MULTISENSOR IMAGE REGISTRATION ALGORITHM COMBINING SIFT AND PARTICLE SWARM OPTIMIZATION FOR APPLICATION IN MULTISPECTRAL IMAGERY

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1. INTRODUCTION

Registration of multispectral images with other sensor image such as optical, SAR images, which is the process of estimating the misalignment between two images, is a crucial preprocessing for many applications of multispectral images [1], such as fusion and change monitoring. Recently, some methods have been proposed for multisensory image registration in remote sensing [2]-[5], such as Pixel Migration method proposed in literature [5] is effective to find the correct solution. Unfortunately, well registration performance is severely limited to the situation when geometric deformation is not significant, while it is unable to obtain satisfactory results when the deformation is large. In addition, how to choose appropriate bands of multispectral images to be registered is an extremely important problem related to registration accuracy, while there is little relative work.

In this paper, to solve the problems, a step-wise algorithm combining Scale Invariant Feature Transform (SIFT) and Particle Swarm Optimization (PSO) is proposed for multispectral image registration with other sensor images. Firstly, information entropy as a rule is used to select a suitable band image from the misaligned multispectral images for registration. Secondly, a SIFT modified by combining with local invariant moment is used to search optimally matched points for coarse image registration. Then, the parameters of the coarse registration model are used to initialize an optimization process controlled by PSO where local gradient is used as a rule for searching optimal parameters for final registration.

2. METHODOLOGY

2.1 Selection of appropriate band

Different band plays different role in multispectral image registration with the different sensor images. This fact is taken into very few considerations in the current researches. In the proposed algorithm, image information entropy is utilized to search the appropriate band with the maximum image entropy. The selected band image with maximum entropy can provide more effective information for the registration. Fig.1 shows that registration accuracy varies with different spectral band image that has different information entropy. The information entropy of single spectral-band image I is given as follows:

$$Entropy(I) = \sum_{i=0}^{n} P_i \log_2 P_i \quad \textbf{(1)}$$

where n represents the biggest gray scale corresponding to radiometric solution n_b of image I and $n = 2^{n_b} - 1$, P_i is the statistical probability of gray scale *i*.

2.2 Coarse registration combining SIFT and local invariant moment

When there is significant deformation and resolution difference between input images pairs, conventional methods cannot get satisfactory results. In the proposed algorithm, SIFT and local invariant moment are combined for coarse registration. SIFT is a local descriptor extraction method which has valuable characters such as invariance to illumination and viewpoint [2]. Unfortunately, the standard SIFT algorithm is not fully applicable to the image pairs with big resolution difference. In this case, there are many incorrect corresponding points' pairs in the results. Invariant moment [4], based on regional gray statistical information, can compensate this shortcoming by selecting different sizes of windows relative to resolution difference. In this algorithm, SIFT is firstly used to find candidate points pairs, and then the Euclidean distance of corresponding points is calculated. Secondly the invariant moment descriptor is generated to calculate the Euclidean distance of moment descriptor of candidate point's pairs. Then we sort the weighted results and obtain the final correct corresponding points pairs.

$$Final_i = EU_{moment_i} \cdot EU_{sift_i} \quad (2)$$

where EU_{moment} is the Euclidean distance of moment vectors of corresponding points pair while EU_{sift} stands for Euclidean distance of sift vectors.

2.3 Refined registration using PSO

PSO is a stochastic, population-based evolutionary search algorithm. Compared to the disadvantage in fine tuning capabilities of Genetic Algorithm (GA), PSO shows a better performance. The object function is as follows:

$$F(P) = \arg\max_{P} \sum_{(x_i, y_i) \in S(P)} grad(x_i, y_i) \quad (3)$$

where P represents the transformation model parameters and S is the pixel set in reference image $I(x, y)$ under transformation P. Additionally $grad(x, y)$ means the gradient at coordinate (x, y).

3. EXPERIMENTS AND ANALYSIS

3.1 Data description

Image data used in this paper includes four image sets, the details are shown as follows:

Set 1: one image is part of London, UK, SPOT panchromatic data, 10m space resolution. And the other is of the same area from TM data, 28m space resolution.

Set 2: image pair is of some place in Qingdao china, one is hyperspectral image with 3.5m space resolution and the other is visible image with 2m resolution.

