Extracting 2D Shape Features for Early Detection of Alzheimer's Disease

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Abstract— AD is a progressive disease which in its early stages, memory loss is mild, but in severe stage, patients lose the ability to speak and respond to their environment as a result of the brain tissue degeneration The diagnosis of Alzheimer Disease (AD) in its earlier stage is very important. Because early diagnosis is used to prevent a patient from death. The proposed system helps to diagnosis accurate detection of Alzheimer's disease. In this paper, the input Magnetic Resonance Image (MRI) is preprocessed using median filters and then segmented into Grey Matter (GM), White Matter (WM) and Ventricle. The useful and informative features like shape features are extracted from segmented MRI images for early detection of AD. Finally, a linear Support Vector machine (SVM) is implemented to differentiate AD subjects with normal subjects. Experimental results are shown to demonstrate the accuracy of the proposed method.

Key words: Alzheimer's disease, Dementia, Magnetic Resonance Imaging(MRI), Mild Cognitive Impairment (MCI), Support Vector Machine(SVM)

I. INTRODUCTION

Alzheimer's disease (AD) is the most common cause of cognitive impairment in older people and one of the major healthcare issues of the future. In the starting stages of Alzheimer's, the people are experiencing confusion, difficulty in memorizing events and neighbours. [1.2].There is also an urgent need to find treatments to slow down, stop, or entirely prevent AD symptoms as soon as possible.

An accurate early detection of Alzheimer's and its progression allow the patients to take preventative measures, such as changing their life style and taking medications that can reduce the symptoms of the disease. However, early detection of AD is still challenging process [5]. The diagnosis of AD includes mental status, physical exam and psychpothrough analyzing the different imaging techniques such as MRI, PET and SPECT images.

Brain imaging techniques have had a strong power on the scientific study of AD. They are expected to play critical roles in the effort to find effective AD. In the last 20 years, the researchers are highly interested in the development and use of brain imaging techniques for the scientific study, early detection, tracking, treatment and prevention of AD. Brain MRI analysis plays important roles in AD diagnosing and find its progression overtime [2,4].

According to the Alzheimer's Association, the progression of AD comes under four different stages; Mild Cognitive Impairment (MCI), Mild Alzheimer, Moderate Alzheimer, Severe Alzheimer. Mild cognitive impairment (MCI) includes "mild changes in memory and thinking that mislead the day to day activities and execution". Therefore, accurate diagnosis of AD patients in the early stage is very important.

A. Symptoms and signs of AD

AD can affect various people in different ways. The following are the major signs and symptoms of AD.

- Loss in Memory
- Facing problems in planning or taking decisions
- Difficult to handle day to day activities
- Difficult to identify correct time or place
- Difficult to understand visual images and identify blood relationships
- speaking or writing problems
- Misplacing things in home
- poor judgment about anything
- Removal from work or social activities
- Changes in behaviour

