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Medical Image Registration Using Novel Point Matching Algorithm

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Abstract— *Abstract-* **Accuracy and time consumption are the two main problems in satellite image registration method. Here, we proposed novel point matching algorithms, called RANSAC(Random Sample Consensus) Algorithm and FSC(Fast Sample Consensus) algorithm. It has two sets: sample and consensus set. These sets has large number of correct matches. ISCM(Iterative Selection of Correct Matches) algorithm is used to increase correct correspondence. In this proposed method it has a less number of iteration to analysis the resultant image. IPRA(Removal of imprecise points) algorithm is to achieve less number of iteration by removing the imprecise points in input image. It increases the accuracy in resultant image. SIFT(Scale Invariant Feature Tranform) is one of the features to detect and describe local features in images. SIFT extracts SIFT keypoints from a set of reference images. This experiment shows that our novel point matching algorithm increases the number of correct matches and also it increases the accuracy of the result.**

Index Terms- **Medical image registrstion,RANSAC**

I. INTRODUCTION

IMAGE registration is one of the process which is used to transforming the different set of data in a single coordinate system. In this, data is in the form of photo graphs. The process of aligning the two or more images that are taken from various view points, various dimension or varies in time. Mostly image registration used in various fields such as, vision of computer, medical field, brain biological mapping. Registration is necessary to compare or integrate data obtain from various measures. Image registration is a point matching method .The points which are matched by using the input images. If the images are not properly registered, this leads to misregistration which is known as “Registration noise”. Registration noise changes the detection accuracy. Here the points are selected manually (i.e., control points).If the registered pair is too large, it become impractical.

Image registration is spilt in to two types called as: 1.feature based methods, 2.intensity based method. Here one image is taken as a reference or source image, other images are taken as target. The process of image registration is to align the target image with the reference image. Intensity based methods compare the intensity patterns via metrics. The correspondence of the feature based images are found between points, lines and contours. Intensity based images registered in the form of whole image or sub image. By using this correspondence, the geometric transformation between two images are found.

The advantage of this method is fast and robust, only for some cases. Now-a-days, point matching is important research in feature based methods for some cases. In image registration, similarity is found between images. The degree of similarity is measured between the intensity pattern of two images. Example of image similarity, includes cross correlation and mutual information. In this project, we mainly concentrate on novel point matching method.

These are the four methods in image registration such as, feature detection, feature matching, transformation estimation, transformation and resampling. In this, feature points are invariant. SIFT feature is one of the way to construct the matching pair. In this method, outliers are removed and correct matches are increased. Outliers have the negative effect in the image. It leads to inaccuracy in result. The point matches at the images are randomly selected. If the point cannot be matched at first neighbor, then it take the second nearest candidate for their point matching process. For this point matching method, it uses several method for matching the point by several iteration process. But our process of image registration, various algorithm is used to decrease the iteration process. In this, our proposed method is based on TAR(Triangle Area Representation) value of the KNN(K nearest neighbors). By using the point matching method, time is reduced and result is more accurate than other point matching methods.

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To increase the point matching process in less number of iteration, here we use some algorithm called as, FSC, ISCM, IPRA, SIFT, RANSAC. FSC is used to increase the reliability & efficiency of the image. This FSC extracts the subset ch from the set c. ISCM algorithm is used to greatly increase the number of correct matches. In this method, only the nearest neighbor of the SIFT feature keypoint is regarded as best candidate on it. IPRA is the one to remove the imprecise points in the images. Imprecise point means removal of outliers. This is one of the important method to improve the accuracy of the result. Here the transformation errors beyond the pixels σ is removed from their correspondence set. SIFT is one of the most powerful method for the obtention of local descriptors. The SIFT feature is to transform the image data into scale invariant coordinates relative to local features. RANSAC is one of the estimator, it selects a sample randomly choose from consensus set for final model parameter. It is perform to find the correspondence point. RANSAC is time consuming process to remove the outlier when it is in majority. RANSAC algorithm is a robust and an efficient method. In most of the method, only the outliers are removed. But in the current method, the number of correct matches also increased.

II. PROPOSED METHOD

In our proposed method, pair of image is taken as input images. After that, preprocessing process is done to remove the noises in the image. In the preprocessing process, the algorithms such as RANSAC, FSC, ISCM, IPRA, SIFT feature are used to achieve the desire result with high accuracy, robustness, reliability and efficiency. Finally, the PSNR value, RMSE value and time consumption for the project was estimated.

