OBJECT ORIENTED FEATURE EXTRACTION FROM AERO-IMAGERY

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ABSTRACT

Based on the analysis of problems in automatic interpretation of aero-imagery , a new method called operator guided semi-automatic processing for feature extraction is proposed and realized by seed based region growing and structual information aided feature extraction algorithms.

KEYWORDS : Image Interpretation , Object Extraction , Operator-Machine Coorperation, Knowledge-Based Techniques .

1. INTRODUCTION

To replace or partly replace the heavy eyes -hands-work by machine vision, is a goal, for which photogrammetrists yearn. Since Hobrough first invented the image correlator, more than 30 years research has been paid to image matching dedicating for automatic generation of DEM. Due to the high cost and several problems left in fully automatic systems, research on semi-automatic system seems to be more interesting recently. As a typical example, Gagnon proposed a microcomputer based photogrammetric system DVP (Gagnon, 1990), which combined automatic image matching with manual measuring and plotting.

Research in photogrammetric landform feature measuring and plotting is also originally aimed at fully automatic image interpretation. Many failures at the past years sobered us to recognize that the technology of artificial intelligence at the recent stage is very difficult to realize a fully automatic understanding of the image of aerophotographs. But it is no doubt that several useful tools have been provided by artificial intelligence and computer techniques. One of the most important tasks is to investigate how we can make optimum combination of the new tools with the tranditional manual techniques, to make a progress, which is not ideally the best but actually better in production efficience. It should be noticed that such strategy has been widely adopted in the field of artificial intelligence recently.

It is observed that the procedure of manual interpretation of image includes actually three steps, i.e. the first , affirming the existence of a object, i. g. a rectangular pattern in the image is recognized it is a building , the second , detecting the details of the object, such as the edges, corners and shadow , and the third describing the obtained objects by symbols . By manual operation, the first step normally can be implemented easily and fast, and it takes much working time for the third step. However by machine processing , the most difficulty is at the first step, and the other two steps are relatively easy (Fig. 1) . According to the fact mentioned above, the main consideration in this paper is to realize object oriented image feature extraction . The objects are recognized by manual operation or operator aided semi-automatic processing , then features are detected and described by computer processing . The following two measures should be taken into account:

1) to develope techniques for image segmentation and contour extraction with restrained conditions.
2) to establish an operator guided semi -automatic system.

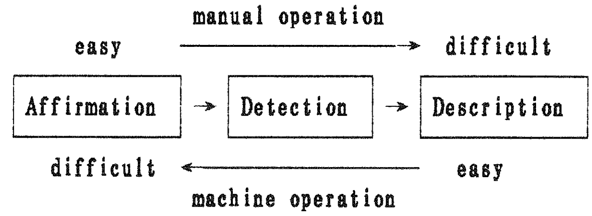


Fig. 1 Image Interpretation Procedure

2. SEED-BASED REGION GROWING ALGORITHM

2.1 Difficulties in Image Segmentation

Image segmentation often meets difficulties at the ragged boundaries and unhomogeneous regions , which may cause the unclosed boundaries of the regions and the non-meaning holes within the regions. In order to solve such problems, many attempts have been carried out and results differently in advantage and disadvantage (Haralick, 1985) . It has been shown that the blindness in the segmentation procedure is due to be lacking knowledges during the region growing . Therefore , to develop knowledge based algorithms for image segmentation has been in great demand. A distinguish contribute in this field has been made by Matsuyma (Matsuyma, 1988). However, it is still difficult to formalize the knowledges of objects, particularly of objects in the aerial image with complex image structure.

2.2 The Strategy of Seed Based Growing

In order to resolve the contradiction between the limitations of techniques and the urgency of application , a strategy called seed based region growing is proposed. The attribute of a region is affirmed by manual interpretation, and the operator drives a floating mark into the region to plant at least one seed. Then the region growing will be performed automatically. Because of the combination of manual operation and automatic processing in feature recognization, detection and description , the efficience and reliability can be better than that in either manual or machine operation

2.3 Algorithm and experiments

For realizing the strategy, an seed based region algorithm is designed and the experiments with real data are performed.

