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MULTIMODAL FEATURE EXTRACTION FOR THE DIAGNOSIS OF ALZHEIMER'S DISEASE

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Abstract: - Alzheimer's is a degenerative disease, where dementia symptoms slowly worsen over time. Brain cell connections, the cells themselves degenerate and die, slowly destroying memory and other mental functions. Mild Cognitive Impairment (MCI), the early stage of Alzheimer's (AD), is used for clinical trials. Different imaging techniques have been used to help diagnose the disease. A few of them are magnetic resonance imaging (MRI), computed tomography, positron emission tomography. Each of these offers something different towards the detection and possible treatments for Alzheimer's disease. The primary role of MRI image in the diagnosis of AD is the assessment of volume change in characteristic locations which can yield a diagnostic accuracy of up to 87%. The special PET scans use radioactive tracers to highlight amyloid protein plaques in the brain, which are a hallmark of AD. These features from MRI and PET images are extracted for diagnosis. Fusion of these features can improve the accuracy of diagnosis. Fusion can be done using Pulse coupled neural network (PCNN). A PCNN is a two dimensional neural network. Due to some defects of original PCNN for data fusion, the dual channel PCNN is used to implement multimodal image fusion. This method gives additional features for better diagnosis of AD.

Keywords: MRI features, PET features, fusion, PCNN

1. Introduction

Alzheimer's is a deadly disease, where dementia symptoms slowly worsen over a number of years. Brain cell connections and the cells degenerate and die, gradually destroying memory and other mental functions. In the early stages, the memory loss is mild, but with late stage AD, individuals lose their ability to carry on a conversation and respond to their environment. The current Alzheimer's treatments cannot stop Alzheimer's from progressing, they can slow the worsening of symptoms and increase the quality of life for those with Alzheimer's.

Alzheimer's Disease(AD) will become a global burden over the coming decades. Neuroimaging techniques, such as magnetic resonance imaging (MRI), computed tomography (CT) and positron emission tomography (PET) have been widely used in the assessment of AD, along with other non-imaging biomarkers.

MRI image can detect brain abnormalities related with mild cognitive impairment (MCI) and can be used to tell which patients with MCI may eventually develop AD. In the early stages of AD, an MRI scan of the brain may be normal. But in later stages, MRI image may show a decrease in the size of different areas of the brain.
Positron emission tomography (PET) provides images of brain activity based on oxygen consumption, blood flow, or glucose use. These will be different for patients with AD. But sometimes even these scans cannot reveal the microscopic changes in brain tissue that characterize Alzheimer's disease. Thus, they cannot identify the disease with certainty.

