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A Novel Approach to Alzheimer's Disease Stage Classification using Supervised Learning Approach

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Key words: Support vector machines, gray level co-occurrence matrix, Alzheimer's, dementia, Naive Bayes classifier, kNN

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Abstract: Medical imaging playsa major role in diagnosis of diseases, machine learning play major role in diagnosis of medical images using computer-aided diagnosis. As India's urban population is goon increasing Neurological disorders also increases, Alzheimer's is one of the major dementia of neurons and make the death tally as high next to cancer. Estimating the stage of the Alzheimer's is a challenging task. We use T2 Weighted Brain MRI and Extract the Texture Features from those images. Train the classifier and perform crossover validation using those features. Support Vector Machines (SVM) give the good classification accuracy than comparing to the Naïve Bayes classifier and KNN. Test the classifiers with unknown images. The result is compared with clinical information SVM gives 100% accuracy.

INTRODUCTION

The modern days working environment has changed due to globalization. Working stress is increasing on persons which cause neurological disorders such as dementia. Alzheimer's disease is due to dementia it is a progressive neurological disorder. Generally it appear at the age of 60's. But due to the change in food habits and working environment it appearing in young person's below 40 years of age.

Alzheimer's is the 3rd in major cause of death next to heart diseases and cancer. As India is the second largest in population and developing rapidly in economic. Change in the working Environment and food habits causes Alzheimer's.

Memory loss is the major symptom of the Alzheimer's. It is due to loss the connection between the nerves. White matter of the brain get decreases because of losing the nerve cell connection. Hippocampus volume reduction is observed as primary symptom of Alzheimer's using MRI. Radiologist diagnosis the disease using Imaging technology. But due to visual impairments, less frequent and un characterized imaging features, radiologist face problem to correctly diagnosis the disease.

The texture of the brain is different from one stage to another stage. We come to know that due to the Alzheimer's brain get shrinks, Enlarges its ventricles, change in white and gray matter volume, change in hippocampus size.

Biomarkers are used to evaluate the biological changes carried due to Alzheimer's disease[1-5]. Which are used to measure ß-amyloid, total tau and phospho-tau-181 in Cerebrospinal Fluid (CSF). This technique is the most acceptable method to diagnose AD with high specificity and sensitivity. But Biomarkers are not useful for early diagnosis of the disease. Moreover, it need to use intracerebral-ventricular injection. To collect

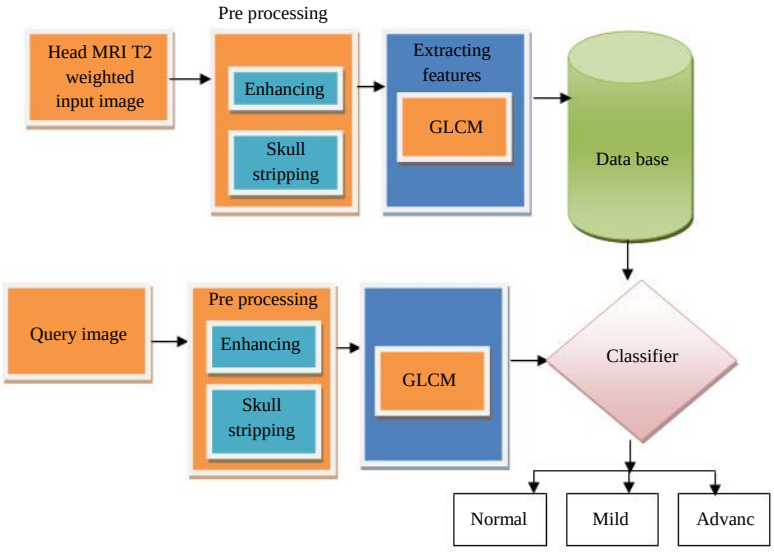

Fig. 1: Work flow

the CSF the clinical staff need to take utmost care without damage brain tissues and spinal card. This is one of the most critical mechanism to estimate the Alzheimer's where they estimate the tangle and plague of the brain tissues for Alzheimer's analysis.

As CSF Biomarkers have remarkable drawbacks. Body Fluid Based Biomarkers are needed to diagnosis the Alzheimer's[6]. Although, saliva or urine can be easily collected, blood analysis is the gold standard it is still unknown how the concentration of analyses in the blood directly correlates with pathological changes in the brain, especially in AD.

Brain Imaging is used for different brain disorders such as Tumors, subdural hematomas and stroke but not used for severity of the AD[7-9]. Volumetric analysis is used by analyzing manually or semi-automatic techniques using SPM-5 using MATLAB environment. There the neurologist need to calculate the total volume of the different regions such as white matter, gray matter, CSF and sum together come to conclusion about the stage of the disease.

