

A Survey of Recent Approaches for Detection of Alzheimer's Disease

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Abstract: -- Alzheimer's is a progressive and irreversible neurological disease. It is the most common cause of dementia in people of the age group 65 years and above. Detection of Alzheimer's disease in the early stage is very crucial as it can prevent serious damage to the patient's brain. Many different methods have been proposed to detect Alzheimer's disease. In this paper, we have surveyed different techniques and approaches for detection of Alzheimer's disease.

Keywords:-- Alzheimer's Disease, Magnetic Resonance Imaging (MRI), Mild Cognitive Impairment (MCI), Positron Emission Tomography (PET), Biomarkers, Hippocampus.

I. INTRODUCTION

Alzheimer's is the most common cause of dementia in the people of 65 years and above [8]. The earliest symptom of Alzheimer's is memory loss. Other symptoms include confusion with time or place, problem with words while speaking or writing etc. As Alzheimer's disease is a progressive disease it slowly destroys memory, thinking skills and eventually the ability to carry out the simplest tasks. It is likely that damage to the brain starts a decade before memory and other cognitive problems become evident. The plaques and tangles in the brain are still considered some of the main features in the Alzheimer's disease. The damage initially appears in the hippocampus, a part of the brain essential in forming memories. The additional parts of the brain are affected as more neurons die. By the final stage of Alzheimer's, the brain tissues are shrunk significantly and the damage is widespread. Quite recently, considerable attention has been paid to early detection of Alzheimer's disease as reversible and treatable causes of dementia can be ruled out and medications are more effective in early stage of Alzheimer's. Various techniques are developed for early detection of Alzheimer's, using these techniques for early and specific recognition of Alzheimer's disease at prodromal stages is of crucial importance. In this paper, we provide a survey of different techniques and approaches used for detection of Alzheimer's disease.

The organization of the paper is outlined as follows: Section II presents the techniques used for detection of Alzheimer's disease and Section III concludes the survey.

II. APPROACHES FOR ALZHEIMER'S DETECTION

A. Detection Without Using MRI Scans

Ali H. Al-nuaimi et.al [1] developed robust EEG-based biomarkers for detecting Alzheimer's disease in early stages. This approach was developed to quantify the slowing of the EEG in the time domain based on the changes in the EEG amplitudes. The authors claim that the proposed approach outperforms the Lempel-Ziv complexity (LZC) approach in discriminating between Alzheimer's and normal subjects and, has sensitivity and specificity values of 100% and 88.88% respectively. The authors also claim that the proposed approach gives an accuracy of 92.30%.

Jiehui Jiang et.al [2] proposed a Computed Aided Diagnosis (CAD) tool for diagnosis of Alzheimer's Disease based on the PiB PET images. The CAD Tool is based on Machine learning kernels which combines Principal Component Analysis (PCA), Independent Component Analysis (ICA) and Support Vector Machine (SVM). To evaluate the tool, the comparison was carried out with the traditional visual assessment (VA) methods. The data was divided into four groups. In group 1 all the data was considered; the AD and MCI were labelled

together and the Health Control data was labelled separately. In group 2, only AD and Health Control data was considered. In group 3, only the MCI and Health Control data was considered. In group 4, all the data was considered but the Health Control, AD and MCI data was labelled separately. The authors claim that the proposed tool has more accuracy as compared to the traditional VA method and the existing CAD tools. The authors also claim that the proposed system gives an accuracy of 92.45% with the linear kernel and an accuracy of 88.68% with the RBF kernel in group 1. In group 2, the proposed system gives an accuracy of 90.38% with the linear kernel and 86.54% with the RBF kernel. In group 3 the accuracy obtained by the proposed system using both the linear kernel and the RBF kernel is 89.17%. The proposed system gives an accuracy of 87.50% with the linear kernel and 84.17% with the RBF kernel in group 4.

R. Chaves et.al [3] proposed an approach to design a computer aided diagnosis (CAD) system for detecting Alzheimer's disease with 18FFDG and Pittsburg compound B (PiB) Positron Emission Tomography (PET) biomarker analysis based on Association Rule (AR). In this proposed approach, the 3D Region of interest (ROI) were obtained using an activation estimation method. The ROI are used by Apriori algorithm to obtain Association Rule from controls and the classification is performed on the percentage of verified rules by each subject. The authors claim that the proposed technique outperforms Principal Component Analysis (PCA) in combination with Support Vector Machine (SVM) and has an accuracy of 86.11%.

