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Early Detection of MCI

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Abstract: ***Dementia is the brain disorder, that effects the mental cognitive function. Dementia has different stages. when the person is in the early stage they have short memory, losing or misplacing things, the person have more memory loss in moderate stage. During last stage patient completely depends on other for everyday activities. MCI has come to be recognized as an intermediate state of clinical impairment where an individual has mild cognitive symptoms but generally continue to function normally in the community. it is important to determine AD at an earlier stage which is Mild Cognitive Impairment (MCI). Toxic changes may start in the brain at the beginning stage of Alzheimer's disease. MRI Images are used to detect disease at the earlies stage. Wavelet Transform is applied on the MRI Images followed by any feature selection. Machine learning algorithm is used to make prediction. This paper goes through all those studies and techniques used by scientists to unravel the progression of Alzheimer's disease.***

Keywords: MRI, medical image compression, discrete wavelets, feature selection, Machine learning algorithm.

I. INTRODUCTION

Brain disorder is a disease which causes drastic changes in the brain structure. This may be causes due to mental stress or any other mental illness which leads to memory loss, that may occur at a stage of life. The brain disorder is also known as dementia. But there is one of the diseases which occurs to only old aged person, which causes person to lose his memory to such a extent that it affects the daily activities of that person and that disease is known as Alzheimer's Disease. There are many stages in this dementia, based on the structure of the brain [1]. Earlier stages of the disease can be treated with high accuracy, but as the stages shift to AD, it leads to incurable state of the person.

There are 3 stages for the disease. Cognitively Normal (CN), the second stage is Mild Cognitive Impairment (MCI), and the person in this stage can remain in the same stage or move to the next stage which is the final stage known as Alzheimer's Disease (AD). Mild cognitive impairment has been gestated as a disorder that occurs in between the normal cognizance and dementia, where Dementia describes a group of manifestation like influence the consciousness, intelligent and social crisis are enough to interfere with routine activities. This stage of the dementia is an uncertain stage, where a person may stay [2] or may progress further into dementia. As a result, prediction of the probability of mildly affected individuals developing Alzheimer's disease is increasingly indispensable. However, successful prediction of the ongoing stage of patient can offers to the opportunity for the possibility of disease-modify in therapies which intend to slow or prevent AD.

Notably, patient cannot change or convert from one brain disorder to another. As one gets diagnosed with normal performances over a long time after being in MCI stage, the liability of patients not suffering from AD being captured is increased by MCI ailment. Furthermore, although the concept of MCI seems to be broad, however amnesia changes based on the procedure used to describe various criteria.

There are changes like shrinking in the size of hippo-campus region which can detected on brain image capturing techniques like Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET), Functional Magnetic Resonance Imaging (fMRI), Electroencephalography (EEG) [3], etc. These different techniques provide different types of brain image that is captured. So, selecting a optimal technique for capturing the brain will lead to higher predictability of stages of the dementia.

This paper reviews on the better possible ways for detecting the stages of the disease with the help of Machine Learning. The review of hybrid classifier and 3D wavelet transform is discussed in the further section of this paper. The selection of features and optimising those features are explained in depth in this review paper.

II. LITERATURE SURVEY

A novel classification system was developed in [4] to differentiate between the different stages of AD, According to 3D MRI scanning. From the first step based on the project all the 3D Magnetic resonance images were pre-processed to convert into a balanced volumetric image. later, for the pre-processed image three-dimensional wavelet transform is applied for extracting co-efficient of wavelets. Further step is to apply principle component analysis (PCA) for feature reduction or also known as dimensionality reduction. On the basis of the feature reduced, the paper submitted about 9 classification procedures namely 3 specific classifiers as linear-SVM, kernel-SVM, and kernel-SVM trained by PSO with varying time coefficient of acceleration (PSOTVAC).

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This paper [4] validates the effectiveness and efficiency of using three-dimensional discrete wavelet transform.

In the paper by B A Sujathakumari et.al.[5], Using Magnetic Resonance Imaging (MRI) the authors have proposed an algorithm for detection of early stage of Alzheimer's disease that is (MCI)[5] .First, Magnetic Resonance Image scans are exposed to segmentation using the SPM tool available in MATLAB from which the gray-matter images are collected. 2D Dual-Tree Complex Wavelet Transforms was applied for the resulting images for feature reduction.

