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Comparison of Image Registration Methods for Satellite Images

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Abstract- Although various Automatic Image Registration methods have been proposed in past few years, several drawbacks avoid their common use in practice. The recently proposed scale invariant feature transform approach has already revealed to be a powerful tool for the obtaining keypoints in general but it has a limited performance when directly applied to remote sensing images. In this paper, we are comparing work done on image registration methods on basis of technique used to register the images.

Index Terms- Automatic Image Registration, Centroids, Euclidean Distance, Image Segmentation, and Scale Invariant Feature Transform

I. INTRODUCTION

Image registration is the process of transforming different sets of data into one coordinate system, [01]. Data may be multiple photographs, data from different sensors, from different times, or from different viewpoints. It is used in computer vision, medical imaging, military automatic target recognition, compiling and analyzing images and data from satellites. Registration is necessary in order to be able to compare or integrate the data obtained from these different measurements.

Image registration is the process of overlaying two or more images of the same scene taken at different times, from different viewpoints, and/or by different sensors, [02]. It is also a classical problem encountered in image processing applications in which, the final information is gained from the combination of various data sources like in image fusion, change detection, multichannel image restoration and can be applied in the fields of change detection, cartography, medical imaging and photogrammetry.

Image registration is the process by which we determine a transformation that provides the most accurate match between two images. The search for the matching transformation can be automated with the use of a suitable metric, but it can be very time- consuming and tedious, [03]. Computational time becomes even more critical with the current increase in data. As a result, high performance image registration is needed, [04].

In remote sensing applications, generally manual registration used which is not feasible when large number of images need to be registered because of manual selection of control points. Therefore, it leads to the need of automatic image registration, [05]. Automatic image registration is to perform the image registration task without the guidance and intervention of users. The tremendous amount of incoming satellite images from the Earth Observing System (EOS) program and from new missions with hyperspectral instruments mandate the need for automatic image registration, [06].

The flow diagram for process of Image Registration is as shown in Figure 1.

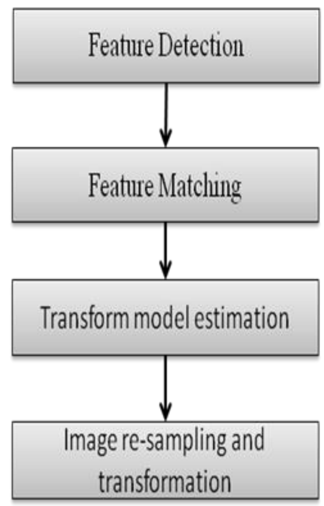

Figure 1: Flow Diagram of Process of Image Registration.

In general, we can describe the process of Image Registration in four steps as follows, [07]:

1. Feature detection: In image, we detect salient and distinctive objects such as closed-boundary regions, edges, contours, line intersections, corners, etc. in both reference and sensed images.
2. Feature matching: The correspondence between the features in the reference and sensed image established.
3. Transform model estimation: The type and parameters of the so-called mapping functions, aligning the sensed image with the reference image are estimated.
4. Image re-sampling and transformation: The sensed image is transformed by means of the mapping functions.

Image registration is widely used in remote sensing, medical imaging, computer vision etc. In general, its applications can be divided into four main groups according to the manner of the image acquisition, [08]:

1. Different viewpoints (multiview analysis): Images of the same scene are acquired from different viewpoints. The aim is to gain larger 2D view or a 3D representation of the

scanned scene. For example, Remote sensing—mosaicing of images of the surveyed area.

2. Different times (multitemporal analysis): Images of the same scene are acquired at different times, often on regular basis, and possibly under different conditions. The aim is to find and evaluate changes in the scene that appeared between the consecutive images acquisitions. For example, Computer vision — automatic change detection for security monitoring, motion tracking and Medical imaging—monitoring of the healing therapy, monitoring of the tumour evolution.
3. Different sensors (multimodal analysis): Different sensors acquire images of the same scene. The aim is to integrate the information obtained from different source streams to gain more complex and detailed scene representation. For example, Remote sensing—fusion of information from sensors with different characteristics like panchromatic images, offering better spatial resolution, color/multispectral images with better spectral resolution, or radar images independent of cloud cover and solar illumination.
4. Scene to model registration: Images of a scene and a model of the scene are registered. The model can be a computer representation of the scene, for instance maps or digital elevation models (DEM) in GIS, another scene with similar content (another patient) etc. The aim is to localize the acquired image in the scene and to compare them. For example, Medical imaging—comparison of the patient's image with digital anatomical atlases, specimen classification.

In this paper, we discussed general process of image registration in section I. In next section II we will be discussing methods of image registration and then work done by various authors in section III and comparison in table I in section IV.

