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A Survey of Registration Techniques in Remote Sensing Images

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Abstract

Background: Image registration is one of the challenging issues in remote sensing applications. In last few years a wide variety of image registration techniques have been proposed. This paper reviews various registration techniques of satellite images. The approach discussed in this paper includes feature extraction and selection, feature matching, transform model estimation, transformation and resampling. **Methods:** The methods of registrations which are applicable to multi temporal, multi spectral, multi angle and multisensory are discussed. Automatic registration of remote sensing images deals with various problems such as intensity variations, illumination changes, geometric distortions, noise etc. For solving all the registration problems various techniques are presented for various applications. There are two types of registration involved, one type is intensity based and other one is feature based. Literature evaluation of various techniques describes the methods applicable for each application. **Results:** The findings shown that SIFT is the best suitable method for feature extraction. This survey helps researchers for attain information about registration of remote sensing images. **Application:** Image registration can be applied in various applications such as Multispectral classification, Environmental monitoring, Change detection, Image mosaicking, Weather forecasting, creating super-resolution images etc.

Keywords: Feature Extraction, Feature Matching, Image Registration, Image Resampling, Remote Sensing, Transformation Model

1. Introduction

Satellite image registration is an important and challenging image processing task to match and align different images which is captured at different atmospheric conditions or by using different sensors or at different positions. In remote sensing, image registration is carried out mainly for weather forecasting, image mosaicking, change detection, image fusion and environmental monitoring. In most of the traditional image registration methods, the control points are selected manually and applying the transformation model. But this process is time consuming and less accurate. So extraction of control points automatically helps to solve the performance issues of manual selection of control points. In automatic image registration, the extraction of control points in both images is the initial step and then the correspondence between the images are evaluated by using a matching strategy criteria and finally the transformation parameters are estimated. The existing image registration techniques can be classified into two classes[6]: Area based and feature based methods. The salient features in the images are not detected in area based methods, and adopt optimization algorithms and in feature based techniques features are detected in both images and these features are used to obtain the transformation parameters for registering the two images. Feature based methods are widely used and main advantages of this approach is that they are fast and robust to noises, complex geometric distributions and significant radiometric differences[4]. The pros and cons of different registration methods are discussed.

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The rest of the paper is described as follows. Section 2 describes various image registration methods and performance evaluation is given in Section 3. Finally section 4 contains the summary of conclusion.

2. Image Registration Methodology

Image registration is widely used in the field of remote sensing. The applications of image registration can be categorized according to the images taken at different times (multi temporal), different viewpoints (multi view), different sensors (multi modal). Due to various categories of satellite images, it is important to adopt different techniques to each registration task. Other than atmospheric variations, spacecraft attitude, orbital parameter, thermal distortions leads to improper registration[20]. Most of the image registrations methods consist of four steps such as feature extraction, feature matching, transform model estimation and image resampling and transformation and the block diagram is shown in Figure 1. In the very initial stage we have to decide the type of features detected. Correct matches should be finding out in the matching stage to avoid the occurrence of mismatch features.

Feature Extraction: In this step the features like edges, corners boundaries etc. which can be called as control points are detected from sensed and reference images by using various detectors like EHLF[1].

Feature Matching: In matching strategy the correspondence between the features are detected from the sensed and reference image are established.

Transform Model Estimation: With the help of the selected features the parameters of the transformation model are estimated.

Image resampling and transformation: The sensed image is resampled by using the parameters of transformation model.

2.1 Feature Extraction

In feature extraction, the salient features are extracted from both reference image and the image to be registered and Figure 2 shows different feature extraction methods used in registration. M. Gong and S. Zhao[4] proposed a fully automatic registration approach using SIFT as preregistration step for feature detection. The proposed algorithm discussed[4] works well in different situations like multispectral, multisensory and multitemporal and for the automatic registration of single band, multispectral, hyper spectral and high spatial resolution images H. Concalves[9] proposed SIFT method which transforms scale invariant coordinates to relative features. The feature points detected by SIFT is shown in Figure 3. SIFT offer better performance in machine related applications that can be implemented in FKP[19] systems. An Improved SIFT[10] method is explained[8], where the SIFT features are extracted from optical and SAR images and this method has improved performance in various aspects like key point detection, dominant orientation assignment and support region selection. Another method of feature detection technique using MIMF operator for the extraction of control point SID automatically which can be applied to LiDAR and optical images[11]. Y. Li[1] emphasized the importance of radiometric co-registration by proposing descriptor called EHLF which has flexible design and fast computation which can be applied to multi temporal high resolution satellite[6] imagery. Another feature detection method called Adaptive Phase Congruency Feature Detector algorithm (APCFD) which is applicable for registration of remote sensing images. J. Kong[18] proposed a multi-scale feature extraction method for the registration of infrared remote sensing images in which the registration is more fast and accurate than traditional methods.

