A Neuro-Fuzzy Approach for Anomaly Identification in Brain fMRI using K-Means Algorithm

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***Abstract*—Now-a-days a Conflict identification and categorization in brain functional MRI (fMRI) are inherently a toilsome in research. It is particularly because of the overlapping intensity distribution between the healthy and pathological tissues in the fMRI. The important features of that characterize the brain have to be diagnoses for efficient categorization and deblocking of contradiction from fMRI. Since MRI suffers from substantial grayscale contrast the categorized procedure should be done in a trained manner. This work proposes a Neuro-fuzzy based system for categorization and deblocking of abnormalities from Brain fMRI. The work consists of three major stages such as Feature deblocking, categorization and conflict detection. In the feature deblocking phase vital data that drive to categorization are analyzed. Texture and Wavelet features are used as discriminating features to diagnose the image class. The categorization phase discriminates the normal and pathological fMRI slices using feed forward Back propagation neural network. The categorized abnormal images are then applied for feature extraction and comparison of them with a ground truth data.**

Keywords—Anomaly, Functional MRI, Wavele, Neural network, Neuro-fuzzy

I. INTRODUCTION

An Identification of anomalies in brain fMRI is a vibrant area in research. The analysis and study of the brain are a major consideration due to its potential for studying initial growth patterns and morphological modifications in the anomaly detection. The major ailment that affects the brain is the Brain tumor. Functional Magnetic resonance Imaging (fMRI) is an extremely developed medical imaging technique that provides more information about soft tissues. The extracted data is enough for manual analysis and this has been one of the highest obstacles in the effective use of fMRI [2]. As a result, Additional studies concerning fMRI brain classification on the images is required .Hence there is a requirement for automated systems for study and classification of such medical images[1][3]. With this is in view the proposed work portrays a Neuro fuzzy approach for identification of anomaly in Brain fMRI.

II. PROPOSED METHODOLOGY

This research paper proposes a conceptually simple supervised technique to analyze MRI brain images for abnormality detection. The phases of this technique fall into three sections such as

- Feature Extraction
- Classification using neural network

The approach for anomaly detection is depicted in the following Fig.1.

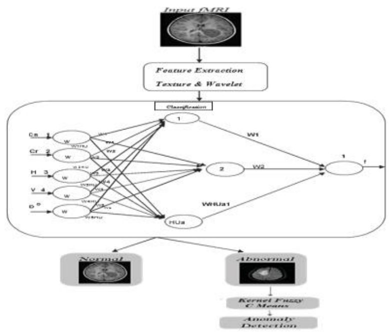

Fig.1. Approach for anomaly detection

A. Feature Extraction

Prior to segmentation, it is necessary to extract the features from the input images. The attributes have to be chosen carefully such that they represent maximum related information that is essential for entire characterization. The following features are extracted as the discriminating details for classification.

- Texture Features extraction
- Wavelet Transform Features extraction

The feature extraction procedures are detailed below.

1) Texture Features extraction

The term texture here means extraction of the required information needed to classify the given image. Contrast and correlation values are a part of texture features. They are essential features as they show the difference in luminance of objects within the image. They also elucidate the variance in gray level of the image. With respect to fMRI, contrast terms for the relative difference of signal intensities in two adjacent regions of the image [6]. The exclusive extraction of two statistical features, contrast and correlation, of an input fMRI brain image is done using the equations (1) and (2).

Contrast: $$C_n = \sum_{i,j} |i-j|^2 \, p(i,j) \quad (1)$$

Correlation: $$C_r = \sum_{i,j} \frac{(i-\mu_i)\,(j-\mu_j)\,p(i,j)}{\sigma_i\,\sigma_j} \quad (2)$$

Where μ =Mean; $$\mu = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} p(i,j)^2 \quad (3)$$

σ =Standard Deviation;

$$\sigma = \sqrt{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(p(i,j)-\mu)^2)} \quad (4)$$

Where, $p(i,j)$ represents the value of pixel at the given point (i, j) in the fMRI image.

