

A Novel MRI Image Segmentation Algorithm based on Modified Neural Network Model

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Abstract

With the rapid advancement of the computer assisted medical applications, the MRI image segmentation has been a hottest research topic. In the neural network is used for the image segmentation, we need a lot of training data, because of the large amount of the data, computing speed is quite slow, not suitable for real-time data processing, lead to the low resolution image segmentation, the resolution is not high, this paper proposes a fuzzy image segmentation algorithm of the BP neural network. Fuzzy set theory is used to subtract the characteristics after area of the image segmentation, reduce the dimension of feature vector. We adopt the revised neural network to undertake the experimental simulation compared with the other state-of-the-art approaches. The result proves the effectiveness of our methodology. Our algorithm could segment the regions of interest with the ability of eliminating the out side noise which achieves the better robustness.

Keywords: *Medical Image Segmentation, MRI Image, Neural Network, Feature Selection, Fuzzy Set Theory, Mathematical Optimization, Image Representation*

1. Introduction

Image segmentation is according to the certain rules to divide the image into the several mutually disjoint that has certain properties of the area, the attention to a part extracted from the image of the further research and analysis and processing [1-2]. The result of image segmentation is the basis of the image feature extraction and the recognition of image understanding, the study of image segmentation has been a hot spot and focus in the study of the digital image processing techniques that makes the subsequent image analysis and image segmentation to identify the amount of data to be processed by the advanced stage of processing, such as greatly reduced, and retain information about the image structure characteristics at the same time [3-4]. Image segmentation has other names in the different areas, such as the target outline, target detection technology, threshold technology, target tracking technology, technology itself or its core is actually image segmentation techniques [5-8].

With the development of computer image processing technology, computer aided diagnosis play a more and more important role in medical diagnosis that can get the interested in the target image segmentation technology as is the foundation of medical image analysis. How to improve the accuracy of medical image segmentation is a hot spot in the field of medical image processing [9-10]. Based on the literature survey, the classic image segmentation algorithms can be summarized as the following parts. (1) Threshold segmentation method. Threshold segmentation method is in the field of image segmentation was proposed earlier segmentation technology and application. Threshold segmentation method is the most direct and the most practical method, which makes it to get widely used segmentation algorithm in the image segmentation algorithm, and by

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reference to the fields. Threshold segmentation method is to use the threshold parameters for image segmentation, these thresholds according to characters of the image characteristics of the different participants with gray threshold, texture feature threshold, the threshold selection of naturally becomes the key to the threshold segmentation method [11-12]. (2) The segmentation technology based on the regional characteristics. Regional characteristic segmentation technology combine the regional characteristics of the consistency principle as regional division criteria can adopt the regional characteristics of such as color features and texture features, gray. Regional characteristics segmentation technology in image segmentation, similarity of pixels for consideration, also more fully uses the space characteristic of the image which has high precision [13-14]. (3) The segmentation technology based on the edge detection. Edge detection segmentation technology on the processing strategy with a serial edge detection segmentation technology and primary parallel edge detection segmentation technology operator edge detection technology is the most simple and the common method. Researchers can choose according to their needs different operator is applied in edge detection, the use of boundary operator to complete the image edge detection, in order to better complete image segmentation, often need to some other operation. (4) Image segmentation based on the genetic algorithm. Genetic algorithm is mimic natural biological evolution process and mechanism to solve the problem of a class of the self-organization and adaptive artificial intelligence technology. To this, scientists have conducted a lot of research work, and successfully applied to various types of the optimization problems, in the segmentation of complex images, people tend to use more parameters to carry on the information fusion, in the optimal values of many parameters involved in calculating process, the optimization calculation is one of the most important, the characteristics of natural evolution algorithm that is applied to the computer which will be able to solve many problems [15-17].

