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A COMPREHENSIVE APPROACH FOR MEDICAL IMAGE REGISTRATION

K.Sravani[1], Bhuvaneswari Balachander[2], Dr.D.Dhanasekaran[3]
[1]Student, Saveetha School of Engineering, Chennai.
[2]Assistant Professor , Saveetha School of Engineering, Chennai.
[3]Principal, Saveetha School of Engineering, Chennai.
Email: sravskaviti79@gmail.com

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Abstract

Image registration is a crucial issue in medical imaging. It is a process of aligning two images into a common coordinate system thus arranging them in order to monitor minute changes between the two. The registration is done on Magnetic Resonance Images. Registration algorithms compute transformations to set correspondence between the two images. Thus unique connections between locations of two images are more likely, helping to avoid local optima during registration. The additional information contained in multi-channel images can help render the registration process more accurate. Multiple image channels are used to characterize each image location more uniquely. The channels here represent the protocols namely T1, T2, Flair, FA, DTI. The feature extraction of images are done by means of Gabor Filter. Since the number of channel is too large, Independent Component Analysis is used for eliminating the redundant information. Similarity Measures are done because of the high computational costs related with estimating the multivariate mutual information between two images with an inconsistent number of channels. Based on the dissimilarity metric, the image matching problem is composed as a cost function. By computing it, the deformation field of the registration is obtained. This paper, enhances the complementary information of brain images and fuse them to produce a coordinated image, in which less reliable/redundant information from different channels are eliminated. It helps in the diagnosis of diseases.

Keywords: GWT; ICA; Fusion; Similarity measure; Registration;

I. Introduction

Image processing methods, which are possibly able to envision objects inside the human body, are of special interest. Promote in computer science have led to reliable and coherent image processing methods useful in medical diagnosis, treatment planning and medical research. In clinical determination using medical images, consolidation of useful data obtained from separate images is often desired. The procedure of mapping points from one image to corresponding points in another image is called Image Registration. The goal in image registration is to produce a mapping function f: x → x that transforms the spatial coordinates x of a target image T to the spatial coordinates x0 of a source image S. For the source and target images to be registered the mapping function f should be chosen in such a way as to maximize some similarity measure between the two images. Mathematically, the image registration problem can be stated as:

$$\text{Max} : I(S(f(x))\ T(x)f)\ .$$

where I(..) represents the chosen similarity measure or cost function. In terms of efficiency or accuracy, the multi-channel images T and S may be first preprocessed to yield better result. Image registration essentially consist of following steps.The multichannel images are first subjected to a preprocessing step then to reduce or supplement the number of image channels, depending upon the application. Next the images are registered using a multi-channel algorithm. Once the spatial transformation that registers the images has been optimized, it is applied to the original data and any necessary post processing operation is then performed for final output.

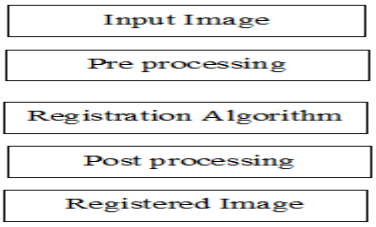


Figure 1: steps involved in Image Registration.

II. Existing Work

The T1 and DTI images are fed as Input. The feature extraction of images are done by means of Gabor Filter. The task of the feature extraction and selection methods is to obtain the most relevant information from the original data and represent that information in a lower dimensionality space. Independent Component Analysis is used for eliminating the redundant information. Similarity Measures are done because of the high computational costs associated with estimating the multivariate mutual information between two images with an arbitrary number of channels. Based on the dissimilarity metric, the image matching problem is formulated as a cost function and optimized.

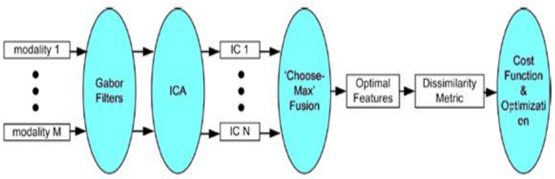


Figure 2: Flowchart of the Registration Framework

A) Limitations of Existing System

1. Deformable multichannel registration over the T1 and DTI Images is done.
2. They are less robust and efficient.
3. Since different modalities characterize different tissue types, using the information from channels will result in reduced accuracy in the areas where the driving modality does not characterize the underlying tissue type well. And this problem is more challenging when anatomical information is relatively evenly distributed across modalities without a "dominating" modality that gives enough anatomical information to drive the registration.

