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Feature Based Registration of Brain Mr Image

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ABSTRACT
Medical image processing is a difficult problem. Not only a registration algorithm needs to capture both large and small scale image deformations, it also has to deal with global and local intensity variations. Two main problems occurs during the registration process of non rigid image. First, the correspondence problem occurs between the template and the subject image due to variation in the voxel intensity level. Second, in the presence of bias field the occurrence of interference and noise will make the image sensitive to rotation variation. To avoid these problems and to calculate efficiently a new feature based registration of non rigid brain MR image using Uniform Pattern of Spherical Region Descriptor is proposed in this paper. The proposed method is based on a new image feature called Uniform Pattern of Spherical Region Descriptor. This uses two features namely Uniform pattern of spherical descriptor and Uniform pattern of gradient descriptor to extract geometric features from input images and to identify first order and second order voxel wise anatomical information. The MRF labeling frame work and the α- expansion algorithm are used to maximize the energy function. The defected region in the image is accurately identified by Normalized correlation method. The input image for evaluation is taken from the database Brain web and internet Brain Segmentation Repository respectively. The performance can be evaluated using Back propagation networks.
Key Words: Non rigid image registration, Rotation invariance, Normalized correlation.

I. INTRODUCTION

Image registration is important in many imaging applications especially in medical image analysis. In diagnostic imaging there exist always a need for comparing two images of different imaging modalities such as MR, and PET images for disease diagnosis.

Registration of non rigid brain MR image plays a vital role in Medical image analysis. Its medical applications includes brain disease diagnosis and statistical parametric mapping based on the nature of transformations and the details extracted from the image, the Non rigid image registration is broadly classified into three categories, Land mark based registration , Intensity based registration and Feature based registration. In Land mark based registration, several land marks are obtained from the input image using manual land mark fixing techniques. Using this manually located landmarks the anatomical features of the images are extracted [1].This method is computationally efficient because it requires prior knowledge about the manually placed landmark points. The accuracy of registration and complexity of this method increases as required number if dependable landmarks from the image increase.

Most of the elastic deformation based non rigid image registrations depend on the assumption that the image intensity remains constant between the images [2]. But it is not always true and it affects the registration accuracy. This method will detect the defected region by comparing the intensity of the image in an fully automatic mode , so the variation in the anatomical voxel wise intensity will affect the registration accuracy [1].

In some cases the registration process may be trapped at local minima, because of the possibility of occurrence of variation between the intensity and the anatomical similarity, this will reduce the goal of optimizing intensity similarity between the template and the subject images [3]. In feature based approaches [4] different signatures are identified for each voxel and then the registration is carried out as a feature matching process. To remove the effect of intensity gray level differences, intensity standardization procedures are employed [5]. The sub volume deformation model used in Hierarchical Attribute Matching Mechanism for Elastic Registration (HAMMER) algorithm uses the Geometric Moment Invariant (GMI) features as the adopted feature to drive the registration process. But this approach requires a Pre- segmented image [6]. The defected regions in the images are accurately determined by comparing the extracted features between the template and the subject images. The registration process is formulated as a feature matching and optimization problem the selected features determine the accuracy of registration process [7]. Many factors such as extracted features, transformation models and the similarity measures may affect the registration accuracy.

Over the passed decades in non rigid image registration there exist two main challenging effects that tend to affect the registration process. First , the intensity similarity and the anatomical similarity will not be always remain same because MR image intensities do not have fixed tissue meaning in image scale even within the same pattern for the same body region and also the intensity information alone are not sufficient to fully characterize the anatomical difference between different tissue classes [8]. Second, during image acquisition the non uniformities such as rotation variation and variation in the gray level bias fields adversely affect the registration process and this will also produce interference and noise abnormalities while processing the image for registration. To overcome these two effects a new registration algorithm is formulated and it is based on a novel feature called Uniform Pattern of Spherical Region Descriptor. This algorithm is robust and it will maintain the rotation invariance property and reduce the effect of gray level bias field. The effect of noise in the image can be removed by suitable filtering techniques. Therefore a new feature based non rigid image registration method based on Uniform Pattern of Spherical Region Descriptor is proposed. In this method this Uniform Pattern of Spherical Region Descriptor will act as the signature for each voxel and it is in variant to rotation and monotonic gray level field. The Uniform Pattern of Spherical Region Descriptor feature is combined with Markov Random Field and the energy function is optimized with alpha expansion algorithm. The sample images are obtained from the database Brain Web and Internet Brain Segmentation Repository respectively.

