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A Review on Robust Algorithm for Early Detection of Alzheimer's Disease

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Abstract*:* Alzheimer's disease is a common neurological disorder and it is generally affected in elderly people. This illness condition creates lots of issues in the affected people. This disease makes a person lose his memory and will have trouble in doing his daily activities, and thus in the advanced stage of this condition leads to death. No treatment is available to completely relieve this disease but it is better if we detect this disease at its earliest stage as necessary aid can be provided. In this review paper we will use Alzheimer's Disease (AD), Cognitively Normal (CN), Mild Cognitive Impairment non-convertible (MCInc) and Mild Cognitive Impairment convertible (MCIc) data. These data are available from the ADNI (Alzheimer's Disease Neuroimaging Initiative) and they are passed through some of the processes for proper detection. The process includes pre-processing, feature extraction and classification. Different principles are used in each stage and different levels of accuracy are obtained. MCIc is the type of data which leads to Alzheimer's disease at a later stage. First section in this paper gives general idea about the Alzheimer's Disease and its associated problems. Second section discusses the detection of early stage of Alzheimer's Disease with various technologies. Third section includes performance comparison of different techniques.

Keywords: AD, CN, MCIc, MCInc

I. INTRODUCTION

Alzheimer's disease is a major medical illness condition affecting the elderly people. People who are of the age 65 and above are more suffering from this disease. The persons affected with this disease will lose their natural ease to perform their daily work and are more exposed to memory loss, confusion and later on to death. The person's affected with Alzheimer's would initially have MCI and it is difficult to predict, if the MCI would convert into AD or not. There are 100 billion nerve cells in our brain and these neurons have their connection. The brain cells performs many functions and these cells store energy and communicate between them.

Alzheimer's disease is advanced due to the plaques and tangles [3] formed in the brain. Alzheimer's disease prevents the functionality of cell in the brain. As one region of the brain is affected, it gradually spreads on to the other region. As a result the brain cells will lose their ability to do the work and eventually the person will die. Figure 1.1 shows a healthy brain and Alzheimer's affected brain.

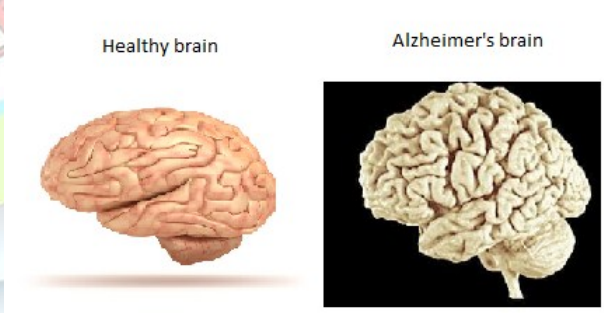

Fig 1.1 Healthy brain and Alzheimer's affected brain

Alzheimer's disease is one of the most common causes that lead to dementia. Dementia is a general term used for memory loss and other cognitive abilities, which are serious enough to interfere with daily life. Alzheimer's disease accounts for 60 percentage to 80 percentage of dementia cases. Symptoms are usually developed slowly and it will

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get worse over time, and at its final or later stages it will become severe enough to intervene with daily tasks.

Increasing age is one of the major factors for the occurrence of this disease. The majority of people affected with this disease are 65 and older. According to previous statistical estimates around an approximation of 200,000 Americans under the age of 65 have Alzheimer's disease.It is estimated that by the year 2020, approximately 70% of the world's population aged 60 will be affected by this disease.

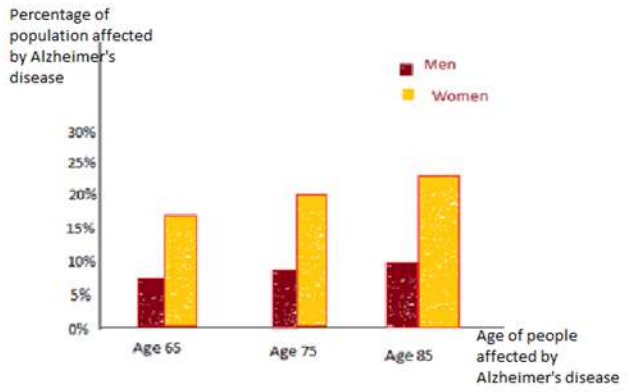

Fig 1.2 Statistics result of year 2007

Figure 1.2 is the statistics result of year 2007. Statistically from this figure it proven that women are statistically more likely than men to develop Alzheimer's disease. Sixteen percent of women above 71 years old develop the degenerative brain disorder. But only 11 percent of men of the same age are affected with it.

Alzheimer's may be treatable. This disease is not reversible, but might be treatable. Appropriate treatment can slow the rate of growth of this disease.

