# Adaptive Markov Random Field Model for Area Based Image Registration and Change Detection

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## ABSTRACT

***Image registration is an important step in image processing task. It is obtained from the combination of two images. Satellite imaging is widely used for various real time applications such as environment monitoring, weather forecasting , medical image processing and in computer vision. These images are captured with the help of different sensors and different acquisition time which affects the performance of real time application. Significant information can be extracted by applying image registration techniques. Various techniques have been proposed by addressing the issue of image registration which is based on feature based image registration and area based image registration. Satellite images have huge amount of data in which feature based image registration techniques fail to perform image registration efficiently. To overcome this, area based image registration technique is proposed. The proposed approach follows Markov random field model for image registration to improve the efficiency of registration. The proposed approach is a modular scheme and does not require any metric computations which help to achieve low complexity during implementation. The model is implemented using panchromatic and multispectral images that acquired from different satellites. The algorithm is experimented for remote sensing, coastal and conventional images. The result shows that proposed method is able to perform efficiently for image registration and is evaluated using the parameters such as Mutual index(MI), Root Mean Square Error(RMSE), Standard Deviation (SD) and Correlation Coefficient(CC).***

**Keywords:** Area based registration, Adaptive markov random field, Coastal image, Remote sensing, Satellite system

## I INTRODUCTION

Recently, remote sensing imaging methods have been considered as promising technique for atmosphere monitoring, earth information retrieval in local, global and regional scale. This information includes various crucial data about land such as land area coverage, classification of land, land mapping, regions extraction based on classes such as soil, forest, water or mountains etc. In order to extract efficient information, remote sensing images are captured by varying acquisition angles of camera and different time of acquisition. During image acquisition crucial information which is related to earth as useful for observations is divided into various images. In order to analyze efficiently, these images need to be combined together without losing any information. Combination of these images is known as image fusion. After image fusion, change detection in nature of land need to be examined which is carried out by performing image registration scheme.

Alignment of two or more images which are aimed to capture the same scene at different time, different angles and different sensors is known as image registration technique. During this process of image registration, one image is known as reference image and other images are called as sensed image. According to image registration technique, sensed image is processed through registration methodology where pixel coordinates arealigned according to the coordinates of reference image pixels. This process results in image transformation which is further superimposed on the given reference image by considering visual perception constraints. The superimposed image contains huge amount of informative data in a single output image which is denoted as fused image.

The image registration is growing very rapidly which motivates to develop efficient techniques for computer vision and remote sensing applications.Image registration, techniques can be classified into two main categories which are area-based image registration [5] and feature-based image registration [6]. In area-based registration technique, image feature extraction is not performed and optimization algorithms are used to carry out the fusion process. These methods consider intensity distribution for registration.

Feature based image registration methods utilizes intensity value and feature extraction by considering two images. This process is suitable for complex scenarios where intensity varies for each acquisition scenario. Complex geometric deformations occur which makes it significant to apply feature-based registration technique. The process of feature based image registration involves preprocessing, feature selection technique, feature correspondence image transform and resampling

Image registration is applicable in the following research areas: computer vision, pattern recognition, and remotely sensed data processing. In general, its applications can be divided into multi-view analysis, multi-temporal analysis and multimodal analysis according to the manner of the image acquisition.

- In multi modal image registration, same scene images are acquired with the help of various sensors where each sensor works at different frequency. This technique provides more complex and detailed information about scene since images are acquired by different sensors. This approach is widely used in remote sensing imaging application where panchromatic images and multispectral images are acquired. Another application is in medical imaging where MRI, PET image acquisition is considered [1].
- In multi view image registration, same scenes of images are acquired at different viewpoints or different angles. The main aim is to obtain larger view of 2D or 3D scene for efficient information extraction. This technique can be illustrated in remote sensing and computer vision technique by performing image mosaicing and shape recovery respectively [2].
- In multi temporal image registration, images of the same scene are acquired at different times, often on regular basis, and possibly under different conditions. The images which are to be registered are always having the change in illumination because illumination will change as time changes. The main aim is to find and evaluate changes in the scene which are appeared between the consecutive images. Examples of applications are remote sensing, monitoring of global land usage, planning of landscape. Computer vision: automatic change detection for security monitoring, motion tracking. Medical imaging: monitoring of the healing therapy, monitoring of the tumor growth [3].
- In scene to model registration [4], images of a scene and model of scenes are registered to carry out desired output.