II. UNIFORM PATTERN OF SPHERICAL REGION DESCRIPTOR

Uniform Pattern of Spherical Region Descriptor is a new region based descriptor that combines the distribution function of two 2D descriptors namely Uniform Pattern of Spherical Structure and Uniform Pattern of Spherical Gradient. Uniform Pattern of Spherical Region Descriptor is the 2-D joint gray level distribution of these two region descriptors. Uniform Pattern of Spherical Region Descriptor is used to extract the rotation and monotonic gray level transformation invariant function from the subject image.

A. Uniform Pattern of Spherical Structure

It is an region descriptor that is used to extract the anatomical feature from the subject images. The texture classification in 2-D can be obtained by proper design of this 3-D descriptor [4]. The obtained 2-D features are converted into 3-D by using Uniform Pattern of Spherical Structure. We define a sphere S_v with center voxel V with radius R and N_v samples are uniformly taken on the surface of S_v using the sampling methods proposed in [4], where S_v is a sphere taken from an input image G, in which each voxel V ϵ G. Tri linear interpolation method is used to interpolate the samples which do not fall exactly on the image sampling grid. Then the image is converted into proper binary numbers by Otsu's global thresholding technique. Intensity of voxel are taken as the major components for the thresholding operation. The intensity of voxel I on the surface of S_v is compared with the voxel intensity of the center voxel V. Hence each voxel i are thresholded to a binary number "0" or "1" by using the equation

$B_i = 0$, if $I_i < I_v$ (1)

$B_i = 1$, if $I_i > I_v$ (2)

Where I_i is the intensity of the neighboring voxel I and I_v is the intensity of the central voxel. B_i is the binary value. This binary value gives the voxel wise interaction between the neighboring voxel and central voxel. The thresholded surface which resembles the geometric features surrounding the voxel V is called the Binary Pattern of Spherical Structure. Since the relative intensity variation does not alter in this process, the Binary Pattern of Spherical Structure is said to be monotonic gray level transformation invariant. The Uniform Pattern of Spherical Structure and Binary Pattern of Spherical Structure has two continuous regions of 0's and 1's.

B. Uniform Pattern of Spherical Gradient

Uniform Pattern of Spherical Gradient is an another region descriptor which is delivered based on the local binary patterns. It gives the second order voxel wise information. Binary Pattern of Spherical Gradient is the binary pattern obtained from Uniform Pattern of Spherical Gradient and it is monotonic gray level transformation invariant. Each voxel in the Binary Pattern of Spherical Gradient have the same labels. The discriminant power of the Gradient Spherical Pattern is depend on the angle space between the patterns. The angle space between the patterns can be divided into four , inorder to prevent the image from noise and histogram sparsing, these four angle spaces are given as,

$I(V_i) = 1$, if $\square\ V_i \in [0, \pi/4]$ (3)

$I(V_i)= 2$, if $V_i \in [\pi/4, \pi/2]$ (4)
$I(V_i)= 3$, if $V_i \in [\pi/2, 3\pi/4]$ (5)
$I(V_i)= 2$, if $V_i \in [3\pi/4, \pi]$ (6)

The Binary Pattern of Spherical Gradient and Uniform Pattern of Spherical Gradient are converted into two uniform areas. When number of possible labels to represent the angle space is increased, it is very difficult for a Binary Pattern of Spherical Gradient to be Uniform Pattern of Spherical Gradient. The time complexity analyzed and the largest connected component is obtained by using the BFS algorithm which needs O(N) time. It takes constant computation time.

III. FEATURE EXTACTION USING UNIFORM PATTERN OF SPHERICAL DESCRIPTOR

Feature based approaches attempt to find the correspondence and transformation using distinct anatomical features that are extracted from images. These features include solidity, area and perimeter of anatomical structures. Feature based methods are typically applied when the local structure information such as mutual information and correlation are more significant than the information carried by the image intensity. They can handle complex between-image distortions and can be faster. In this approach normalized correlation and Mutual information are taken as the parameters of registration. Mutual information-based registration begins with the estimation of the joint probability of the intensities of corresponding voxels in the two images. This joint probability of the intensities of corresponding voxel is used as the signature for every voxel.. The mutual information can be used to parameterize and solve the correspondence problem in feature-based registration. Correlation is used to compare several images of the same object, e.g. to analyze development of the disease. The processing steps to extract feature using Uniform pattern of Spherical Structure is given below.

1. Sample images are taken from the data base Brainweb and Internet Brain Segmentation Repository.
2. Sample images are taken as the input images.
3. Input images are converted into Binary number by comparing its intensity to the intensity of the Central voxel.
4. Check whether the binary value of the neighboring voxel is equal to the binary value of the i^{th} voxel, if it equal, state that the image is Uniform Pattern of Spherical Structure , or repeat the step till it becomes true.
5. A rotation-invariant orientation measure $\theta\vartheta i$ is defined for each neighboring voxel of the thresholded input image , which is the angle between the orientation and the direction of can be calculated by,
$$\theta\vartheta = \arccos(\nabla\vartheta.(\vartheta - \vartheta i)/(\nabla\vartheta.(\vartheta - \vartheta i)) \quad (7)$$
As the monotonic gray-level transformation affects the absolute gradient magnitude of each neighboring voxel, the gradient orientation remains the same.
6. The original binary spherical gradient region centered at the reference voxel can be obtained by computing the gradient information of the voxel.
7. Combine the result of step 4 and step 6. Made the result as the signature for each voxel in the image.
8. Edge detection is done using Canny's approach and proper segmentation is carried out.
9. The features such as solidity, area and perimeter are extracted.
10. Then the image is registered and classified.

