Volume 3, No. 7, Nov-Dec 2012

ISSN No. 0976-5697

International Journal of Advanced Research in Computer Science

RESEARCH PAPER

Available Online at www.ijarcs.info

ANN based Classification of 3D MR Images of Brain using Frequency filter enhancement

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Abstract: This paper introduces classification of 3D MR images of brain, after enhancement using frequency filtering technique. The proposed method uses voxelwise spatial intensity matrix as features for the ANN classification. The approach consists of three key steps: (1) Convert 3D MRI from spatial to frequency domain (2) Select high frequency components to enhance the image. (3) Again convert the 3D MRI from frequency domain to spatial domain. Experiments are carried out to indicate the high efficiency of the method to classify the 3D MRI from ADNI (Alzheimer's Disease Neuroimaging Initiative) dataset into AD (Alzheimer's Disease), MCI(Mild Cognitive Impairment) and Normal.

Keywords: Magnetic resonance image, frequency filter, fast Fourier transform, artificial neural network

I. INTRODUCTION

Magnetic resonance imaging (MRI) is an important method in identification of dementia. The use of MRI in the practical assessment helps to distinguish different types of dementia, particularly in their early stages. The different pathological processes that produce cerebral dysfunction at a cellular level also produce macroscopic effects that can be detected in vivo with imaging. For these reasons, neuroimaging in general, and MRI in particular, is an essential part of the investigation of a patient with dementia. Regarding similar works in the area, Torabi M.et al [1] categorized the features of interest in features of the spatial domain (FSD's) and Features of the frequency domain (FFD's) which are based on the first four statistic moments of the wavelet transform. Extracted features have been classified by a multi-layer perceptron artificial neural network (ANN), achieved 79% and 100% accuracy among test set and training set respectively. Ahmad M.Sarhan [2] proposed a system that extracts classification features from stomach microarrays using the DCT.

The features extracted from the DCT coefficients are then applied to an ANN for classification (tumor or none—tumor). Simulation results showed that the proposed system produces a very high success rate. Abiodun M. Aibinu et al [3] explained of Inverse Discrete Fourier Transform (IDFT) in the form of Inverse Fourier Transform (IFFT) is one of the standard method of reconstructing Magnetic Resonance Imaging (MRI) from uniformly sampled K-space data. highlighted the three major problems associated with the use of IFFT in MRI reconstruction.Briefs about introduction to MRI physics; MRI system from instrumentation point of view; K-space signal and the process of IDFT and IFFT for One and two dimensional (1D and 2D) data. AmirEhsan Lashkari [4] used DFT for preprocessing of 2D MR images, especially for noise reduction.

II. METHODOLOGY

Selected 200 subjects from Normal MCI and AD categories. Used 100 for training , 50 for testing and 50 for cross validation. MRI preprocessing was done using statistical parametric mapping software (SPM5; Welcome Department of Cognitive Neurology, Institute of Neurology, London,UK, http://www.fil.ion.ucl.ac.uk/spm/) website accessed on 21 November 2010) with the VBM tool Updated version VBM5.1 toolbox Published by Christian Gaser on May 13, 2009. Jena script http://dbm.neuro.uni-jena.de/vbm.html; in MATLAB. Image by image VBM normalization is carried out. VBM calculates the bias-corrected whole brain image in normalized space. For frequency filter analysis, MIPAV (medical image processing, analysis and visualization application software, Imaging Science Laboratory, CIT, NIH, see http://mipav.cit.nih.gov/) [5] is used. The overall methodology is demonstrated in fig.1.