Several methods have been proposed for AD diagnosis. In 2010 Margarida Silveira, Inst. de Sist. e Robot., Inst. Super. Tecnico, Lisbon, Portugal, Jorge Marques introduced brain imaging as a biomarker for Alzheimer's disease [5]. They said that in the case of functional imaging such as PET, further investigation is needed to determine their ability to diagnose AD, at the early stage of Mild Cognitive Impairment (MCI). PET images of the AD Neuroimaging Initiative (ADNI) database were used for the diagnosis of AD and MCI. Boosting classification method, a technique based on a mixture of classifiers, that performs feature selection concurrently with the segmentation thus is suited to high dimensional problems.
In 2011 C. Davatzikos et al introduced Prediction of MCI to AD conversion, using MRI, CSF biomarkers, and pattern classification [2]. MRI patterns were examined along with cerebrospinal fluid (CSF) biomarkers in serial scans of AD. In 2012 R. Chaves;J. Ramírez; J. M. Górriz; I. A. Illán proposed CAD system[8] for the AD detection with PET biomarker analysis. The ADNI dataset is used for testing and a comparison is conducted in two different sets: normal versus AD or normal versus Mild Cognitive Impairment (MCI) subjects. 3D Regions of Interest (ROI) are obtained with an estimation method for both of the biomarkers considered independently or in a combined way without repetition. These ROIs are used as input for an Apriori algorithm in order to obtain ARs from controls. Classification is performed taking into account the percentage of the verified rules by each subject.
In 2013 Ben Ahmed,.O. , Benois-Pineau.J, Ben Amar.C , Allard, M. introduced early AD detection with bag of visual words and fusion on structural MRI[1]. In that they recognized AD in structural MRI using visual similarity. Again in 2013 S. Liu et al., proposed Neuroimaging biomarker based prediction of AD with optimized graph construction [9]**.** The prediction of AD severity is very much important in AD diagnosis and patient care, especially for patients at an early stage when the clinical intervention is most effective. To achieve accurate diagnosis of AD and identify the persons who have high risk to convert to AD, they proposed an AD severity prediction method based on the MRI predictors analyzed by the region-wise atrophy patterns.
In 2015 Chetan Patil,M G Mathura.S. Madhumitha,S Sumam David evaluates the utility of image processing on MRI to estimate the possibility of early detection of AD. It demonstrates the applications of image processing techniques such as K-means clustering, wavelet transform, watershed algorithm and a customized algorithm tailored for the specific case. It was implemented on the open source platform that facilitates the implementation and utility of the developed products in the hospitals without requiring any of the proprietary Softwares. The results obtained from the project could help the analysis to detect AD at an early stage.
Again in April 2015 Siqi Liu,Sidong Liu, Weidong Cai, Hangyu Che, Sonia Pujol, Ron Kikinis, Dagan Feng *i*ntroduced multimodal fusion for early diagnosis of AD[12]. MRI scan and PET are used for diagnosis. It is very difficult to detect the disease from the early stages. Features from MRI and PET are extracted and fused for classification using deep learning. Classification is done separately using MRI image, PET image. The class obtained from both can be compared to the result of multimodal fusion. If all the methods give same result ,the diagnosis can be considered as accurate.
The rest of the paper is organized as follows. Methodology is given in section 2. Conclusion is given in section 3.

2. Methodology

Block diagram of the proposed system is given in figure. 1. MRI and PET data are collected. Preprocessing is done to remove the noise which will affect the accuracy of diagnosis. MRI and PET image features which are required for diagnosis are extracted. These features are then fused.

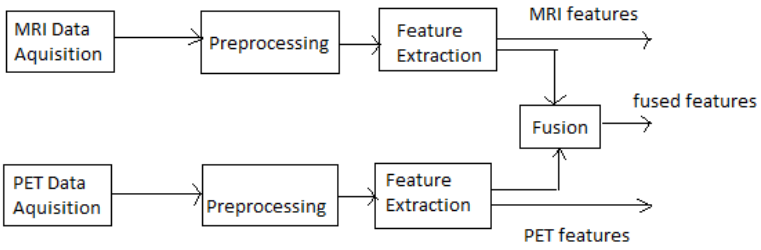

Figure 1: Block Diagram.

2.1 Data Acquisition

Dataset is acquired from ADNI database. MRI and PET images of different persons are taken and are added to training database. The features of the test image can be compared with the features of images in the database for disease diagnosis.

2.2 Preprocessing

Getting an effective method of removing noise or blur from the images, before processing them for further analysis is a great challenge for the researchers. The noise can degrade the images at the time of capturing or transmission of images. Prior to applying image processing tools to an image, noise removal from the images is done at highest priority. Many algorithms are available, but have their own merits and demerits. The kind of the denoising algorithms to remove the noise depends on the types of noise present in the image.

Patch based Singular Value Decomposition (SVD) is a good method for denoising images affected with all types of noise. The images are divided into square patches of appropriate size and then SVD is applied. After decomposition low rank approximation of singular matrix is taken under the assumption that noise is present in the lower singular vectors. Then the patches are aggregated to obtain the Denoised image. Decreasing the patch size performance of denoising can be improved.