The organization of the paper is as follows: Literature Survey is presented in section II. The proposed model is discussed in section III. Experimental analysis is given in section IV and Section V depicts concluding remarks

## II Related Work

In this section, the existing methodologies used for image registration of satellite image data in recent years are discussed. There are various challenges present in the field of image registration which need to be addressed. Satellite images are acquired by using various sensors and different conditions of data acquisition affects the registration performance. Size of data can be considered as another paradigm which affects the performance of image registration model. During satellite image acquisition process, navigation error and cloud interactions causes disturbance which is a crucial parameter. In order to address this issue of satellite image registration various techniques have been proposed recently. Chen et al. [7] presented a combined approach of image fusion and registration for remote sensing imaging application. According to this method, image fusion problem is formulated with the help of convex optimization process which helps to reduce the complexity of optimizer. Dynamic gradient sparsity property is applied to perform image fusion.

Based on Scale Invariant Feature Transform (SIFT) feature extraction technique,Fan et al [8] developed a new scheme for optical and synthetic aperture radar image registration for remote sensing image applications. SIFT is applied to perform initial matching during image fusion process. Later, initial matched feature are refined with the help of spatial relationship between features and registration parameters are estimated.

In addition to image fusion and registration, change detection is also addressed. During multispectral image acquisition, noise and interference is induced into original image which degrades the quality of image registration and change detection. In order to perform this, spectrum channels are mapped into feature space for noise and redundancy removal from the input image. Based on deep belief network, change detection scheme is applied for multispectral image processing [9]. Similarly, Conditional Random Field (CRF) based scheme is applied for change detection which extracts region connections in high-resolution images acquired from remote sensing. CRF modeling and fuzzy c-means algorithm is applied to perform clustering on the potential region of image. Potential region is estimated by using Euclidean distance measurement [10].

A new method for image registration and change detection in remote sensing applications is proposed. In order to do this, huge amount of high resolution data is optimized using deformation grid and changes are detected using temporal information of image [11-14].

The main contributions of the work are defined as:

(i) Development of a joint scheme for image registration and change detection
(ii) Formulation of low complex model for image registration application
(iii) Implementation of unsupervised methodology for prior information extraction from the satellite image

## III PROPOSED METHODOLOGY

This section presents proposed approach of image registration for Panchromatic and multi spectral image. Fig 1: shows block diagram of proposed image registration approach. According to this approach, initially two images are considered for registration process. By considering these images, pixel wise image transformation model is applied which provides transformed image. In the next stage, image wrapping is applied which is used for Gibbs energy modeling. The Gibbs function is used to determine whether system is in equilibrium or not and the composition at which it will occur. Once the energy is modeled, then energy function is computed. The next stage carries with the implementation of adaptive markov model. The main feature of the AMRF is the introduction of a relative homogeneity index for each pixel. The use of the index is to determine appropriate weighting coefficient for the spatial contributionin the MRF classification .Energy computation is followed by image labeling and pixel classification. Finally based on pixel classification technique, images are registered and change detection is performed.