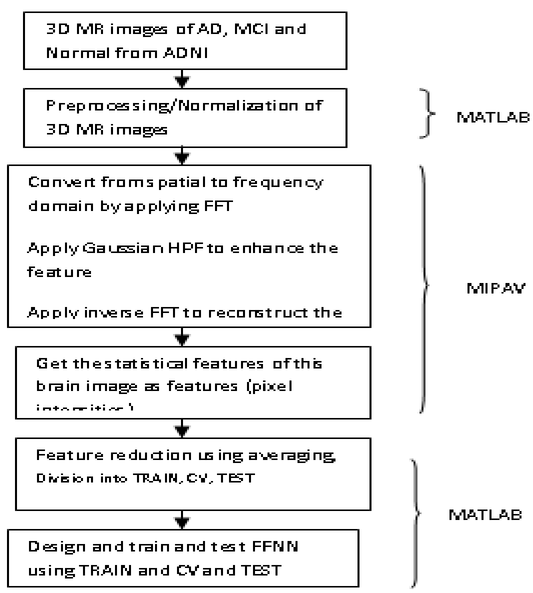

Figure 1. Overall Methodology

A. Image Enhancement:

There are two main approaches to filtering an image. The first is the convolution of an image and kernel in the spatial domain. The second is the multiplication of an image's fourier transform with a filter in the frequency domain. The fast fourier transformation (FFT) algorithm, which is an example of the second approach, is used to obtain a frequency-filtered version of an image. Processing images by filtering in the frequency domain is a three-step process:

a. Perform a forward fast fourier transform to convert a spatial image to its complex fourier transform image. The complex image shows the magnitude frequency components. It does not display phase information.
b. Enhance selected frequency components of the image and attenuate other frequency components of the image by multiplying with Gaussian high pass filters
c. Perform an inverse fast fourier transform to reconvert the image from the frequency domain to the spatial domain.

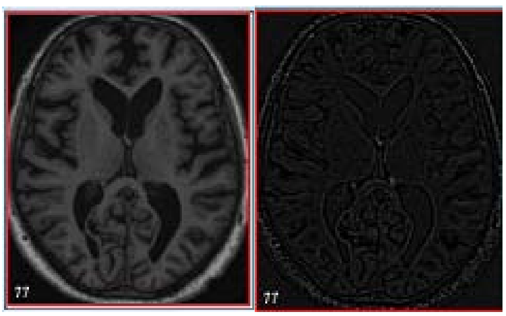

Figure 2. Original and Gaussian high pass filtered MRI

B. Feature Extraction:

voxelwise spatial intensity matrix of 3D MR image is used as features for the ANN classification. Fig.3 shows voxelwise intensity histogram for the original Vs filtered image. From this fig. it can be seen that during filtering data is compressed to a great extent. As the intensity matrix derived in MIPAV contains large number of values feature reduction is carried out using histogram quantization.

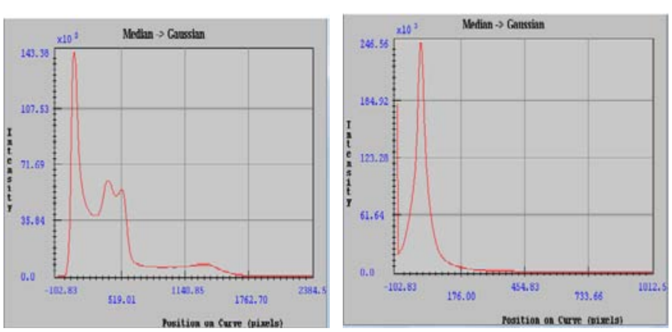

Figure 3. voxelwise intensity histogram for the original 3D MRI Vs filtered

C. ANN Classifier Design:

ANN [6],[7]training is carried out in Matlab. Supervised neural networks are trained to produce desired outputs in response to sample inputs. Feedforward networks have one-way connections from input to output layers. They are most commonly used for prediction, pattern recognition, and nonlinear function fitting. Training algorithms used are gradient descent (GD) method and the Levenberg-Marquardt algorithm (LM). Various activation functions are tried to find the combination suitable for problem in hand. Finally a modified logsig, symmetrical sigmoid and purely liner are chosen respectively at three layers. During the training phase, the network is presented with sets of pairs (input and desired output) for training and cross validation sets. The network is iteratively updated till validation error fails to coincide with training error.. Tab. I and Fig.4 give all the details of FFNN used.

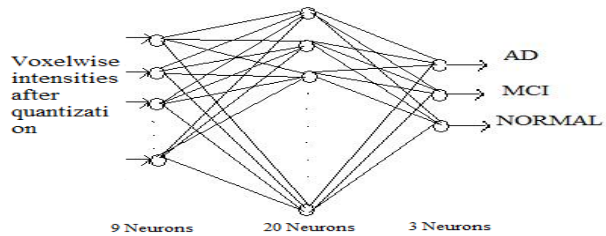

Figure 4. Neural network architecture

Feed forward neural network is used. Training experimentation is carried out several times by varying various ANN parameters like training function; learning rate, hidden layer neurons. Final training curve is as shown in Fig.5.

