Comparative Study of Different Classifiers For Alzheimer's Disease

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Abstract- *Abnormality detection in Magnetic Resonance (MR) brain images is a challenging task. Earlier and correct detection of Alzheimer's disease (AD) is an essential stage in the treatment of individuals suffering from AD. For that classification between Normal controls (NC), Mild Cognitive Impairment (MCI) and AD patient is necessary. With manual techniques for identifying the presence of Alzheimer's disease through brain MRI is too expensive and time consuming. Therefore the entire work is towards the development of computer aided diagnostic tool for Alzheimer's disease classification. The image classification technique is able to give the information about presence of abnormality in the input brain image which is used in this project work to detect the Alzheimer's disease. The main objective of this paper is to differentiate the different abnormal brain images based on the optimal feature set. For experimentation Open Access Series Of Imaging Studies (OASIS) with patient diagnosed with NC, MCI and AD is used. The project has 3 models which classify MRI images: 1) AD vs. MCI 2)AD vs. NC 3)MCI vs. NC .Initially optimum features are extracted and selected with Gray Level Co-Occurrence Matrix(GLCM) and without GLCM.The results are applied to k-NN classification technique and performance is evaluated. Then performance of this classification is improved using ADABOOST classifier. This system got 100% classification accuracy using ADABOOST classifier. The obtained classification results are verified from the Radiologist that assures the correct classification of various stages of Alzheimer's disease*

I. INTRODUCTION

Neurodegenerative diseases consist of great variety of personality disorders whose transformation is not directly related to the visional analysis made by radiologist, who can hardly evaluate precise differences. Neuroimaging becomes an important tool in the early diagnosis of neurodegenerative diseases by extracting objective patterning and then explaining invisible relations from structural magnetic resonance (MR) images. Abnormality detection in Magnetic Resonance (MR) brain images is a very challenging task. The difficulty in brain image analysis is mainly due to the need of a detection technique with high accuracy within quick convergence time.[1]

Alzheimer's disease (AD) is the utmost familiar type of dementia and main cause of disability worldwide. Early detection of AD is necessary to provide the patients with good and timely treatment. Structural Magnetic Resonance Imaging (MRI) is a powerful diagnostic tool which gives high resolution images and high brain tissue contrast. In this paper implemented methods helps to diagnose AD at an early stage of development. There are three stages of Alzheimer's disease: Normal controls (NC), Mild Cognitive Impairments (MCI), and the AD. The fundamental goal of the this paper is to classify the various abnormal brain images based on the most favorable feature set .In this project ,MRI image dataset is taken from the Open Access Series of Imaging Studies (OASIS) which consist T1-weighted MRI images. The features are extracted with GLCM (Gray Level Co-occurrence Matrix) and without GLCM method. Then this feature vector is given to k-NN classifier and ADABOOST classifier. K-NN is one of the classifier which is used for classification of images due to its ease and simplicity. The performance of this classification is the improved by ADBOOST classifier. ADABOOST have been applied to distinct region with enormous progress which owed to their substantial analytical foundation ,proper prediction and high simplicity. These classification techniques classify the MRI images into NC, MCI and AD images. The performance is then evaluated in terms of various parameters such as accuracy, error rate, sensitivity and specificity.

This brief is organized as follows. Section II shows some related work, section III gives an idea about Alzheimer's disease and basics of MRI and its role in diagnosis of AD. Section IV presents the description on classifiers: K-NN and ADABOOST. Section V presents the implemented methodology. Section VI contains results and discussion and the conclusion is presented in section VII

II. RELATED WORK

Automated brain disorder diagnosis with MR images is becoming increasingly important in the medical field .Image classification technique categorizes abnormal images into different groups.

