T1 and T2 MRI Brain Images Registration and Fusion Technique

Sunanda Dixit, Mahesh B V, Suma V

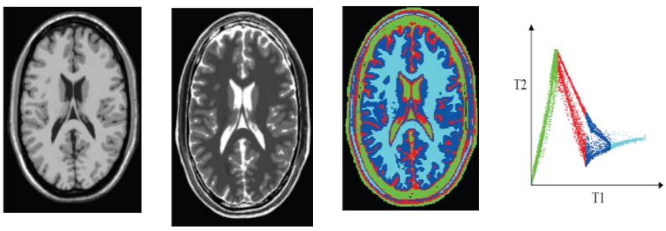
Abstract: Fusion of the medical images and registering them will improve the diagnosis and treatment for brain pathology. Image registration plays a major role because multimodal images intensity levels are to be aligned based on relationship between the images. Image registration is proposed where T1 image is a target image where T2 is registering image. Optical flow with SIFT is applied to register T2 image. The registered T2 image is fused with T1 image by applying curvelet transformation and averaging method. Entropy and Mutual Information (MI) parameter is used to evaluate the system performance. The results of the system give better entropy and MI value.

Keywords : Registration, Fusion, MRI, Optical Flow, SIFT, Curvelet transformation, Mutual Information (MI), Entropy

I. INTRODUCTION

Image processing techniques spread in a wide range for detection of diseases in an early stage by analyzing the human body anatomy. There are various medical imaging techniques are used now days such as MRI, CT, PET etc. All this types of imaging techniques provides the 2D images. In the medical imaging techniques, it is crucial to detecting the diseases and to analyze the volume and complexities.

MRI is the widely used non-invasive imaging technique, Radio waves and magnetic field are used to cross section of the body images, like brain, lungs etc. The 3D model of brain represented using 2D cross sectional image. 2D images cannot give complete and accurate information and it may lead to wrong results. Understanding of the 2D images required more experience and special training.



a)T1 Mode (b)T2 Mode (c) labelled Anatomy (d) Joint Histogram

Figure 1: Different medical imaging techniques

Radiologists uses 3D model to analyse the brain using a pair of 2D images. It is easy to interpret to a physicians, 3D model helps to analyse the brain using a pair of 2D brain images. 3D model helps in better understanding and make easy to measure the geometrical characteristics. The extracted data helps in finding the stages of tumor, in tumor identification, planning for surgery, and also to research filed [01]. Perfectly aligned slices of T1 and T2 brain images are depicted in the figure 1(a) and figure (b). The intensity difference of the images shown in figure (c) and figure (d) [02].Image registration technique embodies the alignment of images taken from different imaging methods or images taken at different timings. It finds the spatial transformation between corresponding elements of the image.

Researchers presented different registration techniques, such as shift invariant feature transformation, principal component analysis, etc. [03][04]. There are two classifications of image registration techniques. One is feature based and other one is intensity based.

In medical imaging more rich and valuable information is obtained by multi-modality fusion techniques which employ the combination of multiple images taken from different imaging devices. Efficient algorithm is used to fuse the image.

The computed tomography (CT) image only gives information regarding bone tissue and boundaries will be not be given in case of soft tissue. To get more information on soft tissue Magnetic Resonance tissues (MRI) images are used. Tissues with dense bones or lungs comprise of gases; MRI scan has very poor imaging. The radiological feature varies in MRI. The observation of anatomic structure information is easy in the T1 weighted MR image. The T2 weighted images are related to water. In medical diagnosis and treatment planning multi-modality plays a major role. In medical imaging image fusion plays a vital role.

In this paper deals with the proposal of a system to register and fusion of 2D MRI brain image. Here T1 is a target input image while T2 is a source image for registering the T2-image. T1-image is fused with the registered T2-image. The fused image shows the complete information about the brain and helps in analyzing the anatomy of the brain.

The paper is organized in the following way. The literature survey is Section II explains the Literature survey, Section III explains the Methodology, Experimental results are shown in Section IV and Section V concludes the proposed work.