2.3.1 Growing Way Starting from the seed, region is growing alone the way in spread manner which is effective in accordance with the consideration of processing speed and memory sapce. The technique of exchanging indicating signs marked on contour of region boundary is implemented to reduce the memory space occupied by algorithm.

2.3.2 Criterion of Growing Assuming the grown region has N pixels with mean gray $\bar{x}$ and dispersion S:

$$S = \sum_{i=1}^{N} (x_i - \bar{x})^2$$

the t satistic can be constructed

$$T = (y-\bar{x}) \cdot \sqrt{(N-1)N/(N+1)S^2}$$

here y is the gray value of the present pixel P. The criterion is as

$$P \in \begin{cases} w1 & \text{when } T > T_{\alpha/2} \\ w2 & \text{when } T < T_{\alpha/2} \end{cases}$$

here , the w1 and w2 indecate the pixel inside and outside of the region respectively. $T_{\alpha/2}$ is a statistic threshold value which is determined by the significance level α, normally α can be taken very small (0.001~ 0.0001).

2.3.3 Description of the Region Boundary The region boundary is described by chain codes. The steps of the procedure are as following:

(1) Record chain codes alone the boundary according to the rule shown in Fig. 2

Direction	0	45	90	135	180	225	270	315
Codes	0	1	2	3	4	5	6	7

Fig. 2 Chain codes

(2) Calculating the curvature at each chain point:

$$a = [\sum_{k=i}^{i+n-1} \cos\theta(k) - \sum_{k=i-n}^{i-1} \cos\theta(k)]$$

$$b = (\sum_{k=i}^{i+n-1} \sin\theta(k) - \sum_{k=i-n}^{i-1} \sin\theta(k)]$$

$$CUR(i) = \mathrm{arctg}(a/b)$$

here CUR(i) is the curvature at point i, $\theta(k)$ is the chain direction at point k, the point number k is within a range 2n as shown in Fig. 3.

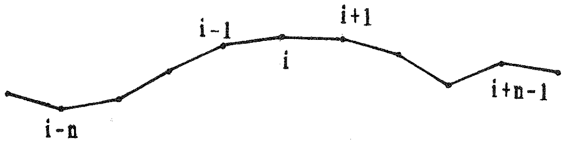


Fig. 3 curvature

(3) Data compression and contour modification. Data compression can be performed by restoring the key points with extreme values of curvature. According to the curvatures variation , the contour of the region can be modified , for example a small concave corner which is indicated by a minimum value of curvature can be detected and replaced by a straight line . It can also be modified by operator guided processing and object models.

3. GEOMETRIC CONDITION RESTRAINED IMAGE FEATURE EXTRACTION

Under the strategy of operator guided processsing , the structural knowledges about objects in the grey scale images are described by geometric conditions, which can be used to aid the feature extraction.

3.1 <u>Model Drived Hough Transformation</u>

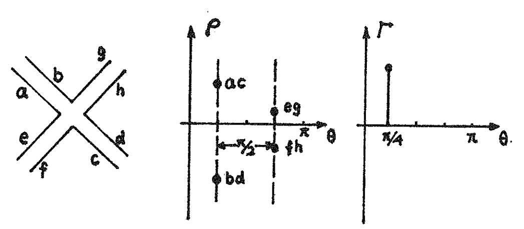
3.1.1 <u>The problems in normal procedure</u> It is observed in practice that there are some problems in the normal procedure of Hough transformation:

(1) It can only determine the parameters of a line , but not determine the start and the end points of the line.

(2) Due to effect of noise , the point with extreme value in Hough space is not detected easily.

(3) False points or false lines may be extracted in some cases.

3.1.2 <u>Model drived Hough transformation</u>
Fig. 4b shows the Hough space with parameter ρ and θ.



(a) feature (b) Hough space (c) θ space

Fig. 4 Model drived Hough transformation

As an example, the features of Fig. 4a correspond to 4 points in Fig. 4b. The corresponding relation can be formed as a θ function shown in Fig. 4c.

$$\Gamma(\theta)=\sum_{\rho=-\infty}^{\infty}H(\rho,\theta)+\sum_{\rho=-\infty}^{\infty}H(\rho,\theta+\pi/2)$$

It is more easy to detect parameter θ of lines in θ space than that of the 4 single line in hough space. Furthermore, the line parameters of 4 lines can be determined by the known object models.