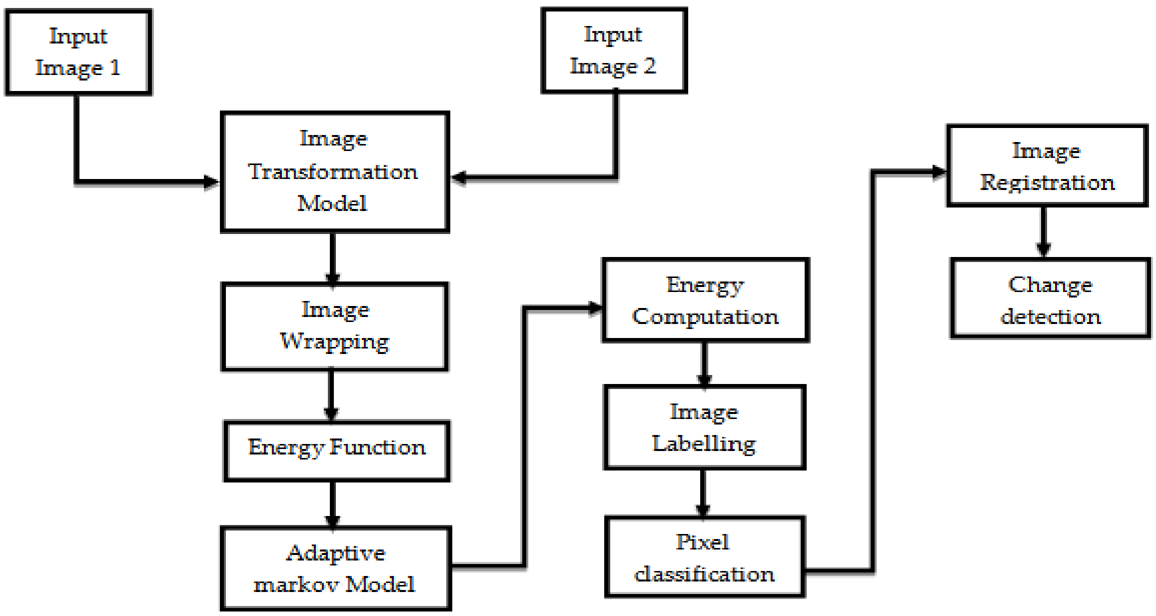



**Fig1:** Block diagram of image registration

The algorithm for the proposed method is shown as follows.

**Step 1**: Initialize land region labeling. For initial pixel to total number of pixels, assign pixel classes as $L(S) \in \gamma^{S}$. Compute probability density function based on Gibb's energy distribution
**Step 2**: Estimate number of Cliques for each labeled pixel
**Step 3:** Find potential Gibb's energy for each cliques
**Step 4:** Apply affine transform for given remotely sensed image
**Step 5:** Resample and remap image to represent affine transform model
**Step 6:** Apply chain rule to estimate the probability of mapped data. This stage provides the probability of data mapping for registration. Since input images are taken at different time interval which results in variation of pixel

values, energy and intensity of image. This affects the pixel labeling process. To optimize this, adaptive markov model is applied.

**Step 7:** Initialize adaptive markov model
**Step 8**: Define registration energy parameters based on the probability variation
**Step 9:** Apply pixel deformation resulting in pixel displacement estimation.
**Step 10:** Apply energy on similarity measurement for energy estimation.
**Step 11:** Measure displacement and apply similarity criterion for registration.

Energy based registration is modeled by considering labeled data from AMRF and finally change detection scheme is performed with the help of energy variation computation.

## IV EXPERIMENTAL RESULTS

In this section, qualitative analysis of the proposed method against the existing methods is demonstrated. In order to achieve this goal, the experiment is carried out to study the performance of the proposed method with the other existing techniques. The proposed method is tested by conducting three experiments and performance is quantitatively measured using Mutual information (MI), Root Mean Square Error (RMSE), Standard Deviation (SD), Normalized Mutual Index (NMI) and Cross Correlation (CC).

**Experiment 1: Remote sensing image**

Initially the performance is evaluated for Quick bird satellite image dataset. This dataset consists of multiple temporal structures which covers 9km$^2$ region during acquisition.The proposed model is applied for multispectral images which are acquired from satellite such as QuickBird.This section describes the performance evaluations which are used to show the comparative analysis of proposed model. In Quickbird images, 0.6 m spatial band of panchromatic resolution is present and it includes four multispectral bands such as blue (450-520 nm), red (630-690), green (520-600 nm) and NIR (760-900 nm) with a spatial resolution of 2.4 m. For performance analysis local global region dissimilarity is measured by considering the input image shown in Fig 2 a). For image registration one sensed image and another target image is considered . In Fig 2: (b), grayscale conversion of image is displayed which is used for further processing. For registration process a sensed image is obtained as shown in Fig 2 (c). The grayscale image and the sensed image need to be registered by applying proposed technique. Fig 2(d) shows the final registered image. In order to evaluate the performance, results are compared with existing image registration techniques. This analysis is presented in Table I which depicts high values of MI, NMI and CC and low values for RMSE and SD for the proposed method as compared with other methods. Fig 3, shows graphical representation of a comparative study by considering evaluation metrics as mutual information, normalized mutual index and correlation coefficients. From the Fig 3, it is observed that the proposed method has higher values of MI,NMI and CC. Hence the proposed method works better when compared to other techniques.