Among all of the existed algorithms, the neural network based approaches gain the satisfactory results. Segmentation method based on neural network is the basic idea of the linear decision function is obtained by training the multilayer perceptron to, then classifying pixels using decision function to achieve the goal of the segmentation. In recent years, with the research and progress of the neurology, the third generation of pulse coupled neural network as a new type of the artificial neural network model, its unique approach offers a new way for the image segmentation. Pulse coupled neural network has captured can produce ignition pulse propagation, the integration of time and space effects of the input image the adjacent tend to have similar input neurons firing at the same time. So for gray image, it has the natural ability of split, with the different target area for the corresponding neurons in the input image at different time of ignition, which will be divided in different areas [18-21]. Under this background, in this research paper, we analyze the novel MRI image segmentation algorithm based on modified neural network model which will be discussed later.

2. The Proposed Algorithm

2.1. The Review of MRI (Magnetic Resonance Imaging) Images

X-ray and magnetic resonance imaging are clinical used for craniocerebral disease the most effective way to diagnose. Due to imaging principle, highlight the anatomic structure is also different. MRI soft tissue contrast of general high resolution, clear demarcation between the brain gray matter, does not suffer the interference of skull structure, especially suitable for inspection after the cranial concave and brainstem lesions; MRI is not sensitive to calcification, but unfavorable to differential diagnosis of the disease. Instead, the CT showed calcifications sensitive and soft tissue contrast, after cranial concave bone structure is easy to produce artifacts, interferes with the brain stem

and cerebellum. Therefore, two kinds of the image provide the diagnostic information can complement each other that will two complementary action of basic radiographic image fusion can make up for the defect of incomplete information and inaccurate, improve the accuracy of diagnosis. Image fusion technology at the same time for preoperative determination of the scheme determination of surgery, radiation therapy provides a more accurate tool.

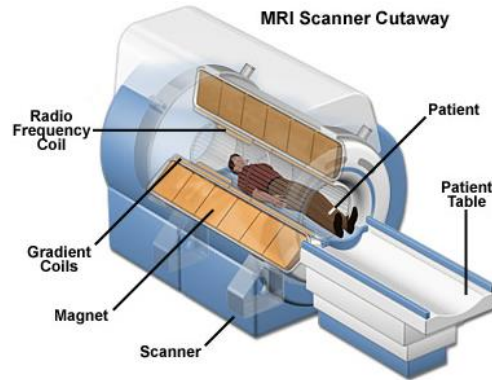


Figure 1. The Magnetic Resonance Imaging System

As shown above, the MRI system is demonstrated. MRI using hydrogen nuclei spin imaging, water molecule containing the two hydrogen atoms, because each part of the human body tissue water content is different, so as to form the basis for MRI image contrast. Skull bone cortex is not water and is low in the MRI image signal. Current clinical use T1 weighted and T2 weighted more pulse sequence in MRI imaging, T1 weighted as reflect the relationship between the proton spin system with surrounding environment, then the T2 weighted images reflect the relationship between protons and proton MRI of T1 and T2 weighted images, cranial areas are in the dark space. The traditional method of MRI image segmentation will always follow the methods reflected by the formula 1~3.

$$c(r_1) = \max \{c(r)\}; \quad c(r_2) = \min \{c(r)\} \quad (1)$$

$$f(x, y) = 0 \vee 1 \quad (2)$$

$$g(x, y) = \sim f(x, y) \quad (3)$$

After image segmentation and the gray level inversion, skull and background gray with the bright area, so need to remove the background. For high signal in skull skin fat boundary, its skull area is separated from the background, so available the contour tracking method to remove background [22-23]. Due to the lower resolution, it is to use a pixel instead of a small area, the average gray level of the gray levels of pixels as village, so the lower resolution that not only the average height of histogram is reduced and the threshold will drift.

2.2. The Traditional BP Neural Network

Multilayer forward feedback neural network is the more widely that used artificial neural network, the BP learning algorithm is one of most famous one of multilayer forward feedback neural network training algorithm. The algorithm in the field of the image processing and image recognition has made remarkable achievements, its main

idea is to use known to determine the model of network training samples, and then using the trained network for image processing and recognition [24-26].

