AUTOMATIC REGISTRATION OF SAR AND OPTICAL IMAGE BASED ON MULTI-FEATURES AND MULTI-CONSTRAINTS

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1. INTRODUCTION

With the development of remote sensing technique, there is an increasing interest on images from multi-sensors. However, because of the huge differences between different sensors, registration becomes more difficult and more complex, especially between SAR and optical images. When either pixel based or feature based method is adopted, there will be many false matched situations. How to extract accurate corresponding points in different images is critical for registration between SAR and optical images.

Many researches have been done to solve this problem. Zitova [1] proposed a parametric corner detector, which was designed to handle blurred and noisy data. Fabio Dell'Acqua [2] used road junction as cross-road features, these features are matched using correlation and geometrical analysis. Zhang [3] proposed a method using closed regions to fulfill automatic coarse registration between multi-source satellite images. Maximally stable extreme region (MSER) was also a way to extract region features. Yosi Keller [4] used an implicit similarity method to achieve multisensor image registration. Because of the complexity and diversity of images from multiple sources, these methods and techniques have both advantages and disadvantages. For optical and SAR images, an automatic registration method based on multi-features and multi-constraints is proposed in this paper.

2. PROPOSED REGISTRATION ALGORITHM

Aiming at the difference of SAR and optical sensors, this paper proposes a two-stage method based on multi-features and multi-constraints. Firstly, corresponding closed regions are extracted automatically to achieve the coarse mapping parameters as geometrical restriction. Secondly, we extract all the Harris corner points and cross-road features between two images, and introduce correlation analysis and mutual information to match the control points. Finally, multi-constraints are used to wipe off the false matched points. The final retained matched points are derived as Ground Control Points (GCPs) for registration.

The two stages are included in this method.

Stage One: Coarse registration. Closed regions are extracted, and they are used to get coarse mapping parameters. After that, Hu's moment invariants and a cost function are used to find corresponding regions.

The cost function can be described as follows:

$$\Gamma = \left|\frac{a_1 - a_2}{a_1 + a_2}\right|^{\frac{1}{2}} + \left|\frac{p_1 - p_2}{p_1 + p_2}\right| + \left|\frac{r_1 - r_2}{r_1 + r_2}\right| + \left|\frac{c_1 - c_2}{c_1 + c_2}\right|$$

Where a_i is the area of region i, p_i is the perimeter length, r_i is the length of the bounding rectangle, and c_i is the width of the bounding rectangle [5].

Only when the two methods have same results, two corresponding regions can be determined. And the centroids of matching regions are used as GCPs. The flow of Stage One is shown in figure 1.

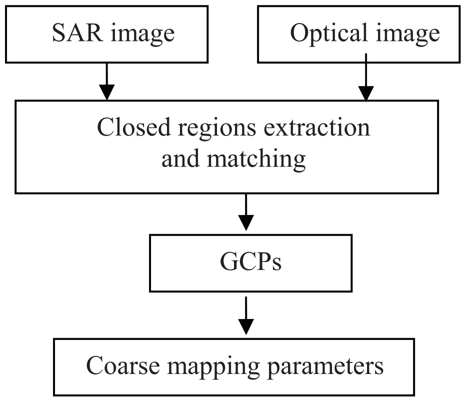

Fig. 1 Coarse mapping parameters

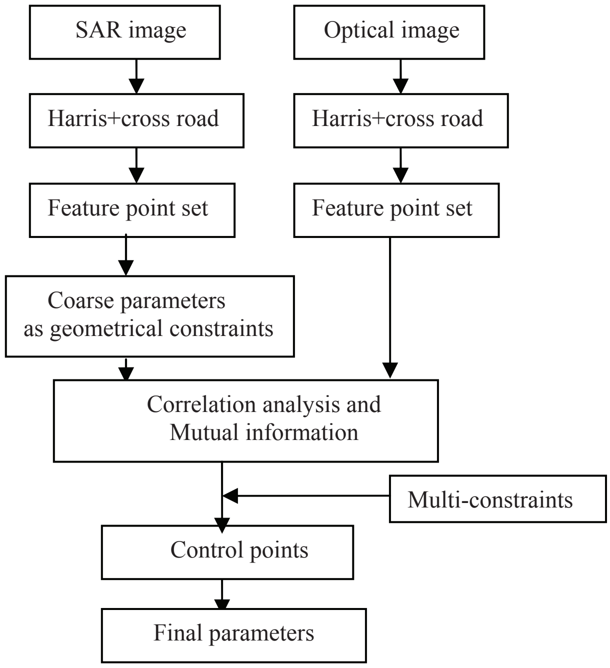

Fig. 2 Accurate mapping parameters

Stage Two: Fine registration is carried out. After the cross-road features and Harris corners are extracted, the coarse mapping parameters are used to map SAR image's points to the optical image's space. The candidates within a close neighborhood in the SAR image will have corresponding candidates that are spatially close to each other in the optical image. The flow of Stage Two is shown in figure 2.

Unlike the common method, in which the measure of similarity is computed for window pairs from the SAR and optical images and its maximum is searched, multi-constraints are adopted to get accurate GCPs. Multi-constraints can be described as follows:

(1) The computation of the mutual information and normalized cross-correlation between the pair of points will both produce the maximum values, which should be greater than a threshold value.

(2) The pair of points must be in conformity with a bidirectional matching [5].

(3) If excessive candidates of control points in SAR image are corresponding to one optical GCP candidate, all matched points will be deleted.

