Intensity Based Registration for Needle Placement

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Abstract— Image registration is a vital problem in medical imaging. It has many potential applications in clinical diagnosis. Registration algorithms compute transformations to set correspondence between the two images. In medical image registration, vibrations and movements are the main problems that are observed in camera based diagnostics various registration techniques are there but most commonly used method are either a feature-based or intensity-based image registration. But no such automated methods are available that may helpful to perform camera based surgery, by Analysing the wound from different directions to find out the location of needle where it is need to be placed, also to calculate the depth and number of stitches to be required. This can be done by using intensity based image registration, where two images of same wound taken from two different angles are registered.

Key words: Image Registration, Medical Image Registration, Similarity Measures

I. INTRODUCTION

Image registration is a vital part of image restoration that uses objective criteria and previous information to enhance images. Image registration is the method of estimating an optimum transformation between two images from one view to other. In image registration one of the images is referred to as a reference image and other image is known as a target or sensed image. In many of image processing application, automatic image registration is required where the images of same scene are obtained from different viewpoints, with different sensor and at different times. To perform image registration geometrical transformation is required to be applied to align target or sensed image with reference image. Advance, computer science has led to reliable and efficient image processing methods useful in diagnosis, treatment planning and medical research. A large group of medical applications are there that are using different types of registration methods. In medical image registration the basic concept is to align different pre-operative images of the patient's body to be scanned. These images may in 2-D or 3-D and moreover PET, MRI and CT etc are used to acquire intensity volumes in intensity based registration. In medical IR two commonly used approaches are intensity based and feature based. Regardless the above two approaches intensity and feature based, there are some core components which are required for every methods of image registration. These are transformation model, optimization and similarity metrics. Transformation model helps to determine geometrical transformation which is needed for alignment of sensed image to the reference image. Optimization process helps to choose the best optimal transformation model. At last similarity metrics, used during mapping process where it helps to evaluate the similarity of the images.

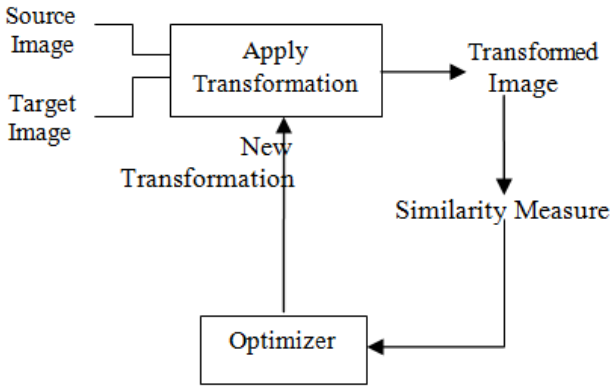

Fig. 1: Components of Image Registration

II. RELATED WORK

There are different types of techniques that are used in the field of medical image registration, but there are many problems in existing techniques that are discussed in the following survey.

Zhiyong Xie and Gerald E. Farin presented a paper "Image Registration Using Hierarchical B-Splines" [1] In this paper application of Hierarchical B-splines, in the form of free form deformation, provide a natural way for image registration due to its global- to-local influence, coarse-to-fine matching, and computational efficiency. This method can also provide a way to reduce memory overload. When a large data set is used in registration, the data sets at different levels can be divided into some small regions and stored. These data files can be loaded into memory as needed. But there is a drawback regarding validation, as Validation is an important issue in image registration. Unfortunately, there is no standard method is mentioned to evaluate a system.

M. Hub, M. L. Kessler & C. P. Karrer presented a paper "A Stochastic Approach to Estimate the Uncertainty Involved in B-Spline Image Registration" [3].In this paper author proposed a method that is used to distinguish the areas of the same image that is based on the performance of mono model B-spline registration i.e. in which area the B-spline registration performing well and which it is quite less accurate. It is stochastic approach where the basic idea is to focus on the local sensitivity of the similarity measure to additional deformations after registration. This can be performed only by dividing the images into sub regions that are differ in magnitudes. A color display of these regions helps to identify the image regions where the anatomy mapping as well as dos is likely to be inaccurate. In B-spline image registration the resulting coefficients are subjected to randomly performed variations.

Marburg have presented a paper entitled "Pose Priors for Aerial Image Registration"[4].In this paper shows the importance of RANSAC tool for estimation of inter image geometries using point correspondence. But the randomised nature of the RANSAC makes it insufficient for

large number of wrong matches. This paper has presented the four methods of utilising geometries algorithms that help in estimation of the inter-image in a very much restricted number of iterations, even in the presence of low numbers of inliers.

