Available online at www.sciencedirect.com
SciVerse ScienceDirect
Procedia Engineering 29 (2012) 2859 – 2863
Procedia Engineering
www.elsevier.com/locate/procedia

2012 International Workshop on Information and Electronics Engineering (IWIEE)

A Novel Method of Multispectral Imagery Registration Based on Minor and Noise Component Criterion

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Abstract

For multispectral imagery, spatial registration between bands is a very important part of the overall quality of the multispectral imagery product. In this paper, a multispectral imagery registration method is presented. It takes minor and noise component of sample covariance matrix as measure criterion, utilizes mutual information method to create registration seed sources, uses smooth filter to extend trapping width of registration curve. Experiments were conducted using multispectral imagery from the ETM Satellite. Control points optimal searching experiments show that the presented method can improve the efficiency and accuracy of multispectral imagery registration greatly.

Keywords: multispectral imagery; registration; minor and noise component criterion

1. Introduction

Multispectral imagery, which integrates the capabilities of spatially imaging and spectrally detecting sensed object or region, has been wide used in growing fields, such as remote sensing, reconnaissance and surveillance, medical, etc. Multispectral imaging sensors sample the incoming light at several different wavelength bands. Due to a number of factors, such as temporal changes, viewpoint differences, unknown scene overlap, non-coaxial and so on, the multispectral imagery may suffer from spectral and spatial misaligned. So imagery registration is a necessary step in the processing of multispectral imagery [1, 2].

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doi:10.1016/j.proeng.2012.01.404

Due to the significant differences in scene reflection and radiation at different wavelengths, automated registration of the multispectral imagery can often be unreliable, particularly between visible and near-infrared imagery [1, 2]. The performance of features-based registration Method algorithm is affected by the feature extraction. As for the multispectral images, some important features may not commonly exist. For example, Processing ETM satellite multispectral imagery with the scale-invariant feature transform method [3], simulation results show that no suitable control point be funded between mostly bands. The relationship among multispectral imagery intensities is complex; though area-based methods omit the step of feature detection, it also affects the performance of intensity-based registration method [4]. For example, Processing ETM satellite multispectral imagery with the mutual information method, TM1 and TM4 band image is usually misaligned.

This paper describes a multispectral imagery registration method. It utilizes multi-bands imagery information simultaneously. Contrasting to traditional band-to-band registration, it improves the registration reliability greatly.

2. Minor and noise component similarity measure criterion

A multispectral cube consists of several images where the third dimension is represented by many contiguous spectral bands. When some band images are misaligned, the spectral information (endmembers) of some pixels will been confused. In general, these confused endmembers are different from intrinsic endmembers. These new endmembers belong to minor component and their quantities increase with the misregistry deviation. Their variation can be observed through computing the eigenvalues of multispectral imagery covariance matrix. Based on this property, a minor and noise component criterion was defined. The best alignment is reached when their minor and noise component is at its minimum [5].

Based on linear mixture model, in a matching window of L spectral bands imagery, the sample covariance matrix of the data vectors x is defined as:

$$K_x = E\{[(x - E(x)][(x - E(x)]^H\} \quad (1)$$

Where L-vector x is the spectral observation data in a scene pixel, E denotes an ensemble expectation. The covariance matrix is a Hermitian matrix, let $U = [u_1, u_2, ..., u_L]$ and $\Sigma = diag[\lambda_1, \lambda_2, ..., \lambda_L]$ be the eigenvector and eigenvalue matrices of the sample covariance matrix, assume $\lambda_1 \geq \lambda_2 \geq ... \geq \lambda_L > 0$ and $\lambda_M > \sigma^2_{\max} > 0$, K_x can be rewritten as

$$K_x = U\Sigma U = \sum_{i=1}^{L} \lambda_i u_i u_i^H = \sum_{i=1}^{M} \lambda_i u_i u_i^H + \sum_{i=M+1}^{L} \sigma_i^2 u_i u_i^H \quad (2)$$

Where σ_i^2 is eigenvalue of system noise.