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Sunanda Dixit, Computer Science and Engineering Department, BMS Institute of Technology and Management, Bangalore, India. Email: sunandadixit_cse@bmsit.in, Sunanda.bms@gmail.com

Mahesh B V. , Tata consultancy Services, Bangalore, India, Email: mahesh_ait@hotmail.com

Suma.V, Information Science and Engineering department, Dayananda Sagar College of Engineering,Bangalore, India, Email:sumav@gmail.com

II. LITERATURE REVIEW

Lianghao Han [05] has proposed a system with a nonlinear biomedical based medical image registration. In the process the first step is, finite element (FE) based modeling is applied to detect the deformation of the pectoral muscle which is damaged physically. In the subsequent process of deformation is analysed by rigid intensity based image registration. The FE analyses do not cover because of approximation and simplification of biomedical models. The performance of the system is evaluated using Dice Similarity Coefficients (DSC).

Praveen Kumar Reddy Yelampalli [06] has proposed a novel local feature descriptor based on recursive Daubechies patterns (RDbW). In the local texture the pixel relationship is used to find the daubechies wavelet decomposed center to define and decode.

The further fusion process employs affine transformation function based on Procrustes analysis (PA) as well as wavelet based fusion method majorly employed in spatial alignment for multimodal images (medical images). The registered images are RDbW features that are used in spatial alignment for multimodal images (medical images). The system performance is evaluated by comparing the existing system and it gives better accuracy. Seema S presented a detailed 3D image reconstruction methods for under water images survey. [07]

Su M et.al [08] optical flow and Speed Up Robust Features (SURF) is proposed for multimodal brain image registration. The image transformation is done by histogram specification then image is registered. SURF feature points are being extracted and then the registered image preliminary features are obtained. Optical flow algorithm gives the better accurate result for the registered image. Multimodal brain image is used for system evaluation.

Image registration using DWT and application of Gaussian pyramids is proposed by Shakir H et.al [09]. Using Gaussian pyramids the image registration LL,LH,HL and HH sub-bands are derived, the dwt is applied both reference and target image. Maximum MI and CC values are used to calculate the quality of the registered image.

An intensity based medical image registration is proposed by Lakshmanan A.G et.al [10].Brain image with lesion and various noise level are tested. The registered image is used to reduce the time for decision making for treatment as well as various diagnosis.

Aboozar Ghaffari [11] has proposed image registration method based on similarity measure. In the similarity measure, the main challenging task is to spatially varying distortion which causes the performance degradation directly. Using the monomodal image, based on singular values a new similarity measure is modified SSD. Image registration and distortion correction are performed in parallel.

Ganesh Lakshmanan [12] has proposed system for image registration based on intensity. The affine transformation is applied to MRI brain images and normal images. The performance of the system is test with MRI brain images with various level of noise.

Bhavana. V [13] has presented a system for fusion of multi modality imaging of medical image. In this system they considered a PET and MRI image for fusion. The images are pre-processed and enhanced. The enhanced imsage is applied to transformation for fusion, DWT is fused for fusion. The accuracy of the system is about 80-90%, when compared to other existing system it shows better performance.

Xiaojun Xu [14] has proposed a discrete fractional wavelet (DFRWT) image fusion technique.The value of p raning from[0,1]. The input medical images which act as a source are decomposed by DFRWT with different p order. The mode coefficient in sub-band images changes leading to sparsity character.

B.Deepa [15] has presented a system on gradient discrete wavelet transformation, with PCA and DTCWT based fusion method to improve the information in MRI image. Initially DWT is applied for fused image then gradient is measure to get the final image. The fused image gives the clear picture for detecting the abnormality. 90% accuracy is obtained in the proposed method compare with other techniques.

A. Paper Submission Criteria

Any one author cannot submit more than 05 papers for the same volume/issue. The authors of the accepted manuscripts will be given a copyright form and the form should accompany your final submission. It is noted that:

- Each author profile along with photo (min 100 word) has been included in the final paper.
- Final paper is prepared as per journal the template.
- Contents of the paper are fine and satisfactory. Author (s) can make rectification in the final paper but after the final submission to the journal, rectification is not possible.

