A Review and Analysis of Image Misalignment Problem in Remote Sensing

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Abstract— In change detection analysis, the accuracy of matching techniques depend solely on the accuracy of correction methods (such as geometric correction method, intensity variation methods) used before the actual alignment is performed. When the poor correction methods are used during image processing, errors such as matching errors, localisation error and alignment error, may arise during the detection and matching of image features (such as points,contour) hence causing image misalignment which may in turn affect the change detection accuracy. This paper reviews some of the challenges faced during image registration together with the current image registration techniques. It also reviews the errors associated with most of the image registration techniques due to use of poor or inappropriate image processing techniques.

Index Terms— Image Misalignment, Image Registration, Change Detection, Remote Sensing.

1 INTRODUCTION

Image registration is the rationale of overlaying two or more images of the same scene captured at different times, from different viewpoints, and by different sensors or same sensor [12]. These images are often called sensed images or target image and reference images or source image.

Majority of the authors reported that change detection ac-curacy depends solely on image registration accuracy. According to [1][6][11], it is so important to achieve accurate image registration results in order to avoid induction of false and missed changes that may lower down change detection accuracy.

However literature shows that improvements have been made but there is still much effort required to further improve on some the existing image registration techniques. This paper reviews some of the challenges faced during image registration together with the current image registration techniques. It also reviews the errors associated with most of the image registration techniques due to use of poor or inappropriate image processing techniques and suggest more efficient methods for alignment as future work. Section 2 describes some of the challenges faced during image registration. Some the current image registration tech-niques are also reviewed. Section 3 presents several errors that are faced during image registration. Section 4 concludes this paper.

2 IMAGE REGISTRATION

2.1 The Challenges

This subsection describes and examines the causes of the challenges faced during image registration process. More emphasis is put on the causes of the problems. Some of the image registration problems include geometric distortion, differences in images such as intensity, contrast, resolution, sensor and environmental noise.

a) Geometric distortion

All remote sensing images regardless of the type of sensor used during image capturing, they are subject to geometric distortion. This is due to an attempt of accurately representing three dimensional images as two dimension images hence causing relief displacement. The two type's geometric distor-tion includes:

i). Tangential scale distortion

This type of geometric distortion is caused by the rotation of the scanning optics. The problem occurs When the scanning mirror rotates at a constant speed, causing the IFOV of the sensor to move faster (relative to the ground) and closer to edges hence scanning a larger area as it moves closer to the edges .

ii). Skew distortion

The problem is seen to result in the instance of satellite orbit, where the eastward rotation of the Earth causes the sweep of scanning systems to cover an area slightly to the west of each previous scan hence resulting in to an image skewed across the image.

b) Difference in images.

The difference in the images (such as resolution, contrast non uniformities, illumination, and intensity) may occur due to being captured at different wave length by different sensors at different time. Hence making it difficult to compare images with different features such as image of different intensities [7], it's not easy to construct descriptors [4] that can provide global information about feature point, in order to effectively differentiate signals in feature descriptions and also help dur-ing matching process [10].

Table 1 shows the challenges faced by most of the re-searchers during image registration. However these challenges are the major causes of image misalignment problem in change detec-tion analysis.

Table 1: Majors challenges in image registration

Image registration problems	cause
Geometric distortion	-variations in platform stability including changes in their speed, altitude, and attitude during data acquisition
Difference in images such as contrast non-uniformities, resolution, intensities, illumination	-Varying atmospheric condition. -use of different sensors

The next section gives an overview of the currently pro-posed image registration techniques to tackle some of the major problems that affect change detection accuracy.

2.2 Current Image Registration Techniques

Several image registration techniques have been proposed to deal with several challenges (such as geometric distortion, intensity variations, sensor noise and environmental noise) faced during image registration, but literature shows that image misalignment still exist with all the image registration techniques.

One of the most applied image registration techniques proposed are feature based, they involve matching features such as points, edges during image registration.

