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Computational Intelligence-Based System in the Support of the Diagnosis of Brain Tumors: An Approach through Fuzzy C-Means Method

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Abstract: Brain tumor is a major cause of an increased transient between children and adults. This article proposes an improved method based on magnetic resonance (MRI) brain imaging and image segmentation. Automated classification is encouraged by the need for high accuracy in dealing with a human life. Detection of brain tumor is a challenging problem due to the high diversity in tumor appearance and ambiguous tumor boundaries. MRI images are chosen for the detection of brain tumors as they are used in the determination of soft tissues. First, image preprocessing is used to improve image quality. Second, the multi-scale decomposition of complex dual-wavelet tree transformations is used to analyze the texture of an image. Resource extraction draws resources from an image using gray-level co-occurrence matrix (GLCM). Therefore, the neuro-fuzzy technique is used to classify brain tumor stages as benign, malignant, or normal based on texture characteristics. Finally, tumor location is detected using Otsu threshold. The performance of the classifier is evaluated on the basis of classification accuracies. The simulated results show that the proposed classifier provides better accuracy than the previous method.

Key words: Bioinformatics, neuroimaging, tumors, fuzzy c-means.

1. Introduction

Around the world, the detection of brain tumors becomes a challenge for an early diagnosis in some cases of brain cancer. In order to speed up this process, it is essential to develop computational systems to aid in the diagnosis, so that computer intelligence techniques are gaining popularity in this area, due to their high diagnostic capacity and effective classification, as well as better processing capacity and analysis of laboratory tests. Thus, starting from the principle the central question of this work is to investigate with resources of artificial intelligence, particularly fuzzy logic. The use of magnetic resonance (MRI) imaging is one of the techniques widely used in medical diagnostic applications. This work consists in applying the automatic classification method that called fuzzy c-means in MRI imaging of the human brain to aid in the detection of tumors. This type of segmentation is based on the region growth method that differs from conventional classification methods by using the fuzzy set concept, which is appropriate to deal with inaccuracies and/or uncertainties in certain regions of a given image. In order to verify the efficacy of the fuzzy c-means method, the segmented images were compared with the same images, but segmented by means of another algorithm, called Otsu. The objective was to perform segmentation via the fuzzy c-means method on MRI imaging of the human brain to aid in the detection of tumors.

2. Materials and Methodology

In the present study, MRI imaging of the brain was used from which the c-means fuzzy method was applied to improve the detection of tumors. The fuzzy classification partitions a set of data into a number of homogeneous clusters from an appropriate measure of similarity, to better analyze the properties of the image.

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The most used method of fuzzy clustering is the fuzzy c-means algorithm, proposed by Dunn and generalized by Bezdez [1, 2]. The fuzzy c-means algorithm was applied to the images with the objective of segmenting them, detecting the borders between structures of the cerebral cortex tissue of different characteristics. This process consists of dividing the MRI images into classes, which make up groups in which each is separated by level of similarity. For the validation stage of the method all the tests were performed using the following criteria: (1) the identification of the set of descriptors that presented the best results, called the best input set; (2) identification of the best set of rules; and (3) the definition of the pertinence functions, whose parameters and method of defuzzification are most suitable to be used with the best set of inputs and the best set of rules. The defuzzification stage, responsible for the interpretation of the output fuzzy set, exists in systems such as proposed by Mamdani [3]. It is used to generate a unique numerical value, from all possible values contained in the nebulous set obtained in the inference stage to generate the control action. Thus, the defuzzification process produces an output (a real value) from the fuzzy output set obtained by the inference system [4]. The objective is to obtain a single real number that best represents the inferred fuzzy values. The rules can be formulated basically from two methods: (1) knowledge of specialists (which, in the case of a medical application, must be a physician or other professional who is directly involved in the process and possessed theoretical and empirical knowledge of its operation); or (2) knowledge of numerical or historical data [5]. The writing of the computer program code to implement the fuzzy c-means method was performed in the MATLAB environment R2010a (student version).