IV. IMAGE SEGMENTATION

Image segmentation is useful in many applications. It can identify the regions of interest in a scene or annotate the data. We categorize the existing segmentation algorithm into region-based segmentation, data clustering, and edge-base segmentation. Region-based segmentation includes the seeded and unseeded region growing algorithms. Region-based methods mainly rely on the assumption that the neighboring pixels within one region have similar value. The selection of the similarity criterion is significant and the results are influenced by noise in all instances. The threshold is made by user and it usually based on intensity, gray level, or color values. The regions are chosen to be as uniform as possible. In this proposed method this segmentation assigns label to every pixel in the image. The defected regions are detected by comparing the template image with the different set of segmented image with several iterations. In the segmentation process 2x2 median filtering is used to filter out the noise in the image and to preserve the edges. Gamma correction is done to adjust the intensity values of every voxel in the image. The accuracy of this technique is higher compared to intensity based approach since the proposed method is monotonic gray level and rotation invariant.

FEATURES	INTENSITY	UNIFORM DESCRIPTOR
GRAY & WHITE MATTER	3.27	15.17
GRAY & CSF	3.44	16.03
WHITE & CSF	3.08	16.84

Table 1: Features of image volume obtained from brain web

V. IMAGE REGISTRATION

The goal of image registration process is to remove artificial differences in the images introduced by the patient movement, differences in imaging devices etc. Both multi and mono-modality registration plays an important role in medical applications. In neurosurgery tumors are typically identified and diagnosed using MRI. Registration of these modalities allows the transfer of coordinates of tumors from the MR images. On the process of registration some distortions such as monotonic gray level fields and unnecessary rotations may spoil the registration quality. Using the Uniform Spherical patterns approach the interferences occurring during registration process can be eliminated. Depending on the defected region in the image the features such as area, perimeter and solidity varies and this defect can be exactly determined using Normalized correlation method.

NC (g) = Cf (g) / (no. of iterations) ***(8)***

Where Cf (g) denotes the correlation. The segmented image is taken for registration and it is registered to classify to find whether it is normal or abnormal. Minimum gradient will be reached as the normal image is registered and there is no segmented area for normal image exists as it is similar to the template image. Best training performance is identified by performance graph by using the feed forward neural networks.

VI. RESULT AND DISSCUSSIONS

The entire simulation is done in MATLAB and executed. To detect the defected region accurately the proposed method is executed in the non rigid brain image obtained from the Brain web and IBSR database. Hence the registered image is free from rotation and gray level invariant. Fig 1 shows the registered image with extracted feature and its classification. The image is segmented and its area, perimeter and solidity are extracted and it is classified accurately as normal or abnormal image using the normalized correlation.

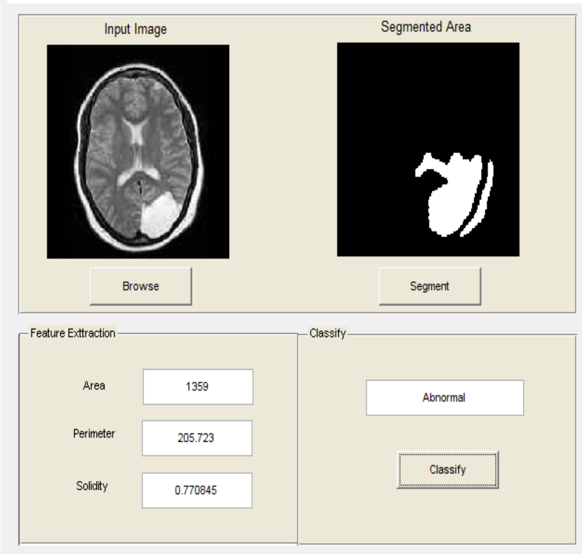

Fig 1. Registered Image with extracted feature and Classification

Several iterations are carried out to find the defected region accurately it is shown in Fig2.

