tolerance. At last, high and low objects are classified respectively into two categories: trees and non-trees.

3. Application

We tested our image segmentation algorithm on a number of aerial images and used the results segmented for an example of automatic aerial triangulation using the observed points grouped.



(A) Original color aerial image

(B) Disparity image

(C) The results of preliminary segmentation

(D) Final result segmented

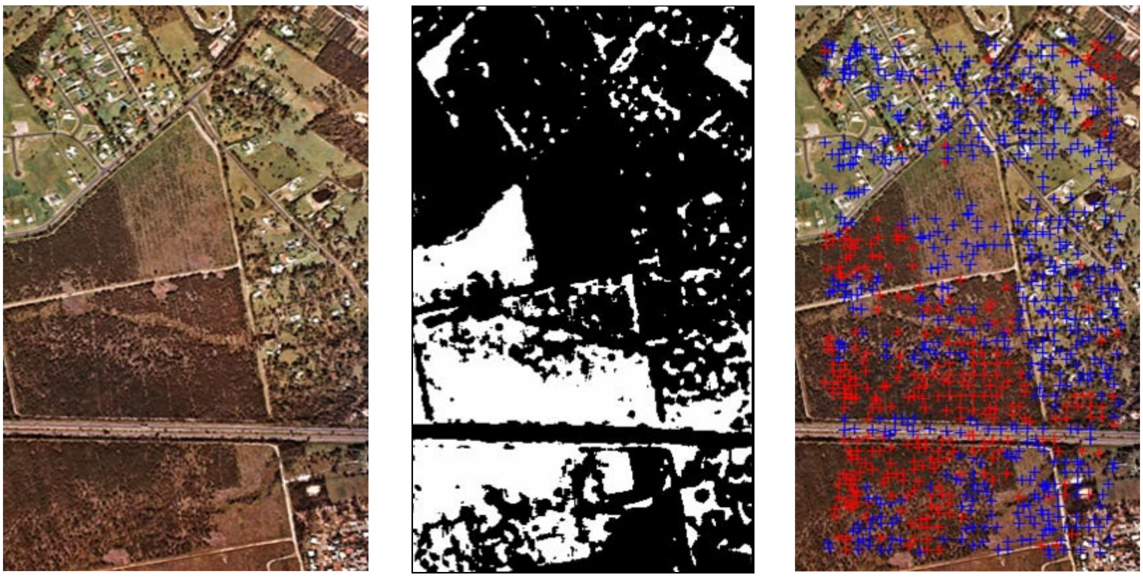
Figure 2. The results of aerial images segmentation

3.1. Aerial images segmentation

In our experiment , 12 color aerial images are used. The photography scale of color aerial images is 1:8000. The principle focal is 152.987mm. The scanning resolution is 96 μm. The photo size is 23cm ×23cm. An example of aerial images segmentation is shown in Fig.2. The piece of color aerial image, shown in Fig.2(A) contains density trees, sparse trees, houses, roads, grass and ground. Fig.2(B) shows corresponding disparity image that is grey image including 256 levels. It can be seen that high density trees and some houses reveal light white and grey, while the low sparse trees ,grass and ground are dark grey and black. This is due to the higher objects such as high density trees and some houses versus grass and ground have bigger grey values. According to the disparity image, high and low objects are recognized and the results shows in Fig.2(C), where white and black areas express respectively high and low objects. From Fig.2(C) can be seen that in the high regions, there are mainly density trees ,high sparse trees and a few houses, and non-trees objects such as some lower houses ,grass, road, ground and lower sparse trees are classified into low region. Finally, on the basis of preliminary results, the trees are refined by Fuzzy C-Mean with the texture and color features listed in Table 1 in the high and low areas and Fig. 2 (D) shows the final segmented results in which trees and non-trees are expressed as white and block areas. In compare with the preceding results shown Fig. 2(C), some lower spare trees belonged to non-trees in the preliminary segmentation are classified to the trees region. In particular, the number of pixels classified as non-trees due to the difference height between trees is small and a large number of pixels are correctly classified. At last, in this paper, an architecture of the observed points grouped based on above segmented results is proposed in order to improve the quality of aerial triangulation in forest –covered regions.

3.2. The automatic aerial triangulation of the observed points grouped

The comparison of results of the automatic aerial triangulation that the observed points on trees and non-trees are divided into different groups and automatic aerial triangulation using united points is the main task of the subsection. Generally, the matching accuracy and reliability of the observed points on trees are lower than of the observed points on non-trees. If the observed points on trees and on non-trees are grouped before the adjustment, the accuracy of automatic aerial triangulation would be improved in the forest-covered regions. To be divided automatically the observed points, above results of aerial images segmentation are used . Fig.3 shows the procedure grouped observed points. Fig. 3(A) and Fig. 3(B) is respectively an original color aerial image and segmented results. The result of the observed points grouped is shown on Fig.3(C),where red and blue cross express separately the observed points on trees and non-trees. In this paper, the comparison is done on the basis of two blocks of aerial images. Description of the blocks is shown in Table 1 and the results of two blocks adjustment in two different conditions are listed in Table 2.



