Overview on segmentation and classification for the Alzheimer's disease detection from brain MRI

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Abstract— *The several studies projected that approximately 115 million people will be affected from Alzheimer disease (AD) worldwide by the year 2050. Early detection of AD is important so that preventative measures can be taken place. The human brain Magnetic resonance imaging (MRI) data have been used to detection of AD. Due to the variation and complexity of brain tissue the MRI data analysis for detection AD is considered as difficult process. The objective of this study is to explore the recent published segmentation and classification techniques and discuss the usability in AD detection of the human brain MRI data.*

Keywords — *Alzheimer disease, MRI Data, Medical Image, Segmentation, Classification.*

I. Introduction

The world's elder population comprises nearly 900 million people [1]. As per the census 2011, India is home to more than103 million people aged 60 years and older [2]. The chronic diseases become more prevalent with the increase of age and a trend exacerbated by changes towards lifestyles and behaviours that predispose towards them [1]. Alzheimer's disease (AD) is globally recognized as the most common form of dementia affecting seniors age 65 and over [3] [4]. The several studies projected that approximately 115 million people will be affected worldwide by the year 2050 [3]. AD causes nerve cell death and tissue loss throughout the brain, resulting to brain tissue shrinking and larger ventricles. When AD is suspected, the diagnosis is first confirmed with behavioural assessments and cognitive tests and often followed by a brain scan which can show whether certain changes have taken place in the brain [3]. There are a number of different types of brain scan. The most widely used are computerised tomography (CT) and magnetic resonance imaging (MRI) [5].

Medical imaging is the technique and process of creating visual representations of the interior of a body for clinical analysis and medical intervention. Medical image processing and machine learning tools can help neurologists in assessing whether a subject is developing the Alzheimer disease. The image segmentation and classification is an important task in MRI data analysis for the AD detection. Image segmentation is intended to partition images into well-defined regions, where each region is a set of pixels that share the same range of intensities, the same texture or the same neighbourhood. The purpose of segmenting images is to remove unwanted information in order to locate meaningful objects from the processed images. The classification is used to produce meaningful patterns from raw data, classify them into different groups based on their characteristics and predict new patterns based on previous knowledge. Due to the advancement of technology in the imaging the various techniques for image segmentation and classification have been reported. The objective of this paper is to study the recent published segmentation and classification techniques and discuss the usability in AD detection of the human brain MRI data.

The organization of the paper is as follows. Section 2 presents the methodology for required to analyse and predict the AD from the MRI, Section 3 reviewing on the existing on the recent segmentation and classification techniques applied for the AD detection, conclusion and future work will be reported in the section 4.

II. Methodology

The process of applying to analyse and classify the Alzheimer's disease is depicted in Fig. 1. The first step is collecting or access the MRI data. There are several organizations which provide access the MRI data of Alzheimer Disease for the research purpose. The researchers are using the Alzheimer's disease Neuroimaging Initiative Database (ADNI) [6] [7] and Open Access Series of Imaging Studies (OASIS) Data set [8]. The second step is data preparation and data pre-processing. In this step the non relevant information is required to remove and the data is reoriented for easier interpretation. In Step 3, image segmentation is performed on the pre-processed 3D MRI Neuro-imaging brain data using different techniques in order to extract the ventricle's area. The image segmentation techniques are classified in various categories on the basis of their process in the image processing. The thresholding Edge detection, Region growing, watershed, texture image segmentation techniques were utilized for the MRI data segmentation. The attributes are selected and In Step 4, attribute extraction, such as surface area, centre of gravity, average intensity and standard deviation in order to analyse the shape of the ventricle. The classification/prediction method in order to assess whether the patient is developing the Alzheimer's disease (AD) is performed by utilizing the machine learning algorithms. In this regards, suitable machine learning algorithm is selected and training of algorithm is performed for model construction. The trained model is evaluated with the test data set. This process is performed until the acceptable result is not obtained.