2.3 MRI Feature Extraction

MRI uses a strong magnetic field, radio frequency (RF) pulses and a computer to produce pictures of organs, bones, soft tissues and all other internal body structures. MRI can detect brain abnormalities associated with MCI and can be used to predict which patients with MCI may gradually develop AD. In the early stages of AD, an MRI scan of the brain may be usually normal. In later stages, MRI shows a decrease in the size of different areas of the brain. MRI images of normal brain and AD brain are shown in figure 2.

Some important features has been extracted as Entropy, GLCM feature, Moment features, area, mean, standard deviation, correlation coefficient features has been calculated. These features can be compared with features of images in training data base.

2.4 PET Feature Extraction

Positron emission tomography (PET) provides images of brain activity based on oxygen consumption, blood flow, or glucose use. These techniques can help diagnosis by revealing defects common in Alzheimer's disease that is distinct from findings for other dementias, such as front or temporal lobar degeneration and dementia with Lewy bodies. PET images of normal and AD brain are shown in figure 3.

The red color in the PET image shows brain activity. When affected with AD, the activity reduces and the red colored area is reduced. By using Region of Interest biomarkers these area can be detected and then features are extracted. But, even these scans cannot reveal the microscopic changes in brain tissue that diagnose Alzheimer's disease. Thus, they can't identify the disease with certainty.

2.5 Fusion

MR and PET features are concatenated for shared representation. Fusion is done using Pulse Coupled Neural Network (PCNN). A PCNN is a two dimensional artificial neural network. Each neuron in its network relates to one pixel in the input image, receiving its corresponding pixel intensity as an external stimulus. Each neuron also connects with the neighboring neurons, and receives local stimuli from them. The external and local stimuli are combined in an internal activation system, which collects the stimuli until it exceeds a dynamic threshold, resulting in a pulse output. Through iterative computation, PCNN neurons produce pulse outputs. Due to some defects of original PCNN for data fusion, the dual channel PCNN is used to implement multimodal image fusion. Two parallel feature matrices are directly input into PCNN. The weighted coefficients of PCNN are automatically adjusted.

3. Conclusion

This paper explains the methods for diagnosis of AD. Features from structural MRI can detect the possibility of AD. Features based on brain activity provided by PET also can be useful. In the earlier stages, these features can confuse possibility of AD with other dementia. So instead of using single modality features, fusing MRI and PET features, the accuracy of diagnosis can be improved.

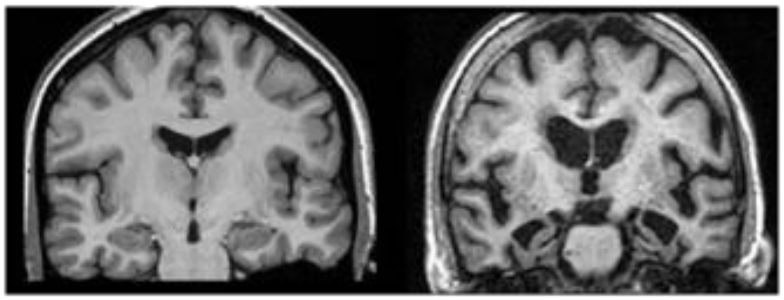

Figure 2: MRI brain images. Healthy (left) and AD (right)

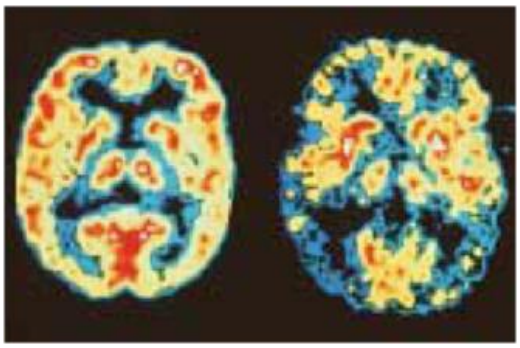

Figure 3: PET brain images. Healthy (left) and AD (right)

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