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A Review on Methods for Feature Extraction and Classification for the Automated Detection of Alzheimer's Disease

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Abstract: Alzheimer Disease (AD) is a type of Dementia which is a neurodegenerative progressive disorder. No treatment can stop or prevent the growth of this disease. Magnetic Resonance Imaging (MRI) is the best tool for the early detection of AD. This paper presents the review of feature extraction and classification techniques used for the early detection of AD which are used earlier. Proposed algorithm for the early detection of AD is also stated in the paper.
Keywords: Alzheimer Disease, Mild Cognitive Impairment, Magnetic Resonance Imaging, ALFF

I. INTRODUCTION

Human "Nervous System" involved control and coordination of various body functions. It consists of highly specialized cells called Neurons. These are the cells which detect and receive information from different sensory organs and integrate them to determine the mod of response of a living body.

Dementia is a syndrome which is a chronic and decline in cognitive function due to the damage in brain cells. Now a days it becomes a major global health and social threat. According to the survey of World Health Organization (WHO) done in the year 2019, 50 million people have dementia and every year 10 million new cases add into it. It causes due to deterioration in memory, thinking behaviour and the ability to think. The early symptoms of dementia include memory problem, difficulty in word finding, lack of initiative, changes in personality or behaviour and day today's function at home or at work [1-3].

Dementia is classified into various types namely Vascular Dementia, Dementia with Lewy Bodies, front-temporal lobar degeneration, mixed Dementia, Parkinson's disease, Alzheimer disease[4-5]. Most common type of Dementia is an Alzheimer's disease. It affects 60-80% people over the age of 65[6].

Alzheimer is the fastest growing disease that causes death of brain cells. This disease interrupts the travelling of neurotransmitters. Thus, the neurons fail to pass the signals between brain and sensory organs. This happens because of two proteins in the brain such as Beta amyloid which aids to develop amyloid plaques and Tau which develops tangles in brain cells [7-9].

Alzheimer disease is a neurodegenerative disorder that is characterised by progressive cognitive and functional deficits. No treatment stops or reverses its progression [10-11]. In the developed countries, with the increase in elderly population, Alzheimer disease is going to be a major problem in socioeconomic implications. According to a recent survey, affected people will be doubled in the next 20 years. Therefore, the diagnosis of the AD in the early stage is very important [12].

The precise diagnosis and early detection of AD is a difficult task. Another difficulty is caused by confusion of non-AD syndromes of Dementia. The Mild Cognitive Impairment (MCI) is a prodromal stage of AD. It is observed that MCI patients are at high risk of AD progression. [13-14]

Neuroimaging techniques such as Magnetic Resonance Imaging (MRI) and Positron Emission Tomography (PET) have been widely used in the assessment of AD.[15-20]. Combine use of neuroimaging techniques with selected biomarkers can contribute to the early and specific diagnosis of AD. MR Imaging is considered the preferred neuroimaging examination for AD as it allows for accurate measurement of 3D volume of brain structure, specifically the size of hippocampus and related regions.

II. LITERATURE REVIEW

Pre-processing: Pre-processing is the first stage. The main aim of pre-processing in the brain MR images is error removal and MR image enhancement. The initial stage of pre-processing generally includes the steps normalization, noise removal , Segmentation. In the case of neuroimaging, skull stripping and enhancement is the main task of image enhancement. The enhancement is done by modifying intensities of pixels [21-23].

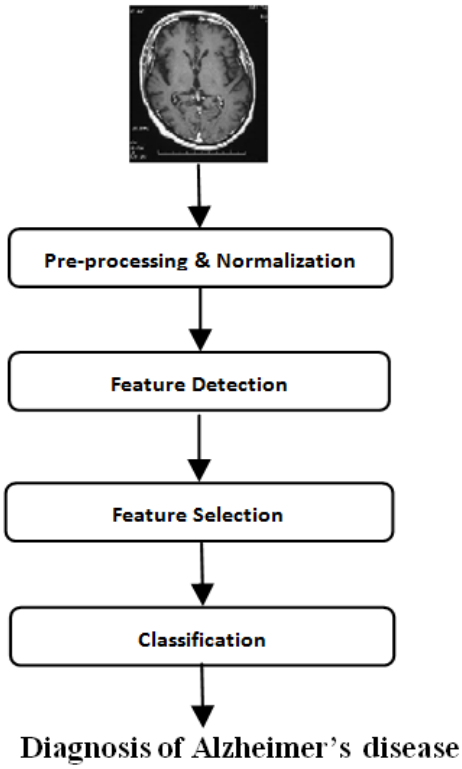

Figure 1 Block Diagram of General Framework of the Steps in the Diagnosis of Alzheimer's Disease

This paper presents the study of various methods or approaches for feature extraction and classification which will be useful for the constructive completion of advance study on Alzheimer Disease.

Feature Extraction: The main goal of feature extractor is to characterise an object which is to be recognised by measuring the similar object in the same category. They are supposed to be simple to extract, invariant to irrelevant transformations, incentive to noise and useful for discriminating patterns in different category. Different approaches are used for extraction of features from MRI data. The approaches are voxel-based, vertex-based, and ROI-based. There are various methods to find out the relevant features for the classification of healthy and unhealthy brain.