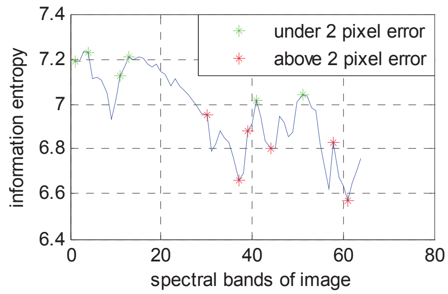
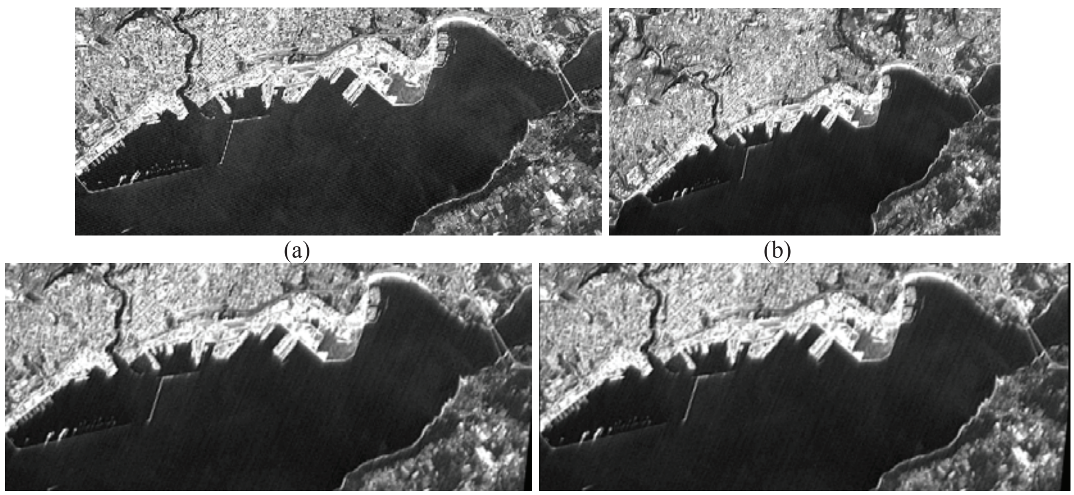


Fig.1. Information entropy varies with registration accuracy for different spectral bands. The green points represent good performance with registration accuracy under 2 pixels, while the error of the reds is more than 2 pixels.



(a) (b) (c) (d)

Fig. 2. Reference image (a) and target image (b) are used as initial input images. (c) illustrates the coarse registered image, and refined result is shows in (d).

Table 1 Comparison of local gradient extremes between proposed algorithm and pixel migration algorithm

Methods / Test images	Pixel migration algorithm	Proposed algorithm
Set 1	1.058898635×10^6	$1.0611405793708109\times10^6$
Set 2	5.49245475×10^4	$5.9753251041171326\times10^4$
Set 3	1.001467933×10^6	$1.0201607590094523\times10^6$

Table 2 Comparison of registration pixel error between proposed algorithm and pixel migration algorithm

Methods / Test images	Pixel migration algorithm	Proposed algorithm
Set 1	2.9959	2.6610
Set 2	1.3052	1.2877
Set 3	1.1976	0.9459

Set 3: one image is from SPOT panchromatic data, 10m space resolution shown in Figure 2 (a) and the other is multispectral image as shown in Figure 2 (b), 20m space resolution, obtained by SPOT XS.

3.2 Experiments for Coarse registration

Respectively, appropriate bands of three sets of pictures are successfully selected based on information entropy. In set 1, with the maximum entropy value, red band is selected from TM data. In set 2, band 3 is selected as input of following work while in set 3, we chose band 2. After the procedure of band selection, coarse registration based on SIFT and moment is performed and rough results are obtained. Set 3 is taken as example to illustrate the process and result of coarse registration as shown in Figure 2.

3.3 Experiments for Fine registration

To validate the effectiveness of the proposed algorithm, the pixel migration algorithm given in literature [5], which adopts local gradient rule and GA optimization method, is introduced into our experiments. Here suppose that the target image has been coarsely aligned with the reference image. Both of the proposed algorithm and the pixel migration algorithm are performed on the target image coarsely registered.

Table I and Table II respectively provide the comparison of local gradient extremes between proposed algorithm and pixel migration algorithm and the comparison of registration pixel error between proposed algorithm and pixel migration algorithm. It can be found from Table I that PSO performs better than GA when search range is limited to a small area obtained by coarse registration procedure. For all three sets, PSO can find more precise maximum extreme of gradient sum. Table II indicates that the performance of proposed algorithm is better than that of pixel migration algorithm. The pixel error of the proposed method is lower than former approach.

4. CONCLUSIONS

In this paper, an algorithm of multisensory image registration is proposed for multispectral images. In the proposed algorithm, firstly information entropy is used to select an appropriate band from the target multispectral image. And then the SIFT is modified to more accurately extract registration control points, combined with the local invariant moment. After the target multispectral is coarsely registered to the reference image with high-resolution, PSO and local gradient are utilized to realize finer registration. The experimental results prove that the proposed algorithm can effectively realize the registration for multispectral and other sensor images, especially, while there are big differences of imaging characteristics and spatial resolution that cannot be resolved by the pixel migration algorithm.

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