STRUCTURAL CHARACTERISTICS AIDED IMAGE MATCHING

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ABSTRACT

Many image matching algorithms take only the local gray information for matching processing. When this local area has similar characteristics to one or some more neighbouring areas, the matching results may be wrong. For enhancing the reliability at such situation, some structural characteristics of biger image-area are extracted by image segmentation and used to aid the local gray-level correlation.

1. INTRODUCTION

Photogrammetric image matching techniques developed rapidly during the passed few years, particularly by applying the least-square matching method, it is able to get very high precision comparable to manual measurements, but there still are some difficulties in obtaining results with high reliability(Rosenholm 1987). Many image matching algorithms take only the local gray data, e.g. a small patch pair, for matching processing, that is one of the reasons leading the low reliability. Experiments show that the unreliable matching may come not only from the areas with poor texture but also from the areas with very densy texture. Applying the technique called edge based image matching can avoid the first problem, but still has trouble in the second case. Fig. 1 shows a typical situation.Due to the similar edge feture, point I may be misdirected to point J by matching only a small patch pair. It is observed that to solve such a problem some aditional information is necessary. For instance, When the upside boundary AEFB is taken into consideration, I and J will be easily distinguished by distances IE and JF. Because the region boundaries are got from structural analysis of large image area and used as additional information only, we call this method structural characteristics aided image matching.

2. EXTRACTION OF STRUCTURAL INFORMATION

The task of photogrammetric image matching is not "what is it?", but rather "where is it ?". The correspondence to be investigated is not between the scene and the image, but between the left and the right images. The extracted structural characteristics are applied only as additional information of the local gray data to enhance the matching reliability. Therefore the extraction procedure designed for our purpose is much simpler than that used for image understanding system. The main parts of the procedure are: noise elimilation, image segmentation and structural characteristics description.

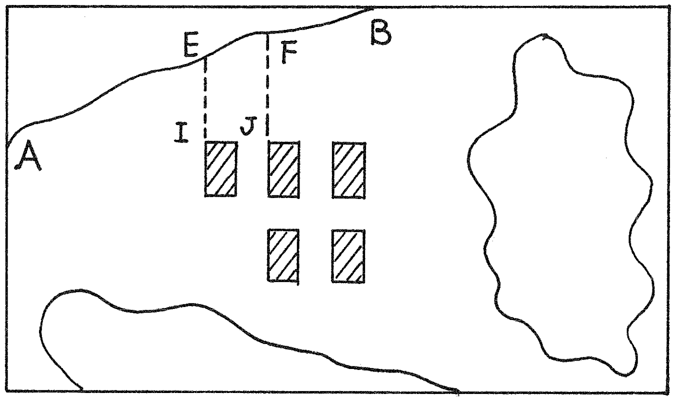

Fig. 1: Similar edge feture

2.1 NOISE ELIMINATION

Many image-smoothing oprators can remove the noise, but simultaneously blur the sharp edges, which are favorable for image matching. Nagao and Matsuyama (1980) proposed a sophisticated algorithm, called edge-preserving smoothing, which resolves the conflict between noise elimilation and edge degradation. It looks for the most homogeneous neighborhood in a picture, and then gives each point the average gray level of the selected neighborhood. It removes noise in flat regions without blurring sharp edges or destroying the details of the region boundaries. Actual implementation of the edge-preserving smoothing is listed as follows.

Step 1: Take a window of 5x5 pixel around the processing point (x,y). Calculate the gray-level variances on each of the nine masks as shown in fig. 2, e.g. four pentagonal, four hexagonal and one square.

Step 2: Detect the position of the mask where its gray-level variance is minimum and give the average gray-level of the mask elements to the point (x,y).

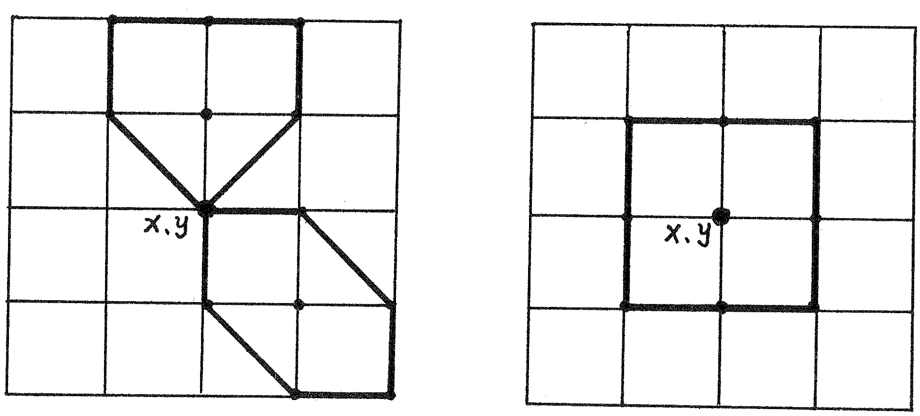

Fig. 2: Nine masks for the edge-preserving smoothing

Step 3: Apply the step 1-2 to all points in a picture.

Step 4: Iterate the above process untill the gray-levels of almost all points in a picture do not change or change less than a given threshold.

2.2 IMAGE SEGMENTATION

Right after the edge-preserving smoothing, each of the left and the right pictures is segmented into several homogeneous regions by edge detection. To avoid the difficalties in determining the threshold and in thinning the edges, a method called integrated step has been developed for edge detection. All the gray-level increments along several adjacent points are integrated into a large step(fig. 3). The large step value is used for detecting the region edge/boundary according to the threshold from the smoothing procedure, then the edge is sharped at the midiam of the large step. Instead of two dimensional processing, the picture is dealt with in X and Y direction separately.