III. METHODOLOGY

In medical imaging the image registration technique is widely used for establishing the correspondence between two images. Spatial transformation technique is computed by registration process to align two different images correspondence. The registration process computes a spatial transformation. This will align the source image to a target image. In this paper image registration based on feature is proposed. Once the image registration is done, the registered T2-image being fused with T1-image.

Figure 2 shows the proposed system architecture, the targeted image is T1 2D MRI brain image and source image is T2. T2 registration with T1 using optical flow with SIFT. The registered T2-image is fused with T1-image by employing curvelet and average technique. The fused 2D MRI brain image gives more structural information to analyze.

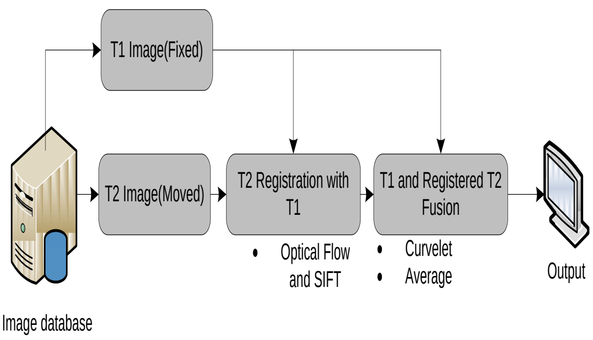


Figure 2: proposed System Architecture

- Input Image: Here 2D MRI brain images T1 and T2 are considered as n input. Both T1 and T2 are the same model images but taken with the different timings. Two different relaxation times of T1 and T2 is comprised by the tissue.
- T1 Image: T1 - time constant is the rate at which the equilibrium state is achieved by the excited protons. The time taken for the spinning of protons due to the influence of the external magnetic field is measured by T1. T1-weighted images are derived through usage of short TE and TR times.

3.1. T2 Image: The rate at which excited protons reach equilibrium is measured by T2 time constant. Time taken by the spinning protons leading to losing phase coherence among nuclei by spinning perpendicular to the main field gives T2.

3.2. Feature Extraction: The feature is a valuable information of an unique attribute. To get accurate analysis of data different modalities of images are considered for fusion. The features comprises of different image modalities. Images of different modalities subjected to medical images used for registering and fusing which improves the multi resolution feature extraction. The major landmarks points of an image are registered in feature based image. For the registration the features should be unaffected by designated operation or transformation due to noise, shape or any other physical abnormalities. Medical images can be distorted due to presence of noise.

3.2.1 Optical Flow : Let I(x,y,t), depicts the image pixel gray value. $l(x,y,t)^t$ at time t, $I(x+\Delta x, y+\Delta y, t+\Delta t)$ represents the second image gray value of the pixel in the Eq. (1). Using histogram specification on both the images the brightness constant assumption is considered and it is expressed as below

$$I(x,y,t) = I(x+\Delta x, y+\Delta y, t+\Delta t) \quad (1)$$

Eq. (1) can be represented by Taylor linear formulation rewritten as in the following eq.2 linear partial derivatives formation.

$$I_x u + I_y u + I_t = 0 \quad (2)$$

In Eq. (2) the symbol I_x, I_y, I_t represents brightness of the pixel taken from the spatio-temporal derivatives [15]. The vectors u and v denotes the optical flows between the continuous frames as an original work,

$$E(u,v) = \iint_{\Omega} \left\{ \frac{(I_x u + I_y v + I_t)^2}{\partial^2\left[\left(\frac{\partial u}{\partial x}\right)^2 + \left(\frac{\partial u}{\partial y}\right)^2 + \left(\frac{\partial v}{\partial x}\right)^2 + \left(\frac{\partial v}{\partial y}\right)^2\right]} \right\} dxdy \quad (3)$$

In Eq. (3) the symbol ∂ denotes the weight of smoothing term and Ω denotes image area. The optical flow is usually estimated with following eluer-lagrange partial differential equations corresponding to Eq. (3) by gauss-seidel iteration scheme.

$$\left\{ \begin{aligned} \frac{\partial u}{\partial \tau} &= \Delta u - \frac{1}{\alpha} I_x (I_x u + I_y v + I_t) = 0 \\ \frac{\partial v}{\partial \tau} &= \Delta v - \frac{1}{\alpha} I_y (I_x u + I_y v + I_t) = 0 \end{aligned} \right\} \quad (4)$$

In Eq. (4) Δ symbolizes the optical flow divergence.