Imene Garali et.al [4] proposed a method to classify Alzheimer's disease based on the computation of features extracted from region histograms for ranking region of interest (ROI) on PET brain images. In this approach, the brain is segmented into ROI and different combination parameters for region are used to select and rank ROI. The top ranked ROI are then introduced into a SVM Classifier. A random forest classifier is also applied to the feature data. It is observed that the SVM classifier gives better results as compared to the random forest classifier and there is reduction in computational time.

Ali H. Al-nuaimi [5] proposed a Tsallis entropy method for quantifying changes in the EEG. In this proposed approach, the Tsallis entropy for each subject from a reference dataset and each EEG channel is computed. The entropy values are normalized and these normalized Tsallis entropies are used to create reference feature vectors. The k-means clustering is used to compare the feature vectors for a new dataset to the reference vectors for discriminating between the Alzheimer's disease and normal subjects. The EEG analysis to derive the biomarkers was divided in the development phase and the testing phase. The Tsallis entropy is computed in both the phases. Two datasets were obtained, dataset A was used for the testing phase and dataset B was used for the development phase. The authors claim that the proposed approach gives enhanced performance for Tsallis entropy based biomarkers for detection of dementia. The authors also claim that the accuracy using dataset A is 84.6% and the accuracy using dataset B is 78.8%.

B. Detection Using MRI Scans

Yang Han and Xing-Ming Zhao [6] proposed a computational approach known as Hybrid Forward Sequential Selection (HFS) for detection of Alzheimer's Disease based on feature selection. The HFS approach detects informative features from MRI data by combining the filter and wrapper approaches. In this approach, the data used was obtained from the Alzheimer's Disease Neuroimaging Initiative (ADNI) database and the images used are T1-weighted MRI images. The features are ranked and selected from top to bottom as per the rank list and, the classification is done using the Support Vector Machine(SVM) classifier. The authors claim that the proposed work outperforms other popular feature selection methods and is effective in prediction of Alzheimer's disease. The authors also claim that the proposed work improves the diagnosis accuracy and reduces the computational cost.

M.Rangini and Dr. G. Wiselin Jiji [7] proposed a hippocampal segmentation method based on AdaBoost. The authors compared two different classification techniques, SVM with manual feature selection (manual SVM) and SVM with automated feature selection by AdaBoost (Ada-SVM). In this approach the AdaBoost and Ada-SVM are implemented in a hierarchical decision tree framework to improve

their classification ability. The features are selected by the AdaBoost and for further classification the selected features are incorporated into the SVM classifier. The authors claim that Ada-SVM outperforms FreeSurfer.

Devi Sarwinda and Alhadi Bustamam [8] proposed an enhancement texture approach known as the advanced local binary pattern (ALBP) method which was introduced as the 2D and 3D feature extraction descriptors. The principle component analysis (PCA) and factor analysis were used for feature selection as ALBP produces a great number of features. The multiclass classification was done using the SVM classifier. The authors claim that the results show better accuracy and performance as compared to the previous LBP method. The authors have also claimed that the proposed method achieved average accuracy between 80% to 100% for both the whole brain and hippocampus data. For multiclass classification of whole brain image, the uniform rotation invariant ALBP sign magnitude outperforms other approaches with average accuracy of 96.28%. The authors concluded that the feature vector extracted has high dimensions and needs high computation for processing. Improvement can be done by extracting features using parallel computing approaches from large brain datasets of MRI.

S. Saraswathi et.al [9] proposed a method for detecting Alzheimer's disease from MRI images using a combination of three different machine learning algorithms. The Extreme Learning machine (ELM) is used for classification. Feature Extraction is done using a Voxel-based Morphometry approach. The Genetic Algorithm (GA) is used for feature selection and for reducing the high dimensional features required for classification and the optimization of the classification results is done using an Advanced Particle Swarm Optimization (PSO) algorithm. The authors claim that the GA-ELM-PSO classifier gives an average training accuracy of 94.57% and testing accuracy of 87.23%.

Rigel Mahmood and Bishad Ghimire [14] developed an automated system for classification of Alzheimer's disease based on mathematical and image processing techniques. The Principal Component Analysis was used for reduction of the high dimensional MRI image vector space to 150 dimensions and a multi-class neural network was employed to categorize the reduced dimensions from PCA. The neural network was trained

and tested using the OASIS database. The authors claim that the proposed approach has nearly 90% accuracy for Alzheimer's detection and classification.