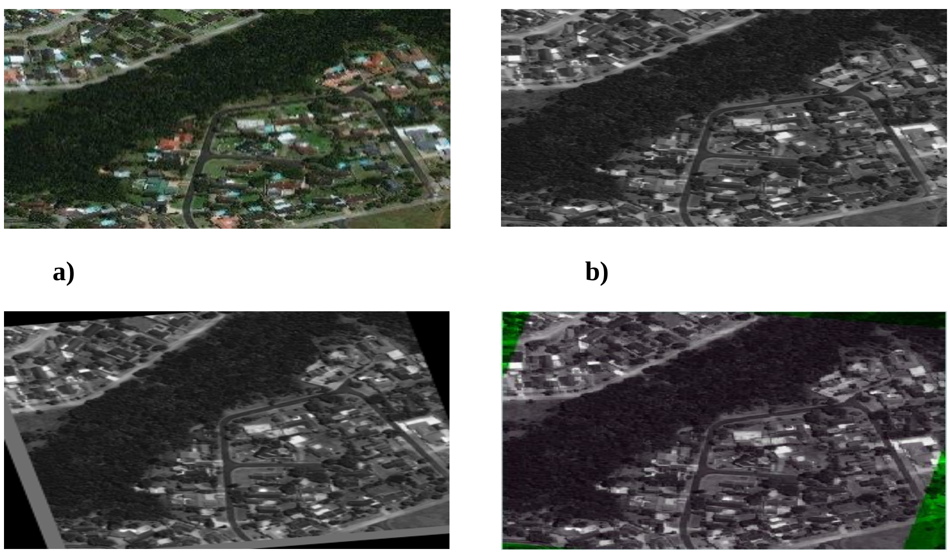



**Fig 2:** a) Reference Image b) Grayscale Image c) Sensed Image d) Registered Image

**Table I:** Performance comparison for proposed methodwith other existing methods.

| Registration | MI | RMSE | SD | NMI | CC |
|---|---|---|---|---|---|
| SIFT Method | 0.5220 | 5.59 | 4.38 | 0.35 | 0.58 |
| Modified SIFT | 0.5931 | 4.63 | 3.95 | 0.41 | 0.74 |
| MIHT | 0.6613 | 4.10 | 3.30 | 0.58 | 0.69 |
| Co-registration | 0.6801 | 3.85 | 2.85 | 0.61 | 0.78 |
| Proposed | 0.7538 | 2.12 | 1.24 | 0.72 | 0.85 |