The wavelets obtained from the dual tree wavelet transform are then combined with the other personal information like whether the patient is male or female or considering the age of the patient and is passed onto a proposed classifier algorithm.

Another novel significant publication by Tang, Y.Lu and Yuan [6], where author proposes a 3 Dimensional scattering wavelet transform, that is used to filter the hyper-spectral image cube data using a series of wavelet decomposition, complex modulus, by implementing the local weighted averaging. Wavelet transform used has the scattering feature that captures the spectral-spatial information from the Magnetic resonance image for classification. In the classification step, a support vector machine (SVM) algorithm is used as a classifier which provides capability to intercourse with high-dimensional data.

A novel algorithm is proposed and developed [7] which identifies whether the patients are suffering from Alzheimer's disease or Mild Cognitive Impairment against the Healthy Normal [7]. 3D wavelet transform applied for extraction of feature and for feature reduction PCA is applied, which transforms the feature space into linearly variables which are uncorrelated. Linear SVM algorithm is used for classification purpose. To improve the efficiency of classifier additional data is considered.

A classification algorithm is planned [8] which provides a three-class classification approach, i.e. the classification of Alzheimer's patients among the normal patients using structural Magnetic resonance images. The first step involves obtaining of probability maps using the modulated gray-matter of T1-weighted Magnetic resonance images,[8]. 3D-DWT is applied on the five regions of brain in the second stage, and these regions are affected by AD. This step is used to obtain features for the further steps. In the last stage, Fisher's discriminant ratio is used to obtain minimum set of relevant features. Based on the values obtained for specificity, sensitivity and classification accuracy, the efficiency of the classifier algorithm is evaluated.

A paper by Farooq, Anwar, Awais and Rehman proposes a Deep convolutional neural network-based algorithm for the detection of AD and other stages that leads to AD using Magnetic resonance imaging. The diagnosis and prediction of Alzheimer's in elderly aged people is quite difficult and requires a highly discriminate feature representations for classification, as they have the similar brain patterns and pixel intensities in the MRI scans. To learn such feature representations of the MRI data, Deep learning techniques are used. In this paper, a four-way classifier [9] is implemented to differentiate late-MCI (LMCI), mild cognitive impairment (MCI), Alzheimer's (AD) and cognitively normal persons. Proposed system is implemented on the ADNI dataset with a high-performance graphical processing unit-based system and new state-of-art results are obtained for multiclass based classification of the Alzheimer's disease. The proposed technique results in a prediction accuracy of 98.8% with being the simplest of all.

A paper by K.R. Kruthika, H.D. Rajeswari discussed a Deep Neural Networks (DNNs), that improves the efficiency of classification and is applicable for Content Based Image Retrieval (CBIR). The paper [10] explores various methods based on CNN for Alzheimer Disease prediction by utilizing Magnetic resonance image (MRI) data, and DNN is used for AD detection. In the paper, they have proposed that use of point-capsule networks and CNN with previously trained 3D auto-encoder would improve the predictive performance of the system when compared with the deep CNN trained initially. The three-dimensional Capsule Network performs better than the 3D-CNN with autoencoder.

A paper published by Yang Wang, Xiaoqian Che & Siliang Ma explains a three-dimensional wavelet transform based on the bi-orthogonal refining ideas for Rician [11] noise removal. Due to de-lineating property of the wavelets, 3D wavelet transform is used to obtain the coefficients which provides the detailed and approximate information. The next step is using the lateral filtering on the coefficients which depicts approximate information to preserve the edge features of the MRI data. Finally, on applying the inverse on 3D wavelet transform on the selected sub bands, author has obtained with the denoised image at the end. In this method, the combined property will significantly reduce the blurring of image features which will aid for better accuracy in classification.

This paper [12] introduces a better algorithm based on 3D DWT which is used for analysing 3D MRI. The Developed algorithm consists of decomposition of the brain data using the 3D-DWT, weighted sub-bands or coefficients with intensity value of its own, and brain images reconstruction from the sub-bands obtained. This method does not use thresholding technique unlike classical DWT. Implementation Outputs were evaluated with signal related parameters. The results shown from this technique were compared with Median filter, Gaussian filter and 2D DWT. Weighted 3-D DWT was yielded with the lowest error rates.