Guy Nir, Ramin S**.** presents a paper entitled as "Model-Based Registration of Ex Vivo and In Vivo MRI of the Prostate Using Elastography" [9].This paper proposed a novel registration method that uses a patient-specific biomechanical model acquired using magnetic resonance elastography to deform the in vivo volume and match it to the surface of the ex vivo specimen. The objective of this paper is to develop and validate a method for an automatic and accurate 3-D registration between ex vivo and in vivo MRI .Method used in this paper allows solving the registration problem on a regular grid by using a variational approach and eliminates volume meshing

Myronenko A**.** presented a paper entitled "Intensity based image registration by minimizing residual complexity" [20] This paper presents a similarity measure that is based on the assumption of non-stationary and complex varying intensity distortion in mono-model setting. To drive this similarity measure, intensity correction field its adaptive regularization is solved analytically to make similarity measure more robust. This similarity measure is referred to as residual complexity. Favouring smooth or piece wise smooth residual are the two basic functions of residual complexity that will help in better alignment of two distorted images due to spatially varying intensity distortions. These functions can also helps the RC to get minimized while sparsely coding the residual images. Moreover this measure is best for complex interactions and provides accurate results for registration for both real world and artificial problems. There is a drawback of this approach, that it can only be used for same modality images.

Dwarikanath M. and Ying S**.** presented a paper entitled "MRF-Based Intensity Invariant Elastic Registration of Cardiac Perfusion Images Using Saliency Information.". This paper presents a Markov random field based method was proposed that uses saliency and gradient information for elastic registration of dynamic contrast enhanced (DCE) magnetic resonance (MR) images of the heart. Saliency information contributes to a contrast invariant metric to identify similar regions in spite of contrast enhancement. This makes it suitable for elastic registration where matching local information is crucial. Although saliency provides highly similar maps for a pair of contrast enhanced images, its robustness can be further improved when used as a similarity measure. On the other hand, gradient information can be influenced by noisy datasets and does not accurately register the boundary of the LV in cardiac images. A combination of saliency and gradient information overcomes their individual limitations resulting in good registration performance. A saliency-based narrow band graph cut method was used to speed up the registration process. Saliency information was used to identify pixels undergoing deformations and reduce the number of graph nodes. There is drawback of proposed method that it is not suitable to perform registration on images having different modalities.

Po Su, Yang J. Presents a paper entitled "A Fast CT and CT Fluoroscopy Registration Algorithm with Respiratory Motion Compensation for Image-Guided Lung Intervention"[8].This paper, proposed a fast CT–CTF deformable registration algorithm. The objective is to register pre-procedural 3-D CT image onto the real-time captured CTF image for 3-D lung intervention guidance. To improve registration accuracy, respiratory motion compensation (MC) framework is incorporated into the registration procedure. A parallel implementation strategy is adopted to accomplish the registration in several seconds.

In this paper a multi-resolution approach of registration is used that contain three levels of resolution. Moreover it also incorporates a framework of motion compensation which is required to improve the accuracy of registration. The main motive of using this framework is to find out the deformations between CTF and intermediate CT. This deformation must be smaller to achieve accurate results of registration. During its implementation an equal number of processor are required for an equal number of blocks to have a good performance.

Christopher R**.** presented a paper entitled "A Novel Accurate Mini-optical Tracking System for Percutaneous Needle Placement"[10].The work done in this paper shows that there are a few qualities that a surgical tracking system must have like standard work flow, accuracy, reliability and simple to use. This paper shows implementation of an accurate minioptical tracking system for percutaneous needle placement with clinical precision. The image registration technique used is having a bright future scope on MR imaging applications and environments.

Andrea M. Michela G. presented a paper entitled "On the Potential of Information Theoretic Indicators for the Detection of Image Vibrations and for Image Registration on JET"[19]. This paper shows the difficulties that occur in camera based diagnostics like vibrations and movements in field of view. It is not easy to measure vibrations directly as the accessibility of the optical systems is strongly limited and too complex. To compensate these movements and vibrations of camera and their optics image registration is used. This paper proposed three registration indicators to enhance the accuracy of registration. These indicators are mutual information, cross correlation and entropy. Here cross correlation is a similarity measure that defines the similarity pattern between two images .Mutual information is used to define mutual dependencies between two random variables. And the last one is entropy use to detect vibrations and provides a maximum success rate.

III. PROPOSED WORK

To improve these techniques image registration can be used for automated skin stitching, which will help to perform minor medical operations automatically by Analysing the situation themselves.

- Take Images of the wound from different angles and sides will be taken.
- Convert both images into gray scale images.
- Region interest for both the images is to be finding using active counter algorithm.
- Apply Intensity based Image registration to register both the images.