III. Proposed Work

Inter-subject multichannel image registration algorithm, 1) Combines complementary information from different modalities which characterize different aspects of the anatomy, the multichannel image registration is expected to be more robust and accurate. 2) The deformation field obtained is common to all the modalities, therefore the spatially normalized images of all modalities can be jointly statistically analyzed, in contrast to using separate registrations for each of the modalities which usually generates inconsistent deformation fields. 3) Although different modalities can provide complementary information, a considerable portion of the information could be overlapping and hence "redundant" or less reliable. By controlling the redundancy, the multichannel image registration can be more efficient and reliable.

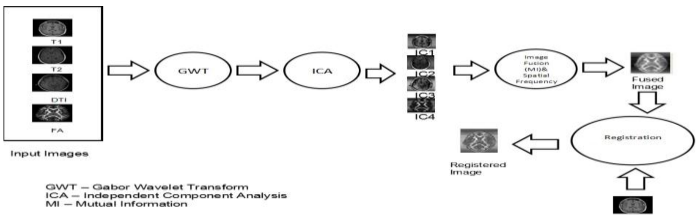


Figure 3: Multi-channel image fusion and registration scheme.

IV. Image Pre-processing

Image preprocessing steps includes the feature extraction, ICA whereas the registration is based on the Image Fusion.

A) Feature Extraction (Gabor Features): For the multi-scale decomposition method, we use Gabor wavelets, as Gabor wavelet transformation has been shown to be optimal in the sense of minimizing the joint uncertainty in space and frequency, and has been widely used for feature extraction, and hence, more appropriate for the purpose of matching/registration. At the same time, just like coefficients of DWT, the magnitude of the coefficients of Gabor wavelets is also a reliable measure of the characterization ability of each modality. Thus Gabor wavelets are a better choice for both feature extraction/matching and tissue characterization ability measurement, for our proposed information fusion-based Multichannel image registration. A 2D Gabor filter can be viewed as a sinusoidal plane of particular frequency and orientation, modulated by a Gaussian envelope:

$$G(x, y)=s(x, y).g(x, y)$$

Characterize the spatial extent and bandwidth of along the respective axes, and are the shifting frequency parameters in the frequency domain. Using G(x,y) as the mother wavelet, the Gabor wavelets, a class of self-similar functions can be obtained by appropriate dilations and rotations of G(x,y) through:

$$G_{(m,n)}(x,y)=a^{-m}.G(x',y')$$

$$\text{Where } x' = a^{-m}.(x\cos\theta + \sin\theta),\ y' = a^{-m}.(x\sin\theta + y\cos\theta),$$

$a > 1$, $= n\pi/O$, $m = 1....S$, $n = 1....O$.

O Indicates the number of orientations, S the number of scales in the multi-resolution decomposition and x is the scaling factor between different scales. These parameters can be set according to reduce the redundant information (caused by the non-orthogonality of the Gabor wavelets) in the filtered images.

B) Independent Component Analysis

"Independent component analysis (ICA) is a method for finding underlying factors or components from multivariate (multi-dimensional) statistical data. What distinguishes ICA from other methods is that it looks for components that are both *statistically independent*, and *non Gaussian*." "Fast ICA" algorithm is a "batch"-type algorithm that uses some pre-processing steps for ICA, like whitening and centering, which improve convergence speed of the ICA search procedure. The main step of "Fast ICA" is iterated as long as the statistical independence of the outputs is not achieved.

1. ICA Mathematical approach

"Given a set of observations of random variables $x_1(t), x_2(t)...x_n(t)$, where t is the time or sample index, assume that they are generated as a linear mixture of independent components: $y=Wx$, where W is some unknown matrix. Independent component analysis now consists of estimating both the matrix W and the $y_i(t)$, when we only observe the $x_i(t)$."

2. Principle Component Analysis

PCA has been successfully applied to human face recognition. PCA consists on a transformation from a space of high dimension to another with more reduced dimension. If the data are highly correlated, there is redundant information. PCA decreases the amount of redundant information by de correlating the input vectors. The input vectors, with high dimension and correlated, can be represented in a lower dimension space and de correlated. PCA is a powerful tool to compress data.