MATERIALS AND METHODS

Proposed system: Morphological changes in the brain is used as attributes. To collect those attributes texture information is used. The images collected from Harvard Medical School are initially preprocessed using enhancement and Skull stripping algorithm. Work flow is shown in Fig. 1.

Feature extraction: Gray Scale Co-occurrence Matrix (GLCM) is used for feature extraction. The matrix that gives the probability successive pixels of same intensity in the image. It is a 256×256 square matrix. Preprocessed image verifies the pixel intensities in horizontal direction and write the number representation in the GLCM Matrix.

The procedure continues for all the pixels and note down how many times the same pixels are come side by side based on this we calculate the probability used to find the texture parameters of the image.

Features and database generation: The GLCM used to generate statistical texture parameters such as mean in x direction, mean in y direction, correlation, homogeneity, energy, entropy, standard deviation in x direction, standard deviation in y direction, Angular secondary moment, variance, cluster shade, inertia, skew and skew coefficient, etc., all these features are used to generate the required a data base. This data base is used to train and validate the classifiers.

Classifier: Classifier is used to bifurcate the stage of Alzheimer's disease based on the features that extracted by using GLCM, the features are stored in data base. We use support vector machines classifier having its path in statistics give good results even having small data set. SVM is used as binary classifier used to separate two classes. But our data set is having multi classification for this One Versus all (OVS) or one to one mapping method is used.

Let the training set is having x data set points as (a_1, b_1), ..., (a_n, b_n). Where, a_n is the p dimensional feature vector b_n represent the class that be labeled to train the classifier. A hyper plane with great variance represented

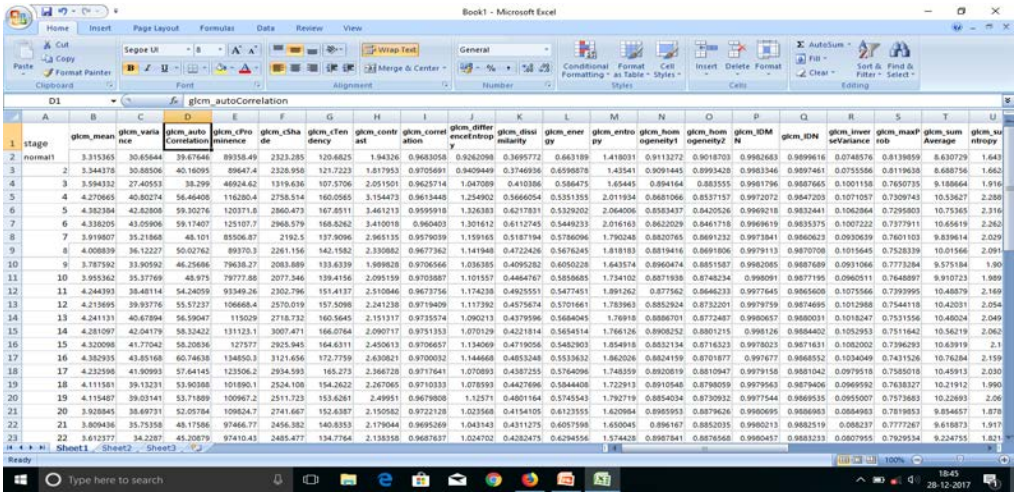

Fig. 2: Data base in CSV file

Table 1: Statistical parameters of training classifiers

Classifier	AUC	CA	F1	Precision	Recall
SVM	1.00	0.981	0.951	0.971	1.00
KNN	0.983	0.981	0.957	0.971	1.00
Naive bays classifier	1.00	0.907	0.815	0.688	1.00

with a real vector $\vec{q}$ which is perpendicular to the hyper plane and a offset parameter p is used to make the margin (Table 1 and 2):

$$\vec{q}\vec{a_i} + p = 0$$

If the offset become zero then the hyper plane pass through the origin. As the SVM is risk minimizing algorithm it is interested in maximum margin between two classifiers. Two parallel planes are taken if the data set is lineally separable. And no data is placed in-between the hyper plane. As the SVM is binary classifier then we can apply this algorithm by considering one versus all or one to one mapping. In one versus all algorithm one class data is taken as +ve and remaining all classes are labeled as –ve and train the classifier and repeat this procedure for all the class. The algorithm is carried using the given formula:

- $\vec{q}\vec{a_i} + p \geq 1$ the given data set is belong the bi = 1 class
- $\vec{q}\vec{a_i} + p \leq -1$ the given data set is belong the bi = -1 class
- $\vec{b_i}\left(\vec{q}\vec{a_i} + p\right) - 1 \geq 0$ use as a classifier kernel