BLOCK DIAGRAM:

Input Image 1
Preprocessing
Input Image 2
ISCM
FSC
IPRA
SIFT Feature
Plot Matching Points
Estimations
PSNR
RMSE
Time

A. *Fast Sample Consensus (FSC)*

In FSC, reference image and sensed image is taken. We extract subset Ch, from set C. After that, we select the global affine transformation to represent the relation between reference image and sensed image. This transformation model is widely used in practice and it can also be represent the majority of deformation. It is represented as,

$$(\hat{x}, \hat{y}) = T((x, y), \theta)$$

Where $T((x,y),\theta)$ is affine transformation model, θ is the parameter in affine transformation model, the pixels of reference image and sensed image are (x, y) and $(\hat{x}, \hat{y})$.

In this, we extract two point features $\{p^1, \ldots, p^l$ and $\{p^1, \ldots, p^k$ for the correspondence construction. Let as define this correspondence as $c_i = p_i, p_i, p_i$ with coordinates (x_i, y_i) and (x_i, y_i). The tentative correspondence set is denoted as $C = c_1, \ldots c_i, \ldots c_n\}$.

There are many outliers in tentative correspondence set C, but it is important to find correct correspondence without outliers. But in satellite image registration it is difficult to remove the outliers. RANSAC is one of the algorithm which effectively removing the outliers from the input image and it also used to achieve high rate of accuracy.

In this, RANSAC algorithm selects the samples and found the largest consensus in same data set. By utilizing RANSAC set C directly, it is time consuming and unstable. In this paper, we proposed FSC to improve reliability and efficiency of the algorithm. The process of extraction subset C_h is given follow, so we find key points distance ratio.

SIFT is one of the effective measure for the obtention for local descriptors. It contains five major steps: scale space extrema detection, localization of keypoint, assignment of orientation, keypoint descriptor and matching of keypoint. SIFT features are matched by the distance ratio d_{ratio}, it denotes the ratio between the distance of nearest and second nearest neighbor. Key point is defined as nearest neighbor with minimum Euclidean distance. The process of FSC is discussed in *Algorithm 1*.

Algorithm 1 for FSC:

Input:

- C_h **:** sample correspondence set ;
- C:Total tentative correspondence set;
- N: No. of iteration.

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Output: Using this algorithm, transformation model parameter is obtained.

1) Take n=0
2) **for** i =1 : N
3) Select three correspondences randomly $c_i^h, c_j^h \wedge c_k^h$ from C_h.
4) Evaluate transformation model parameters θ_i by $c_i^h, c_j^h \wedge c_k^h$.
5) Evaluate the transformation error for every correspondence in set C by parameter model θ_i and C_i is made up with error less than 1 pixel.
6) **If** size (C_i) > n , then **do**
7) n = size (C_i).
8) Evaluate transformation parameter model θ by Consensus set C_i .
9) **end if**
10) **end for**

B. Iterative Selection of Correct Matches (ISCM)

The result of FSC algorithm is very close to the optimal solution. In this, a novel method is proposed, called Iterative Selection of Correct Matches (ISCM). ISCM algorithm is used to achieve more accurate result and it also increases the number of correct matches. Christo Ananth et al. [19] presented an automatic segmentation method which effectively combines Active Contour Model, Live Wire method and Graph Cut approach (CLG). The aim of Live wire method is to provide control to the user on segmentation process during execution. Active Contour Model provides a statistical model of object shape and appearance to a new image which are built during a training phase. In the graph cut technique, each pixel is represented as a node and the distance between those nodes is represented as edges. In graph theory, a cut is a partition of the nodes that divides the graph into two disjoint subsets. For initialization, a pseudo strategy is employed and the organs are segmented slice by slice through the OACAM (Oriented Active Contour Appearance Model). Initialization provides rough object localization and shape constraints which produce refined delineation. This method is tested with different set of images including CT and MR images especially 3D images and produced perfect segmentation results.

The process of ISCM is discussed in *Algorithm* 2.

Algorithm 2 for ISCM:

Input:

- $\{p^1, \ldots, p^{lo}\}$: reference image in the overlapped area;
- $\{p^1, \ldots, p^{ko}\}$: sensed image in the overlapped area;
- θ: the transformation model;
- T: No. of neighbors.

Output: Using this algorithm, the correspondences set C_{total} is obtained.