Among the image registration techniques, active contour segmentation and mutual information method produces better image registration results compared to all methods that use point feature this is because active contour segmentation involve matching edges rather than point which saves time. It is capable of extracting geometric details of the feature edge compared to methods that use point feature to register image, also it is less sensitive to errors (localisation errors, matching errors, alignment errors),below are some of the current image registration techniques.

1) A fully automatic and fast non-rigid image registration technique [10]

The technique was proposed to deal with difference in illuminations, difference in resolutions of the images. In this technique point features of the images under study are auto-matically detected by the wavelet pyramid and selected by the Harris corner method. Then later extracted point features of the two images (sensed image and reference image) are matched using scale invariant feature transforms. According to [10], the method is fast and robust although it is not capable of stating the properties of geometry in the SIFT (scale invariant Feature transform) key point location.

2) A wavelet multi-resolution based feature extraction techniques [2].

The technique was presented to increase relief displace-ments, increase the searching speed feature extraction method. In this method a wavelet multiresolution property is used to automatically detect the feature points in the two images under study. The extracted feature points are then matched using the normalised cross correlation. The method is fast but it only applies to grey scale feature points and also it does not resolve the geometric distortion but however [2] recommends the use of a true orthorectification technique to solve the geometric distortion in images under study.

3) A combination of active contour segmentation and mutual information [9]

Here the active contour segmentation method was pre-sented to improve the searching speed of the mutual informa-tion. The active contour segmentation method partitions the image in order to extract the edges of the images under study. Then later corresponding edges of the images are matched using mutual information method. The method is computationally fast. But not accurate enough due to error caused due to failure to deal with the geometric distortion.

4) Automated Inter-sensor or Inter-band Satellite Image Registration System [7]

The technique was proposed to eliminate sensor and environmental noise, contrast non-uniformities, and inter-sensor and inter-band intensity mapping differences. In this technique a novel modified German–McClure M-estimation scheme that uses a robust phase-adaptive complex wavelet feature representation to robotically match control point. Then an iterative refinement scheme is used to improve the control point pair localization. According to the author the technique produces better results as compared to state-of-the-art M-SSD and ARRSI registration algorithms [7].

5) Robust scale invariant feature transform descriptor [4]

It was originally proposed to deal with huge variation in both geometry and intensity in the images under study. The novel proximity matrix is used to extract the feature point from the images under study, and then later robust scale invariant feature transform descriptor is used match the feature points of the two images. The proximity matrix is used during feature extraction because the matrix combines the geometric information of feature points with the gradient information of feature points' neighbourhood. According to [4], the method is computationally fast compared to the scale invariant feature transform descriptor although there it still faces a problem of large view point difference between images in a particular degree which leads to inaccuracy during matching process hence resulting into image misalignment.

2.3 Summary Of The Existing Image Registration Techniques

Table 2 shows some of the current image registration tech-

niques that has been discussed previously, emphasizing the strength, weakness, type of remote sensed imagery used.

Table 2: Comparison of existing image registration techniques

Author	Techniques	Strength	Weakness
Yu, L., D. Zhang, et al. 2008	A fully automatic and fast non-rigid image registration technique	Computationally fast. Robust against the varying rotation, scaling, illumination	It cannot state the geometry properties in the SIFT key point locations. Only suitable on multi-source images than high resolution images
Hong, G. and Y. Zhang 2008	A wavelet-based feature extraction technique	Fast, control points are automatically selected Local distortion that exist in different sensors and different temporal images.	Not robust; can only be applied on the grey value feature points. Cannot resolve the relief displacement of individual above ground objects, such as buildings and trees
Yang, Y. and X. Gao 2009	combination of active contour segmentation and mutual information,	Robust Fast	Not accurate enough, produces the average geometric registration error is 0.7217 pixels which is still high.
Wong, A. and D. A. Clausi (2010).	Automated inter-sensor or inter-band satellite image registration system,	Robust in such a way that it can be applied to largely distorted imagery because it takes considers scale and rotation.	-the method ignores the image details and the intensity differences in the images yet they are important
Liu, X., Z. Tian, et al. (2011)	Robust scale invariant feature transform descriptor (R-SIFT) based on affine transformation and a novel proximity matrix	The method is computationally fast compared to the scale invariant feature transform descriptor	There is still a problem with large view point difference between images in a particular degree which leads to inaccuracy during matching process.

