THE NORMALIZED SIFT BASED ON VISUAL MATCHING WINDOW AND STRUCTURAL INFORMATION FOR MULTI-OPTICAL IMAGERY REGISTRATION

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1. INTRODUCTION

Automatic image registration, which is often employed as a pre-processing step prior to image fusion, is an important issue in remote sensing applications. The automatic registration for multi-optical imagery is an active research field especially. The imaging mechanisms for multi-optical imagery are different, which throws a big difficulty in the registration between them. Currently, many algorithms have been developed, which can be grouped in two categories: area-based registration and feature-based registration [1]. Automatic area-based registration over lies on the gray statistic characteristic; thus it adapts to the registration between images acquired by the same sensor, and does not make sense in the registration between images acquired by the different sensors, or lack of texture [2]. In the method of automatic feature-based registration, features should be distinct, spread all over the image and efficiently detectable in both images. SIFT (Scale Invariant Feature Transform) [3] has been shown to provide superior performance for image registration between aerial, medicine, or remote sensing imagery acquired by the same sensor [4, 5]. However, when applying SIFT in registration between imagery acquired by different sensors or with big differences in resolution and angle, few matching couples are obtained. Aiming to this problem, three improvements have been proposed in this paper, and a new registration algorithm called normalized SIFT based on visual matching window and structural information (NSIFT-VMW-SI) is presented.

2. METHODOLOGY

In the algorithm NSIFT-VWM-SI, first, the construction of visual matching window (VMW) increases the matching probability between SIFT keypoints; second, the normalization of SIFT keypoints makes them more robust to the differences in hue; third, the matching couples

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This study was supported financially by the National High Technology Research and Development Program of China (No. 2007AA12Z157), the National Natural Science Foundation of China (No. 40901234).

are checked by the consistency of structural information for different optical imagery, which improves the robustness of registration. The algorithm mainly consists of five steps: (1) construct the VMW of reference image (R-VMW) and VMW of sensed image (S-VMW); (2) extract the SIFT keypoints in R-VMW and S-VMW respectively, and then process them by normalization; (3) obtain the visual matching couples in R-VMW and S-VMW; (4) check the consistency of structural information between visual matching couples to eliminate the wrong matching couples; (5) obtain the corresponding matching couples in reference image and sensed image; (6) generate the transform model guided by the least square adjustment equation. With this model, the sensed image is registered and the automatic registration is achieved.

3. EXPERIMENTAL DATA

To validate the feasibility of this algorithm, two pairs of images, comprising SPOT-5(P) and Landsat-5 TM, SPOT-5(P) and ASTER were used as experiments. SPOT-5(P) and Landsat-5 TM images cover the Olympic Field in Beijing, China, and the differences in resolution and angle between them are 10 times and 14.480065 degrees respectively. SPOT-5(P) and ASTER images cover the city of Zhangye town, Gansu Provience, China, the difference in resolution and angle between them are 6 times and 10.3826 degrees respectively.

4. RESULTS AND ANALYSIS

In figure 1(*a*) and (*b*), every line links one point in reference image and the corresponding point in sensed image, which denotes a matching couple. Figure 1(*a*) has 2 matching couples obtained by the algorithm SIFT; figure 1(*b*) has 45 matching couples obtained by the algorithm NSIFT-VMW-SI. In figure 1(*b*), the blue lines denote the matching couples with consistent structural information, and the yellow lines denote the matching couples with inconsistent structural information. The registered TM image is depicted as figure 1(*c*), its scale and angle is identified with SPOT image. Furthermore, a mosaic of alternate strips of registered TM, SPOT and the sum of them depicted in figure 1(*d*). The mosaic image suggests a high quality registration with linear features lining up well.