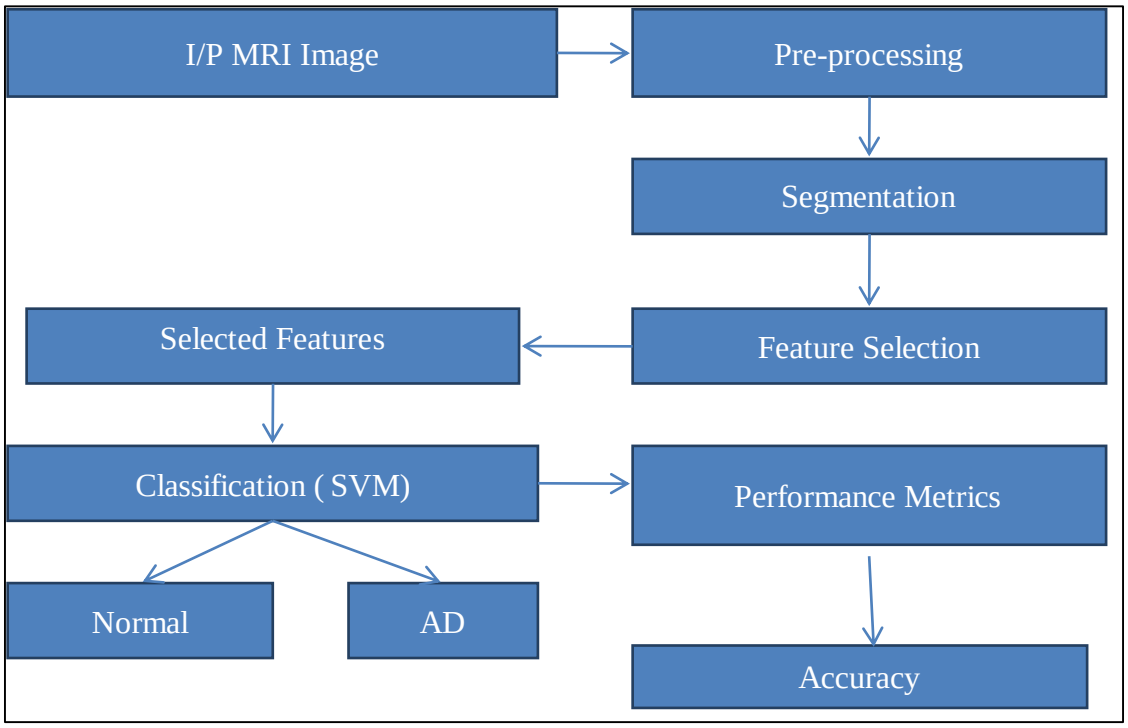
II. RELATED WORK

Researches proposed several methods to identify the imaging biomarkers in order to analyze the mild cognitive impairment (MCI) and AD by investigating the brain MRIs of the given subjects and focusing on particular regions that are more affected

in the disease progression [7 ,8]. The MRI scan is chosen due to its clarity in soft tissue differentiation and high spatial resolution so that it can provide classification of little anomalies in the brain.[5, 8].

III. PROPOSED WORK

The proposed system is making use of SVM classification algorithm to detect Alzheimer disease at early stages. This automatic image classification system is used to differentiate between Normal persons and persons with AD. The following figure shows the architecture of the proposed system of finding whether the person is affected from Alzheimer's disease or the person is normal.



Fig, 1: Architecture of proposed system

A. Algorithm:

1) Get the input MRI image from the data set
2) The input images are segmented intoWhite Matter (WM), Gray Matter (GM) Cerebro Spinal Fluid (CSF).
3) The segmented MRI image is then used for the ventricle segmentation.
4) The segmented MRI image is used for 2D Shape feature extraction.
5) The segmented GM, WM, CSF are viewed in 3D view using the 3Dtool.
6) Extract the 2D features.
7) Classify the image using SVM Classifier.
8) Evaluate the Performance.

1) Image Dataset

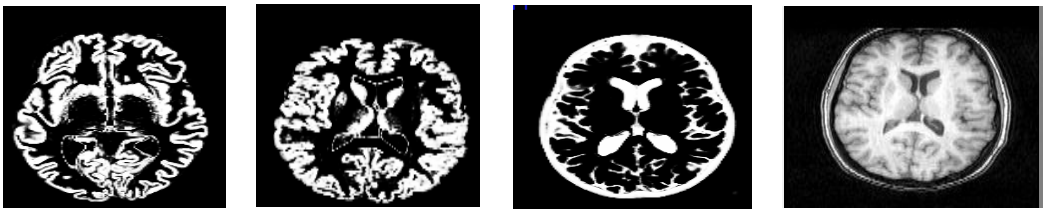
MRI is an advanced medical imaging technique which provides rich set of information for detecting Cerebrospinal Fluid (CSF) level in brain images. MRI normally determines the type of tissue present for each pixel based on the information gathered from both MR images and prior knowledge of the brain.

The MRI images are taken from Alzheimer's Disease Neuroimaging Initiative (ADNI) database [9].It includes more than 900 subjects of age 50 years to 90+ years with an annual follow-up of 3 years. All ADNI subjects are scanned at screening, three months from the screening MRI, and within two weeks before or after Month 6 and subsequent annual visits.