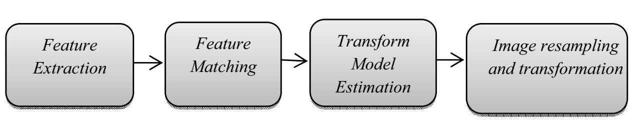


Figure 1. Image registration workflow

2.2 Feature Matching

Features detected from feature extraction step are matched according to certain criteria in the feature matching step by using any of the methods in Figure 4. The feature based methods adopts an SCM[8] method for

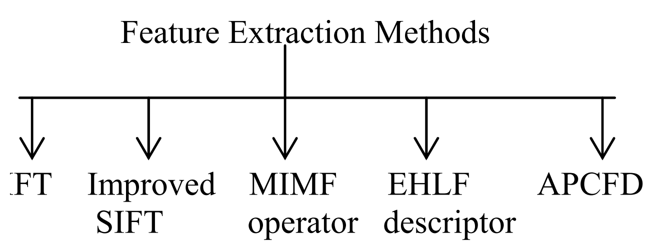


Figure 2. Feature extraction methods

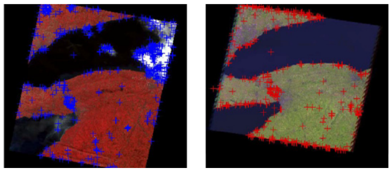


Figure 3. Feature points detected by the SIFT algorithm. Set of feature points (marked by cross)[5].

matching the features by using KNN matching method of improved SIFT. Z. Song[5] proposed a new feature matching strategy called TAR for remote sensing images. For images with large geometric distortions a spatial matching method is adopted[1]. Another feature matching method is proposed by K. Zhang by combining TAR and KNN and this KNN-TAR[17] method can remove the outliers from the initial matching result even when the outliers are of high proportion. For high resolution TerraSAR—X and Ikonos image registration, Mutual Information[13] method is utilized. For multi angle image registration NCC[3] is used and is applicable to the areas with little variation in topography. Another method of matching the features is by the evaluation of cost function[2] obtained by the segmentation of images. SIFT[4] matching method is adopted through nearest neighbor approach and an outlier removal method is used for removing the false matches. To overcome the problems of SIFT another feature matching method called UR-SIFT is proposed by A. Sedaghat[10]. A. Li[14] proposed a new matching strategy in the fine registration stage called Iterative closest point frame work in which the matching pairs are determined by a bidirectional matching criterion in terms of feature similarity and spatial consistency. An improved random sample consensus (RANSAC) algorithm called fast sample consensus (FSC) is proposed by Y. Wu[15] which is highly accurate. An adapted anisotropic Gaussian scale-invariant feature transform (AAG-SIFT) method[16] is proposed by F. Wang to obtain stable and precise matches for Synthetic Aperture Radar (SAR) image registration. A pair of SPOT/Landsat images in Figure 5 is matched and shown in Figure 6.

2.3 Transform Model Estimation

Transformation parameter estimation is a crucial step in the registration process of remote sensing images. In this step, a mapping function and the estimation of parameters are done.

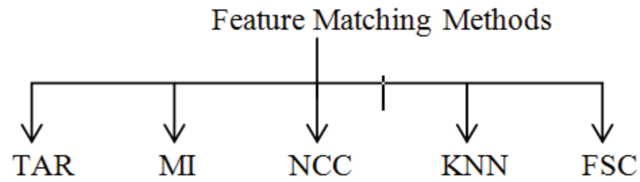


Figure 4. Feature matching methods.

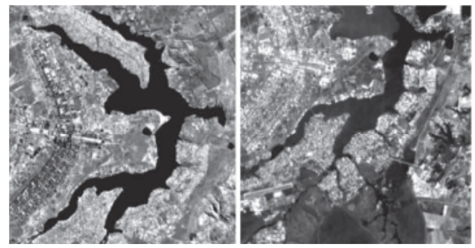


Figure 5. A pair of two different sensor (SPOT/Landsat) images[15].

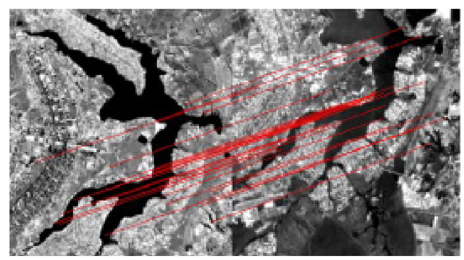


Figure 6. Matched image[15].