3. Results and Discussion

Fig. 1 is the original image, without any processing, in which the fuzzy c-means method is applied. Fig. 2 shows the resulting effect after grouping into two classes, which is equivalent to Boolean logic. Figs. 3 and 4 already can identify the identification of a brain tumor, which has in its constitution a different tissue than would be observed in a healthy condition. This is due to fuzzy logic, which is able to indicate scalable values for the gray scale in MRI images, varying their values between 0 and 1 [6]. The fuzzy c-means technique was tested on different MRI images and a greater efficiency was observed in aiding the detection of brain tumors when compared with the results obtained by the Otsu algorithm. The Otsu algorithm also presents a segmented image, but with a less refined edge than the result obtained with the fuzzy c-means algorithm, proving in this way that the fuzzy c-means algorithm presents a better result than the Otsu algorithm. It is worth mentioning that with the segmentation of the image in 2 classes, they are not sufficient to discriminate the existence of the tumor,

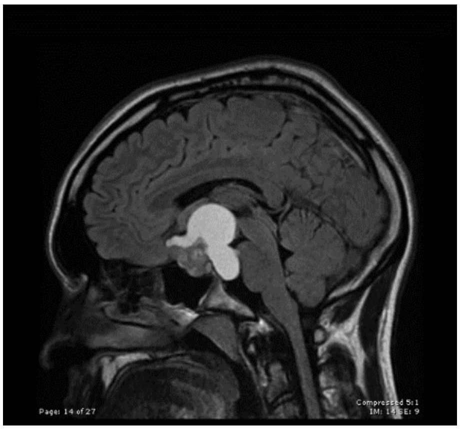

Fig. 1 Original image.

Fig. 2 Segmentation by 2 classes.

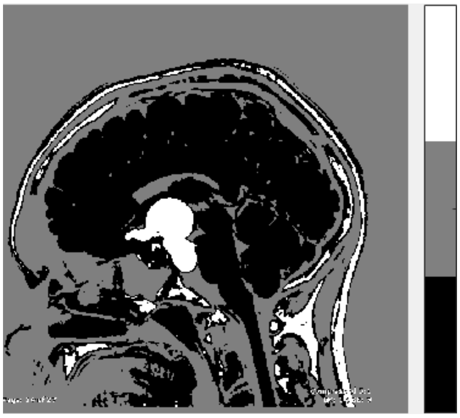

Fig. 3 Segmentation by 3 classes.

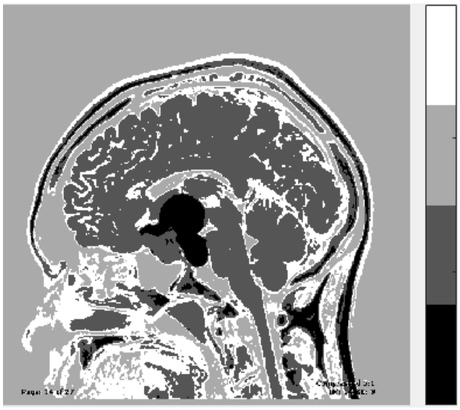

Fig. 4 Segmentation by 4 classes.

making the segmentation result equivalent to the configuration of a binary image, the same as in Boolean logic.

4. Conclusions

By means of the fuzzy c-means segmentation method, which is based on the theory of fuzzy numbers to extract the region of interest, satisfactory results are detected in the detection of brain tumors in relation to the results obtained with the Otsu method; this occurs due to the influence of fuzzy numbers, for which a pixel may belong to more than one region, but with different degrees of pertinence [7, 8]. For future work, it is intended to evaluate the feasibility of developing a portable computational tool in different operating systems, in order to make teaching of different occurrences of anatomical abnormalities that can be observed through the application of the fuzzy c-means method, in MRI imaging to aid in the detection of brain tumors.

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