Hierarchical Feature Extraction forEarly Alzheimer's Disease Diagnosis

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Abstract:- **There are different stages of Alzheimer's disease. In our paper we have proposed a method to detect those having mild cognitive impairment (MCI) which is at the early stage of Alzheimer's disease (AD). We have proposed a novel voxel-based hierarchical feature extraction (VHFE) method for the early alzheimer's disease diagnosis. Firstly, we have parcellate the whole brain into several regions of interest (ROIs). Then, the brain feature maps of each subjectmade up of the fetched voxels and are fed into the convolutional neural network (CNN) to learn the deeply hidden features of the brain. Finally, to test the efficiency of our proposed method, we test it with the subset of the database.**

Keywords: Alzheimer's, ADNI, fMRI, Deep-Learning, Featureextraction, Data Processing

INTRODUCTION

Alzheimer's disease is a neurodegenerative disease, it is very slow in the beginning but it catches pace with time. Although Alzheimer's disease is difficult to detect in the initial stages using MRI, groundbreaking advancements are done using PET scan images. Almost 1.60% of deaths in India occur due to Alzheimer's disease. In the research papers that we have accumulated, the majority of classification is done by looking at the accumulation of amyloid beta protein in the hippocampus. There are many machine algorithms used to classify or detect the stages. Some of them are Deep Learning which includes Back propagation algorithm, Convolutional neural network of Inception V3 architecture and so on.

In the United States of America approximately 5.8 million people who are 65 years or older ail from Alzheimer's disease. 60 % to 70 % of the total world population which is 50 million with dementia are said to have Alzheimer's disease. The onset of dementia is identified by symptoms which include forgetting conversations and recent events. As the disease advances the person with Alzheimers will lose the ability to perform day to day tasks and will develop memory impairment which can be severe. Conditions of patients taking medications might improve slightly or progression of symptoms might be slowed down. As a result of this the patient might have a sense of independence and their abilities to perform functions can be maximized. There have been many camps and services and programs which are being held all over the world to provide some comfort to the Alzheimer's patients. Currently no treatment for Alzheimer's disease has been found that can cure Alzheimer's disease or alter the process of disease in the brain. Dehydration, infectionwhich can lead to death and malnutrition are some of the complications which can occur due to severe loss of brain function.

Functional magnetic resonance imaging (fMRI) measures the small changes in blood flow that occur with brain activity. It may be used to examine the brain's functional anatomy, (determine which parts of the brain are handling critical functions), evaluate the effects of stroke or other disease, or to guide brain treatment. fMRI may detect abnormalities within the brain that cannot be found with other imaging techniques.

MATERIALS AND METHODS

Datasets: We have chosen two datasets from the ADNI database to confirm this framework proposed in the research. ADNI is a longitudinal multicenter study designed to develop clinical, imaging, and biochemical biomarkers for the early detection and tracking of AD.

All the required subjects in our research has been selected from the ADNI database. We have chosen two datasets (ADNI-1 and ADNI-2) here to verify the

method proposed in this article. The ADNI database is been composed of three different stages of subjects: normal controllers (NC), mild cognitive impairment (MCI), and AD.