Treatment of Alzheimer's is more effective when detected in the early stages. One of the most effective treatments is obtaining an early and accurate diagnosis which is the most crucial one.

Alzheimer's will get worse when time passes. In its early stages, memory loss will be mild, but with late-stages of Alzheimer's, individuals losses their ability to carry on a conversation and respond to their environment. Alzheimer's is reported as the sixth leading cause of death in the United States of America. Those with Alzheimer's live an average of eight years after their symptoms become noticeable to others, but their survival can range from four to 20 years, depending on age and their health conditions [6].

Alzheimer's has no current permanent cure, but treatments for symptoms are available and the research over this disease is still continuing. Although current Alzheimer's treatments cannot stop Alzheimer's from progressing, they can temporarily slow the worsening of symptoms and improve quality of life for both Alzheimer's patients and their caregivers. Today, there is a worldwide effort to find better ways to treat the disease and prevent it from developing.

An earlier diagnosis will enable the person to participate in their own legal, financial, and long-term care planning and to make their wishes known to family members, so that the family members can support the patient. So it is empowering.

Early detection of Alzheimer's will help the affected persons family. This gives families more opportunity to learn about the disease, develop realistic expectations, and plan for their future together – which can result in reduced stress and feelings of burden and regret later in the disease process[1].

There are different techniques used in each stages of preprocessing, feature extraction and classification and different accuracy is obtained.

II. Related Work

There are some symptoms which are not leading to Alzheimer's disease. Only some memory loss symptoms will lead to the disease. Thediagnosis and treatment of reversible conditions can improve brain function and reduce symptoms. Diagnoses are more accurate if it isearly in the disease process.

In the paper 'Alzheimer's diseases towards biomarkers for an early diagnosis' disease was detected using the invasive technique and it is dependent on the detailed analysis carried on clinical basis [2].This technique is defined as one that is carried out by entering the body through the skin or through a body cavity or anatomical opening, but with the smallest damage possible to these structures.

'Voxel-based morphometry of the human brain: methods and applications' : In this paper an univariant image analysis is mainly focused but this image failed to detect the spatial distribution in its patterns. In this a whole-brain unbiased objective technique, also known as voxel-based morphometry (VBM), has been developed to characterize brain differences using structural magnetic resonance images. Voxel-based morphometry of the human brain: methods and applications is the paper which gives brief description of VBM. Initially the images are normalized in

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this and then they are segmented into white and gray matter and smoothed using an isotropic Gaussian Kernel. Finally, a series of voxel-wise comparisons of gray and white matter in different groups of subjects are performed, and this comparison is done using Random Field theory to correct for multiple comparisons. [4].

The paper 'An image processing protocol for the analysis of MR images from an elderly population' have discussed some steps in preprocessing. First step in the preprocessing is removal of extracranial tissues in which we do skull stripping and they are manually edited. After this t test is done and in this we separate white and gray matter and cerebrospinal fluid [13].

Cross-validation is a machine learning technique to evaluate predictive models by partitioning the original sample into a training set to train the model, and a test set to evaluate it. Ninety percent diagnostic accuracy is achieved using cross validation. This is referred in the paper 'Detection of prodromal Alzheimer's disease via pattern classification of magnetic resonance imaging'. Retrospective evaluation of serial scans obtained during prior years revealed gradual increases in structural abnormality for the MCI group, often before clinical symptoms, but slower increase for individuals remaining cognitively normal. [5].

The technique used is 'Non-negative Matrix Factorization (NMF) SVM, is explained in paper NMF-SVM' based CAD tool applied to functional brain images for the diagnosis of Alzheimer's disease. In this paper the feature extraction was carried out on the result obtained from Single Photon Emission Computed Tomography (SPECT) and the Positron Emission Tomography (PET) scans [7]. SPECT scan which integrate two technologies computed tomography (CT) and a radioactive material (tracer). Before the SPECT scan, we are injecting with a chemical that is radio labeled, which emits a gamma rays that can be detected by the scanner. The computer collects the information emitted by the gamma rays and then the collected image is translated into two dimensional cross-section. These cross-sections can be added together to form a 3D image [14]. MRI images give direct 3D image which is more clear and accurate. MRI images are obtained without any effort. Thus MRI images are more efficient than SPECT and PET images. This paper presents a computer-aided diagnosis (CAD) technique for the early diagnosis of the Alzheimer's disease (AD) based on nonnegative matrix factorization (NMF) and support vector machines (SVM). Nonnegative matrix factorization is the feature extraction technique in which evolution and convergence properties of hybrid methods based on both sparsity and smoothness constraints for the resulting nonnegative matrix factors are discussed [15].