M.Evanchalin Sweetly and G. Wiselin Jiji [15] proposed an Alzheimer's detection technique based on Particle Swarm Optimization (PSO) and Decision Tree Classifier. In this proposed work, noise reduction is done using the Markov random filter and normalization is performed over the processed images. The feature extraction is performed over the normalized images using Principal Component Analysis (PCA) and moments. The extracted features are reduced using Particle Swarm Optimization and the Decision Tree Classifier is then used for classification of Alzheimer's Disease. The proposed approach has accuracy of 92.07% for similar work on SPECT images and accuracy of 86.71% for PET images.

Devi Sarwinda and Aniasi M. Arymurthy [10] proposed a computer aided system for detection of Alzheimer's disease based on feature selection approach for texture analysis using 3D MR images. The feature selection approach using the Kernel PCA is combined with the feature extraction of 3D descriptor. The feature extraction is done using Complete Local Binary Pattern of Sign and Magnitude from Three Orthogonal Planes. The Support Vector Machine (SVM) is used as the classifier. The authors claim that the proposed method gives an accuracy of 100% for classification of Alzheimer's disease and normal brain, whereas for Alzheimer's and MCI the proposed method gives an accuracy of 84%.

Lauge Sorensen et.al [13] tested the hypothesis that hippocampal texture is associated with early cognitive loss. T1 weighted MRI scans from ADNI database, independent datasets from AIBL and metropolit 1953 were used for the training purpose. It was found that hippocampal texture is superior to volume reduction as predictor of MCI-to-AD conversion in ADNI. Authors concluded that hippocampal texture has a higher differentiation capability between stable MCI and MCI-to-AD conversion as compared to hippocampal volumetry. They also concluded that there is a high correlation between texture and hippocampal FDG-PET uptake. Their findings support the hypothesis

that texture gives different information than volume and is more sensitive to early detection of AD.

Chetan Patil et.al [12] presented an approach to evaluate the utility of image processing on the Magnetic Resonance Imaging (MRI) scans to estimate the possibility of an early detection of AD. The hippocampal atrophy was considered for diagnostic tests for AD. T1 weighted MRIs were used for the purpose of image processing to evaluate atrophy. They demonstrated the applications of various image processing techniques such as K-means clustering, wavelet transform, watershed algorithm, including a customized algorithm implemented on the open source platforms, OpenCV and Qt. The region of interest was extracted using the boundary detection algorithms and the segmentation was done using the k-means clustering algorithm. The brain and hippocampal volume calculation was implemented. The authors claim that in case of Alzheimer's the overall brain volume is less as well as the difference between the grey and white matter is higher. The authors also claim that their proposed approach is useful to technical as well as medical community.

Mayank Agarwal and Javed Mostafa [11] described ViewFinder Medicine (vfM) as an application of content-based image retrieval to the domain of Alzheimer's disease and medical imaging. It was found that using their multi-level approach, the classification performance matched the best result reported in the medical imaging literature. Up to 87% of patients were correctly classified in their respective classes, giving an average precision of about 0.8. A relevance feedback function was added due to which the precision improved to 0.89. The vfM combines textual information with low level features for classifying and finding similar scans. Experiments were conducted to evaluate the system performance using the T1 weighted contrast enhanced MP-RAGE MR images. The first set of experiments were performed to estimate the efficiency of using the classification module in the system. The second set of experiments were performed to measure the accuracy of classification. To establish the classifier accuracy 10fold cross-validation was used. The DCT, DWT, LBP and other possible combinations were used to compare the classification accuracy and the classification accuracy with these models was contrasted with the fusion model. The authors claim that the performance using the LPB is

higher than DCT and DWT and the maximum accuracy using the fusion model is 86.7%. The authors also claim that the classification accuracy with the skull information removed is higher than the whole-brain images.

III. CONCLUSION

It is concluded from the survey that Alzheimer's detection techniques based on MRI scans have higher accuracy rate as compared to non-MRI based methods. Accuracy of almost 100% can be achieved for distinguishing between Alzheimer's and normal brain while using MRI based methods. Non-MRI based methods can achieve accuracy up to 92%. MRI based methods are more cost effective as compared to Non-MRI based methods such as PET and SPECT based methods. Also, capturing MRI scan has better response time as compared to PET & SPECT scans.

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