- Précised location of the needle is detected and required number of stitches is calculated after getting registered image.
- Optimize the exact parameters like Root mean square Error, Peak Signal to noise ratio, CPU time, Mean squared error

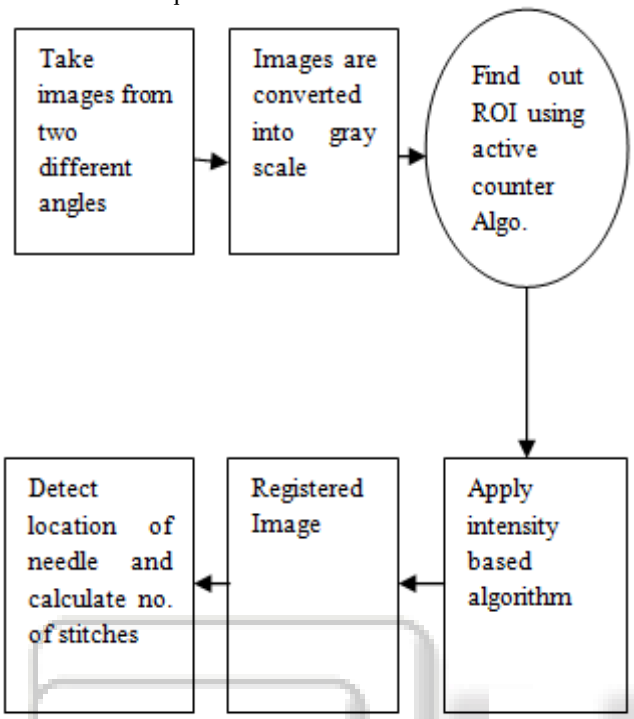

Fig. 2: Data Flow Diagram

IV. EXPERIMENTAL RESULTS

Image registration is an important part of image restoration that uses objective criteria and prior knowledge to improve pictures. Image registration is the method of estimating an optimum transformation between two images from one view to other. In many of image processing application, automatic image registration is required where the images of same scene are obtained from different viewpoints, with different sensor and at different times. To perform image registration geometrical transformation is required to be applied to align target or sensed image with reference image.

In medical image registration, many problems are analyzed in existing techniques. Like vibrations and movements that are observed in camera based diagnostics while using feature based methods that may cause inconsistent results. To solve these problems image registration can be used for automated skin stitching, which will help to perform minor medical operations automatically by analyzing the situation themselves.

The experiment is performed on ten different images. The proposed work is implemented with the help of MATLAB 9.0.The results are calculated based on four parameters: peak signal to noise ratio, mean squared error, root mean squared error and CPU time.

Fig1 and Fig.2 are the two images of same wound are taken from two different angles using some optical system. That will help to perform image registration. Here one of the images is referred to as reference image and other image is referred to as target or sensed image. Fig.3 and Fig.4 shows the images taken from two different angles are converted into gray scale images. The need of performing this step is to minimize value of entropy i.e. to minimize the color variations. In fig.5 and fig.6 region of interest of both the images is detected, this can be perform after converting the images into gray scale images. Region of interest is the process of extracting the area on which the registration is needed to be performed. In Fig.7 and fig.8 Intensity based registration is performed on both the images to obtain the registered image.Fig.9 shows the number of stitches to be required.

A. Parameters Analysis:

1) Entropy:

- Entropy is used to minimize the color variations. For this we have converted the images taken from two angles into gray scale images because gray scale images contain only two colors that is black and white.

2) Peak Signal to Noise Ratio:

- PSNR as overall used to represent distinction or differences between two images and this criterion helps to know the quality of restored image. To check the quality of restored image we have calculate the PSNR value before and after restoration. More will be the PSNR value, smaller be the distinction between two images.

3) MSE of Registered Image:

- Mean square error is defined as square of differences that may be either in intensity or in feature distance between one or more pairs of images. For accurate results minimum achievable value of MSE is required