A machine learning approach for personalized and cost-effective detection of AD based on: 1) locally weighted learning 2) a sequential selection of biomarkers to reduce their cost [10]. Two set of classifications are discussed in this paper: CN–AD and MCIc–MCInc. The approach is closer to the clinical setting, where not all biomarkers are available all at a time. Lazy learning methods provide useful representations and training algorithms. This is for learning about complex phenomena during autonomous adaptive control of complex systems [18].

'Machine learning framework for early MRI-based Alzheimer's conversion prediction in MCI subjects' refers a semi-supervised learning method with RLR(Regularized Logistic Regression) which uses only a minimum region for feature extraction [8]; so that an upgradation in this section is required to obtain features from a wide area. Multiple kernel based multimodal Alzheimer's disease classification is an effective and accurate diagnosis of Alzheimer's disease and MCI [9]. It uses multiple sets of scans for the feature extraction and classification, instead of focusing on a single scan such as MRI. Machine learning-based method for detecting Alzheimer's disease has many limitations while applying for clinical diagnosis. In this method, we combine three modalities of biomarkers, that is, MRI FDG-PET and CSF biomarkers AD (or MCI) and CN using kernel combination method [16].

The characteristics of the methods for learning the biomarkers are as follows:

1) We used a semi-supervised learning method

2) We perform a feature selection on MRI data from AD subjects and normal controls without using data from MCI subjects via regularized logistic regression;

3) We removed the aging effects from the MRI data before the classifier training; this is to prevent the possible confounding between AD and age related atrophies;

4) We constructed the aggregate biomarker by first learning a separate MRI biomarker and then combining it with age and cognitive measures about the MCI subjects by applying a random forest classifier.

The receiver operational characteristic for binary classification with multiple indices and its application to the neuroimaging study of Alzheimer's disease is the paper in which the feature extraction was done using the principal component analysis, an improvement is carried out in order to get a better feature extracted results. In the improvement the DWT and PCA is used because the DWT has an advantage of yielding a good contrast features and when its

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further combined with PCA reduces the dimensions and complexity[12]. After this the extracted features are SVM classified.

III. Performance Comparison

In the previous section, the various methods for developing early detection of Alzheimer's disease have been discussed.

TABLE I
THE COMPARATIVE PERFORMANCE ANALYSIS OF EXISTING SYSTEMS

Technique	Advantages	Limitations
Invasive technique for diagnosis [2]	-less expensive -small cuts are enough -easily curable cut	-longer time -Painful and bleeding -less accurate -need specialized surgeons
-Univariant image analysis -voxel-based morphometry (VBM) [4]	-Image is more clear -Simple -Robust -Accurate for high quality weighted images	- quality reduces for modified images -Non uniformity in intensity
Preprocessing – extracranial tissues are removed and t test [13]	-90% diagnostic accuracy	-consequent low power
Cross validation a machine learning tech for classification [5]	-Non overlapped test result -Unlimited amount of data with timely analysis	-Not regularized method -less efficient
NMF (Nonnegative matrix factorisation) feature extraction using SPECT AND PET images [7][14][15]	-3D image is obtained by combining 2D images -Detailed anatomy	-Interpretability is less -painful procedure -easily manipulatable
Locally weighted learning and lazy learning method [18]	-handle more input -highly accurate -estimate missing data	-Less features are extracted -Interpretability & analysis capacities offered by decision tree classification are lost due to randomization principle [17]
-Semi-supervised learning method with RLR(Regularized Logistic Regression) [8] -Multiple kernel based multimodal Alzheimer's disease classification[9]	-Simple and less complex -Solves over fitting problem	-Only some features are considered so accuracy reduces
DWT and PCA together for feature extraction [12]	- yielding a good contrast features - reduce dimension and complexity	-Feature extraction is less accurate because only two techniques are used

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IV. Future Trends And Conclusion

There are different techniques discussed in review papers. In most of the papers main classification is done between MCI and AD. More efficient early detection of Alzheimer's is the detection of MCIc. MCI is classified into MCIc and MCIcn .MCIc is the earliest stage of Alzheimer's which leads to the disease. But MCInc which will not lead to Alzheimer's. The papers discussed till now did not classify this difference that is the difference between MCIc and MCIcn. The papers discussed gives different techniques in each stage. We discussed about the advantage of MRI images over images obtained using other scanning methods.
As a future work we can propose a more efficient algorithm. We can include more steps in preprocessing, feature extraction and classification inorder to improve efficiency. In feature extraction if we include three steps PCA, DWT and FDR. Machine learning and deep learning classification can improve accuracy. In future new algorithms can be proposed to provide a good classification accuracy between MCIc and AD &MCIc and MCInc.

Further extension uses biomarkers, which can provide a better visualization of MCIc and MCInc MRI images. Incorporating a better feature selection method can also improve the performance of the algorithm as well as it can also reduce the computational time too. We can download more images from ADNI dataset and train with more images, so that the accuracy can be increased.

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