Based on subspace theory, we can decompose signal space into main component subspace, minor component subspace and noise subspace. Though observing the outer eigenvalues， we can approximately estimate the effective spectral dimensionality and the system noise characterization. So the misaligned deviation can been estimated through searching the minimum of minor component.

3. The proposed method

Using minor and noise component similarity measure criterion meet two difficulties. Firstly, mostly multispectral imagery registration methods are band-to-band registration. Minor and noise component similarity measure criterion takes advantage of several band images information simultaneously. So there are more parameters to be optimized. This multivariable optimization problem need a lot of computer time. Secondly, when spatial distribution of different endmembers is chaotically, trapping width of registration performance curves may be very narrow, sometime only two pixels. It brings great difficult in searching its minimum.

To overcome the above shortcomings，a new multispectral registration method is presented, the main steps are illustrated in Fig.1.

Normalized Mutual information method can register visible band imagery effective. It is adapted to pre-register visible band images. Most of images can get sub-pixel accuracy alignment. So registration seed sources are generated. Then every band image is re-aligned with minor and noise component method one by one.

There are some local minimum around the minimum of registration curve. Mean filter is adapted to extend the trapping width of registration curves.

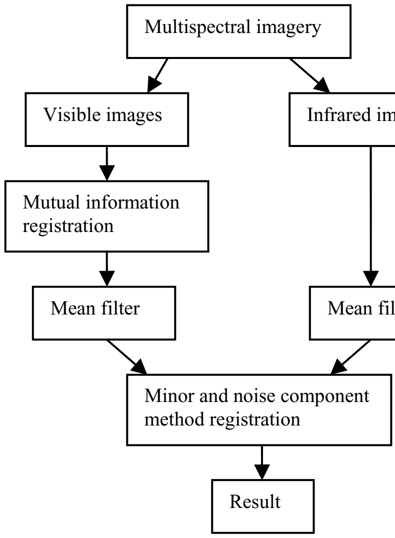


Fig.1. Block diagram of the proposed registration method

4. Experiments and results

Finding optimal matching positions is the key step of image registration [6]. Obtaining a large number of accurate control points，multispectral imagery registration will be a simple work. Optimal search performances of mutual information method, minor and noise component measure criterion and the presented method are tested. Experiments were conducted using multispectral imagery from the ETM Satellite, at the region of Beijing, china (Data coming from University of Maryland Global Observing Laboratory and Institute of Geographic Sciences and Natural Resources Joint Laboratory). Spectral bands of 0.45-0.52μm (Tm1), 0.52-0.60μm (Tm2), 0.62-0.69μm (Tm3) and 0.76-0.90μm (Tm4) are adopted. Images of visible band can get a precise registration using mutual information method. As to registering visible images and near-infrared image, control point is unreliable. Registration between Tm4 band image and visible band images is discussed below.

Fig.2 shows the Tm3 band image. At random position of Fig.2, setting 2 pixels initial misalign at a random direction, control points is searched with Powell optimization searching arithmetic. Size of matching windows is 50×50 pixel. After random simulation a hundred times, Fig.3 shows misaligned deviation histogram of control points.

From Fig.3 (a), we can find that mutual information method is out of work during registering Tm4 and Tm1 band images. Maximums of mutual information should correspond to perfect registration position; it occasionally meets the regularity. Registration performance curve of mutual information is rough; most of control points are trapped into local maximum around initial position.

Fig.3 (b) shows the histogram of minor and noise component measure criterion. Misaligned deviation of mostly control points is less than 1 pixel. Its number can be up to 90% .It is a quite good result in area-based registration infrared and visible image. Fig.3 (c) shows similar results with Fig.3 (b).

Setting 5 pixels initial misalign at a random direction, Fig.4 give the statistical results. Fig.4 (b) shows that about 75% of control points are trapped into local maximum. Fig.4 (c) shows that its error rate declines to 35% with presented method.