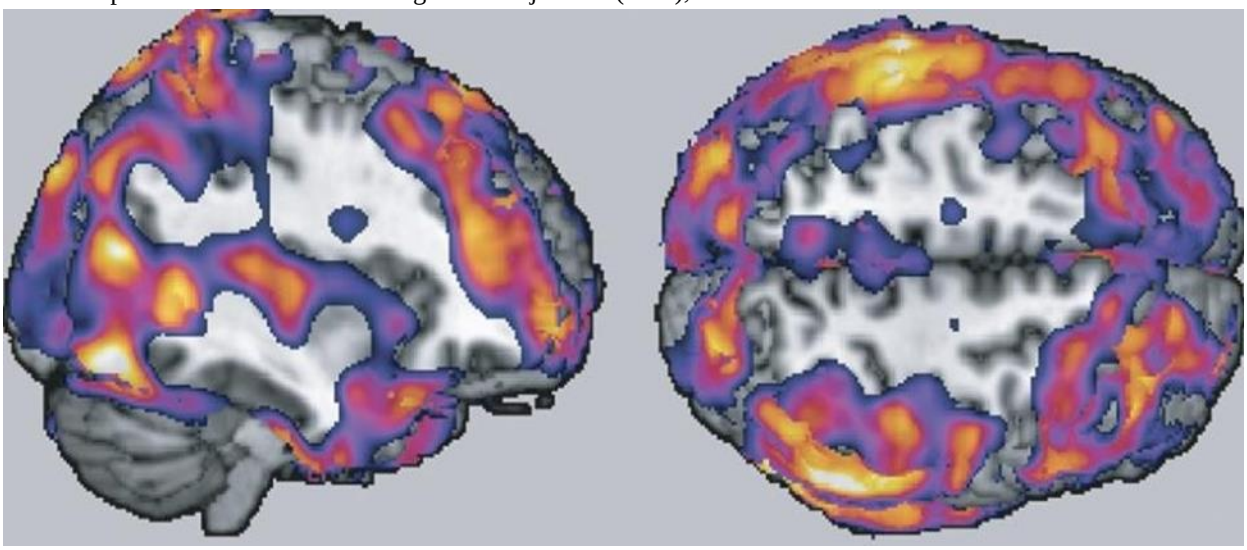

Fig. 1. Brain regions showing reduced CMRglc on FDG-PET in cognitively normal individuals with a maternal family history of AD.

a) Pre-existing modeling techniques:

Pet Scan: Positron emission tomography is a functional imaging technique that uses radioactive substances knownas radiotracers to visualize and measure changes in metabolic processes, and in other physiological activities including blood flow, regional chemical composition, and absorption.

MRI: Magnetic resonance imaging is a medical imaging technique used in radiology to form pictures of the anatomy and the physiological processes of the body. MRI scanners use strong magnetic fields, magnetic field gradients, and radio waves to generate images of the organs in the body.

X-Ray: An X-ray, or, much less commonly, X-radiation, is a penetrating form of high-energy electromagnetic radiation. Most X-rays have a wavelength ranging from 10 picometers to 10 nano-meters, corresponding tofrequencies in the range 30 petahertz to 30 exahertz and energies in the range 145eV to 124 keV.

EEG: Electroencephalography is a method to record an electrogram of the electrical activity on the scalp that has been shown to represent the macroscopic activity of the surface layer of the brain underneath. It is typically non- invasive, with the electrodes placed along the scalp.

FMRI: Functional magnetic resonance imaging also known as functional MRI measures the brain activity by detecting changes associated with the flow of blood. This technique relies on the fact that cerebral blood flow and neuronal activation has been coupled. When the area of the brain is in use, blood flow to that region also increases.

Advantages of using fMRI: The biggest advantage of fMRI is that it does not use radiation like X-rays, computed tomography (CT) and positron emission tomography (PET) scans. fMRI has practically no risks. It can evaluate brain function safely, without invasively and effectively.

fMRI is easy to use, and the images it generates are of very high resolution (as detailed as 1 millimeter). Thus the images that comes from the database will be relatively easier to process using other techniques i.e. Deep Learning.

Image Preprocessing: In order to verify the validity of this method, we have selected subjects form two different subsets from the ADNI database. Then a strictly pre- processing pipeline has been implemented. The T1 imageswere normalized to the template space and then segmented into gray matter (GM), white matter (WM) andcerebrospinal fluid (CSF). We have pre-processed all the data with voxel-based morphometry (VBM8) [8] which is a neuroimaging

analysis. Then, we have used AAL [10] tosegment the volume into several regions of interests. Afterthrowing away the regions that belongs to the cerebellar, we got 90 regions for every subject.

PROPOSED METHOD

Here, we have proposed a VHFE method to mine the inner region abnormalities in structural MRI images. The data processing flow chart is shown in Figure1. At first, we have pre-processed all the structural MRI images. Then we picked all the voxels in each region and fed theminto the matrix respectively. The ROIs were parcellated based on the AAL template and results in there being different number of voxels in each region. We used the Kendall's correlation coefficient to select the most non relevant voxels between the different groups of subjects asthe feature of the first stage. Approximately fifty voxels were selected from each region. Then all the voxels of each region makes the map of whole brain.

The brain map was then fed into CNN to learn the deep hidden features of the inner or between subjects as the feature of the second stage. Finally, the result of a softmaxclassifiers used to evaluate the efficiency of this proposed framework.

CONCLUSION

In this paper, the different image processing techniques, from where the dataset is downloaded, features extracted, and different image classification techniques were discussed. The development of a classification technique for Alzheimer's disease has to be developed considering all the metrics such as accumulation of amyloid protein, Tau-protein, cortical thickness, gray matter density and shrinking of ridges. This shows us satisfying classificationof alzheimer's disease. We have used fMRI images toclassify the data from the ADNI database and we areimplementing deep learning techniques for model training and feature extraction. More research effort should bedevoted on how to increase specificity and sensitivity.This can be done combining many classification metrics.

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