Andrea Rueda et al.[1] developed a new image study method which shows brain patterns which are discriminative and that are correlated to the existence of neurodegenerative diseases and so that arranging objectively any neurological disorder. Jonathan H. Morra et al.[2] focuses on hippocampal segmentation and studied four comparative automated methods using different machine learning algorithms .Kyle S.Marcolini et al.[3] examined and analyzed K-NN ,SVM and Bayes methods for classification of dementia from brain MRI and found that K-NN is good choice for classification. Qi Zhou et al.[4] combined MRI data with different parameters such as Mini Mental State Examination(MMSE) which goes input to a multidimensional space for the classification of AD and MCI. Manhua Liu et al.[5] presented a classification algorithm so as to combine features and decisions into model for classification to be highly correct.. Initially low level classifiers are built and then many high level classifiers are developed which evaluates high level features of brain regions .And then all these classifiers of high level are joined to make eventual decisions. Yong Fan[6] proposed ordinal rank based classification method for classifying AD and MCI. He considers the genetic ordinal acerbity of brain damaged cause by normal aging ,MCI and AD.Ahsan Bin Tufail et al[7] presented an approach based on MRI images to classify between N C,MCI and AD patients and he compared performances of three generally used classifiers that is PSVM,K-NN and ANN.

III. ALZHEIMER'S DISEASE (AD) AND ROLE OF MRI IN DIAGNOSING OF AD

A. Alzheimer's disease (AD)

Alzheimer's disease is a progressive dementia which is caused by successive degeneration of brain cells. Alzheimer's disease affects different areas of the brain so specific functions or abilities are lost. As we grow older, some change in memory is considered to be normal, but the effects of Alzheimer's disease are more severe than simple cases. They include difficulties in communication, learning, thinking and reasoning impairments severe enough to have an impact on individual's work, social activities and family life in the early and middle stage. Following are the changes in brain due to Alzheimer's Disease: 1) The cortex shrivels up, damaging areas involved in thinking, planning and remembering.2) shrinkage is especially severe in the hippocampus, an area of the cortex that plays an essential role in the development of new memories.3) the fluid-filled spaces within the brain which are called ventricles, grow larger[8].

B. MRI and its role in diagnosis of AD

Modern medical imaging technology has given physicians a non-invasive means to have an idea about internal anatomical structures and to diagnose a variety of diseases. Among these imaging techniques Magnetic Resonance Imaging (MRI) is found to be powerful to other techniques especially for brain tissues. This type of scan uses magnetism to build up a picture of the internal parts of the body. The main advantage is having a high soft tissue differentiation for MRI which is very essential for brain imaging as it has high spatial resolution and excellent discrimination. Understanding the brain of Alzheimer's and dementia patients is of a great clinical importance. MRI could help to find Alzheimer's disease at an initial stage before any damage has been done. MR images usually have high contrast as there are varying portions of signal intensity. These Images are weighted against specific contrast mechanisms. In T1 weighted images, cerebrospinal fluid (CSF) is dark and fat is bright; with T2 weighting , reverse of the above case. A Proton density (PD) image gives the combine characteristics of T1 and T2 images.

IV.CLASSIFIERS

A.K-NN classifier

K-NN is the simplest classification technique. An object is classified according to a maximum vote of its neighbors and object is assigned to the class most familiar among its k nearest neighbors. Each sample is being classified which is comparable to its neighboring samples. Therefore, if the classification of a sample is unfamiliar, then it could be concluded by taking into account the classification of its nearest neighbor samples. So if we have an unfamiliar sample and a training set, all the distance between unfamiliar samples and all samples in the training set can be calculated .The distance with the least value resembles to the sample in the training set closest to the unfamiliar sample. Therefore, the unfamiliar sample may be distinguished based on the classification of this nearest neighbor. There are several advantages of K-NN classifier such as non-complexity, high efficient and aggressive classification performance in many regions. It is powerful to noisy training data and is useful if the training data is large.