1) **for** $i = 1 : lo$
2) Find N nearest neighbors of p^i from sensed image in the overlapped area.
3) **for** $j = 1 : T$
4) Evaluate the transformation error of $\{p^i, p_i^j\}$ by θ.
5) **if** the transformation error of $\{p^i, p_i^j\}$ is less than 1 pixel **do**
6) Sum $\{p^i, p_i^j\}$ to C_{total} , from $\{p^i, \ldots, p^{ko}\}$ delete p_i^j.
7) **break**
8) **end if**
9) **end for**
10) **end for**

C. Removal of the Imprecise Points (IPRA)

In this, the set C_{total} is obtained with much more correct matches compared to other methods. To get more accurate result, we should remove some imprecise points (slight displacing control points). In each iteration, the correspondence with transformation error which is beyond σ pixels is removed, to get rapid final result. The process of IPRA is discussed in *Algorithm* 3.

Algorithm 3 for IPRA:

Input:

- C_{total} : total correspondence set;
- σ : Maximum error.

Output: Using this algorithm, final result θ is obtained.

1) **While** 1

2) Evaluate the transformation model θ by the set C_{total} .

3) Evaluate the transformation error for each and every correspondence in C_{total} by θ.

4) Delete the correspondence with transformation error which is larger than σ pixels.

5) **if** when no correspondence is removed **do**

6) **break**

7) **end if**

8) **end while**

D. Random sample consensus (RANSAC)

Random sample consensus (RANSAC) is an iterative method. It is used to estimate the model parameters by random sampling of observed data. RANSAC is a non-deterministic algorithm. In a dataset, the data elements contains both inliers and outliers. To find the optimal fitting result, RANSAC uses voting scheme. RANSAC algorithm is used to increase robustness and high degree of accuracy. It has the ability to solve the correspondence problem.

Algorithm 4 for RANSAC:

Given:

- **d**ata : data point set
- model : model which can be fitted to data points
- n : minimum number of data values
- k : maximum number of iterations
- t : threshold value
- d : number of close data values

Return:

bestfit : model parameters which best fit the data

iterations = 0

bestfit = nil

besterr = something large

while iterations < k {

maybeinliers = n randomly selected values from data

maybemodel = model parameters fitted to maybeinliers

alsoinliers = empty set for every point in data not in maybeinliers

{

if points fits maybemodel with an error smaller than t add point to alsoinliers

}

if the number of elements in alsoinliers is > d {

% this implies that we may have found a good model

% now test how good it is

bettermodel = model parameters fitted to all points in maybeinliers and alsoinliers

thiserr = a measure of how well model fits these points

if thiserr < besterr {

bestfit = bettermodel

besterr = thiserr

}

}

increment iteration

return bestfit

E. Scale-Invariant Feature Transform (SIFT)

Scale-invariant feature transform is an algorithm that is used to detect and describe local features in images. In this, SIFT keypoints are first extracted from the set of reference images. After that, it is stored in a database. Compare each and every feature in a new image to this database. Based on the Euclidean distance, candidate matching features is found. By using the full set of matches, the location, scale and orientation are identified for the new image to filter the good matches. Finally, it gives the accuracy and no. of false matches. The object matches indicates that pass all these test with high confidence.

It contains five major steps:

1) Scale-space extrema detection:

Let $I(x, y)$ as an input image. $L(x, y, \sigma)$ is defined as,

$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y)$$

where is the convolution operation of x and y.

$G(x, y, \sigma)$ is a variable- scale Gaussian and it is defined as,

$$G(x, y, \sigma) = \frac{1}{2\pi\sigma^2} e^{\frac{-(x^2+y^2)}{2\pi^2}}$$

The scale space extrema detection is implemented by detecting the local maxima and minima of $D(x, y, \sigma)$ and it is defined as,

$$D(x, y, \sigma) = \big(G(x, y, k\sigma) - G(x, y, \sigma)\big) * I(x, y)$$

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where k is a multiplicative factor constant. If it is larger or smaller than all of the neighbors, it is selected as keypoint candidate.

2) Keypoint localization:

It performs a detailed fit to the nearest data for location, scale and principal curvatures ratios. The keypoint candidates with a value less than 0.03 and greater than 10 are discarded, because their descriptors are not distinctive.

3) Assignment of orientation:

Based on local image gradient, each keypoint is assigned as a consistent orientation. It performs mainly based on orientation histogram. By this, the descriptor of each keypoint is represented as relative to orientation. Finally, it can achieve invariance to image rotation.