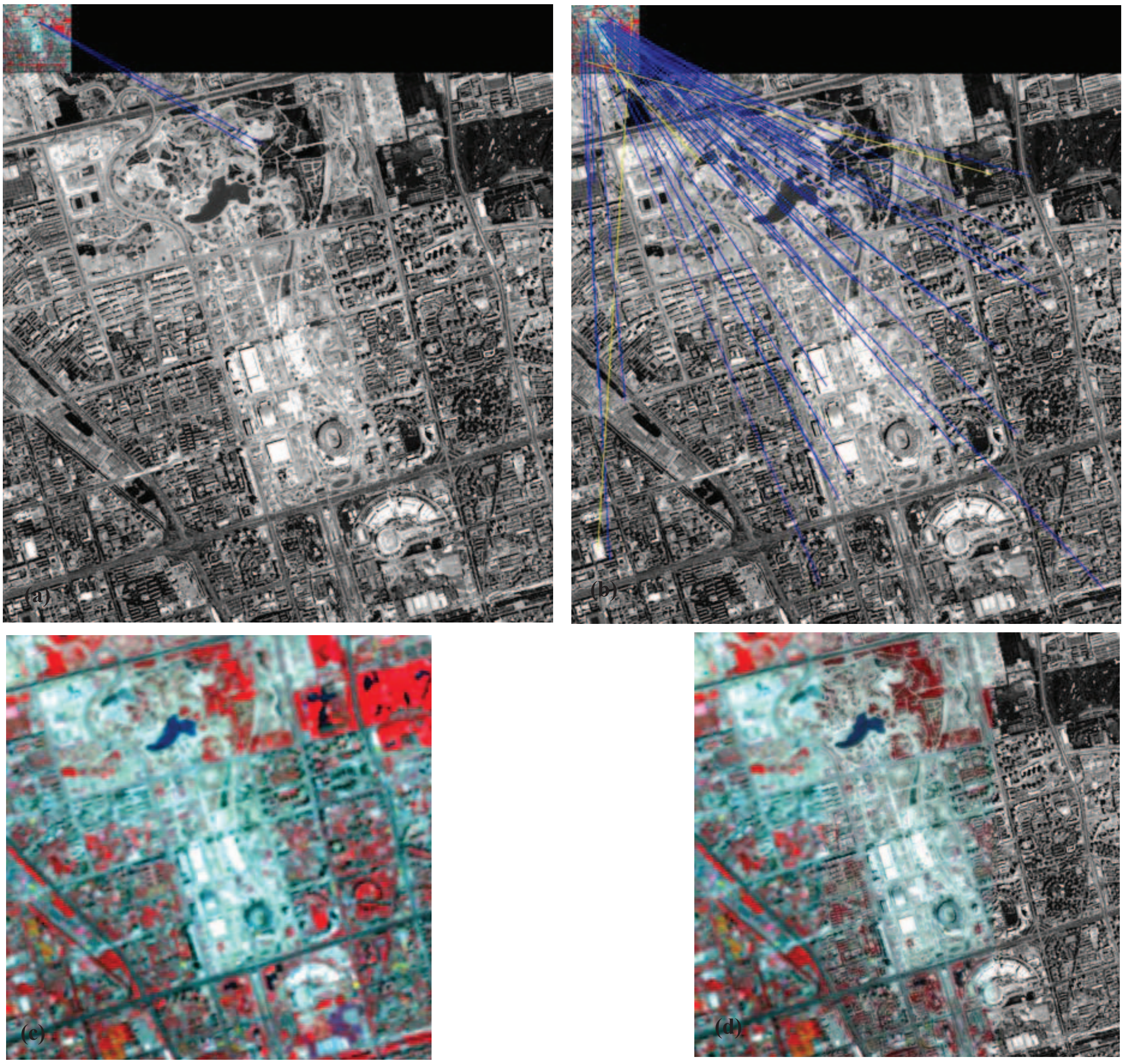

Fig.1 Registration of SPOT and TM images. (a) the matching couples for SPOT and TM obtained by SIFT; (b) the matching couples for SPOT and TM obtained by NSIFT-VMW-SI; (c) the registered TM image, with the same angle and resolution as SPOT image; (d) mosaic image, from the left, registered TM, the sum of registered TM and SPOT, SPOT images are displayed repeatedly.

Some features are extracted manually to check the registration model's precision. The registration model's precision for SPOT and TM images are presented in table 1, it indicates that errors were lower than one pixel, which effectively proves that the algorithm is robust to differences in acquired sensors, resolution and angle between imagery, and has a high precision.

Tab.1 The registration precision for SPOT and TM images

Num of point	**The points in reference image**	**The points in sensed image**	**Difference in row（dx）**	**Difference in column（dy）**

1	(132,232)	(70,45)	-0.824452	-0.0966188
2	(907,417)	(127,77)	0.635667	-0.312386
3	(1677,448)	(189,96)	-0.005251	-0.036542
4	(226,1175)	(57,123)	-0.470365	-0.121796
5	(1202,1331)	(131,157)	0.802111	-0.292325
6	(1853,1042)	(190,147)	0.436414	0.625221
7	(370,1792)	(55,176)	-0.099421	-0.305514
8	(1215,1795)	(123,195)	-0.098757	-0.649711
9	(1588,1687)	(155,194)	0.261984	-0.216991

Due to limit of paper length, the registration results of second group imagery are not listed.

5. CONCLUSIONS

A new registration method named NSIFT-VMW-SI is proposed in this paper. For the experiment presented, the registration precision is lower than one pixel. This algorithm has high accuracy and robustness to registration for imagery acquired by different sensors, from different angles or with different resolutions. Moreover, it is highly automatic.

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