B. Adaptive Boosting Classifier (ADABOOST)

ADABOOST is a machine learning algorithm which is used with many other learning algorithms so as to have better performances. ADABOOST is adaptive because the samples which are misclassified by earlier classifier are recognized into the successive classifier. This boosting algorithm starts by appointing the same weights to all samples in the training data. It then calls the learning algorithm to

develop a classifier for this data, and reassess the weights for each samples as per to the classifier's output. The weight of the accurately classified samples is decreased, and that of misclassified ones is increased. This produces a set of easy instances with less weight, and a set of hard ones with high weight. In the next repetition, a classifier is developed for reweighted data, which targets on distinguishing the hard instances correctly. Then the instances weights are increased or decreased according to the output of this new classifier. All weights are renormalized after updating of all samples. And final value of hypothesis is calculated [9].

V. IMPLEMENTED METHODOLOGY

A. Design Flow of system

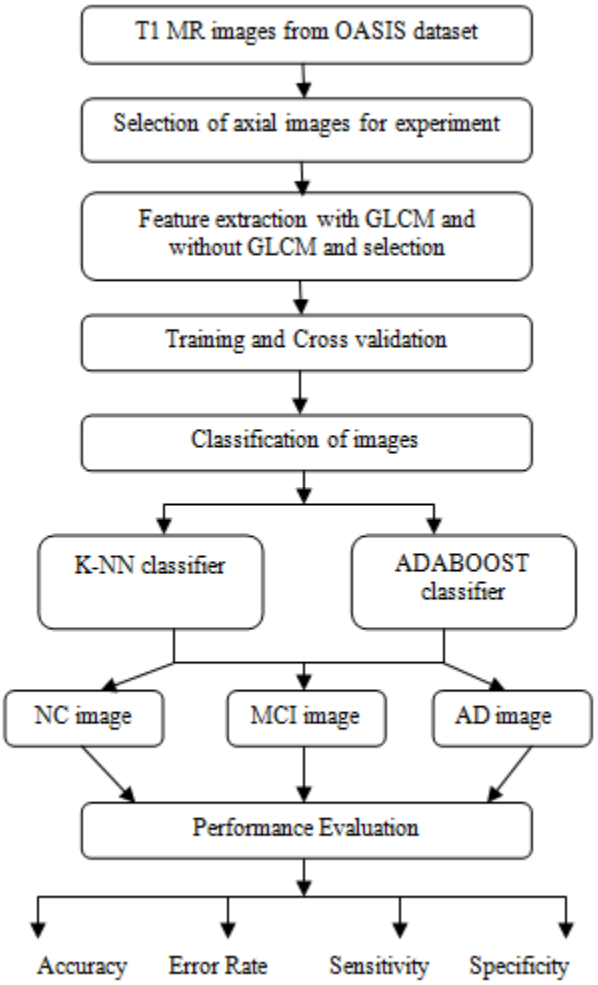

Fig 1:- block diagram for classification

B. Methodology

The public dataset from Open Access Series of Imaging Studies (OASIS) is used.201 subjects (107 NCs, 68 MCIs and 26ADs) selected from rest subject. For experimentation, axial images are selected. In this paper, three databases are used in shown in the table 1below and all dataset contains T1 weighted axial brain images

Table I. Database used in implementation

Database	Model Name	Total images
Database1	AD vs. MCI	94(AD=26,MCI=68)
Database2	AD vs. NC	133(AD=26,NC=107)
Database3	MCI vs. NC	175(MCI=68,NC=107)

Feature selection and extraction is the important step in the classification. A analytical method which examines texture that considers the spatial relationship of pixels is the Gray Level Co-occurrence Matrix (GLCM). We have used Haralick's six features and also we have developed four new features. In this work, these features are extracted using GLCM and without GLCM. After extracting the features, optimum feature set for better accuracy is selected. To validate the performance of K-NN classifier, cross validation is used which tunes the parameters of classifier. In this work, classification is done using K-NN classifier as it is simple and robust in nature. The performance is improved by using ADABOOST classifier as it has no parameters to tune. The performance is evaluated by calculating some parameters such as Accuracy, Error rate, Sensitivity and specificity for each model. The accuracy is improved by selecting the optimum feature set, appropriate K-fold value and using ADABOOST classifier

VI.RESULTS AND DISCUSSION

In the implemented algorithm, the database is about 201 brain MR images and cross validation is done using Kfold=3,5,7,9 by randomly choosing and making the K=1,3,5,7,9.Out of this ,specific kfold and K value is taken into account which gives a better result.