4) Keypoint descriptor:

In this, the computation of image gradient magnitudes and orientations is done around the keypoint location. It is weighted by a Gaussian window. By using the orientation histogram values, each keypoint descriptor is formed and achieve a feature vector.

5) SIFT matching:

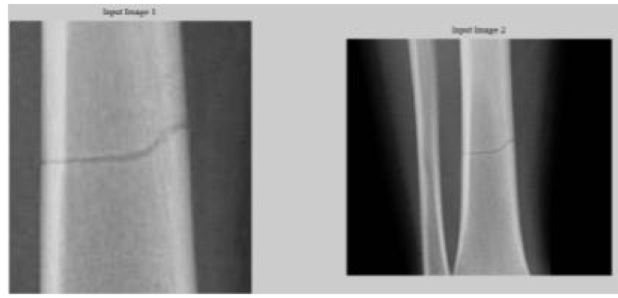
In this, by using the nearest neighbor approach SIFT matching is performed. For the invariant descriptor vector, the nearest neighbor is defined as the keypoint with minimum Euclidean distance. It is efficiently implemented by best-bin-first algorithm.

III. EXPERIMENTAL STUDY

In this experiment, we are chosen three pairs of images for the testing purpose. For these images, the correct matches and correct rate should be found. Correct matches means, the no. of correctly matched point pairs. Correct rate means, it is the ratio of no. of correctly matched point pairs to the total no. of existing matching point pairs. In the imprecise point removing procedure, to achieve an accuracy result, the value of σ is set to avg global error plus 0.5 pixel.

After getting the input image, the preprocessing process should be perform to remove the noises. We use three types of approach in the removal of noises. That is FSC, ISCM, and IPRA. The FSC algorithm was proposed to improve the efficiency and reliability of the images. Here, from the set C, we extract a subset Ch which has the high rate of correct matches. Then find the maximum consensus set in the overall set C and also we have to sample the subset Ch. FSC has much bigger consensus set. So it gives better result than RSCJ.

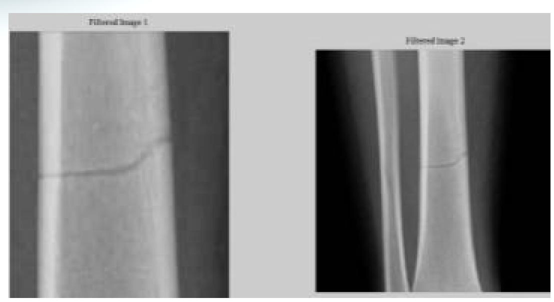
FIGURE 1:



A) Input images

TABLE : 1 corresponding values of RMSE,PSNR,SSIM,CORR and TIME in proposed method

Images	Method	RMSE	PSNR	SSIM
Pair (1)	RSCJ	1.0534	38.018	0.61
	KNN – TAR	1.7708	36.0035	0.57
	RSOC	3.2318	34.0026	0.46
	Only FSC	0.5976	42.0063	0.69
	RSCJ + ISCM + IPRA	0.6198	41.000	0.76
	RANSAC	0.5742	42.0147	0.89



B) Filtered Image

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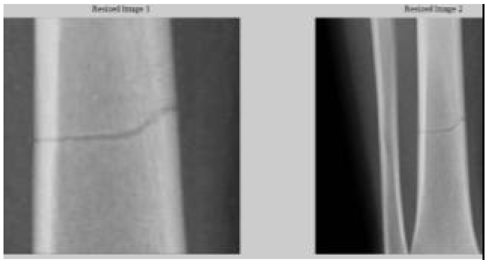
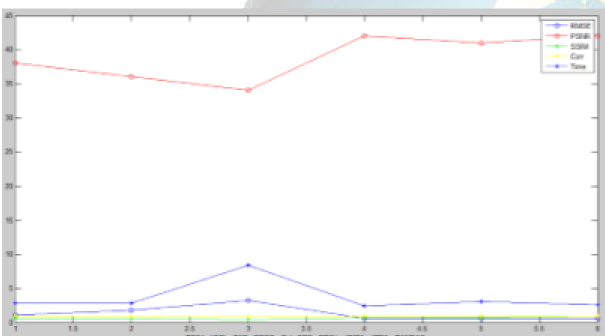
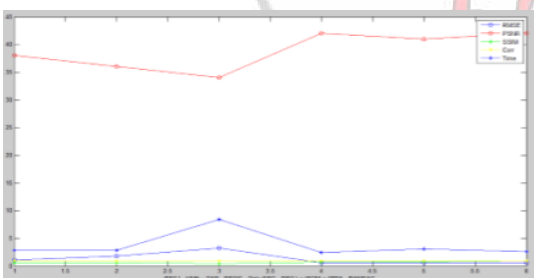