(A) Original color image (B) The result segmented (C) Observed points grouped

Figure 3. The procedure of observed points grouped

Table 2 shows the accuracy values of two blocks adjustment in the two different cases: the observed points

Table 1. Two aerial block data

Description	Photo scale	camera	No. of photos	Focal length mm	control points	Check points	Pixel size μm
Block No.1	1:8000	RC30	12	152.987	16	10	96
Block No.2	1:40000	RC10	48	87.966	124	70	25

grouped and ungrouped. The first column corresponds to the nine common accuracy measures of aerial adjustment, including standard deviation of photo coordination measurement, From Table 2 can be seen that when the observed pointed are divided into two groups, a'priori standard deviation of photo coordination measurement is defined separately as 11μm and 22μm for the Block 1 and 12μm and 25μm for the Block 2, while when the points are not grouped, there is only one value used :11μm for the Block 1 and 12μm for Block 2. This is because the points on trees and non-trees are needed to given different and the thresholds for detecting error and the weights, in order to guarantee the connecting strength of aerial triangulation network that is very important to obtain good results, decrease the negative influence of the points on trees. The effect of the points grouped is clearly seen in the results : the accuracy of photo coordinates in the observed points grouped as compared with the points ungrouped is 53% higher for the Block 1 and 41% higher for the Block 2. The RMS of control points in the observed points grouped is lower 36% (X),69% (Y) and 64%(Z) for the Block 1 and 32%(X),33%(Y) and 42%(Z) for the Block 2, but, the maximum standard deviation of objects in the observed points grouped is higher 2%(X)and 1%(Z) for the Block 1and 7%(X),5%(Y)and 2%(Z) for the Block 2. This is due to the fact that the results of the adjustment by the points grouped is very well within two region, but it has problems that the threshold for detecting error of the points on trees is bigger than non-trees, a few lower accuracy observed points are permitted to be involved in the adjustment. To prevent some bad observed points to participate the final calculation, in practice, the reasonable rate of the a'priori standard deviation of photo coordination measurement is chosen, according to the terrain characteristic of blocks. Note however that the main accuracy measures of the adjustment by the observed points grouped are better than of the points ungrouped for the two blocks.

Table 2. Comparison results of the adjustments in the two different conditions

Description	Block 1		Block 2		Percentage(%)	
	Grouped	Ungrouped	Grouped	Ungrouped	Block 1	Block 2
Pre-Std.dev. of photo coord(μ m)	No. 1 11 No. 2 22	11	No.1 12 No.1 25	12		
Std.dev.of photo coord (μm)	8.08	17.03	6.90	11.61	53	41
RMS control (cm)	7,4,5	11,13,14	45,51,65	66,76,112	36,69,64	32,33,42
RMS check (cm)	20,18,27	30,40,54	65,70,101	80,91,120	33,55,50	19,23,16
Mean Std.dev.of Objects points(cm)	15,14,26	21,20,36	45,53,63	50,58,75	29,30,28	10,9,11
Max. Std.dev.of Objects points(cm)	40,35,70	39,35,69	118,180,172	110,172,175	-2,0,-1	-7,-5,2
Min. Std.dev.of Objects points (cm)	7,7,11	14,14,23	22,23,26	31,32,34	50,50,52	29,28,24
Mean td.dev.of ext.orient(cm)/(mgon)	29,27,17 17,17,9	47,40,29 27,26,16	44,46,34 4.1,4.2,3.3	49,50,40 6.4,8.2,5.4	38,33,41 37,65,44	10,8,15 36,49,39
Max. Std.dev.of ext.orient(cm)/(mgon)	60,54,33 35,34,19	60,52,41 35,33,21	83,82,78 5.5,8.7,5.1	96,85,79 6.0,8.5,5.2	0,-4,20 0,-3,10	7,4,1 8,-2,2
Min. Std.dev.of ext.orient(cm)(mgon)	18,16,9.2 10,9,5	33,31,19 19,19,10	30,32,22 2.8,2.5,1.4	33,37,30 3.0,2.7,1.8	46,48,53 47,52,50	14,13,27 7,7,22

percentage (%)=(U-G)/U , where U and G expresses the accuracy values ungrouped and grouped respectively.

4. Conclusion

In this paper, we have proposed a new algorithm to extract the objects which are higher than surrounding in color aerial images. At first, the original images are segmented into high and low regions according to the disparity images. Next, the trees are extracted by Fuzzy C-Mean in the high and low areas, using a set texture and color features. We demonstrated in a number of aerial images that the correct rates of extraction trees are from 95% to 88%. Finally, we have shown that algorithm can be used to group automatically the observed points in aerial triangulation. The comparison results illustrate that the adjustment accuracy is improved using the observed points grouped in the forest-covered areas. In the future, with this extraction algorithm ,we would analyse that forest affect the accuracy of digital elevation model in the forest-covered regions.

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