TableII:- Haralick's six feature result with GLCM

Database	ADvsMCI		ADvsNC		MCIvsNC	
Classifier	K-NN	Adaboost	K-NN	Adaboost	K-NN	Adaboost
K-Fold	7	-	7	-	7	-
A/I	K=9	T=129	K=9	T=131	K=9	T=391
TP	10	26	16	26	14	58
FN	0	0	0	0	1	7
FP	3	0	3	0	7	10
TN	0	68	0	107	3	100
Accuracy	76.92	100	84.21	100	68.00	90.28
Error rate	23.08	0000	15.79	0000	32.00	9.72
sensitivity	100	100	100	100	93.33	85.29
specificity	0000	100	0000	100	30.00	93.45

Table II, table III and table IV shows that Adaboost classifier is best for classification between AD,MCI and AD

MR images with maximum accuracy. From table III and Table IV, it is clear that with the use of GLCM matrix improves the accuracy for classification for all three classes. Also, it is clear from table III and table IV, newly developed features gives us the maximum accuracy than Haralick's six features. And False Negative(FN) rate is also less for all three classes which should be as minimum as possible.

Table III :-Results for newly developed features without GLCM

Database	ADvsMCI		ADvsNC		MCIvsNC	
Classifier	K-NN	Adaboost	K-NN	Adaboost	K-NN	Adaboost
K-Fold	7	-	7	-	9	-
A/I	K=5	T=105	K=5	T=150	K=9	T=350
TP	9	26	16	25	11	53
FN	1	0	0	1	1	15
FP	2	0	2	0	4	5
TN	1	68	1	107	4	102
Accuracy	71.43	100	89.47	99.24	75.00	88.57
Error rate	28.57	0.00	10.53	0.76	25.00	11.43
sensitivity	90.00	100	100	96.15	91.67	77.94
specificity	33.33	100	33.33	100	50.00	95.32

Table IV :-Results for newly developed features with GLCM

Database	ADvsMCI		ADvsNC		MCIvsNC	
Classifier	K-NN	Adaboost	K-NN	Adaboost	K-NN	Adaboost
K-Fold	7	-	7	-	9	-
A/I	K=1	T=45	K=1	T=57	K=9	T=234
TP	9	26	14	26	11	61
FN	0	0	1	0	0	7
FP	2	0	1	0	4	0
TN	2	68	2	107	3	107
Accuracy	84.62	100	88.89	100	77.78	96.00
Error rate	15.38	000	11.11	000	22.22	4.00
sensitivity	100	100	93.33	100	100	89.70
specificity	50.00	100	66.67	100	42.86	100

VII.CONCLUSION

In the implemented method, we have developed a medical decision support system with three class sets as NC, MCI and AD MR Images. This automated detection system which uses GLCM and supervised learning methods K-NN and ADABOOST obtains very satisfactory and promising results to assist the diagnosis of Alzheimer's disease. The methodology developed in this study is based on using the effective image features and employing feature extraction and selection technique towards distinguishing NC, MCI and AD MR Images. Newly developed features with GLCM works well for all three classes and achieves the accuracy of 84.62% for database 1(AD vs. MCI), 88.89% for database 2(AD vs. NC) and 77.78% for database 3(MCI vs. NC).Classification of MR images of cases at a time is very difficult task for radiologist. This is possible by automatic classification system which requires less time and gives accurate classification. So implemented method would be useful in clinical diagnosis of stages of AD from brain MR images

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