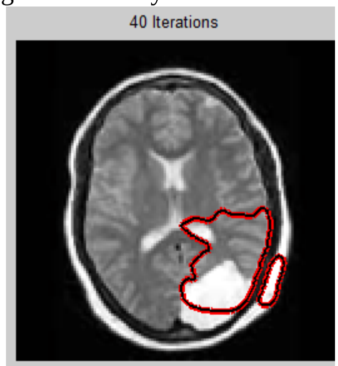

Fig 2. Segmentation a) with 40 iteration

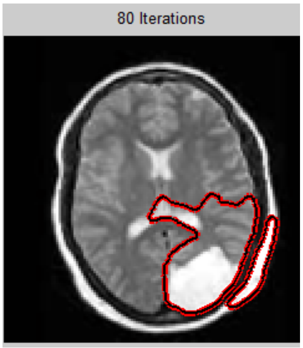

Fig 2. Segmentation b) with 80 iteration

Fig 2. Segmentation c) with 100 iteration

The registration process consists of various pre-processing steps to make the image immune to noise and interference they are shown. In Fig 3 it is shown that the image is filtered with median filter to remove noise and preserve edges. Fig 4 gives the intensity adjusted image and Fig 5 represents the converted binary image which form the basis for the proposed feature extraction technique.

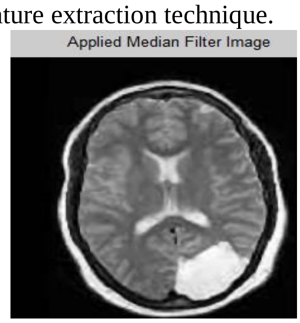

Fig 3. Filtered image

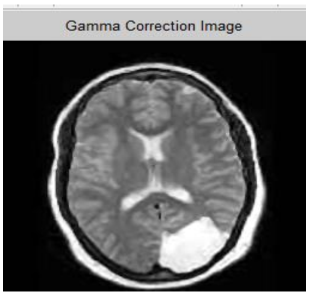

Fig 4. Histogram equalized image

Fig 5. Obtained Binary image

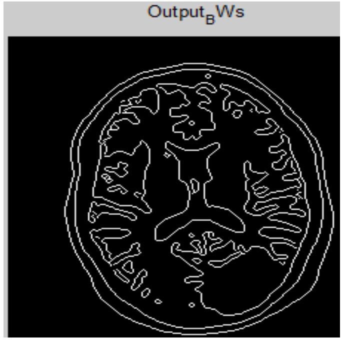

Fig 8. Output Ws

The mutual information and the correlation coefficient are the two parameters used to register the image accurately and to determine the defected region with maximum value. Neural networks are implanted to measure the performance of the process and are showed in Fig 9 and Fig 10.

The spotted image can be clearly viewed, from that features such as area, perimeter, solidity, maximum intensity, minimum intensity can be measured.

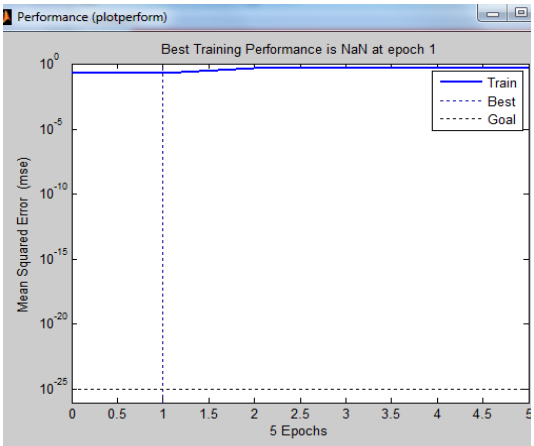

Fig 9. performance graph

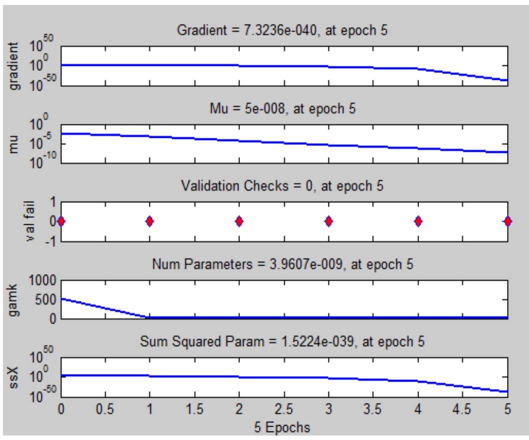

Fig 10. Training Plot

VII. CONCLUSION

Non rigid registration of Brain MR Image using a novel feature based method is proposed. This method is invariant to rotation and monotonic gray level bias fields. Two complementary features of Uniform Spherical Descriptor are used to encode the first and second order voxel wise information. This feature is combined with the MRF labeling frame work and alpha expansion algorithm to drive the registration process. The proposed method is having high power discrimination and is evaluated on the data base obtained from Brain web and IBSR. Higher accuracy, better diagnosis and less computation time are the advantages of this method. By this method 98% of accuracy has been achieved.

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