C) Resized Images

The ISCM algorithm is used to achieve more accurate result and also it increases the no. of correct matches. In the process of remote sensing, we find many false correspondences, but so many correct correspondences are not found, these correct correspondences which may be the correct candidate of the keypoint and it is said to be the second nearest neighbor. To increase the no. of correct matches, we have to judge every keypoint neighbors in the order of distance from the nearest to the farthest. After that, the overlapped area is obtained.

MODEL GRAPH FOR TABULATION :





The IPRA algorithm is also used to obtained the set C_{total}. It is an efficient method to find the rapid final result. When compared to other methods, it gives more no. of correct matches. In this, the imprecise points are removed to get high rate of accuracy. In each iteration, the correspondences set with transformation error beyond σ is removed.

After completing the preprocessing process, SIFT feature is applied on the obtained preprocessing result. It detects and describe the local features in an image. In this, a reference image and a new image is taken. Then extract the keypoints in the reference image and it is stored in a database. After that, compare each feature from the new image to this database. In this, the pixels are represented as a numerical value. Based on Euclidean distance find the correct matches. Finally it gives no. of false matches and accuracy with high confidence.

RANSAC algorithm is also used to improve robustness and accuracy in an image. It is an iterative method. RANSAC uses voting scheme in order to get the optimal fitting result. It has the dataset with data elements which contains both inliers and outliers. It can be used as an outlier detection method. RANSAC is used to solve the correspondences problem.

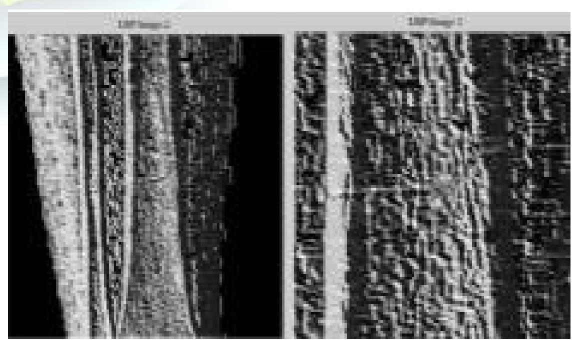
After the extraction of SIFT features, the matching points are plotted with high accuracy. Finally, we need to estimate, PSNR, RMSE and time value. PSNR is usually expressed in logarithmic decibel scale.

To measure the quality of reconstruction of lossy compression codes, PSNR is used. A high PSNR value indicates that the reconstruction is in higher quality. In some cases, it is not possible to get higher quality.

RMSE is defined as the difference between the predicated value or the observed value. These individual differences are called residuals. When it computed out-of-sample, it is called predication errors. It has a good accuracy measure only when compare to forecasting errors for a particular variable, not between the variables, as it is a scale dependent, the root-mean-square error (rmse) is defined as

$$\text{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(rx_i^2 + ry_i^2)}$$

where n is the number of matches and (rx_i, ry_i) is a residual for a certain match.



A) LBP Image

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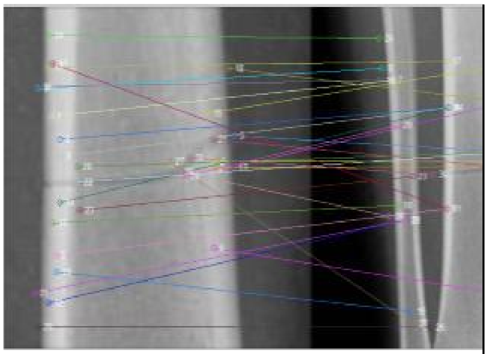

B) Point matching using RANSAC

IV. CONCLUSION

A Novel point matching algorithm and SIFT feature is proposed in this project. The algorithm in this project includes five parts: 1) Using FSC algorithm, the preliminary result is obtained. 2) Using ISCM algorithm, most correct correspondences are found. 3) Using IPRA algorithm, imprecise points are removed to get more number of correct matches. 4) Using SIFT feature, high rate of accuracy is obtained. 5) Using RANSAC algorithm, the efficiency and robustness of the image is greatly increased. While comparing other methods, our algorithms gives best result. We conclude that, our experiment has registration methods with accurate, robust and efficient result.

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