One of the most applied image registration techniques proposed are feature based, they involve matching features such as points, edges during image registration. Among the image registration techniques, a combination of active contour segmentation and mutual information method produce better image registration results compared to all methods that use point feature this is because active contour segmentation involve matching edges rather than point which saves time. It is capable of extracting geometric details of the feature edge compared to methods that use point feature to register image, also it is less sensitive to errors (localisation errors,

Table 2 shows that the method that use active contour seg-mentation as feature extraction method produces better image registration results as it is fast compared to all methods that use point feature because active contour segmentation is good at extracting geometric details of the feature edge. Methods that used wavelet pyramid to extract are computationally fast, can deal with illumination variation in images but not good at extracting the geometric details of the feature points. Therefore a combination of active contour and wavelet pyramid would yield better image registration results.

The next section describes errors the limit the performance of the image registration techniques.

3 TYPES OF ERRORS IN IMAGE REGISTRATION TECHNIQUES

1) Alignment Error

This error occurs if the two images under study are not prop-erly positioned to each during image warping i.e. the sensed image is not properly positioned against the reference image during image warping. Image warping refers to manipulation of an image during image registration such during the correc-tion of geometry distortion.

Alignment errors are some of major problem faced during image registration due to using inappropriate mapping model for geometric distortion and poor calculation of the model parameters.

In order to estimate alignment accuracy, a consistent check is used whereby two or more different image registration methods are applied on a pair of images under study. The result is achieved by applying the two methods then compared. If such results are similar or nearly similar, alignment is considered to be accurate otherwise the alignment is inaccurate.

2) Matching error

This error occurs in instances where the two images under study are wrongly matched, that is where the control points of image 1 are matched with wrong control points of image 2. This is a common mistake made in most of image registration techniques. In order to identify mistakes, a consistent check can be used.

During this process, two different matching methods are applied on the two images where control point of image 1 are matched with the control points of image 2. The result is from the two methods are compared such that if they have a matched pair in common, that indicates that pair is valid and therefore the remaining pairs are excluded for further processing by either using different methods or by applying a

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cross validation to identify invalid control point pair.

In cross validation, the mapping parameters are calculated on the excluded pairs (considered invalid) in order to determine how the excluded points can be mapped to each other through the use of a model. Such that if the displacement is below the threshold, then it's considered to be a valid pair otherwise it's invalid.

3) Localization Error

This error occurs when an image 1 is involved with wrong coordinates in image 2. This type of error is common in cases where the control points are detected using poor or inappropriate detection algorithms.

This type of error cannot be measured directly on the im-age as compared to other types of errors. It can only be meas-ured by using ground truth data sets; ground truth is a process in which a pixel on a satellite change image is compared to corresponding pixel of the real image in order to verify the contents of the pixel on the change image.

Localization error can be reduced through using an appropriate feature detector and increase in localization errors on control points does not necessarily mean inaccuracy. Sometimes it is needed in order to achieve accurate results. Table 3 summarizes errors that are rampant in most of image registration techniques.

Table 3: Common errors faced during image registration

Error	Brief Description	Cause
Alignment Error	This error occurs if the two images under study are not properly positioned to each other during image warping	Use of inappropriate mapping model for geometric distortion. If the model parameters are not properly calculated.
Matching Error	This error occurs in instances where the two images under study are wrongly matched ,that is where the control points of image 1 are matched with wrong control points of image 2.	Use of poor or inappropriate matching technique
Localisation Error	This occurs when an image 1 is involved with wrong co-ordinates in image 2. This type of error is common in cases where the control points are detected using poor or inappropriate detection algorithms.	Poor or inappropriate detection algorithms.