(4) For the control points in SAR image, coarse mapping parameters are used to compute their coordinates in the optical image , then position deviation can be computed. If the position deviation is larger than a threshold value, the matching of the pair of control points will be rejected.

(5) Apply the random sample iteration method to determine the final GCPs.

3. EXPERIMENTS AND RESULTS

In the experiment, two images are acquired over Beijing area, in which the optical image is 1668×1821(3-m resolution)and SAR original image at the same scene is 836×772(6.25-m resolution). Fig 3 shows the original optical and SAR images.

Fig.3.the original Optical(left) and SAR(right) images

Fig. 4.Closed regions extraction results

Fig4 shows the closed regions extraction and matching result of optical and SAR image, respectively. The color represents the corresponding matching regions.

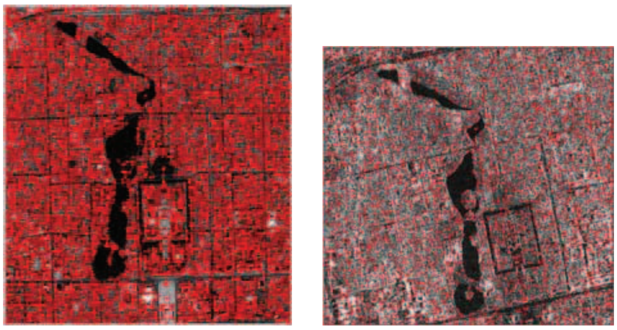

Fig.5. Harris corners and cross-road extraction results

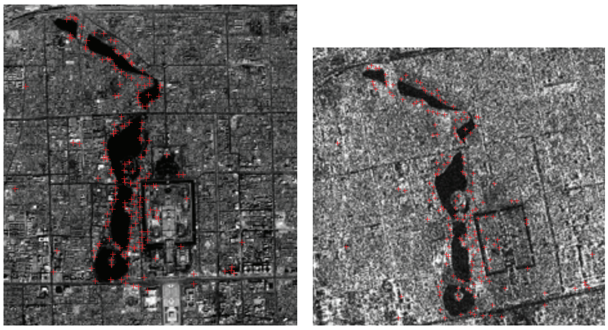

Fig.6. Final matching point pairs

Fig 5 shows the result of cross-road features and Harris corners extraction results. After the multi-constraints are utilized, 179 pairs of points are served as GCPs. The matching results are shown in Fig 6.

The coarse mapping parameters (Affine1) and the final amended mapping parameters (Affine2) are shown in Table 2:

Table 2. The comparison of different mapping parameters

Affine1	a1=1.8817	a2=-0.3437	tx=63.514
	a3=0.3652	a4=2.0186	ty=-98.1388
Affine2	a1=1.9175	a2=-0.3572	tx=54.7782
	a3=0.3402	a4=2.0374	ty =-95.0792

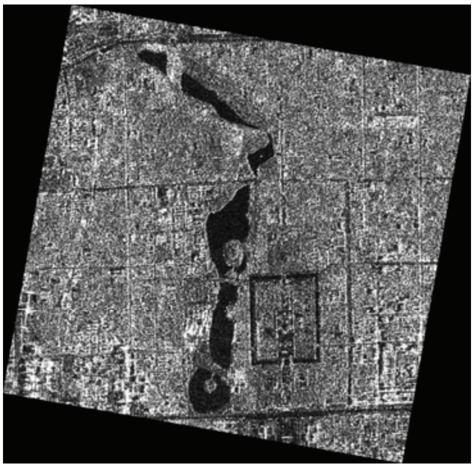

Fig.7. Final registration result

Usually the RMSE is used to examine the precision. In this paper, 10 pairs of points are finally selected as test points. The experiment results show that the method can reduce the possibility of false mapping and the registration error is about one pixel.

4. CONCLUSION

This paper presents an automatic registration method based on multi-features and multi-constraints, which can achieve the automatic registration between SAR and optical images, and the registration error is about one pixel. This automatic method is suitable for the images with homogeneous close regions.

5. REFERENCES

[1] B. Zitova, J. Flusser, "Image registration methods: a survey," *Image and Vision Computing*, vol. 21, pp. 977-1000, 2003

[2]Fabio Dell'Acqua, Paolo Gamba, Gianni Lisini, "Coregistration of Multiangle Fine Spatial Resolution SAR Images," *Geoscience and Remote Sensing Letters*, vol.1,pp. 237- 241,2004.

[3]Zhang ZhaoHui, Pan ChunHong, Ma SongDe, "An automatic method of coarse registration between multi-source satellite images," *Intelligent Sensors, Sensor Networks and Information Processing Conference*, pp. 205-209,2004.

[3] Florence Tupin, Henri Maitre, Jean-Fran¸ cois Mangin, Jean-Marie Nicolas, and Eugene Pechersky, "Detection of Linear Features in SAR Images: Application to Road Network Extraction," *IEEE transactions on geoscience and remote sensing*, vol.36, pp. 434-453,1998.

[4]Yosi Keller, Amir Averbuch, "Multisensor Image Registration via Implicit Similarity," *IEEE Trans.on pattern analysis and machine intelligence*, vol. 28, no.2006.

[5] Paul Dare , Ian Dowman , "An improved model for automatic feature-based registration of SAR and SPOT images," *ISPRS Journal of Photogrammetry & Remote Sensing*, vol.56,pp.13-28,2001.