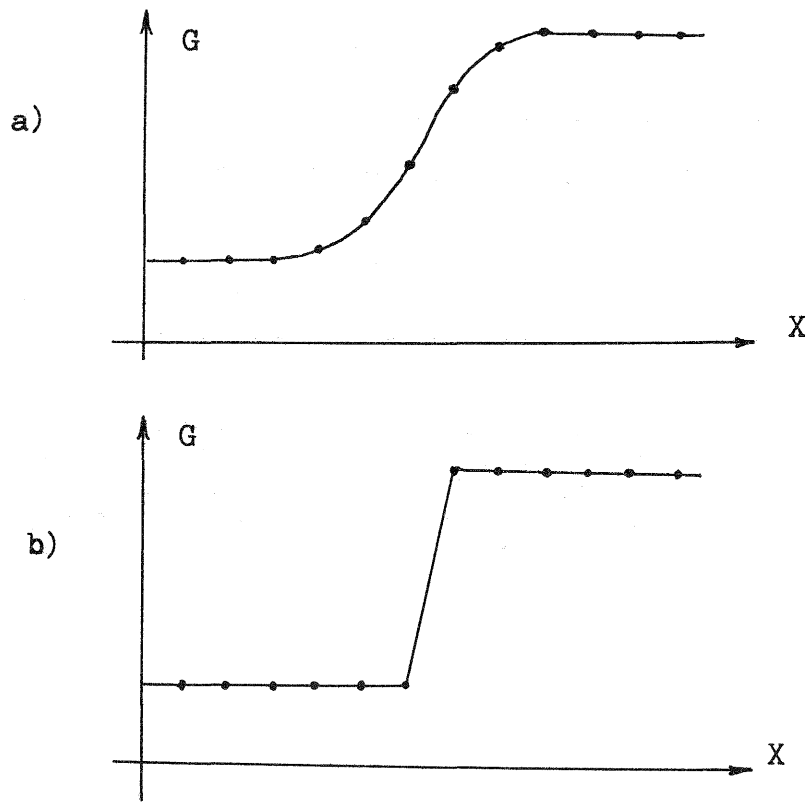

Fig. 3: Integrated step of gray-level
a) original edge; b) sharped edge.

2.3 STRUCTURAL CHARACTERISTICS DESCRIPTION

It is easy to find many approaches for structural texture description in concerned literatures. One of them, which suitable for our application, is introduced by Lumia et al.(1983). They propose to use 26 properties for region structure description.

Though all of the 26 items can be applied to enhance matching reliability, in consideration of processing speed, only the following 4 y-directional parameters are selected:

1) the number of pixels to the upside boundary, e.g. the distance IE shown in Fig.1;

2) the number of pixels to the downside boundary;

3) the mean gray-level along y-direction in the upside region;

4) the mean gray-level along y-direction in the downside region.

The above selection is particularly favorable to epipolar image matching. Because all of the 4 parameters have the same data-structure as the gray-level values and implicate similarity between the left and the right pictures, it is no difficulty to use the structural information in image matching algorithm.

3. STRUCTURAL INFORMATION AIDED IMAGE MATCHING

3.1 HIERARCHICAL CONTROL BASED ON THE SIGNAL TO NOISE RATIO

It is used to implementate progressive matching of the images from coarse to fine detail. But in view of intormation theory, it is better to make hierarchical control based on the signal to noise ratio. A simple approach to take signal to noise ratio into consideration is using the integrated step value mationed above and assuming that the step value is in proportion to the ratio.

Image matching in our procedure is only performed at the interest points, which are selected by comparating the integrated step value with a series of threshold and divided into several hierarchical levels. The threshold set is arranged form high to low value by a ratio of 2:1 between any two adgacent levels. In connection with the threshold set the searching ranges of image matching are half reduced from a high level to a next low level.

3.2 MATCHIN WITH MULTI-INFORMATION AND MULTI-CRITERION

It is obvious that a image matching system, which is expected to produce results with high reliability, presupposes that the input data containing sufficient information. To deal with the multi-information, e.g. the local gray data and the structural parameters, the following criterions are applied for similarity assessment in our program to perform multi-criterion image matching (Lin 1986).

- the edge direction and step value;
- the difference of gray-level of the central pixels;
- the differences of the structural parameters;
- the correlation coefficient of the gray-levels;
- the correlation coefficient of the structural parameters.

The matching algorithm accepts only the unanimous results to ensure the reliability.

3.3 ADAPTIVE CONTRAL

Using multi-information and multi-criterions will enhance the reliability. But it takes more time for processing, when all the information and the criterions are used for every matching point. The adaptive control procedure are designed to improve the processing speed. It leads the different points through some more or some less processing steps with different criterions. Most of the points are quickly to be rejected or accepted by two or three simple criterions. Some difficult points are led into several conflict processing to make sure of the correspondence. A few points need manual interposition.

4. EXPERIMENTAL RESULTS

Based on the above ideal, a program package have been developed and tested by the following data:

- the image No. 1 and 10 of the image matching test data of ISPRS WG III/4,1986;
- a pair of airphoto taken from Yichan, a mountain area, with scale 1:16000;
- two pairs of airphoto taken from Hainan, arubber plantation area, with scale 1:32000.

The matching results have been verified by the enlarged imagery and found no gross errors. the accuracy of the DHM of Yichan and Hainan area are as follows:

Data	RMSE	Tested by comparing with
Yichan	1.4 m	1:5000 topograghic map
Hainan	3.5 m	measurments at WILD BC2 analy. plotter

5. CONCLUSION

It is observed from our experiments that structural characteristics can be used to enhance the matching reliability. The results have not so high precision, but can be used for some applications, e.g. to produce orthophotos, and used as approximations for the least square matching. Further development is necessary to improve the processing speed.

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