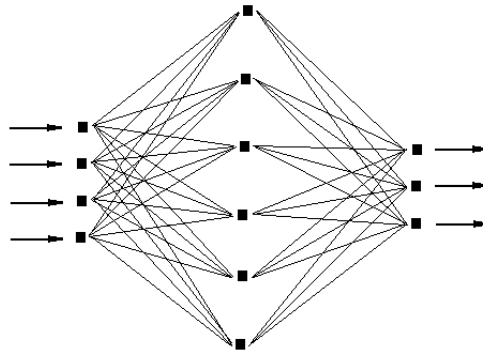


Figure 2. The Traditional Neural Network Model

Training process of BP network is the fixed connection weights between neurons in each layer: the process of the input mode from various input layer nodes directly transferred to the hidden layer nodes. In the hidden layer, through the characteristics of each unit for Sigmoid functions transformation as next layer of input information. This information through the same conversion has been a prequel, until the response signal output from the output layer [14]. In the figure two, we illustrate the primary of the BP neural network structure. The input of the node i can be expressed as follows.

$$x_i^{(q)} = \sum_{j=1}^{n_q-1} w_{ij}^{(q)} y_j^{(q-1)} \quad (4)$$

The corresponding response could be expressed as the equation 5.

$$y_i^{(q)} = f(x_i^{(q)}) = \frac{1}{1 + \exp(-\mu_{x_i}(q))} \quad (5)$$

Output response compared with expected response, and gets the error signal, the signals as a learning along with the forward path comes back in the opposite direction, at the same time can modify the connection weights, step by step until you correct all connection weights between layers, so as to complete a learning process as follows.

$$E = \frac{1}{2} \sum_{p=1}^P \sum_{i=1}^{n_q} (d_{pi} - y_{pi}^q)^2 = \sum_{p=1}^P E_p \quad (6)$$

Input layer is the data buffer memory, its role is to put the data source to load on the network and the number of nodes can be determined by the dimensions of image feature vector. The selection of hidden layer in the layer number and the number of nodes have different point of view, according to a new point of view, as long as the single hidden layer nodes is enough, a hidden layer can achieve the function of the hidden layer can pick up points by the formula 7.

$$NodeNumber = \sqrt{(m+n)} + a \quad (7)$$

Where the m is number of input layer nodes, n represents the output layer nodes.

2.3. The Fuzzy based BP Neural Network

Fuzzy theory is to define dependencies between condition attributes and decision attribute as is by eliminating redundant attributes and can simplify image information space dimension, the simplified decision-making table and can take advantage of the parallel processing algorithm. Neural network through continuous learning to adjust the mapping relationship to complete the input and output so we considered this paper combined neural network and fuzzy theory method for the simplified method of the information, the algorithm combined the fuzzy and the neural network learning and produce a minimum decision inference network [18-22].

According to the literature review, we summarize state-of-the-art clustering ways as the follows. (1) Based on grid clustering method. In order to realize the clustering method based on grid, need to quantify the data space into a finite number of units, then clustering operation on the grid cell. In order to improve calculation efficiency, clustering method based on network volume on the grid for operation, thus to achieve the use of large scale grid instead of a grid of small scale, the purpose of existence of the problems is to lose part of the data and information at the same time. (2) Based on the hierarchical clustering method. Hierarchical clustering algorithm can be divided into the split type and condensed type two kinds of the different forms, split type hierarchy clustering firstly all samples are divided into cluster, through constantly for clustering split, in the turn, generate different levels of the division; Condensed type hierarchy clustering with split type on the contrary, it first divide each sample for category, then clustering tree merge constantly in order to get a different level of basic clustering. (3) Based on partitioning clustering method. Partition clustering algorithm is to divide the target data to comply with the certain standards in the number of the clustering. In the partition clustering algorithm, a very important factor is the criterion function of the clustering algorithm, and the error sum of squares function is the most widely used criterion function.