$H_\theta(a)$, let, we have three classes as normal, medium, advance impairments as i ={1, 2, 3} then find the probability of getting the given data set belong to that

Table 2: Clinical information of Un labelled images

Images	Stages
a	Mild
b	Normal
c	Normal
d	Advanced
e	Advanced

class as $H_\theta^i(a) = p(i/a; w)$ by using this the probability and using maximum value of $H_\theta^i(a)$, we can come to knowledge that the data set belong to the particular class. This give soft max approach gives the probability as a metric decide the classification of the particular data.

RESULTS AND DISCUSSION

We are taken 54 MRI Slices data base to train our classifier. Which are already labeled as normal, mild and advanced. These images are collected from Harvard medical school. They are total 54 images 21 images are normal, 11 images are mild and 22 images are advanced images. Extracted features are converted as. CSV file as shown in Fig. 2. To compare the performance of the classifiers, we use 5 folded Cross validation and generate confusion matrix of KNN, Navy Baye's classifer and SVM as shown in Fig. 3. Using the respective confusion matrix different parameters are calculated such as Classification accuracy, F1 measure, precision, recall and Area Under Curve (AUC). From all the classifiers are

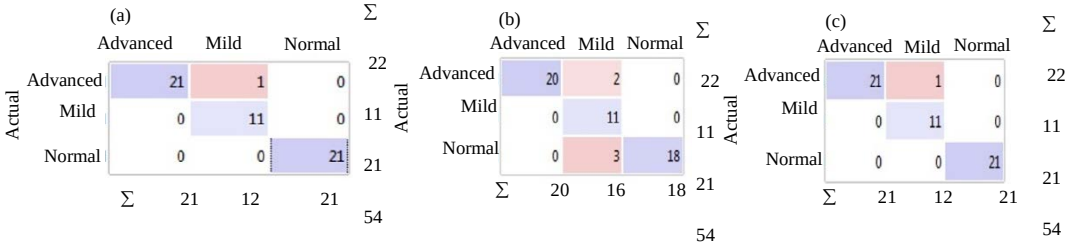

Fig. 3(a-c): Confusion Matrix of individual classifier, (a) SVM, (b) Naive based and (c) kNN classifier

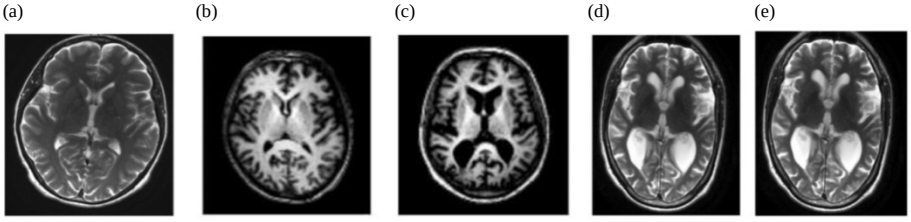

Fig. 4(a-e): Unlabelled test images

Table 3: Prediction of the disease

	Naive Bayes classifier				KNN classifier				SVM classifier			
Images	Advance	Mild	Normal	Status	Advance	Mild	Normal	Status	Advance	Mild	Normal	Status
a	0.00	1.00	0.00	M	0.00	1.00	0.00	M	0.06	0.74	0.00	M
b	0.00	0.00	1.00	N	0.00	0.00	1.00	N	0.00	0.00	1.00	N
c	0.00	0.00	1.00	N	0.00	0.00	1.00	N	0.00	0.00	1.00	N
d	0.03	0.97	0.00	M	0.20	0.80	0.00	M	0.20	0.80	0.00	A
e	0.99	0.01	0.00	A	0.40	0.60	0.00	M	0.52	0.46	0.01	A

**Status: N-Normal; M-Mild; A-Advanced

trained by folded 5 cross validation approach and we conclude from the parameters that SVM gives good AUC and accuracy F measurement precision and recall. And the classifier is also test using different unknown images collected from internet source and verified using our algorithm. Unlabelled images are shown in Fig. 4. Clinical stage of these images is given in Table 2.

On predicting the diseases SVM classifier gives the perfect classification while compare with the clinical information as shown in Table 3.

CONCLUSION

We conclude that the Alzheimer's stages are get classified perfectly by the texture attributes collected from the brain using SVM classifier. The predicted results are compared with the clinical information. The Proposed method gives 100% classification accuracy. This can further be expanded to the Schizophrenia as the texture information of the brain is also play the main role in the classification.

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