3.2 <u>Building Contour Extraction</u>

3.2.1 <u>Automatic Extraction</u> Automatic processing can only be carried out at the condition of good image quality and the given window in which the existence of building is confiremed. The procedure can be briefly present as following:

(1) Edges region focusing with directional masks.

(2) Straight lines detection using heuristic technique.

(3) Straight lines description with parameters, such as direction , length, difference between the two side gray value etc.

(4) Corner formation based on right angule or other given knowledges of buildings.

(5) Building verification by the conditions of contour shape , homongeneus of the region and the properties of edges.

(6) Representation of the detected building contour with the parameters of centre point (x, y), direction , width , length and the mean gray value etc.

3.2.2 <u>Model Guided Building Extraction</u>

As many buildings have similar shapes in the images, the method called model guiled building extraction is proposed to extracting the other buildings with the similar shape as one that has been previously extracted and decirbed. The method is implemented by the following two ways:

(1) Parameter controled detection. As shown in

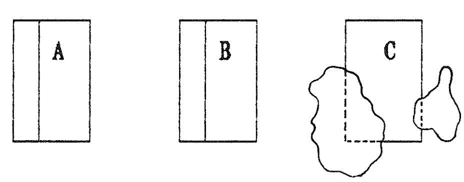


Fig. 5 Model guided extraction

Fig.5 , the image of building C has partly been occluded by trees , but it can detected by using the building parameter sets of building A and B which has been established previously.

(2) Contour templet matching. The building B can be extracted by contour matching method in which the templet of A can be selected from the building representation data base.

4. OPERATOR/MACHINE COORPERATION

As mentioned above, object oriented image feature extraction needs to be implemented in an operator guided semi-automatic processing system. Actually, it is a normal interactive image processing system. However, the most improtant function of this system is to combine the manual operation and the machine processing coorperatively. The following techniques are taken for operator-machine coorperative operation.

(1) When operator recognize an object from the image and input the attribute code of the object, the object parameters for further processing will be automatic determined by searching from established data base.

(2) If precise location of a point is necessary , the operator is only required to drive a floating mark to the approximate location .The algorithm has snap function.

(3) When automatic processing has been in bl nd situation, the operator can make corrections in good time or inpostprocessing procedure.

5. EXPERIMENTS AND CONCLUSION

To veritify the above metioned strategy . A system named CV2 (Computer Vision for 2 -dimensional processing) is designed. The components of CV2 are shown as Fig. 6. Two sets of aerophotographs of urban areas with scale of 1: 2000 and 1: 10000 have been processed. About 75% features, i.e. buildings, lakes, etc. are processed semi-automatically, and the other features , most of them are occluded by some another objects , are processed by manual drived floating mark according to the observing the visual image on the screen.

It is obviously from this research that the knowledges of objects can be used to make object oriented image feature extraction , and based on this techniques, the development of operator guided semi-automatic system for fast processing of aerophotogrammetric data is possible and useful.

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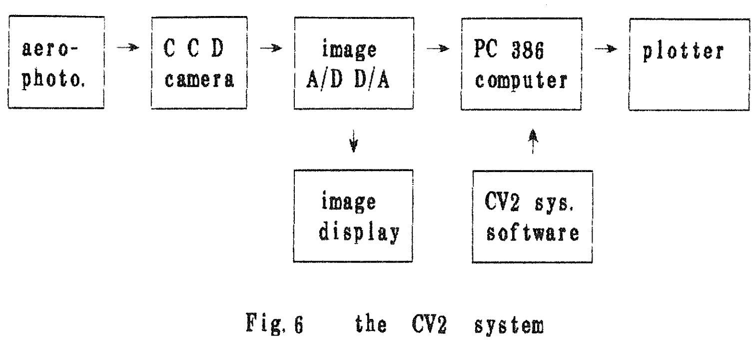

Fig. 6 the CV2 system