Steps to compute the PCA transformation of a data matrix X:

• Center the data

• Compute the covariance matrix

• Obtain the eigenvectors and eigen values of the covariance matrix

• Project the original data in the eigen space

4. Data Centering and whitening

- Centering

$$x = x' - E\{x'\}$$

But this doesn‘t mean that ICA cannt estimate the mean, but it just simplifies the Alg.IC‘s are also zero mean because of:

$$E\{s\} = WE\{x\}$$

After ICA, add W.$E\{x'\}$ to zero mean IC‘s

- Whitening

We transform the x's linearly so that the $x^{\sim}$ are white. Its done by EVD.

$$x^{\sim} = (ED^{-1/2}E^{T})x = ED^{-1/2}E^{T} Ax = A^{\sim}s$$

where $E\{xx^{\sim}\} = EDE^{T}$

So we have to Estimate Ortho normal Matrix $A^{\sim}$

An ortho normal matrix has n(n-1)/2 degrees of freedom. So for large dim A we have to test only half as much parameters. This greatly simplifies ICA. Reducing dim of data (choosing dominant fig) while doing whitening also help.

C) Choose Max Fusion and Dis-similarity Metric

After the ICA step, each IC of Gabor features is "specialized" in depicting one particular tissue type. Therefore, by using the Choose-Max scheme on each voxel, we can choose the optimal Gabor features from the corresponding IC to characterize the underlying structure.

For each voxel, based on the optimal IC obtained through ICA and "Choose-Max" scheme, dissimilarity metric is defined to find the correspondence between two multichannel images.

D) Cost Function and Optimization

Based on the dissimilarity metric, the image matching problem is formulated as a cost function. By optimizing it, the deformation field of the registration is obtained.

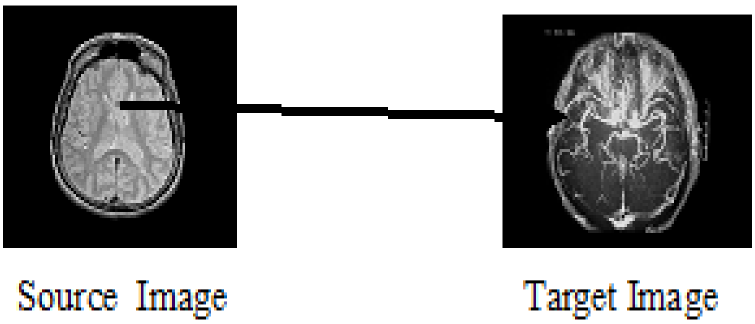
IV. Registration

Image registration is about determining a spatial transformation (T) or mapping that relates positions in one image, to corresponding positions in one or more other images'' . Image registration is performed on a series of at least two images, where one of these images is the reference image or source image to which all the others will be registered. The other images are referred to as target images.

Registration problem is the task involved in finding the optimal spatial and intensity transformations so that the images are matched with regard to the misregistration source. Intensity transformation may not be necessary in all the cases. Finding the geometric or spatial transformation is the key to any registration problem. We find the mapping T that transforms a position x from one image A to another B

$$T\ (xA) = xB$$

The type of transformation is related to the number of dimensions of the images.



Point-based registration methods often uses external markers or anatomical landmarks. Corresponding point sets are usually manually defined in the reference and floating images.

The advantages of the point based registration methods are that they can be applied to any imaging modalities where markers or landmarks are visible and that the calculation of the registration parameters between two point sets is usually fast. A non iterative least squares method can be used to register.

V. Result

The MRI brain images are fused to form a single unified unit. The fusion is done by means of mutual information and the spatial frequency and registered by the interpolation technique.