2) Wavelet Transform features extraction

Though various frequency domain feature extraction methods exist, wavelets are often preferred for their multi resolution analysis. Haar wavelet is applied to extract the features in the image [13]. This 2D wavelet transformation on the subjected images lead to produce horizontal, vertical and diagonal bands of wavelet transform as the features need to be extracted. Such direct extraction of these three wavelet features from the subjected fMRI brain images can be accomplished using the equations (5), (6) and (7).

Horizontal Band: $$H_b = \frac{1}{r}\sum_{r=1}^{m} h_r \quad (5)$$

Vertical Band: $$V_b = \frac{1}{r}\sum_{r=1}^{m} v_r \quad (6)$$

Diagonal Band: $$D_b = \frac{1}{r}\sum_{r=1}^{m} d_r \quad (7)$$

m - The pixel co-efficient, h_r - Co-efficient of the horizontal band, v_r - Co-efficient of the vertical band d_r - Co-efficient of the diagonal band. The extraction of three wavelet features $H_b, V_b,$ and Db from the MRI brain images is done [6]. Hence the feature vector of five features $\{C_n, C_r, H, V, D\}$ are used for classification.

B. Classification using Neural Network

Among all the classification methods, Feed Forward Back Propagation Neural Network (FFBNN) is preferred for the classification of brain MRI images because of its generic nature [12]. Five input layer units are used to represent the five features extracted from brain MRI image $\{C_n, C_r, H, V, D\}$, along with HU_a hidden Units and one output unit, f . The architecture diagram of the FFBNN classifier is portrayed in Fig.2

The FFBNN is trained to get the minimized error value using back propagation learning [8]. Based on the output of the trained classifier, the subjected fMRI image is categorized whether it belongs to normal or abnormal class using statistical and wavelet features.

It is possible to split the given data into set of arrays of different groups with high and low intra cluster similarities. [4, 5]. The extended version of FCM is called as multiple kernel fuzzy c-means. This algorithm is best suitable for pattern classification applications [1].

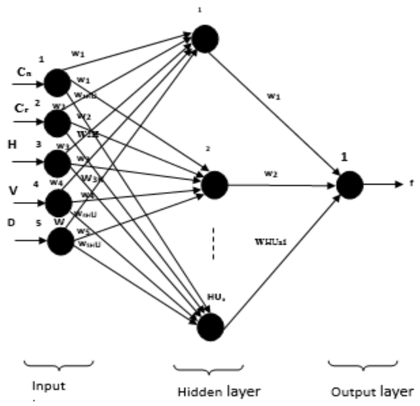

Fig.2. Architecture diagram of the FFBNN classifier

Goals of adopting the kernel functions:

- To generate a set of new distance measure
- To create a non-Euclidean structures in data.
- To maintain the simplicity of computing.

The general example for classification are Support Vector Machines (SVM), Kernel Fisher Linear Discriminate Analysis (KFLDA) and Kernel Principal Component Analysis (KPCA). The actual process happened in the kernel method is conversion of low dimensional inner-product into high- dimensional feature space[12]. The general form of MKFCM algorithm is given by the equation (8)

$$Q = \sum_{i=1}^{c}\sum_{j=1}^{n} u_{ij}^{m} \left\| \varphi_{com}(x_j) - \varphi_{com}(o_i) \right\|^2 \quad (8)$$

To increase the Gaussian-kernel-based KFCM by adding a local information term in the objective function,

$$Q = \sum_{i=1}^{c}\sum_{j=1}^{n} u_{ij}^{m}(1-k(x_j,o_i)) + \alpha\sum_{i=1}^{c}\sum_{j=1}^{n} u_{ij}^{m}(1-k(\bar{x}_j,o_i)) \quad (9)$$

Where, xj represents the intensity of the pixel j. The expression for differentially shaped kernel is given by

$$k_{com} = k_1 + \alpha k_2 \tag{10}$$

Where, k1 represents the Gaussian kernel of pixel intensities. The composite kernel is designed as,

$$k_L = w_1^b k_1 + w_2^b k_2 + w_3^b k_3 \tag{11}$$

Therefore the above formulation is suitable for the multivariate input data and accordingly be suitable to kernel clustering based image segmentation is obtained[1].