Fig. 3: 1st Angle Method

Fig. 4: 2nd Angle Method

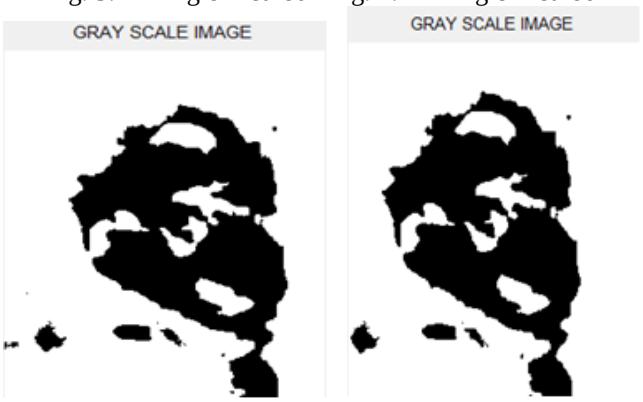

Fig. 5: Gray Scale Image

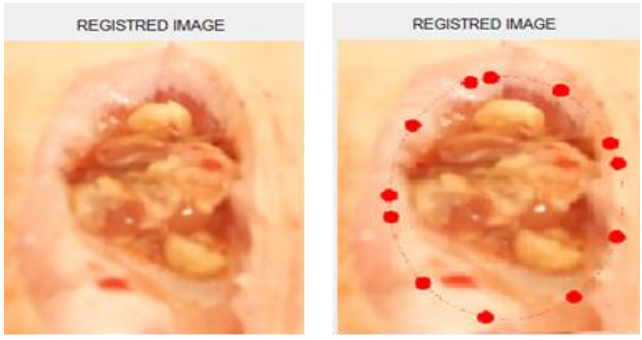

Fig. 6: Registered Image


Fig. 7: Image

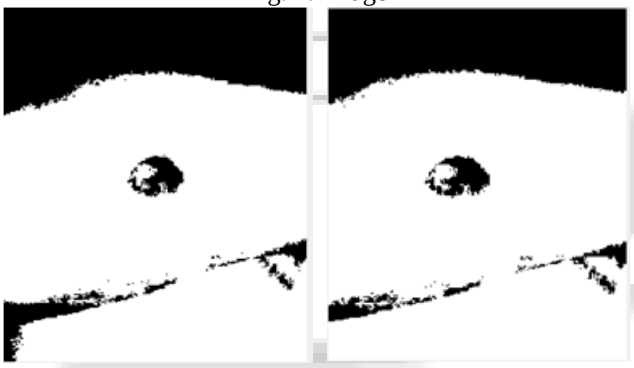
Fig. 8: Image

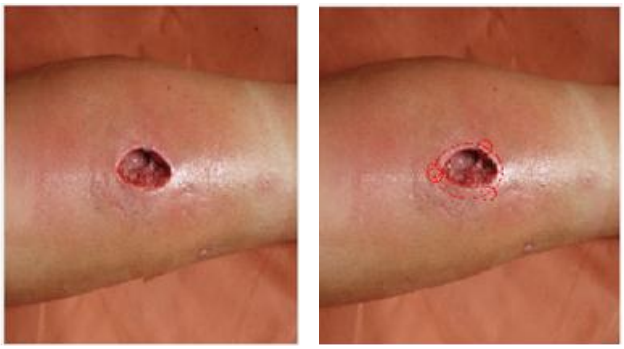
Fig. 9: Image

PARAMETERS	IMAGE 1	IMAGE 2	IMAGE 3	IMAGE 4	IMAGE5
Length	406	80	296	90	110
Width	80	92	112	60	92
CPU Time	0.10736	0.10357	0.87413	0.34051	0.2543
PSNR Before Registration	24.0678	26.0563	35.0969	27.0113	29.0021
PSNR After Registration	69.2197	42.1442	51.1751	55.0643	51.032
MSE Of Registered Image	0.99604	0.015625	0.86911	0.4189	0.3241
RMSE of Registered Image	0.99802	0.99787	0.93226	0.6	05

Table 2: Parameters Analysis

- To perform registration, two images of same wound are taken from two different angles. Both the angles are converted into gray scale images.
- Region of interest is the process of extracting the area on which the registration is needed to be performed.
- Then intensity based registration is performed on both the images to obtain the registered image, after which location and number of stitches are to be found.
- Some parameters such as entropy, PSNR, MSE, RMSE and CPU time have been calculated which helps to measure the performance of the results that how accurate the results are obtained.

V. Conclusion

Image registration is a method of aligning two different images into single coordinate system. It is used areas such as computer vision and image processing, which often require the process of developing a spatial mapping between sets of data. In medical image registration the basic concept is to align different pre-operative images of the patient's body to be scanned. These images may be 2-D or 3-D and moreover PET, MRI and CT etc are used to acquire intensity volume in intensity based registration. Many intensity based medical IR algorithms are available that are useful in various surgical methods .We have reviewed various surgical methods based on IR in our literature review, but no such method is available that is able to analyse the wound to calculate the number of stitches and to detect the location of stitching needle where the needle is need to be placed. To achieve this we have proposed intensity based medical IR algorithm that will be helpful in automatic camera based surgery in analysing the situations themselves.

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