Amulya et al. Compare and evaluate the different methods of feature extraction. The three approaches were compared through Linear Discriminant Algorithm (LDA), Support Vector Machine (SVM) , Bay's classifier and ANN classifiers on MRI data. Pre-processing is done for the skull stripping to remove non brain tissues, noise reduction, normalization before feature extraction. Markov Random Field is used [24].

Akhila J A et al. has done the segmentation based feature extraction on OASIS database of 40 subjects. Segmentation based Fractral Texture Analysis (SFTA) method is used for feature extraction. three features are extracted from binary image. The features are size, mean grey scale and the dimensions of the fractals obtained from binary image. Classification is done with feed forward Neural Network with 97.5% accuracy and precision of 0.975 is obtained [25].

Shuai Mao et al used ALFF and ReHO parameters. Each voxel value is divided in these two parameters DDARSE software tool is used for feature extraction and selection. ADNI MRI dataset is used . in pre-processing bandpass filters and spatial smoothening filters are used for normalization. Feature components are sorted using Fisher Score Algorithm[26].

Jesia Mathew et al. done the pre-processing with VBM8 tool box which helps in Voxel-based morphometry of MRI. Pre-processing steps like Reorientation, cropping, skull stripping, image normalization are done on the MRI images. Pre-processing image is segmented into grey and white matter. Feature Extraction is done with DWT & Principle Component Algorithm (PCA) and Classification is done with SVM [27].

Chuanchuan Zheng et al. reviewed the different methods of feature extraction methods like voxel-based, vertex based and ROI-based methods. LDA, Baysian, SVM and Artificial Neural Network (ANN) are used for classification in the diagnosis of normal and diseased brain [28].

Ayşe Demirhan1, Talia M. Nir et al. Used voxel-based feature extraction method based on segmented tissues probability maps using directly the voxel of the tissue probability maps as a feature using stand score[29-30].

Seixas FL et al was used vertex-based feature extraction method. It denotes the difference between NC, MCI and AD. In this method cortial thickness shows a direct index of atropy caused by dementia.[31-33]

Thies W et al worked on ROI-based method by using segmentation done preferably before feature extraction Chupin et al developed fully automated segmentation method SACHA which automatically segments hippocampus and amygdale based on competitive region growing between these two structures [34-37].

Fukunaga K et al used LDA which is one of popular dimensionality reduction method. It achieved 83% sensitivity, 84% accuracy and 86% specificity on SPECT images[38].

Classification: Plant et al combined a feature selection with classification using bays classifier for the discrimination between AD and NC on MRI data which achieve 92% accuracy [39].

Cuingnet R et al used SVM algorithm for classification . It constructs a hyper plane or a set of hyper plane in an infinite – dimensional space which can be used for classification. SVM lower generalization error than other classifier and hence commonly used to solve pattern classification problems which have limited training samples[40-42].

Dukart J et al used meta-analysis based SVM to diagnose AD and NC on MRI and PET data which achieved accuracy of 90.0% , sensitivity of 91.8% and specificity of 87.8%[43].

Deng X et al showed that using ANN can get higher sensitivity and accuracy in dementia classification for MRI images[44].

Table1 Comparison of Feature Extraction and Classification Methods from Literature in the Identification of Alzheimer's Disease

Sr. No.	Paper	Modality	AD Diagnosis	Techniques Used	Dataset	Accuracy	Highlights of paper
1.	Amulya E.R. et. al. [24]	MRI	Feature Extraction and feature reduction	GLCM and Gabor filter for feature extraction and PCA, LDA and SVM for feature reduction	OASIS and ADNI	--	This paper represents the proposed method with review of feature extraction methods.
2.	Akhila J A et. al. [25]	MRI	Segmentation based feature extraction and classification	Segmentation Based Fractal texture Analysis (SFTA) and Classification with a feed forward artificial neural network.	OASIS dataset with 40 subjects	accuracy of 97.5% and precision of 0.975	Features are extracted from binary image by breaking image into two threshols using Bnary Decomposition Algorithm
3.	Shuai Mao et al [26]	MRI	Feature extraction, feature selection and classification	Functional correlation between different ROI and SVM is used for classification	ADNI 40-subjects 20-Normal 20- AD	97.5 is the recognition rate	Feature Score Algorithm is used for sorting features. ALFF and ReHo features are taken for feature extraction
4.	Jesia Mathew et. al. [27]	MRI	Feature extraction and classification	DWT coupled with PCA for feature extraction and SVM for its classification	ADNI NC=71 AD=87	--	Pre-processing is done with VBM8 toolbox
5.	Chuanchua	MRI	Feature	voxel-based, vertex-	--		

	n Zheng et. al. 28		extraction and classification	based, and ROI-based feature extraction methods and LDA-based, Bayesian, SVM-based, and ANN-based pattern classification methods			

III. CONCLUSION

This paper provide a brief review which is based on the comparison and evaluation of related work done to detect Alzheimer's disease using MRI. Earlier detection of dementia is very essential in today's world which becomes a major global health and social threat. Early detection of Alzheimer Disease would increase the life expectancy in the community of elderly people. Various feature extraction and classification methods are used to extract the features and classify Alzheimer's Disease from MRI. The selection of relevant features yields accurate classification result. Table I shows the analysis of the related works.

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