Table I. ANN architecture used in MATLAB

Network Topology	Feedforw Backpropagation
Trainning Function	Trainlm
Transfer Function	Logsig-Symsig-Purelin Logsig=a = 1/ (1 + exp(n)); Symsig=a= (1- exp(-n))./ (1 + exp(-n));
Learning Function	Learngdm
Performance	MSE
Learning Rate	0.001
No. of Layers	3
Layer1	9 Neurons
Layer 2	20 Neurons
Layer 3	3 Neurons
Epoches	62

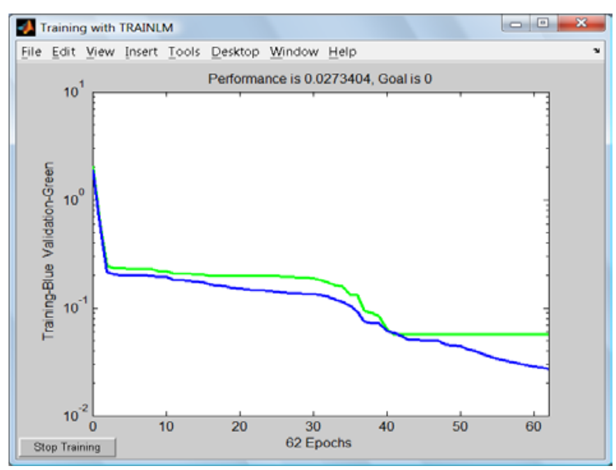

Figure 5. Training curve

III. RESULTS

Table II. Testing Result

Test I/P	Expected Output			Actual Output		
AD1	**1**	0	0	**1.1454**	-0.09797	-0.04754
AD2	**1**	0	0	**0.74622**	0.3587	-0.11364
AD3	**1**	0	0	**1.0953**	0.062949	-0.14514
AD4	**1**	0	0	**0.5488**	0.50294	-0.06094
AD5	**1**	0	0	**1.0289**	0.048231	-0.07096
MCI1	0	**1**	0	0.12805	**0.9411**	-0.06808
MCI2	0	**1**	0	-0.05433	**0.91479**	0.13274
MCI3	0	**1**	0	-0.07919	**0.90269**	0.17363
MCI4	0	**1**	0	0.15003	**0.90805**	-0.06365
MCI5	0	**1**	0	0.61004	**0.6518**	-0.25246
NOR1	0	0	**1**	0.099365	0.080002	**0.81996**
NOR2	0	0	**1**	0.011676	0.17363	**0.80737**
NOR3	0	0	**1**	0.11828	0.24286	**0.63706**
NOR4	0	0	**1**	0.26538	-0.49142	**1.2152**
NOR5	0	0	**1**	-0.02375	0.13885	**0.88058**

Performance is evaluated using following parameters Sensitivity(SE), Positive Predictivity (PP) and accuracy (AC) where,

$$SE = \frac{TP \times 100}{(TP+FN)}$$

$$PP = \frac{TP \times 100}{TP+FP}$$

$$AC = \frac{(TP+TN) \times 100}{(TN+TP+FN+FP)}$$

This evaluation is done every time by applying several test cases, one such test input result is presented in Tab.II, which shows around 99% accuracy. Performance is calculated using formade with other Where, TP- True positive, FP-False Positive, FN –False Negative, FP-False Positive

Table III. Classifier Performance

Sensitivity	Positive Predictivity	Accuracy
99%	99%	99%

IV. CONCLUSION AND DISCUSSION

In this paper, an innovative and robust classification of 3D MR Images of brain into Alziemer's Disease, Mild Cognitive Impairment and Normal is proposed. Gaussian high pass filtering results into enhancement of required feature, as in case of MR images high frequency components are responsible for the changes occurring due to brain dementia. Multiplying an image's Fourier transform with a filter in the frequency domain is proved as efficient tool for MRI feature enhancement. Feed forward neural network classifier is proposed. The performances of the classifier in terms of statistical measures such as sensitivity, positive predictivity and classification accuracy, was found to be excellent.

V. ACKNOLEDGEMENT

Authors are thankful to Alzheimer's Disease Neuroimaging Initiative (ADNI) database (www.loni.ucla.edu/ADNI). Authors are also thankful to Center for Information Technology (CIT), National Institutes of Health (NIH), an agency of the United States Public Health Service (PHS) within the Department of Health and Human Services (DHHS) for software support MIPAV.

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