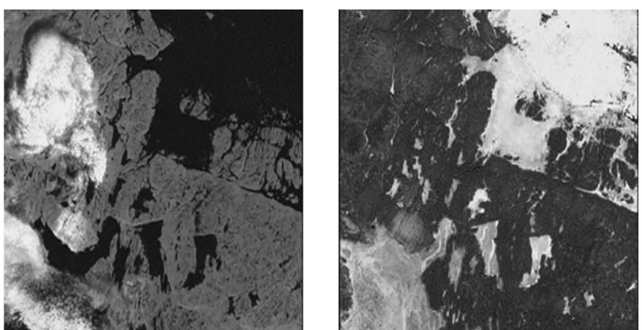
There are two types of mapping function:

- Global mapping function.
- Local mapping function.

Global mapping function uses all control points for estimating the parameters and the image is considered as the combination of patches in local mapping functions[7]. RANSAC[8] is one of the method used for parameter estimation in the registration of optical and SAR satellite images. Both global and local parameters[14] are estimated by using MI procedure to find the registration parameters with the help of a joint histogramming technique and an optimizer. A new robust method of parameter estimation in multimodal image registration is HTSC[5] which can calculate the consensus efficiently. For solving the local distortion problems a new model called TPS[3] is proposed by J. Ma. To reduce the ambiguity of matching of registration A. Li[14] proposed a new registration method based on local structure constraints to find the initial transformation parameters by using a least square algorithm. The transformation parameters that minimize the dissimilarity measure[12] is explained by M. Hasan which includes exhaustive search, heuristic search, and gradient-based search. In Automatic registration of remote sensing images, DLT[6] algorithm is used and squared residual error is selected as the best transformation model.

2.4 Image Resampling and Transformation

In this step the input image is transformed based on the transformation model and resampling function[3]. One of the widely used transformation model is affine[4,12]. An affine transformation is any transformation that preserves collinearity[5]. The sensed image is transformed according to the final transformation model and then resampled using an interpolation method called as bilinear and bicubic interpolation[6]. The two images shown in Figure 7(a),(b) are registered and the result is given in Figure 8.



(a) (b)

Figure 7. **(a)** Reference image[6]. **(b)**Sensed image[6].

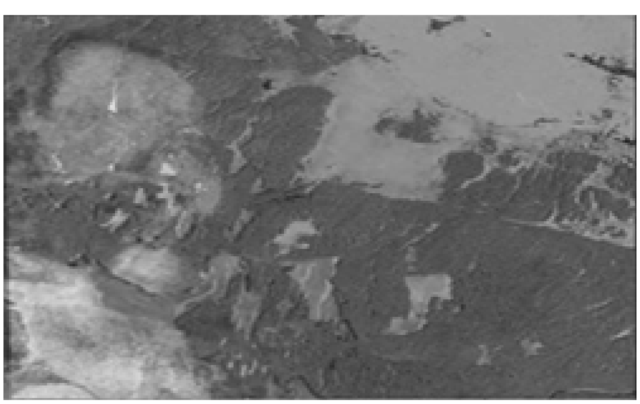


Figure 8. Registered image[6].

Table 1. Different Registration Methods

Registration method	Advantages	Disadvantages	Applications
HAIRIS[2]	Results are accurate even in the presence of Noise	Computational time	Multitemporal Multisensor
Multiangle CHRIS/ Proba image registration[3]	Suitable for areas with little variation in topography	Not suitable for areas with low elevation differences.	Multiangle
Radiometric co-registration method[1]	Lowest NRMSE	Not suitable for fully forested areas	Multitemporal
Coarse-to-fine registration based on SIFT and MI[4]	Improved accuracy achieves good computational efficiency.	Cannot register multiview images	Multispectral, Multisensor, and Multitemporal
HTSC[5]	Accuracy is 80% or higher	Effectively findout the CCs from the candidateswhen they are applied to multimodal image registration	Multimodal
ARRSI[6]	Registration performance and accuracy are relatively high	Manual parameter setting	Multimodal

3. Summary

In Table 1 the different methods adopted for registration and the pros and cons are discussed. It helps to evaluate the methods which are applicable for different situations like multimodal, multisensor, multitemporal, multiangle etc.