In this work, we used 1.5T axial T1-weighted (MPRAGE) MRI scans acquired from patients. A total of 126 brain MRIs from different subjects of 63 CN and 63 AD brain MRIs (24Male and 18 Female) with 3 MRI scans from each subject selected from the central section of the brain [3].

2) Segmentation

SPM8 tool is used to segment the MRI image. The output of this module is segmented GM, WM, CSF images. The ventricle is also segmented. Because the enlargement of ventricles is the major characteristic of AD due to neuronal loss. cerebrospinal fluid (CSF) and surrounded by grey matter (GM) and white matter (WM) are visible in ventricle.



Original Image Segmented GM Segmented WM Segmented CSF

Fig. 2: Segmented MRI image

3) Feature Extraction

In this paper,the following 2D features are extracted from WM,GM,CSF, whole brain and ventricle to diagnose the disease.

- Area
- Perimeter
- Compactness
- Elongation
- Distances
- Rectangularity
- Minimum Thickness
- Mean Signature Value

4) SVM classification

Support Vector Machine (SVM) is a supervised machine learning algorithm that analyze data for image classification and regression analysis. SVM is a widely used method for detection and classification in medical images.SVMs can be used to solve various real world problems in medical imaging.

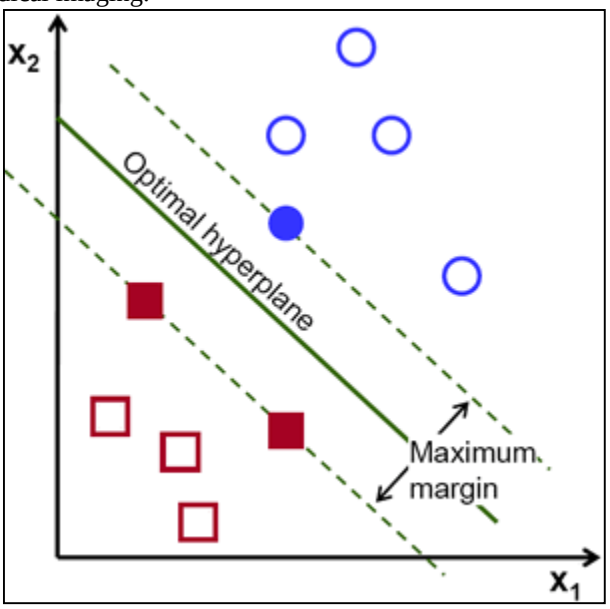
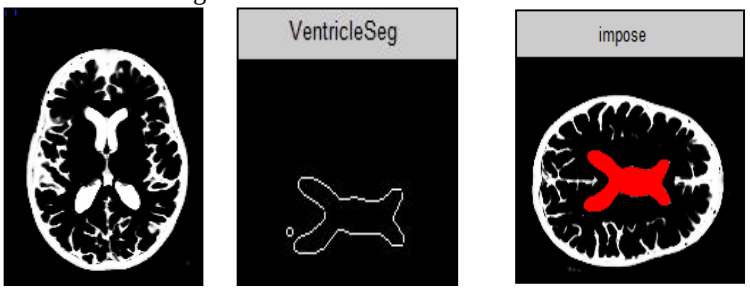


Fig. 3: Block Diagram for SVM

SVM may be linear or nonlinear. In this work, only the linear case is treated. The vector that define the separation hyperplane is called support vector (SV).

IV. RESULTS & DISCUSSION

The segmented MRI image is shown in the figure.