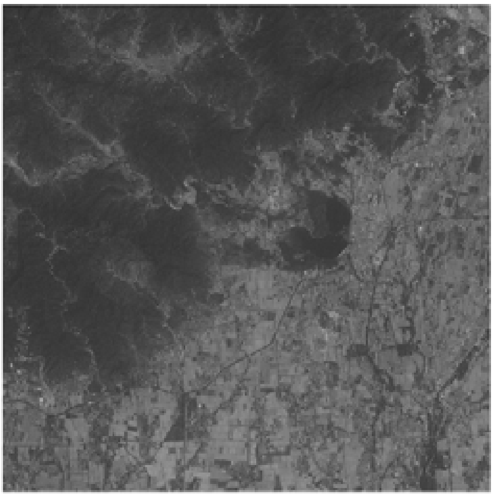
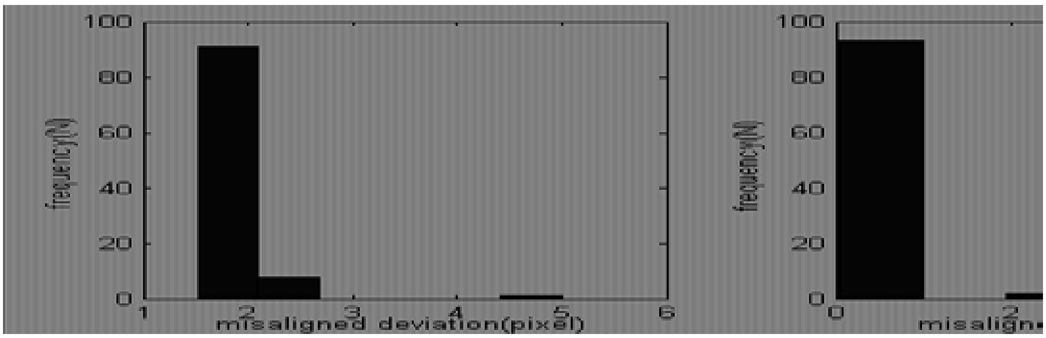


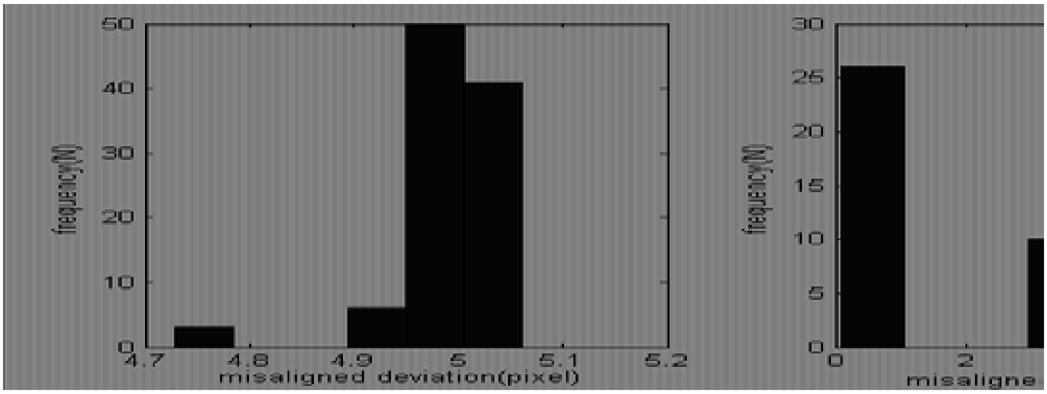
Fig.2. Subsection of ETM satellite multispectral imagery



(a) (b) (c)

Fig.3. Histogram of control point misaligned deviation

(a) Mutual information method, (b) Minor and noise component measure criterion, (c) presented method



(a) (b) (c)

Fig.4. Histogram of control point misaligned deviation
(a) Mutual information method, (b) Minor and noise component method, (c) Presented method

5. Conclusions

In this paper, a new registration method for multispectral imagery is proposed. Setting a small initial misalign, control points optimal searching experiments show that the presented method has an outstanding performance in registration multispectral image, especially for visual and IR images. While, due to spatial complex of image, still have some error control points in our experiments. How to identify them will be our future work.

Acknowledgements

This research was supported by the National Natural Science Foundation of China, grants No. 60878016, the Fundamental Research Funds for the Central Universities of China, grants No. HEUCF20101114

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