3.2.2 Optical flow with SIFT

There are several algorithms to generate descriptors and to detect key points such as SIFT and SURF. In proposed method we have used SIFT descriptor [17] to extract and generate key point features since it is invariant to scale and rotation. SIFT algorithm defines four steps to extract the applicable feature vector.

A. Creation of Scale space

In the first step, determine the dimension space for the Input image (after application of filtering mechanism) through the usage of "Methodology for identification of dimensional space" determined by Equation (5). Scale space function is obtained through representation of internal structure of the image post application of filtering, which is scale invariant [16]

$$S(q,r,\sigma) = G(q,r,\sigma) * I(q,r) \quad (5)$$

$$\sigma = \sigma_0 \sqrt{k^2 - 1} \quad (6)$$

$S(q,r,\sigma)$ represents function of scale space, convolution operation is shown by '*', $G(q,r,\sigma)$ Indicates Gaussian scale, $I(q,r)$ obtains filtered image of the input. σ is the parameter for scale. Mathematically convolution of image and application of Gaussian operator is called blurring (to provide blurred image). q and r denotes coordinators of location.

$$G(q,r,\sigma) = \frac{1}{2\pi\sigma^2} \exp\left\{-\frac{q^2 + r^2}{2\sigma^2}\right\} \quad (7)$$

Difference of Gaussian formula is used for finding the max stable keypoint position. DOG amongst two images is derived by Eq. (8).
Figure3 depicts the extrema in DOG.

$$D(q,r,\sigma) = S(q,r,K\sigma) - S(q,r,\sigma) \quad (8)$$

A. Keypoints Localization

To identify extreme points of $D(q,r,\sigma)$, distinguished all keypoints in same scale by 8 and 9 neighbors in top and bottom position of one scale. In second step, points that have low contrast and localized inadequately are eliminated. Equation (9) represents the extrema Max and extrema Min positions of the Keypoint.

$$L = -\left(\frac{\partial^2 D}{\partial Q^2}\right)^{-1} \frac{\partial D}{\partial q} \quad (9)$$

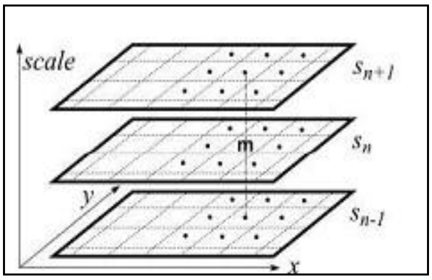


Figure 3: Extrema in DOG

Eq. (10) - value Keypoints as represented in DOG,

$$D(L) = D + \frac{1}{2}\frac{\partial D^{-1}}{\partial q}L \quad (10)$$

If (L value < threshold)
{ Eliminate extreme points with very less illumination.}
Eliminating edges / regions, having low contrast improves efficiency as well as robustness. Owing to certain errors in DOG, to detect corners of each image Harris corner descriptor is incorporated.

B. Assignment of Orientation

In the third step, every keypoint's are associated with orientation for rotational in-variance. Methodology to determine and assign keypoint orientation are stated below.

1. Take S as a scale space Gaussian image.
2. Gradient magnitude calculate

$$m(q,r) =$$

3. $$\sqrt{\left(s(q+1,r)-s(q-1,r)\right)^2 + \left(s(q,r+1) - s(q,r-1)\right)^2}$$

4. An Orientation θ is calculated

$$\theta(q,r) = \frac{\tan^{-1}\left(s(q,r+1)-s(q,r-1)\right)}{s(q+1,r)-s(q-1,r)}$$

Histogram is plot by considering sample points from gradient orientations. (Within a region around the keypoint is considered).

Each sample is weighted by:-
The gradient magnitude.

