Chapter 3
Statistical Features-Based Diagnosis of Alzheimer’s Disease using MRI

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ABSTRACT

Early detection of Alzheimer’s Disease (AD), a neurological disorder, may help in development of appropriate treatment to slow down the disease’s progression. In this chapter, a method is proposed that may assist in diagnosis of AD using T1 weighted MRI brain images. In the proposed method, first- and second-order-statistical features were extracted from multiple trans-axial brain slices covering hippocampus and amygdala regions, which play a significant role in AD diagnosis. Performance of the proposed approach is compared with the state-of-the-art feature extraction techniques in terms of sensitivity, specificity, and accuracy. The experiment was carried out on two datasets built from publicly available OASIS data, with four well-known classifiers. Experimental results show that the proposed method outperforms all the other existing feature extraction techniques irrespective of the choice of classifier and dataset. In addition, the statistical test demonstrates that the proposed method is significantly better in comparison to the existing methods. The authors believe that this study will assist clinicians/researchers in classification of AD patients from controls based on T1-weighted MRI.

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INTRODUCTION

Availability of various medical imaging modalities namely magnetic resonance imaging (MRI), functional MRI, X-ray, computed tomography, positron emission tomography and single photon emission computed tomography allows in-depth study of anatomy and functionality of human body. In this context, analyses of anatomical brain structures using MRI have become increasingly common for diagnostic purposes and identification of disease progression.

Structural MRI is a non-invasive imaging technique with no side effects of harmful rays. It provides extensive detail about the soft tissue anatomy of the brain. Early detection of subtle structural brain changes could help in development of appropriate treatment and slow down disease progression. However, detection of brain atrophy by visual inspection of MR images is very difficult and time consuming. Moreover, it relies on the expertise of clinicians and lacks the automated technique.

Computer-aided image analysis for studying anatomical brain MR image differences is becoming increasingly important for diagnosis of dementia. Alzheimer’s disease (AD) is the most commonly found neurological disorder and common cause of dementia among elderly persons. It causes mental disorder and disturbances in brain functions such as memory, language skills, and perception of reality, time and space.

Many research works have utilized 2D transaxial MRI brain slices to distinguish AD from controls. Bagci & Bai (2007) extracted features using gabor transform, a special variant of short time fourier transform (STFT), which has selective frequency and orientation properties. It extracts both frequency and space information from a non stationary signal with the use of a fixed size window. Unlike Gabor, discrete wavelet transform (DWT) allows analysis of a signal at various levels of resolution which is utilized for feature extraction in the research works (Chaplot, Patnaik, & Jagannathan, 2006; Dahshan, Hosny, & Salem, 2010). Dahshan, Hosny, & Salem (2010) used principal component analysis to reduced a large number of features obtained using DWT. Maitra & Chatterjee (2006) determined a smaller feature set of size 6 using slantlet transform (ST), a variant of DWT. ST and first-order statistics are used to extract feature set of size 6 by Aggarwal, Rana, & Agrawal (2012a). Aggarwal, Rana, & Agrawal (2012b) utilized first and second order statistics (FSOS) to extract a reduced set of relevant features to distinguish AD from controls. Their experimental results demonstrated the superior performance of FSOS in comparison to the state-of-the-art methods based on 2D slices.

Although analysis of 2D slices is not computationally intensive, it may lose relevant information present in neighboring slices. In order to overcome this problem, research community used 3D brain volumes for classification of AD and controls. Kloppel et al. (2008) proposed approaches based on gray probability maps of 3D volumes of whole brain and volume of interest. However, the size of the feature vector so obtained is large. Hence, it suffers from the curse-of-dimensionality (Bellman, 1961) as available number of samples is small and number of features to represent it is large. The research works (Lao, Shen, Xue, Karacali, Resnick, & Davatzikosx, 2004; Magnin, et al., 2009; Ye, et al., 2008) conducted classification with the help of a labeled atlas. However, this predefined atlas might not be specifically intended to study AD patients. 3D based analysis of MRI brain provides better performance in comparison to 2D based analysis at the cost of computational complexity.

Motivated by the research work (Aggarwal, Rana, & Agrawal, 2012b) and utilizing benefits of both 2D and 3D based approaches, a three-step method is proposed in this chapter. In first step, relevant slices from hippocampus and amygdala, which are good marker to distinguish AD from controls, are considered. In second step, features are extracted using FSOS from each slice. In third