4. Conclusion

This paper gives a survey of various registration methods for remote sensing images and it is a framework for future research. Image registration is an important task in image fusion, image mosaicking, change detection etc. For multitemporal image registration SIFT, MI and

HAIRIS methods can be used. The selection of features from the reference and sensed images determine the registration performance. Feature based image registration is more efficient than area based methods for reducing computational time and errors. For multitemporal image registration SIFT, MI and HAIRIS methods can be used. HTSC methods show registration accuracy of more than 80% in multimodal registration. In the presence of noise HAIRIS method produces accurate results of registration.

The future development of image registration in the field of remote sensing focus on weather monitoring, land coverage etc. The computational time and distortion issues are the demands in future registration methods.

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6. References

1. Yonghong L, Davis C H. Pixel-based invariant feature extraction and its application to radiometric co-registration for multi-temporal high-resolution satellite imagery. IEEE Journal of Selected Topics in Applied Earth Observation and Remote Sensing. 2011; 4(2):348–60.
2. Goncalves H, Gonçalves J A, Corte-Real L. HAIRIS: A method for automatic image registration through histogram-based image segmentation. IEEE Transaction Image Processing. 2011 Mar; 20(3):776–89.
3. Ma J, Chan J C, Canters F. Fully automatic subpixel image registration of multiangle CHRIS/Proba data. IEEE Transaction Geoscience and Remote Sensing. 2010 Jul; 48(7):2829 –39.
4. Gong M, Zhao S, Jiao. L. A novel coarse-to-fine scheme for automatic image registration based on SIFT and mutual information. IEEE Transaction of Geoscience Remote Sensing. 2014 Jul; 52(7):4328–38.
5. Song Z, Zhou S, Gaun J. A novel image registration algorithm for remote sensing under affine transformation. IEEE Trans Geosci Remote Sens. 2014 Aug; 52(8):4895–338–912.
6. Wong A, Clausi D, ARRSI: Automatic registration of remote sensing images. IEEE Transaction Geoscience Remote Sensing. 2007 May; 45(5):1483 –93.
7. Zitova B, Flusser J. Image registration methods: A survey. Image Vision Computing. 2003 Oct; 21(11):977–1000.
8. Fan B, Huo C, Pan C, Kong Q. Registration of optical and sar satellite images by exploring the spatial relationship of the improved sift. IEEE Transactions on Geoscience and Remote Sensing. 2013 Jul; 10(4):657–61.
9. Goncalves H, Corte-Real L, Goncalves JA. Automatic image registration through image segmentation and sift. IEEE Transactions Geoscience Remote Sensing. 2011; 49(7):2589–600.
10. Sedaghat A, Mokhtarzade M, Ebadi H. Uniform robust scale invariant feature matching for optical remote sensing images. IEEE Transactions Geoscience Remote Sensing. 2011 Nov; 49(11):4516–27.
11. Palenichka R, Zaremba M. Automatic extraction of control points for the registration of optical satellite and LiDAR images. IEEE Transactions Geoscience Remote Sensing. 2010 Jul; 48(7):2864–79.
12. Hasan M, Pickering MR, Jia X. Robust automatic registration of multimodal satellite images using CCRE with partial volume interpolation. IEEE Transactions Geoscience Remote Sensing. 2012 Oct; 50(10):4050–61.
13. Suri S, Reinartz P. Mutual information based registration of terra sar-x and ikonos imagery in urban areas. IEEE Transactions Geoscience Remote Sensing. 2010 Feb; 48(2):939–49.
14. Li A, Cheng X, Guan H, Feng T, Guan Z. Novel image registration method based on local structure constraints. IEEE Transactions Geoscience Remote Sensing. 2014 Sep; 11(9):1584–8.
15. Wu Y, Ma W, Gong M, Su L, Jiao L. A novel point-matching algorithm Based on fast sample consensus for image registration. IEEE Transactions Geoscience Remote Sensing. 2015 Jan; 12(1):43–7.
16. Wang F, You H, Fu X. Adapted anisotropic gaussian sift matching strategy for sar registration. IEEE Transactions Geoscience Remote Sensing. 2015 Jan; 12(1):160–4.
17. Zhang K, Li X, Zhang JX. A robust point-matching algorithm for remote sensing image registration. IEEE Transactions Geoscience Remote Sensing. 2014 Feb; 11(2):469–73.
18. Kong J, Jiang M. IR remote sensing image registration based on multi-scale feature extraction. International Joint Conference on Neural Networks (IJCNN). China. 2014. p. 1352–8.
19. Shameem Sulthana ES, Kanmani S. Implementation and evaluation of sift descriptors based finger-knuckle-print authentication system. INDJST. 2014 Mar; 7(3):374–82.
20. Giri RK, Sharma RK. Image registration and atmospheric motion vectors retrieval from geo-stationary satellite. INDJST. 2011 Oct; 4(10):1218–25.