Neural network after the input of fuzzy system state variables and implicit layer of network can be defined as input shown in the formula 8.

$$net(k) = \sum_{j=1}^3 w_{ij}^{(2)} O_j^{(1)}(k) \quad (8)$$

In the process of for the neural network training, the training sample of the original numerical range can be very big under certain circumstances an input mode between maximum and minimum values may differ in thousands of times, if not normalized processing that will produce the phenomenon of "decimal" large Numbers, seriously affect the samples of the training effect of the network and therefore, we must to the normalized processing of input mode to make the change to return to limit to a certain value range. Thus in the input layer and hidden layer between join normalized.

We take performance index function as the formula 9.

$$J = \frac{1}{2} (y_r(k+1) - y(k+1))^2 \quad (9)$$

In order to make the output results consistent with original number, after joining the normalized layer and output layer must be corresponding to a numerical reduction zone. Add a search fast convergent to the global minimum of inertia item, there are:

$$\Delta w_i^{(3)}(k+1) = -\eta \frac{\partial u(k)}{\partial w_i^{(3)}} + \alpha \square w \Delta w_i^{(3)}(k) \quad (10)$$

2.4. The Novel Image Segmentation Framework

Regional image information can usually be used two parts to represent the regional content and boundary. The content of image region is usually through color, matrix, with the texture features of images to describe, and image boundary region are often described using image shape feature, such as generally described using rectangular, circular, etc. Fuzzy neural network model is established, among them, the first layer, layer 2 and layer 3 of the node number is four, the fourth floor of the node number is 1 between the third and fourth layer selection of initial values of connection weights of the various rules of the fuzzy membership degree. Every nerve cell in the fuzzy neural network input values for the area, and then use the BP algorithm iteration, the output values for the decision classification and get the final decision results, different equivalence class together to realize the image segmentation.

After the discretization of image data information, we need to iterate through the BP neural network and the BP neural network output layer can be expressed as the weighted coefficient of correction formula as equation 11.

$$\Delta w_i^{(3)}(k+1) = -\eta O_{i(k)}^{(2)} + \alpha \square w \Delta w_i^{(3)}(k) \quad (11)$$

Training is the use of neural network has a clear classification results of training samples, the input pattern into the network from the input layer, through the network computing, the output from the output layer, and then compared the results and the actual value, get the error signals as a mentor, to guide change of network connection weights. The core steps are shown as the follows.

- Set the initial value, select the rules of the rough membership. Every nerve cell in the fuzzy neural network's input values for area.
- According to the fuzzy neural network as a classifier, zoning for the core segmented image and the image into the image of matching area matching between the classes.
- After input for general image segmentation, the classification of image data discretization. Iteration by using BP neural network algorithm, the output category values for decision-making and get the final decision results.
- Different equivalence class together, merging of the different image region, realizes the image segmentation.

3. Experimental Simulation and Verification

In this part, we simulate the proposed algorithm compared with the other methods proposed by the literatures. From the experimental results, this paper puts forward a new fuzzy BP neural network image after image segmentation algorithm for the basic segmentation effect is clear, clear edge information and highlight the target area, at the same time, based on the actual process of programming, improve the accuracy of the algorithm and meet the requirement of real-time image processing. Experiments show that this method is a new and effective image segmentation algorithm proposed. In the figure 3, we demonstrate the neural network modelling simulation. In the Figure 4 and 5, we show the two sets of simulation, respectively.