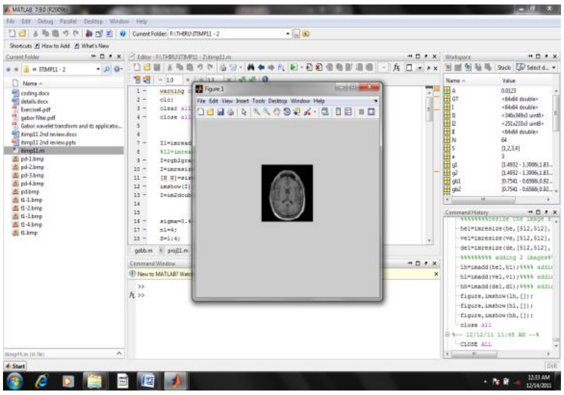


Figure 5.1 Input

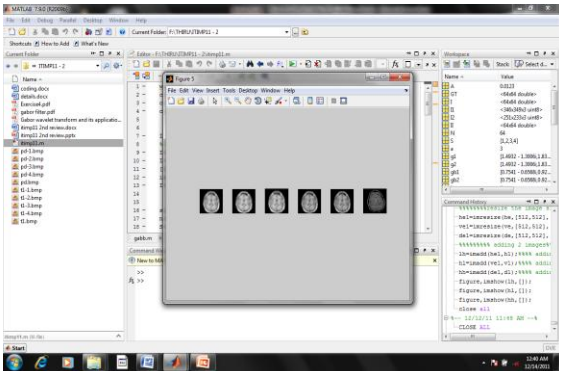


Figure 5.2 Output of Feature Extraction

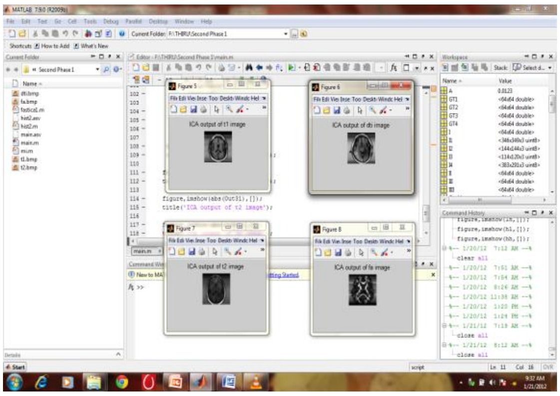


Figure 5.3 Output of ICA

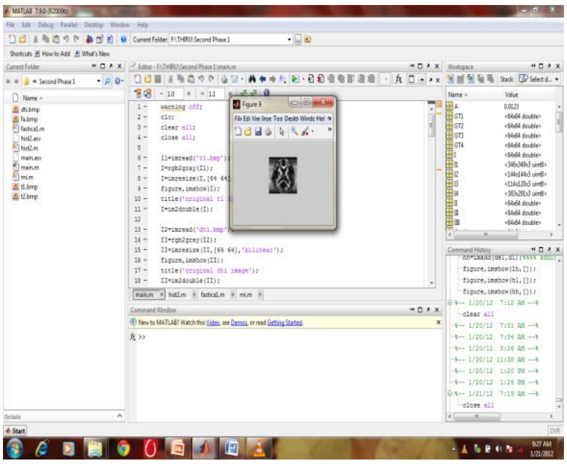


Figure 5.4 Output of Mutual Information based Fusion

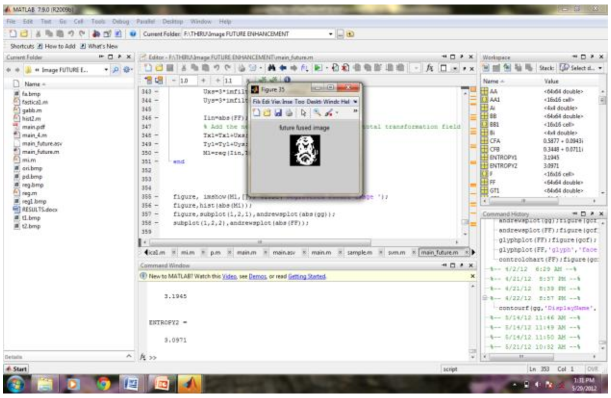


Figure 5.5 Output of Spatial Frequency based Fusion

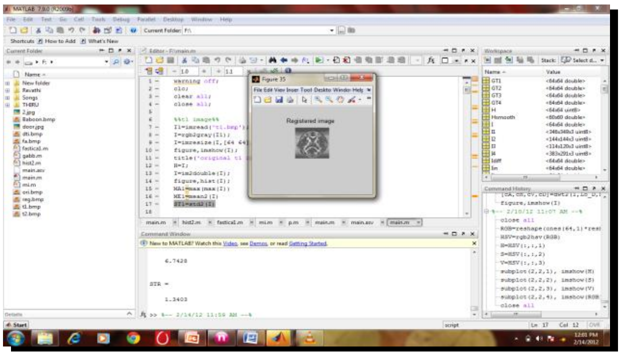


Figure 5.6 Registered Image obtained on the basis of Mutual Information

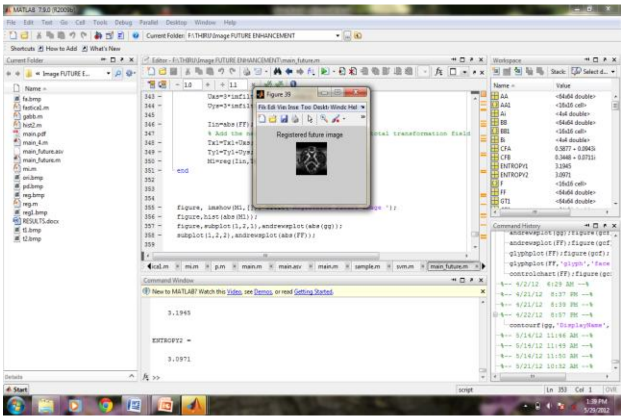


Figure 5.7 Registered Image obtained on the basis of Spatial Frequency.

VI. Performance Measure

Accuracy:

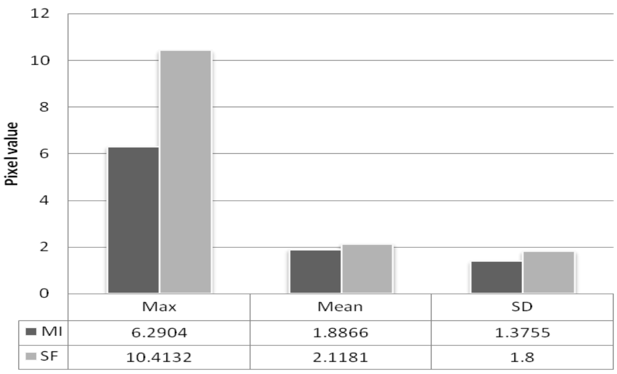
IMAGES	MAXIMUM VAUE OF THE IMAGE	MEAN OF THE IMAGE	STANDARD DEVIATION OF THE IMAGE
T1	0.9373	0.1920	0.2094
AFTER ICA	7.9799	2.3716	1.4864
PD	0.5686	0.1557	0.1692
AFTER ICA	4.4333	1.8463	1.1418
T2	0.7412	0.1408	0.1447

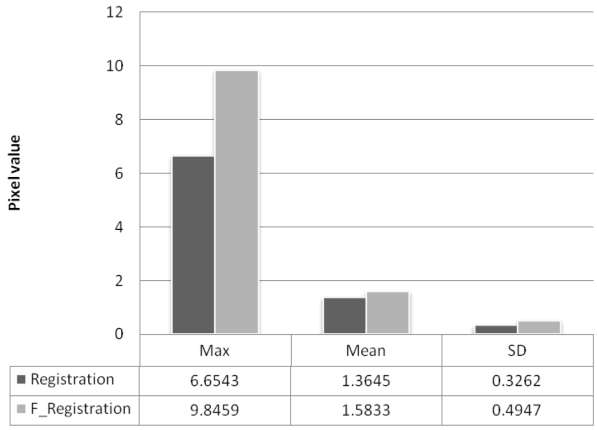
AFTER ICA	7.1313	1.5746	1.0004
FA	0.9961	0.1960	0.2210
AFTER ICA	10.4132	2.2409	1.8511
FUSED IMAGE	6.2904	1.8866	1.3755
SF_FUSED IMAGE	10.4132	2.1181	1.7881
REGISTERED IMAGE	6.6543	1.3645	0.3262
SF_REGISTERED IMAGE	9.8459	1.5833	0.4947

Robustness:

IMAGES	ENTROPY OF THE IMAGE
FUSED IMAGE	3.1945
SF_FUSED IMAGE	3.2256

The comparison graph of the registered image illustrates the level of accuracy and robustness.





VII. Conclusion

The brain images are found with different modalities so the doctor has to go through all the images during diagnosis. In this approach the images with non redundant informations modalities are fused and registered to form a single image .In the future work the idea of an ultimate registration method, able to recognize the type of given task and to decide by itself about the most appropriate solution, can motivate the development of expert systems. They will be based on the combination of various approaches, looking for consensus of particular results.

VIII. References

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