Chapter 60

Classification of Brain MR Images Using Corpus Callosum Shape Measurements

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ABSTRACT

The corpus callosum is the largest white matter structure in the brain, which connects the two cerebral hemispheres and facilitates the inter-hemispheric communication. Abnormal anatomy of corpus callosum has been revealed for various brain related diseases. Being an important biomarker, Magnetic Resonance Imaging of the brain followed by corpus callosum segmentation and feature extraction has found to be important for the diagnosis of many neurological diseases. This paper focuses on classification of T1-weighted mid-sagittal MR images of brain for dementia patients. The corpus callosum is segmented using K-means clustering algorithm and corresponding shape based measurements are used as features. Based on these shape based measurements, a back-propagation neural network is trained separately for male and female dataset. The input data consists of 54 female and 31 male patients. This paper reports classification accuracy up to 92% for female patients and 94% for male patients using neural network classifier.

INTRODUCTION

Dementia is an old age neurological syndrome that disturbs human being memory, thinking and the daily actions. There are about 47.5 million of people with dementia [WHO], and it is expected to be doubled by 2030 ("World Health Organization," 2015).The old age care may be improved by providing additional care, once dementia is detected in early stage. Magnetic Resonance Imaging (MRI) technique has proved to be important for studying brain structures and for diagnosis of diseases related to brain. With the increase in life expectancy and degradation of quality of life, these brain disorders have become serious concern from past few decades. Corpus callosum (CC) is the largest white matter

structure in the brain which connects the two cerebral hemispheres with millions of fibers crossing in between them and controls the communication between various parts of the brain. CC is found to be an important biomarker for diagnosis of various brain disorders such as Alzheimer's disease, Multiple Sclerosis, Autism, Dyslexia and Hydrocephalus, etc.(Elnakib et al.,2012; Hurley et al., 1999; Long & Wyatt,2010**;**He et al., 2008). It has been investigated that most of the neurological disorders have their impact on anatomical structure of CC (Elnakib et al., 2012; Hallum et al., 2010; Prabhakar & Porkuma-ran, 2012). Segmentation of corpus callosum from mid-sagittal MR images has important applications in research since anatomical structure of CC is shown to be correlated to age, sex and neurodegenerative diseases (Yokota et al., 2005; Witelson, 1989).

Dementia MRI data have shown the importance of CC features as important classification parameters to classify normal (non-demented) and demented patients (Hensel et al., 1990; Patil & Yardi, 2012). It has been investigated that dementia patients tend to have reduced CC size as compared to healthy individuals (Hallam et al., 2008). A research has been carried out to find the most discriminating CC features between the two groups (Hensel et al., 1990). Since the accurate classification depends upon the extracted features and quality of CC segmentation, various algorithms have been proposed for 2D and 3D segmentation CC (Adiya et al., 2013; Li et al., 2013; Lundervold et al., 1999). Morphological and textural parameters of CC are found to be the discriminating factors for classifying dementia patients from normal patients (Haralick, 1979; Hensel et al., 1990). Support Vector Machine, Multilayer Perceptron, Neural Network are used as classifiers for detection of dementia from MR images (Patil & Yardi, 2012;Kloppel et al., 2008;Zhang et al.,2014). One work reported 95% classification accuracy for OASIS data with the use of multilayer perceptron classifier (Patil & Yardi, 2012). Another work uses neural network classifier and reported 83% classification accuracy with the same data (Gavadia et al., 2011). The use of SVM classifier for classifying dementia reported 96% of accuracy (Kloppel et al., 2008). The uses of classifiers like, learning vector quantization, radial basis function, and probabilistic neural network are also reported in previous work with classification accuracies up to 83% (Savio et al., 2009). Studies on dementia classification suggest that there is scope for the improvement in classifier accuracies by extracting other interesting features of CC.

In this paper, the segmentation of CC is performed using K-means Clustering Algorithm (Bhalerao & Sampathila, 2014) and shape value measurements of CC are used to design the feature vector and the Back-Propagation Neural Network (NN) classifier is trained (Riedmiller & Braun, 1993). The analysis is performed separately on both male and female patients. MR images of male as well as female data are segmented using K-means algorithm and the shape value measurements are calculated for each CC and then Classifier performance is analyzed for both the genders.

METHODOLOGY

The MATLAB based tool is developed for dementia detection ("MATLAB, "n.d.). The OASIS MR Image database for dementia is considered for analysis, which is freely available with agreed terms. The dataset consists of a longitudinal collection of 85 patients aged from 69 to 90, which include both male and female patients ("Oasis Brain MRI database," n.d.). All the subjects are right handed and for each patient T1 weighted MRI scans are obtained during multiple sessions and the first session data is considered for this study. The images are already preprocessed to reduce any artifacts, acquisition problems and processing errors (Marcus et al., 2010); hence all the images are directly considered as input to the segmentation algorithm. The stages for the detection of dementia using MR images are described in Figure 1.

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