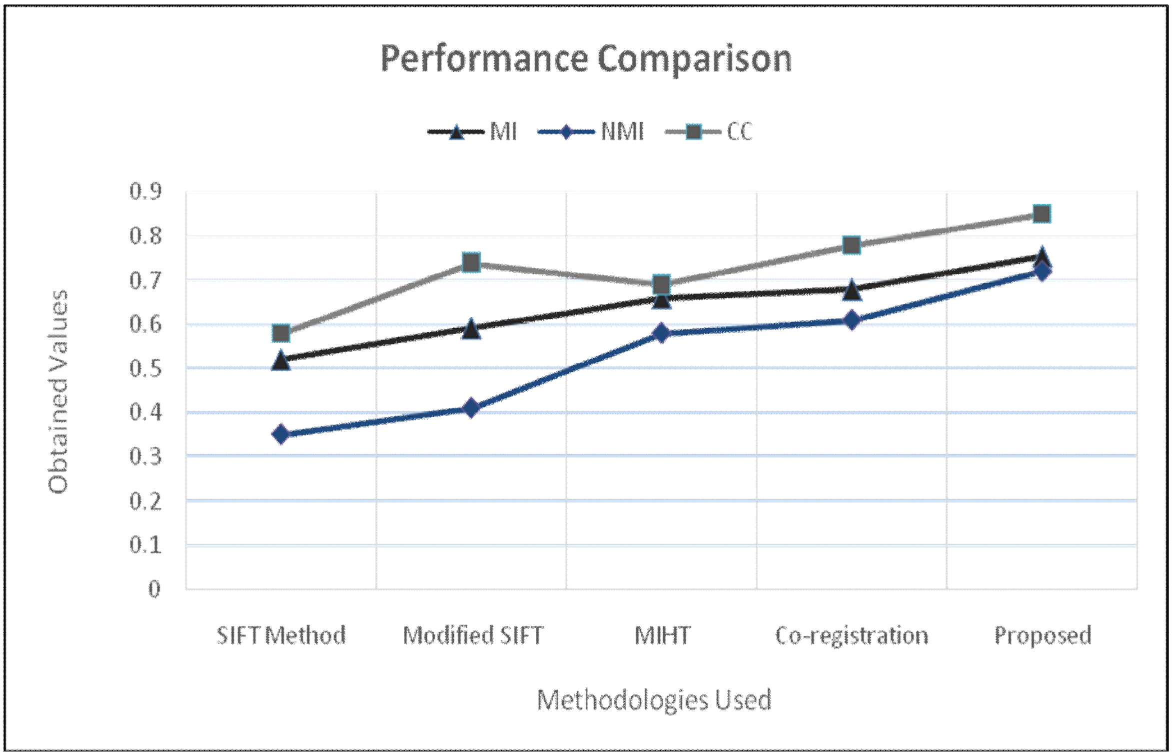
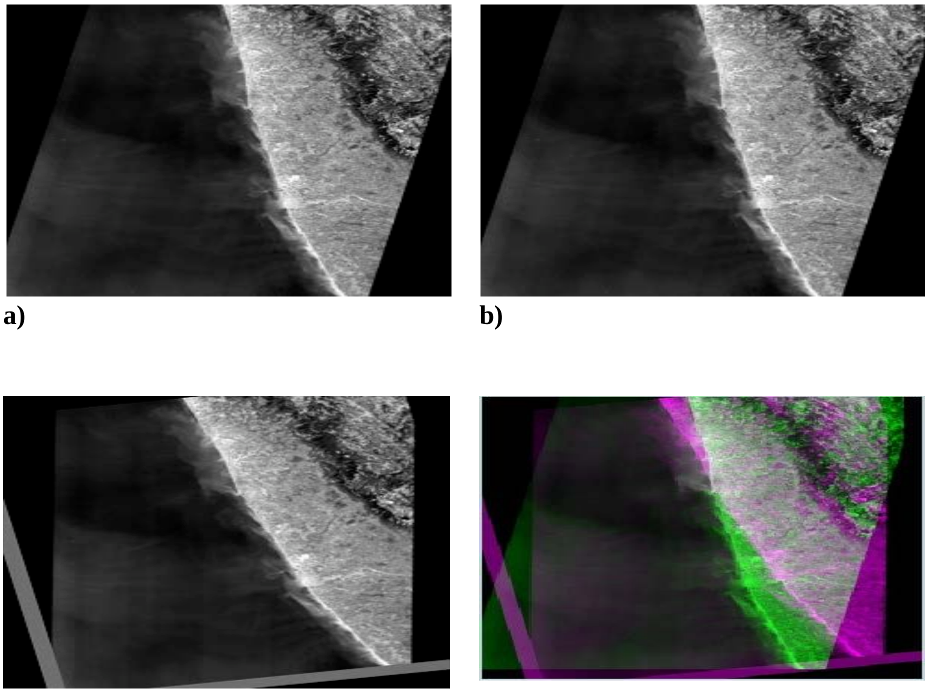



Fig 3: Graphical analysis for proposed method compared with other existing methods

**Experiment 2: Coastal Image**

Similarly, the performance of proposed model for coastal image is considered. The image shown in Fig 4 (a) is the optical image captured by LISS III sensor of Resourcesat 2 satellite. Resourcesat 2 has three camera mounted on a single platform with high resolution sensors. LISS III provides data with a spatial resolution of 23.5 m. LISS III is a multispectral camera operating in four bands, three in the visible and near infrared and one in the short wave infrared region. This image represents coastal area of Karnataka.

The experiment is conducted with the same process as that of experiment 1. The reference image and sensed image is subjected to registration as shown in Fig 4(b) and Fig 4 c). The result is shown in Fig 4(d) with change detection. Table II shows low values for RMSE and SD for the proposed method and high values for MI, NMI and CC when compared with other techniques. The graphical analysis of the proposed method compared with other methods is also shown in Fig 5. It is clear that the proposed method gives high values of MI, NMI and CC. Hence the proposed algorithm provides better values for adaptive markov random field.



a) b) c) d)