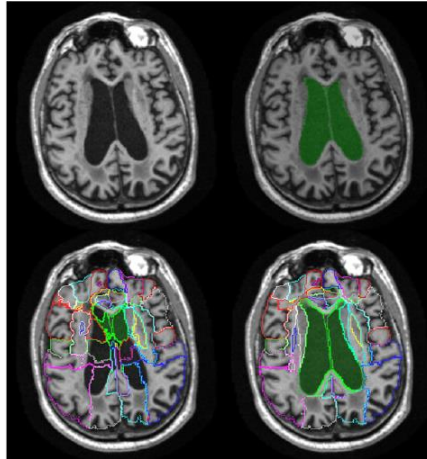


Figure 3. The Neural Network Modelling Simulation

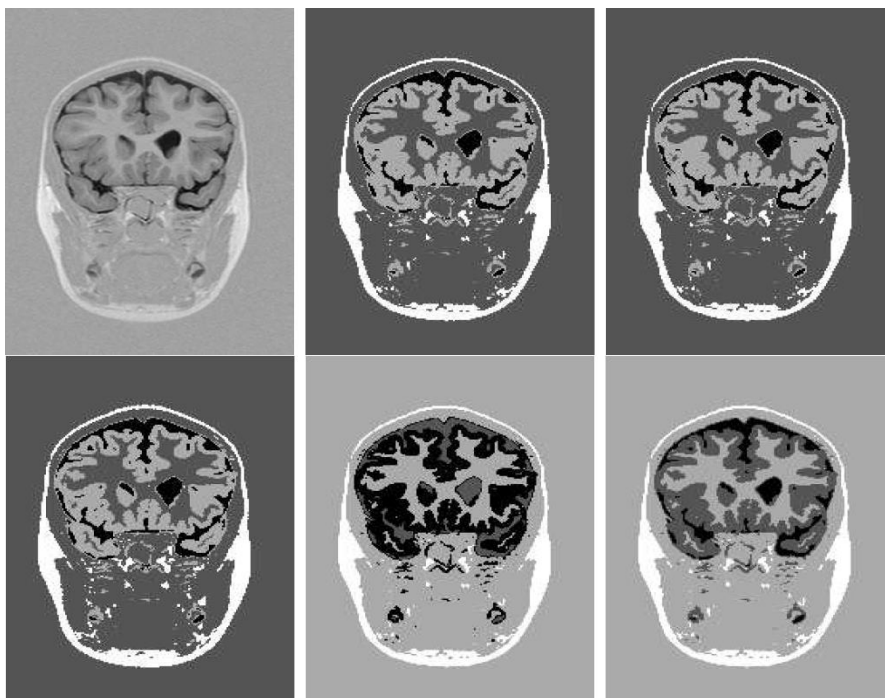


Figure 4. The Image Segmentation Result Set One

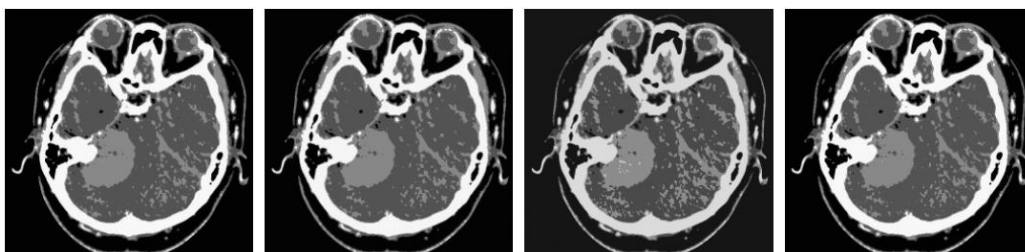


Figure 5. The Image Segmentation Result Set Two

4. Conclusion

In this paper, a new and innovative MRI image segmentation algorithm based on modified neural network model is proposed. In the neural network is used for image segmentation, we need a lot of training data, because of the large amount of the data,

computing speed is quite slow, not suitable for real-time data processing, lead to the low resolution image segmentation, the resolution is not high, this paper proposes a fuzzy image segmentation algorithm of BP neural network. Fuzzy set theory is used to subtract characteristics after area of the image segmentation, reduce the dimension of feature vector, number of neurons, according to the rules of the structure and the classification of the output decision value, the final iteration by using the BP neural network algorithm, the resulting decision results and enter the segmentation of image, the final experimental results show the proposed algorithm can effectively segment image, image segmentation edge is clear, at the same time, the algorithm is effective to shorten the time of the training samples. The experimental simulation verifies the feasibility and effectiveness of the approach. In the future, we will enhance the current modelling procedures to look for better optimization ways.

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