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MRI brain tissue classification using unsupervised optimized extenics-based methods☆

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ABSTRACT

MRI has been a rather important imaging technique in clinical diagnosis in recent years. In particular, brain parenchyma classification and segmentation of normal and pathological tissue is the first step of addressing a wide range of clinical problems. Extenics-based methods are applied in this study for MRI brain tissue classification. Initially, the standard deviation target generation process is employed to select the center point of the extenics-based correlation function without supervision. Then particle swarm optimization is used to modify the extenics-based correlation function. In subsequence, the modified extenics-based correlation function is employed to perform classification using individual images to present the gray matter, white matter and cerebral spinal fluid in the brain. Therefore the proposed method reduce the burden of physicians from huge amounts of multi-spectral information in MR images to make diagnostic work more efficient and more accurate.

1. Introduction

Magnetic resonance imaging (MRI) [1] is conducted by placing the human body in an even, static magnetic field more powerful than the earth's magnetic field by ten thousand fold and radio wave pulses are released to create resonance in the hydrogen atoms in human body water to generate magnetic moment signals and alter the echo signals from the magnetic field to be calculated with computers to form images of human tissue sections. There is no radiation and clinical experiments performed over the years have proven that it is harmless to human bodies. In addition, it also has the advantages of being non-invasive, multi-directional, having high recognition rates and capable of operating with multiple parameters. Moreover, using different frequencies to scan the same section can obtain different intensity features which are then run through powerful imaging sequence variations to provide huge amounts of tissue information. Therefore, it has been an indispensable instrument in clinical diagnosis and medical research in the past years.

In an era where medical imaging technology continues to evolve, an exploration into the human body has made great advances. Since MRI was invented, research projects in related fields have produced six Nobel Prize winners. MRI has indeed pushed medical research to a new milestone and guided clinical diagnosis into the realm of digital technology. Today, medical personnel can adopt medical image processing and compression techniques to shorten the time needed to interpret medical images. They are able to analyze and study the causes of diseases more efficiently and increase the accuracy and objectivity of diagnosis. Consequently, the quality of medical care is greatly upgraded and waste of resources is improved. Without doubt, MRI has its value in medical research and clinical diagnosis.

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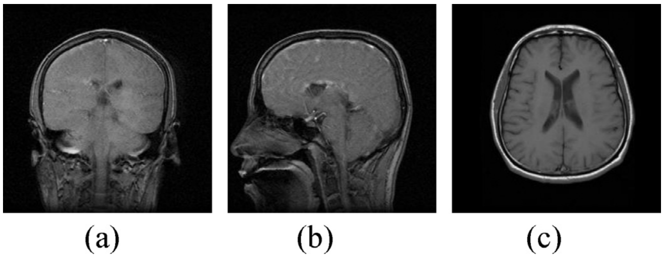

Fig. 1. Three different section images (a) Coronal (b) Sagittal and (c) Axial.

Supervised classification approaches require a priori knowledge of the objects to be classified. Obtaining such prior information is not realistic in many practical applications. The objective of this study is to adopt unsupervised optimized extenics-based methods for classification. First the SDTGP (standard deviation target generation process) is performed to select the center of each cluster and define it as the center point of the modified extenics-based correlation function to create several extendable distances to be adopted as the particles to perform PSO (particle swarm optimization). After optimization, the extenics-based correlation function is employed to perform MRI brain tissue classification.

The SDTGP is conducted mainly for concentration identification by using the standard deviation and also find low-likelihood characteristics with the Gaussian function to establish the pixel vector of each cluster center. If the original extenics-based correlation function is optimized directly, it can cause some extenics-based distances to extend infinitely to become extreme values. Hence, the extenics-based correlation function is modified and adopted as the affinity function to overcome MRI brain tissue classification problems.

The final step is to classify MRI brain tissues, mainly the gray matter (GM), white matter (WM) and cerebral spinal fluid (CSF). The results are presented in images displaying a single type of tissue that physicians can quickly refer to and assess the cause of illness more efficiently and accurately. Physicians will be able to diagnose and assess tumor locations quickly and accurately and remove the tumors.

The remainder of this paper is organized as follows. Section 2 presents the related works. Section 3 describes the sources of image data. Section 4 briefly describes the method to be implemented in this paper. Section 5 conducts a series of experiments to assess the strength of the proposed method. Section 6 concludes some comments.

2. Related works

Over the past years many computer-assisted methods have been reported in the literature [2–4] such as Maximum local energy [2], morphology methods [3], convolutional neural networks [4], etc. Approaches of medical multi-spectral image classification applied today include KFLM (Kalman Filter-based Linear Mixing) [5], OSP (Orthogonal Subspace Projection) [6–7], K-means, Fuzzy C-means [8–10], SVM (Support Vector Machine) [11], extenics [12–13], artificial neural network [14–17], Extenics based artificial neural network [18], Mean-shift [19], etc.

KFLM, OSP and Fuzzy C-means are often used to compare the performance of different classification methods; therefore, they are non-binary. The classification results are all gray scale images and target tissues are presented with stronger gray scale values. Then, 3D ROC (Receiver Operating Characteristic) curves are applied for area-under-the-curve comparison.

Conventionally, the K-means algorithm is the most representative binary classification. Its unsupervised learning is performed by random selection of a number of data entries from the test data to be the initial cluster centers. The distances between each datum and all the cluster centers are calculated one after another and then the centers are placed in the group with the shortest distances. After iteration is conducted each time, the cluster centers are updated until they do not change any more. However, Aristidis Likas et al. [20] point out that K-means is an approach to find local optimal solutions. From the conventional angle of K-means, the data points to be classified are categorized in the group closest to the region. Classification based on data points to be classified at the time will only result in the classification of the data points around the region and the results are dichotomous. However, if the entire distribution is taken into account, all the data points in the region will be considered belonging to the same type. Therefore, they propose a global K-means algorithm to solve the problem.

3. Sources of image data

The MR images applied in this study come from the Department of Radiology of Taichung Veterans General Hospital. The machine used is a Sigma 1.5T SYS#GEMSOW. The images are multi-spectral MRI brain images in which the left and right are reversed. The magnetic field intensity is 1.5 Tesla. Each section image is 256×256 in size. An MRI scanner can scan in three different directions, coronal, sagittal and axial, as shown in Fig. 1. Axial section images are the most commonly seen.

Being non-invasive, emitting no radiation and allowing image sequence variations, MRI is able to provide a lot of tissue information. A series of binary section images of a patient can be obtained with MRI. When such section images are verti-

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