Gaussian window having a value σ [1.5 times greater than scale of the keypoint]

Figure 4 depicts gradient magnitude and orientation.

In the histogram identify the highest peak and compute a value 80% of the highest peak to generate key points with nearby orientation.

For the histogram values that are close to peak, mark them to form a Parabolic curve.

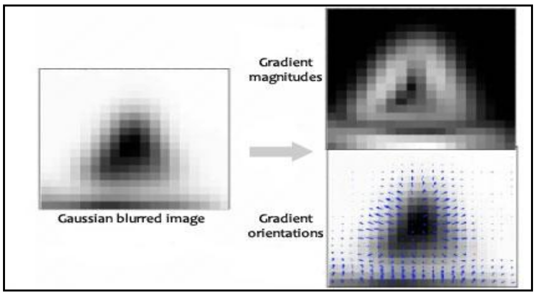


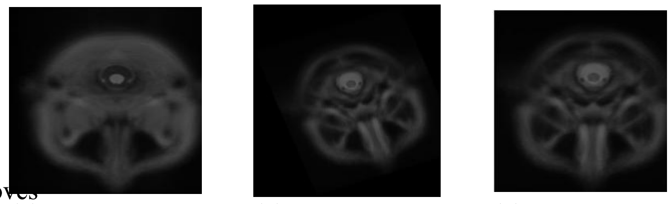
Figure 4: Gradient Magnitude and Orientation Images

C. Keypoint Descriptor

Above steps identifies key point locations for a pre-defined scales and set orientations to them. The above steps have obtained rotation and scale invariance.

IV. EXPERIMENTAL RESULTS

Figure 5 (1) represents the T1-Input image, Figure 5(2) represents the T2-Input image. By applying the optical flow with SIFT, T2 image is registered by considering T1-Image as the target. The T2-Registered image is indicated in the Figure 5(3).



(1) T1- Input Image **(1) T2 - Input Image** **(3) T2 - Registered Image**

Figure 5: T2 is a Registered Image while T1 and T2 are Input Images

V. CONCLUSION

MRI brain image fusion helps the radiologist for finding the abnormalities in brain tumor. The proposed algorithm for image-fusion shall result in enhancement of the Input image as the logic involves analyzing different types of images. The The proposed work depicts the process for image suion technique. Algorithm employed for registration, fusion technique. The test results depicts the registration and fusion of T1 and T2, 2D MRI brain image.

(12)

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AUTHORS PROFILE

Dr.Sunanda Dixit is an Associate Professor in Computer Science and Engineering department at BMS Institute of Technology and Management. She has earned her Ph.D. Degree in Computer Science and Engineering from Visvesvaraya Technological University, Government of Karnataka. She has presented and published 78 research papers. She has authored 2 books in her accolade. She has won many awards in her academic and research achievements, Adarsh Vidya Saraswati Rashtriya Puraskar award, Outstanding Researcher and Scholar Icon, Senior Woman Educator and Scholar Award, Best Faculty Award. She is a member of various professional bodies, senior member IEEE, IET, ISTE Life Member. She is an editorial and technical committee member for various National and International Journals. She is currently supervising 5 research scholars for their Ph.D. degree. Her area of research interest includes Image Processing, Image analysis, Medical Image Processing, Pattern recognition and Big Data and Machine Learning.

Mahesh B.V. is an Enterprise architect adept at designing and implementing effective technical business solutions at Tata consultancy Services. He has published many research papers in journals and conferences.

Dr. Suma V has obtained her BE, MS and Ph.D in Computer Science and Engineering. She is currently Dean of Research and Industry Incubation Centre and Professor in Information Science and Engineering, Dayananda Sagar College of Engineering, Bengaluru. She has published more than 250 international publications which are published in reputed journals and conferences. She is guest editor for several international journals which are indexed in Scopus, Elsevier, Taylor and Francis, Wiley, IGI Global and so on. She is Fellow of Institute of Engineers, Senior Member of IEEE, Member Computer Society of India and ACM. She is recipient of several national and international awards and is being listed in various biographic centers. She is frequently invited as Chief Guest, resource person and key note speakers in various international forums.