**Fig 4.** a) Reference Image b) Grayscale Imagec) Sensed Image d) Registered Image

**Table II:** Performance evaluation for proposed method with other existing methods.

| Registration | MI | RMSE | SD | NMI | CC |
|---|---|---|---|---|---|
| **SIFT Method** | **0.44** | **12.87** | **11.23** | **.21** | **0.36** |
| **Modified SIFT** | **0.48** | **16.51** | **7.07** | **0.33** | **0.39** |
| **MIHT** | **0.52** | **11.74** | **8.88** | **0.42** | **0.52** |
| **Co-registration** | **0.49** | **8.59** | **4.55** | **0.59** | **0.63** |
| **Proposed** | **0.62** | **6.11** | **2.72** | **0.68** | **0.72** |

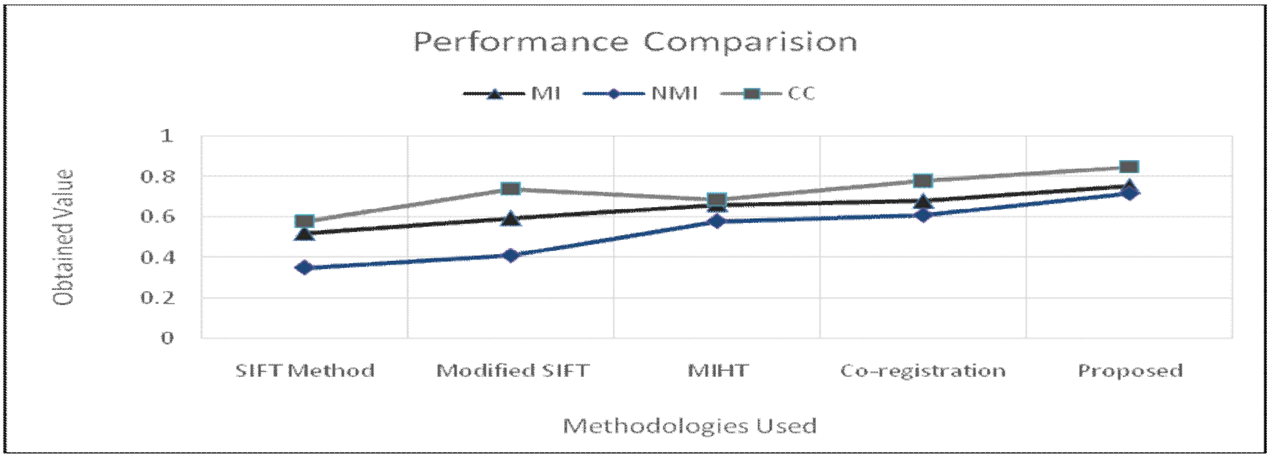
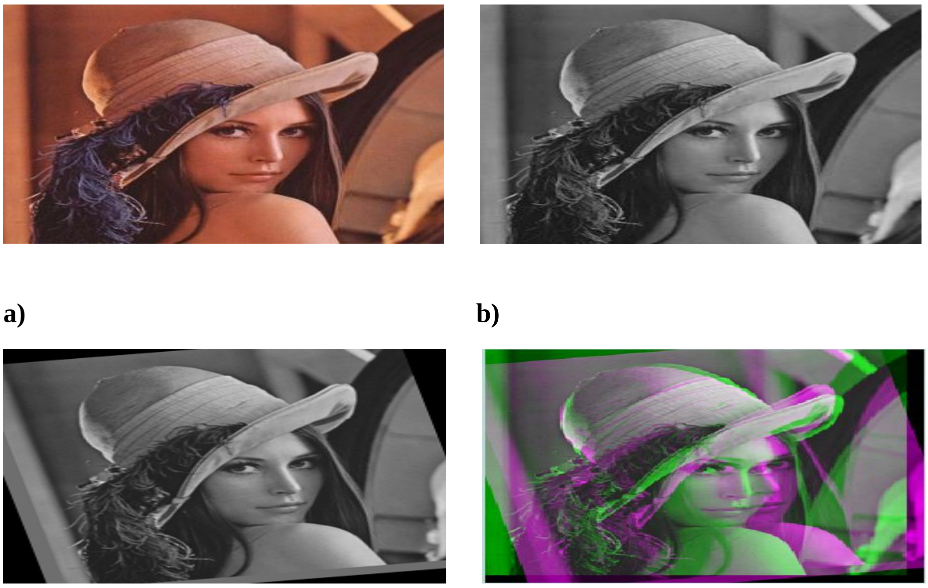