II. Image Registration methods

According to paper [08], various image registration methods are as follows:

1. Intensity-based and feature-based methods: Intensity-based methods compare intensity patterns in images via correlation metrics, while feature-based methods find correspondence between image features such as points, lines, and contours. Intensity-based methods register entire images or sub images.
2. Spatial and frequency domain methods: Spatial methods operate in the image domain, matching intensity patterns or features in images whereas Frequency domain methods find the transformation parameters for registration of the images while working in the transform domain. Such methods work for simple transformations, such as translation, rotation, and scaling.
3. Single and multi-modality methods: Single-modality methods tend to register images in the same modality acquired by the same scanner/sensor type, while multi-modality registration methods tended to register images acquired by different scanner/sensor types.
4. Automatic and interactive methods: Based on level of automation registration method provide they are classified as manual, interactive, semi-automatic, and automatic methods have been developed. Manual methods provide tools to align. Interactive methods reduce user bias by performing certain key operations automatically while still relying on the user to guide the registration. Semi-automatic methods perform more of the registration steps automatically but depend on the user to verify the correctness of a registration. Automatic methods do not allow any user interaction and perform all registration steps automatically.
5. Similarity measures for image registration: Mostly, image similarity methods are being use in medical imaging. An image similarity measure quantifies the degree of similarity between intensity patterns in two images.http://en.wikipedia.org/wiki/Image_registration - cite_note-AG-2 The choice of an image similarity measure depends on the modality of the images to be registered.

III. Literature Survey

In [05], registration method is perform by applying regions considered segmentation on the images with consideration of several attributes such as perimeter, fractal dimension and structural features. Initially the image undergoes through pre-processing stage after which features are extracted from the enhanced image, then matching is done using these features, and finally rotation differences are detected between the images that are to be registered. The purpose of this paper is to perform automatic image registration accurately through segmentation that leads to satisfaction of all the constraints present over image and thus can effectively improve the quality of registered images.

In [09], registration is perform by dividing image into regions and SIFT keypoints. Initially the real image is partitioned into four subregions and then SIFT keypoints are extracted from both real and reference images. After that we establish location constraint relation of keypoints in all four subregions of image i.e. constraint relations between all SIFT keypoints and their corresponding center points. In next step, SIFT matching is performed on real and reference images and mapping is done by calculating minimum distance. Based on these mapping we can correct corresponding coordinates in images in next step and finally in we get output of four center points and the target region. In this paper registration is done using multi-subregions and SIFT. Due to establishment of location constraints and mapping relationship, we get better performance.

In [10], using lake centroids as features automated image registration is done in dynamic lake rich environments. Initially histogram thresholding is applied to both master and slave images. The segmentation result is used to create training samples to classify lakes from the land background. The segmentation is further refined by supervised classification technique using multispectral bands. Areas where pixel values are less than mean value of the water body segment serve as the training set for water bodies. Similarly, pixels having values that are greater than the mean background value are the training set for the background class. Based on these two training sets, the classifier produces Lake Map from all four bands of slave image and master image is processed in same way to produce Lake Map. Now the centroids are calculated for lakes and these centroids are used as tiepoints for image registration. The identical lakes in two images are associated by comparing the Euclidean distance between centroid points in two images. The lakes are said to be identical if their centroids are closet on image and the Euclidean distance is minimum. In this paper, the approach is automated and it achieves subpixel accuracy and is feasible way to register images for lake change detection.

In [11], image registration is done using SIFT and image segmentation. Initially the input image with multi spectral bands is transform to single band. To convert multiple spectral bands into single band, PCA method is used. The PCA image is segmented through threshold segmentation. Here threshold value is determined and according to that image is segmented into intersecting and non-intersecting areas. After segmentation SIFT, keypoints are calculated. After obtaining these SIFT keypoints they applied to bi-variant histogram. According to that algorithm, final set of key points will be obtained through which some evaluation metrics are calculated. For e.g., rms low, rms all etc. These are the key points used for analysis. In this paper, robust and efficient automatic image registration method is proposed in which pair of images with different pixel size, translation and rotation effects and to some extent with different spectral content is registered. This method also achieves subpixel accuracy. Only drawback exists is that the computation time required is more since we have to compare all the SIFT keypoints.

IV. Comparison of Work Done by Authors on Image Registration

Table I - Comparison of workdone by various authors.

Authors	**Yongwei Sheng et al**	**V. babyVennila et al**	**Wentao Lv et al**	**Hernâni Gonçalves et al**
Image Type Used	LandSat	Satellite	SAR & RADARSAT	LandSat
Keypoint	Centroids	Objects	SIFT Keypoints	SIFT Keypoints
Method For Matching	Euclidian Distance	Object Matching	Euclidian Distance	Euclidian Distance
Segmentation Technique used	Histogram Thresholding	Feature Based Segmentation	Region Based Segmentation	Otsu's thresholding

Steps /Stages	Image Thresholding, Image Classification, Centroid Calculation and Image Registration.	Pre-processing, Region considered segmentation, Feature Extraction, Matching and rotation Estimation.	Segmentation of real image, Extraction of keypoints, Location constraints Establishment, SIFT Matching and Mapping.	Conversion to single band, Image Segmentation, SIFT keypoint, Obtention of Matching Candidates, Outliers Removal and Final Set of Tiepoints.

V.CONCLUSION

Various researches on automatic image registration in different fields such as remote sensing, medical, computer vision, etc. are performed. In this paper, we have compared work done by various authors on image registration of satellite images. From comparison, we can say that these methods are time consuming and depend on the size and resolution of the image, which can be overcomed further.

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