An Immune Neural Network Used for Classification

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Abstract

Based on analyzing the immune phenomena in nature and utilizing performances of ANN, a novel network model, i.e., an immune neural network (INN), is proposed which integrates the immune mechanism and the function of neural information processing. The learning algorithm of INN is mainly about the selection of an excitation function and an adaptive algorithm of the network. This model makes it easy for an user to directly utilize the characteristic information of a pending problem and to simplify the original structure through adjusting the excitation function with the prior knowledge, and then the working efficiency and the searching accuracy are both improved. The analysis in theory and the simulating test for the twin-spiral problem show that, comparing with the artificial neural network, INN is not only effective but also feasible. INN can conducively simplify the structure of the existent model and show good working performances when dealing with a pending problem.

1. Introduction

It is well known that the artificial neural network (ANN) has been an important research field of people exploring and imitating the intelligent information processing mechanism of brain neural system. However, it is also necessary for us to note that these existing neural network models are all based on understanding of natural neural system, and established by highly simplifying and abstracting this system, which is propitious to its development and application in engineering practice, but losses some original functions of the natural system at the same time. With the development and wide spreading of ANN's applying, there continually appear some problems, such as the system is prone to plunging into locally extreme state when the learning algorithm is not selected suitably, there exists a conflict between the network complexity and its generalization and so on.

From the deep analysis of the existing network models and algorithms, we can learn about that their methods of setting parameters lack the capability of meeting an actual situation, so that some torpidity appears when solving problems, which is conducive to the universality of the structure or algorithm but neglects the assistant function of the characteristics or knowledge. The loss due to the negligence is sometimes considerable in dealing with some complex problems. Based on this consideration, this paper aims at introducing the concept of immunity into some existing artificial neural networks, so as to design a novel network model which can use the characteristic knowledge for solving problem. This model is presently called *immune neural network* (INN) and it is used for improving the capability of dealing with some difficult problems.

2. The Immune Neural Network Model

In the existing ANN models, an neuron is regarded as a unit which sums all the input signals at first, and then generates a output signal after comparing with a threshold. Distinctive features of this kind of models denote that they have simple structures and good versatility. However, these features simultaneously bring out a lack that they are not considered the active and assistant functions of characteristic information when dealing with a concrete problem. To be exact, there is no interface in these existing models. Based on this consideration, an *vaccinating unit* is designed in a novel model presented in this paper, which is used for utilizing characteristic information and prior knowledge to a pending problem, so as to improve the power of solving a concrete problem.

On designing this model, an neuron is firstly considered to take an important action during information processing, and secondly, all the neurons are similar in basic properties, but different in idiographic forms. Therefore, the excitation function of an neuron should be designed as an variable form. To be exact, basic properties of the function keep unchanged, but its concrete form can be changed through adjusting some of its parameters. To be more exact, the excitation function of any neuron i can designed as the following form, i.e.,

$$u_i = f_i(X, V) \quad (1)$$

where, $f_i(\cdot)$ is a function family with a series of parameters V, and selections of a concrete function form and the concerned parameters have something to do with the pending problem, which is different from the fact that an excitation function of original models is usually selected as

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an universal threshold form or *S*-form. On the other hand, some features of the pending problem are contained in the information processing layer, therefore, the structure of this kind of network is usually more simple, and so as to make the time for network learning short and speed increased.

Taking an immune neural network with one hidden layer for example, suppose the weight matrixes of input layer to hidden layer and hidden layer to output layer are respectively $W^{(1)}$ and $W^{(2)}$, then the output vector Y is:

$$Y = W^{(2)} f(W^{(1)} X, V) . \qquad (2)$$

Suppose the real output of training samples is Z, then the error function can be defined as:

$$E = \frac{1}{2}\sum_{i=1}^{P}\left(z_i - y_i\right)^2 \qquad (3)$$

For the purpose of convenient operation, the gradient-descending method is used for network training. During the training process, for smoothing learning path and increasing learning speed, a synthetic approach of training group by group and the adding momentum items should better be used. In which, the training method group by group is proposed mainly for aiming to the method one by one, and used for increasing the training speed. It first adds all the modifying values produced by a group of samples, and then makes a modification for one time. The method of adding momentum items denotes using the modifying value produced by the former step to smooth the learning path, so as to avoid getting into local extremum. To be exact, the equation of modifying weight W and parameter V is shown as follows:

$$\begin{cases} \Delta W^{(i)}(t+1) = \eta^{(i)} \sum \frac{\partial E}{\partial W^{(i)}}(t) + \alpha\left[W^{(i)}(t) - W^{(i)}(t-1)\right] \\ \Delta V^{(i)}(t+1) = \mu^{(i)} \sum \frac{\partial E}{\partial V^{(i)}}(t) + \beta\left[V^{(i)}(t) - V^{(i)}(t-1)\right] \end{cases}$$

where, α and β are all the momentum factors, and $\eta^{(i)}$ and $\mu^{(i)}$ are learning rates. It is necessary to point that effect of the learning rates$\eta^{(i)}$ and $\mu^{(i)}$ is relatively evident during the training process. If $\eta^{(i)}$ and $\mu^{(i)}$ are great, then the training process is more prone to convergence, but oscillation in the late process. Therefore, at the beginning of training, $\eta^{(i)}$ and $\mu^{(i)}$ are usually set great values, and then are decreasing with the training process.

3. Simulations

In actual test, we study the capability of INN with an example of the twin-spiral classification. At first, we generate 640 points with random noise which respectively belong to two spiral lines ρ_1 and ρ_2 (320 points per each). Where, the angular velocities of the two spiral lines are same(both 4), and in addition, the starting distance are respectively 1 and 7. We select alternately half of the sample points for the training data, the rest are used for the testing data. Finally, we use MatLab5.3 for programming and operate it on a Pentium-233 PC. When the trained network is used for classifying the testing data, there are 7 points in summon which are classified in error, and the correct distinguish ratio is 97.81%. If without noise, then the correct distinguish ratio is 100%, which is highly improved form what is reported in the references [3] and [4].

4. Conclusions

Based on analyzing the immune phenomena in nature and utilizing performances of the existent artificial neural network, a novel network model, i.e., an immune neural network, is proposed which integrates the immune mechanism and the function of neural information processing. This model makes it easy for an user to directly utilize the characteristic information of a pending problem and to simplify the original structure through adjusting the excitation function with the prior knowledge, and then the working efficiency and the searching accuracy are both improved. The analysis in theory and the simulating test for the twin-spiral problem show that, comparing with the artificial neural network, INN is not only effective but also feasible. INN can conducively simplify the structure of the existent model and show working performances when dealing with a pending problem. However, it is necessary to point out that there is also a lot of work to do on the theory of designing and optimizing this model, such as, the algorithm of optimizing excitation function of a neuron in hidden layer, the algorithm of adjusting parameters of the excitation function, the algorithm of network weight matrix training, etc.

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