**Fig 5:** Graphical analysis for proposed method with other existing methods

**Experiment 3: Conventional Image**

In image processing research, it is important to have another bench mark image for image registration and performance evaluation. This image does not have any multispectral bands which makes is easier for image registration



**a)** **b)** **c)** **d)**

**Fig 6:** a) Reference Image b) Grayscale Imagec) Sensed Image d) Registered Image

The image shown in Fig 6 a), Fig 6 b) Fig 6 c) is processed through the similar process as discussed for experiment 1 and 2. The registered image is shown in Fig 6 d). Performance is computed similar to the previous test cases and comparison is shown in Table III. From the graphical analysis shown in Fig 7, it is observed that proposed model shows higher values of MI, NMI and CC and lower values for RMSE and SD compared with other existing techniques. Hence it can be depicted that the proposed model is able to perform better when compared to other state of art techniques.

**Table III:** Performance evaluation for proposed method with other existing methods

| Registration | MI | RMSE | SD | NMI | CC |
|---|---|---|---|---|---|
| **SIFT Method** | **0.74** | **8.27** | **7.12** | **.55** | **0.69** |
| **Modified SIFT** | **0.82** | **4.96** | **8.10** | **0.59** | **0.81** |
| **MIHT** | **0.87** | **5.57** | **6.79** | **0.63** | **0.76** |
| **Co-registration** | **0.81** | **6.23** | **3.83** | **0.89** | **0.87** |
| **Proposed** | **0.95** | **1.08** | **1.81** | **0.92** | **0.96** |

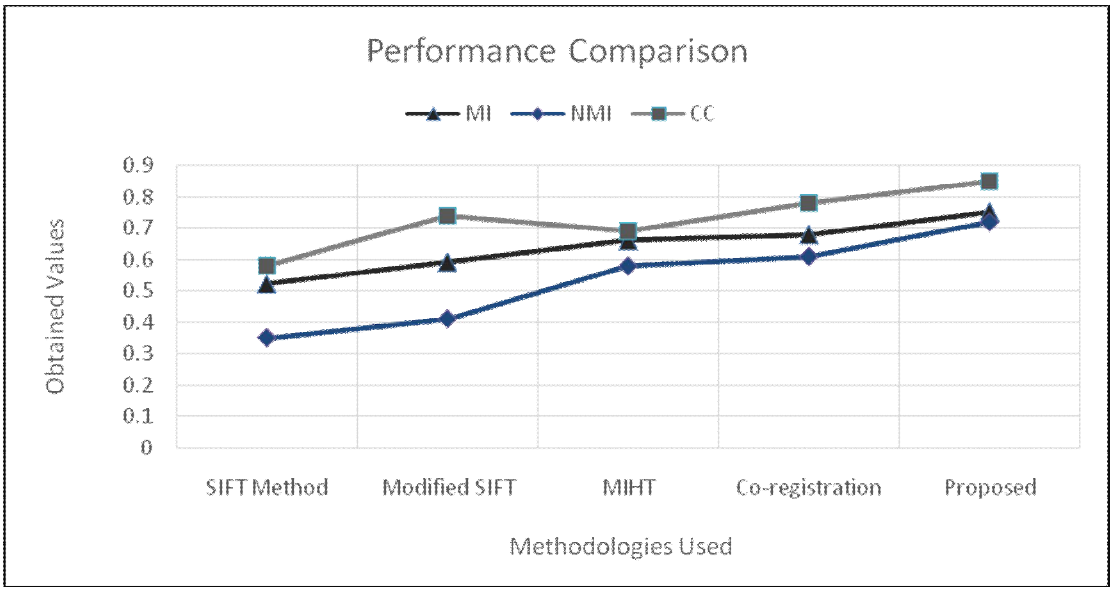



**Fig 7:** Graphical analysis for proposed method with other existing methods

## V. CONCLUSION

A new scheme is developed for image registration and change detection using adaptive markov random field approach. The proposed approach is validated by considering high resolution multispectral and multi temporal data which is obtained from various satellites. The model is modular, metric free and scalable which makes it adaptive and low complex for implementation.A classification model is developed to label the image in terms of change detection and registration. The proposed approach is capable to reduce the registration error in contrast to existing schemes. The performance is evaluated on the basis of statistical parameter which gives higher values of MI, NMI and CC and low values for RMSE and SD compared with other existing techniques. Hence it can be concluded that the proposed model is robust for image registration.

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