Table 3 shows the errors that are due to the use of poor or inappropriate correction methods (geometric distortion correction method, illumination variation correction method, intensity variation correction methods), this minimises the performance of the feature extraction and matching methods during image alignment process. Therefore better techniques are required to solve the problems (such as geometric distortion, varying illumination) before image alignment. And also better feature extraction and matching techniques are required for better image alignment process.

4 DISCUSSION AND CONCLUSIONS

The performance of the extraction and matching techniques depend on the condition of the images under study, it would be better if thorough image processing is perfomed before images are subjected to alignment process. This is will improve on the extraction and matching process since images will be in better condition for a better image alignment.

Therefore much attention should be drawn on the image processing part since it is where the image misalignment errors arise from. Since methods that adopt segmentation[9] during image registration are involved with less segmentation error and fast compared to other methods[4][7][10], better results may be obtained if better image processing techniques is done. Thus, better segmentation process during image alignment may produce image that is less sensitive to errors and noise. Therefore we suggest that both of these processes should be taken in to consideration for a better image alignment, which is the focus of our future work.

5. REFERENCES

[1] Dai, X. L. and S. Khorram (1998). "The Effects Of Image Misregistration On The Accuracy Of Remotely Sensed Change Detection." IEEE Transactions on geoscience and remote sensing 36(5): 1566-1577.

[2] Hong, G. and Y. Zhang (2008). "Wavelet-Based Image Registration Technique For High-Resolution Remote Sensing Images." Computers and geosciences 34(12): 1708-1720.

[3] Jay Gao.(2009),"Digital Analysis Of Remotely Sensed Imagery", isbn: 9780071604659,division: professional,pub date: feb-09,pages: 674,edition: 01

[4] Liu, X., Z. Tian, (2011) "A Novel Adaptive Weights Proximity Matrix For Image Registration Based On R-Sift." AEU - international journal of electronics and communications (0).

[5] Marchesi, S., F. Bovolo, et al. (2010). "A Context-Sensitive Technique Robust To Registration Noise For Change Detection In Vhr Multispectral Images." image processing, IEEE Transactions on 19(7): 1877-1889.

[6] Townshend, J. R. G., Justice, C.O., Gurney, C., Mcmanus, J., "The Impact Of
Misregistration On Change Detection," IEEE Transactions on geoscience and remote sensing, vol. 30, no. 5, 1992, pp. 1054-1060.

[7] Wong, A. and D. A. Clausi (2010). "AISIR: Automated Inter-Sensor/Inter-Band Satellite Image Registration Using Robust Complex Wavelet Feature Representations." Pattern recognition letters 31(10): 1160-1167.

[8] Yan Gao and Jean Francois Mas , 2008. "A Comparison Of The Performance Of Pixel Based And Object Based

Classificatsifications Over Images With Various Spatial Resolutions." Online journal of earth sciences, 2: 27-35.
[9] Yang, Y. and X. Gao (2009). "Remote Sensing Image Registration Via Active Contour Model." AEU - international journal of electronics and communications 63(4): 227-234.
[10] Yu, L., D. Zhang, et al. (2008). "A Fast And Fully Automatic Registration Approach Based On Point Features For Multi-Source Remote-Sensing Images." computers & geosciences 34(7): 838-848.
[11] Yuhaniz, S. S. and T. Vladimirova (2009). "An On-board Automatic Change Detection System For Disaster Monitoring." international journal of remote sensing 30(23): 6121-6139.
[12] Yuhaniz, S., T. Vladimirova, et al. (2005). "Embedded Intelligent Imaging On-Board Small Satellites." advances in computer systems architecture, proceedings. srikanthan, j. xue and c. h. chang. berlin, springer-verlag berlin. 3740: 90-103.
[13] Bunting, P., F. Labrosse, et al. (2010). "A Multi-Resolution Area-Based Technique For Automatic Multi-Modal Image Registration." Image and Vision Computing 28(8): 1203-1219.