A paper by D. Cheng and M. Liu explains about the machine-learning algorithm that has been studied for the analysis of multi-modality neuro-images in quantification, evaluation and diagnosis through computer (CAD) of Alzheimer's Disease. The work [13] explains a method to develop a multi-level neural networks (basically CNNs) to make machine learn and combine all the features for classifying among the subjects using brain scan images. In the beginning, the higher dimensional multi-level CNNs are designed to apply transform to brain content into close-packed high-level features for each modal value of the nii-image. Then, a two-dimensional neural network is cascaded to unit the distinctive features for image grading. This method can instinctively learn the collective features from magnetic resonance imaging and other brain scanned data for AD ranking. No set image segmenting like pre-processing techniques are applied on the brain images.

A journal [14], explains about the features to capture accurately on main AD-related variations from the anatomical brain structures, variations can be observed from regions of the brain like ventricles hippocampus shape or size, cortical thickness and brain volume which can be analysed from the 3D MRI data. This paper [14] is developed to predict the AD which uses the extensive three-dimensional convoluting neural network (3D-CNN). This algorithm can learn common features from the MRI data which captures AD biosignatures and makes machine alter to various data. 3-D network has Fully connected upper layers which are then refined for each function-specific and accurate AD organization.

A paper published by S. Vakili and M. KhaliliIn proposes an algorithm to compress the MRI data. The developed scheme explains, 3D-DWT [15] and set partitioning in hierarchical trees (SPIHT) coding, which are combined to attain effective remodel of brain image. To accomplish the objective, the boosting WT is utilized and is applicable using 3D DWT. SPIHT coding is used for determining the wavelet coefficient of large value from decomposed MRI image.

III. RESULTS

Early detection of MCI includes usage of Wavelets and Machine learning algorithm. MRI images are used as data source. With the implementation of 2D Wavelets and efficient algorithm accuracy of 97.25% can be obtained for the detection of MCI and 97.72% can be obtained for the detection of AD [4]. The output efficiency can be improved by using 3D wavelets and Hybrid classification algorithm.

IV. CONCLUSION

The survey on Alzheimer's Disease early detection gave an advantage of identifying and classifying the various stages in a brain related to shape changes in hippo-campus, corpus, callosum and various other parts related to nervous system. There are three stages before leading to dementia and they are CN (Cognitively Normal), MCI (Mild Cognitive Impairment) and AD (Alzheimer's Disease). Pre-processing of MRI of brain is a crucial process of the system for getting more accuracy on the prediction or detection of the AD stages. MRI is considered because it provides accurate visualization of anatomical structure of tissues of the brain and also the variations of the shape or size of the tissues can be easily analysed. 3D wavelet transform can be used to extract the required features and ICA to reduce the quantity of feature by concentrating on the region of interest. After feature extraction, various stages of the AD are classified using classification algorithm. The subjects can be classified based on these stages of the disease.

The review also shows that different algorithms in machine learning can be used as hybrid for the classification of the extracted features which are compatible with the 3D structure of the MRI. The wavelet transform was mainly used in all the survey papers for feature extraction and feature reduction of the MRI. For early detection, the region affected in the brain is identified from MRI image using 3D-DWT transform algorithm considering different feature combinations such as orientation, edge, texture and colour. 3D-DWT allows even distribution of the image processing.

To detect the Alzheimer's disease at the earliest stage using the MRI scan, Digital image processing can be used on the MRI of brain. For efficient detection of Alzheimer's, a hybrid classification algorithm needs to be developed which is trained to learn features capturing AD related tissues activity like shape of the tissue and predict Alzheimer disease using the MRI scans. The algorithm is pre-trained to capture variations of structural magnetic resonance image and the captured data is used to extract the imaging features from MRI. Alzheimer's disease can be more efficiently detected at the earliest stage using Wavelets and efficient classification algorithm.

This work helps in pMCI (Progressive MCI) and sMCI (stable MCI) detection at the time of screening and thus helping in diagnosis and slowing down the progression to Alzheimer's Disease. MRI-based analysis proposed can be a beneficial supplement to clinical diagnosis and prediction of AD.

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