III. Experimentation Results

As per the simulation results obtained, it is clear that, Kernel Fuzzy C means based image segmentation method produces better result than the existing techniques. Also, the proposed segmentation method is well suitable for the identification of brain tumor from fMRI images due to its highlighted features.

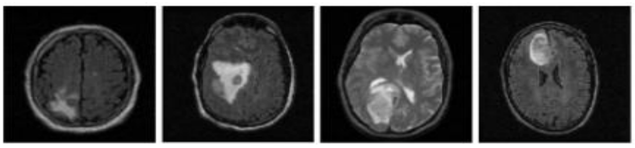

Fig. 3. Sample fMRI Brain images in the database

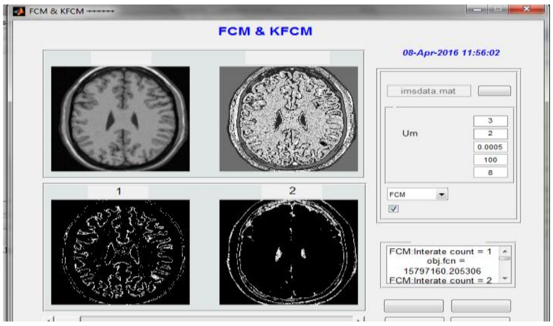

Fig. 4. Segmentation of anomalies using KFCM

IV. Performance Evaluation

A. Entropy (H)

The information profusion of image content which is popularly known as Entropy and its layes value is good.It is very much useful in compartive of different images.

$$H = -\sum_{i=0}^{255} P_i \log_2 P_i \tag{12}$$

Where, P_i represents the probability of pixel gray value i.

B. Peak signal-to-noise ratio (PSNR)

Another important term is peak to signal noise ratio which is expressed as follows:

$$\text{PSNR} = 10\log_{10} \frac{(2^n - 1)^2}{MSE} \tag{13}$$

Where n' denotes the number of bits per pixel and MSE

TABLE 1. Performance measures

Measures	DWT	SVM	FCM	KFCM
Entropy	6.05	6.13	6.315	6.45
PSNR	20.14	23.61	24.56	25.15
MSE	0.327	0.32	0.315	0.28
Accuracy	0.65	0.7	0.77	0.86

C. Mean squared error (MSE)

The Mean square error represents the error between the original and noisy images. This parameter will give the degradation of the original image.

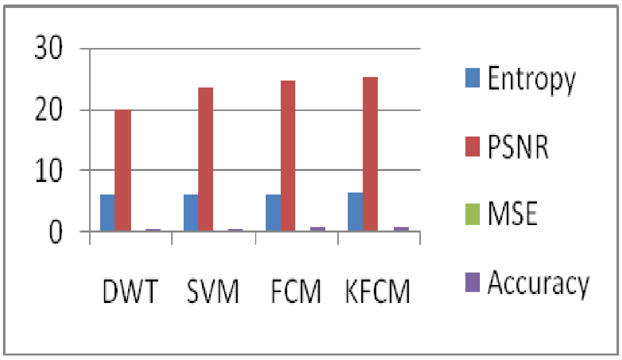

Fig. 5. Graphical representation of Performance evaluation

V. Conclusion

This paper presents a robust and comparison result it becomes more accuracy result. It is possible for fMRI by using tumor detection kernel fuzzy c means segmentation. Membership function level is also possible for this segmentation. FMRI cluster center is assumed one data is used to overlap at two or more cluster image. The proposed image segmentation method is very much suitable for monitoring the growth of brain tumor. Also, the fMRI is a non-invasive technique of analyzing the brain tumor. From the extracted features, it is clear that, the proposed method produces minimum MSE (0.28), high accuracy (86%), improved PSNR (25.15) and comparatively higher entropy (6.45).

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