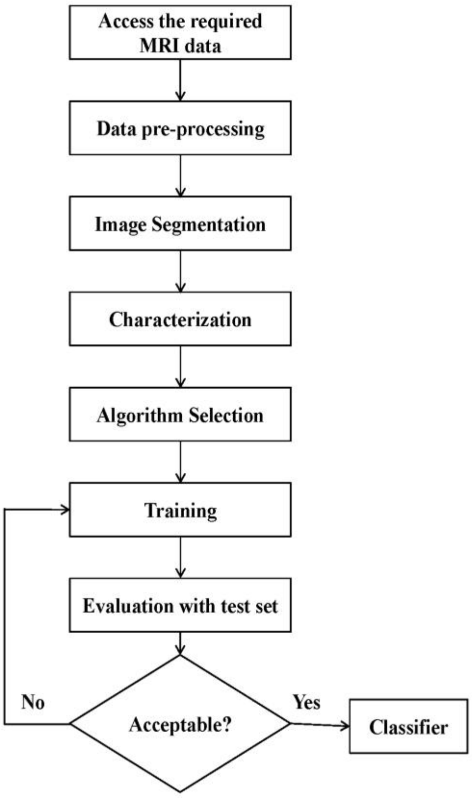

Fig. 1 The process of system implementation

III. SEGMENTATION AND CLASSIFICATION TECHNIQUES FOR ALZHEIMER'S DISEASE

Yang et al. [9] used independent component analysis based classification of Alzheimer's MRI data. The normalized brain images are decomposed into MRI basis functions and the corresponding coefficients using the FastICA algorithm and then, the separated coefficients are fed into an SVM-based classifier for diagnosis of individuals with or without AD.

Casanova et al. [10] illustrated using sMRI data from the Alzheimer Disease Neuroimaging Initiative (ADNI) clinical database and applied large scale regularization approach based on penalized logistic regression to automatically classify sMRI according to cognitive status. They performed their study on sMRI data from 49 cognitive normal and 49 patients' subjects. They reported that both gray matter (GM) and white matter (WM) carry useful information for classification of cognitively normal control and Alzheimer disease sMRI images, producing high levels of accuracy, sensitivity, and specificity.

Sweety and Jiji [11] used particle swarm optimization and decision tree for the AD detection. Features such as eigen brain, eigen vectors, mean, standard deviation, variance, skewness, kurtosis, area, perimeter, eccentricity were calculated from MRI Images and quantitative measures are derived.

Zhang et al. [12] proposed eigenbrain and machine learning method for the detection of AD using 3D MRI scan data. This method achieved high accuracy 92.36±0.94 and they reported eigenbrain method is effective in AD subject prediction and discriminant brain region detection in MRI scanning.

Lorenzi et al. [13] proposed statistical modelling of non-local intensity correlations for the multimodal image analysis in AD. The results reported that non-local approach better than classical PM-based multimodal local correlation models in terms of modelling accuracy and predictive power. The ensemble of the reported results proves the ability of the proposed PLSR in capturing biologically relevant features, and in generalising to unseen structural imaging data of T1-MR scans.

Beheshti and Demirel [14] proposed probability distribution function (PDF) based classification for the AD detection. This study deals with statistical patterns extracted from structural MRI (sMRI) data on four systematic levels; voxel-based morphometric (VBM) technique with 3-Tesla 3D T1-weighted MRI for global and local differences of gray matter, feature extraction based on the voxel clusters detected, utilized the PDF of the VOI to represent statistical patterns of the respective high-dimensional sMRI sample and SVM classifier was applied.

Zang et al. [15] proposed a landmark based feature extraction method and used support vector machine (SVM) classifier for fast AD diagnosis. This technique does not require nonlinear registration and tissue segmentation. 85% accuracy for the AD classification is reported in this study.

Sarwinda and Bustaman [16] introduced as a 2D and 3D feature extraction descriptor. The principal component analysis (PCA) and factor analysis are used as feature selection and SVM classifier was used for the classification.

Beheshti et al [17] applied feature ranking and classification error for the detection of AD from Structural MRI. The voxel based morphometry technique was used to compare the gray matter of AD patients and health control. The raw features are ranked using statistical dependency (SD), information gain (IG), mutual information (MI), Pearson's correlation coefficient (PCC), t-test score

(TS), Fisher's criterion (FC), and the Gini index (GI). The SVM method was utilized for the classification.

IV. CONCLUSIONS

With the advance of computational intelligence and machine learning techniques, computer-aided detection attracts more attention for AD detection. It has become one of the major research subjects in medical imaging. In this study, we reviewed current studies of the different segmentation, feature extraction and classification algorithms.

Future research could focus on investigating other regions that might be more affected, coupled with appropriate features set in order to characterize the new regions. It is suggested to focus on reducing the cost and improving the precision of the algorithms by using more intelligent algorithms such as adaptive seeds initialization and image registration in order to get initial contour for the active contour segmentation method. It is also suggested to focus on the enhancement of the classification algorithms and adding more data to the system.

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