Segmented Image Segmented Ventricle Superimpose for Ventricle

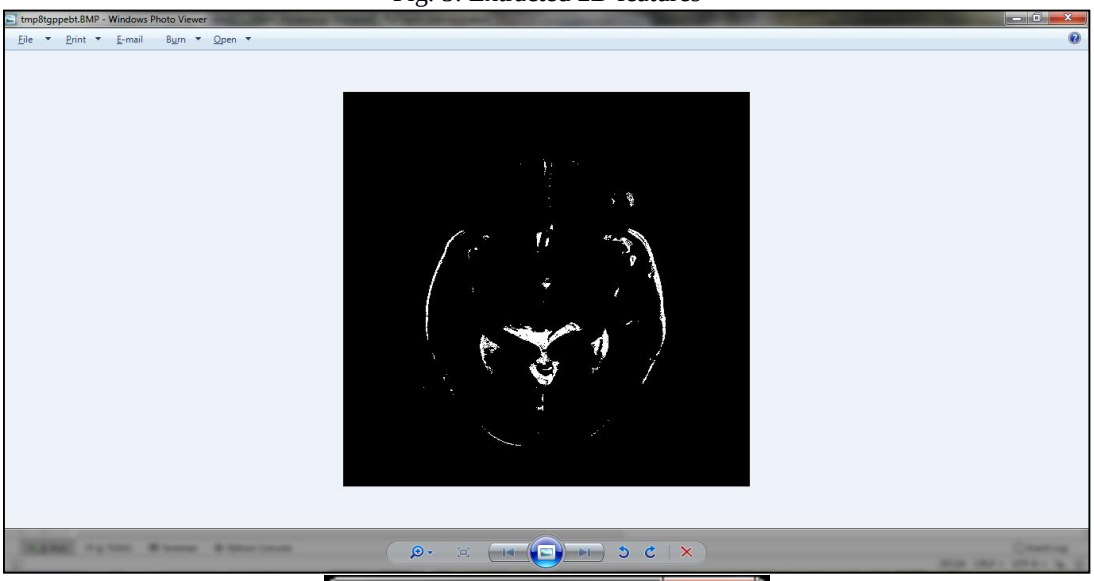
Fig. 4: Segmented Ventricle

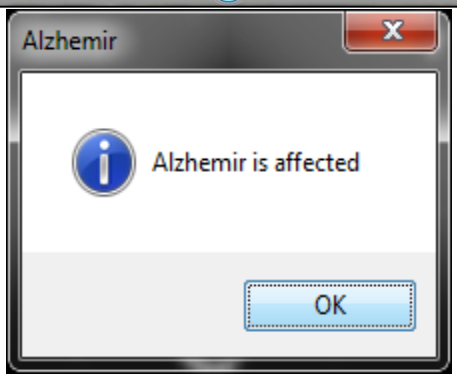
The following features are extracted from the segmented image.

2D SHAPE FEATURES

Features	Patient1	Patient2	Patient3	Patient4
Area	39400	39500	42300	39300
Perimeter	1053	1067	1035	1064
Compactness	1.0003	1.0004	1.0003	1.0003
Elongation	59.879	59.7776	50.5481	59.857
Distances	0.9627	0.9649	0.9712	0.9583
Rectangularity	417	427	427	427
Minimum Thickness	224.0678	224.329	231.9855	223.5501
Mean Signature Value	106910.7	106910.7	109480.7	104658.7

Fig. 5: Extracted 2D features





The following performance metrics are used to evaluate the proposed algorithm

$$\text{Accuracy} = TP+TN\ /TP+TN+FP+FN \quad (1)$$

$$\text{Recall} = TP/TP+FN \quad (2)$$

$$\text{Precision} = TP/TP+FP \quad (3)$$

Where,
TP - the number of true positives (correctly classified AD patients);
TN - the number of true negative (NOR patients correctly classified);
FP - the number of false positives (NOR classified ad AD patient);
FN -the number of false negatives (AD patient classified as NOR).

V. CONCLUSION

The proposed method is to design a Computer Aided Diagnosis (CAD) to detect Alzheimer's disease in its early stage. Extracting features and selecting appropriate features from segmented GM, WM, CSF, Ventricle will provide good

classification results. Automatic image classification system is used to segment the MRI brain images and SVM classifier is implemented in order to predict whether the person having Alzheimer disease or not using selected features. We have implemented our work in python3.6. In future, we planned to consider other brain images such as FMRI and Structural MRI images for detecting Alzheimer's disease at early stage.

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