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The research of digital recognition technology based on bp neural network

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ABSTRACT

BP neural network is widely used in nonlinear modeling, pattern recognition and forecasting etc. Based on principles of BP neural network to digit recognition, using several training functions prepared by the MATLAB neural network toolbox, the paper focus on training of the BP neural network, and uses the Smolensk neural network modeling to simulate it. The result shows that the BP neural network used for the digit recognition is capable for recognition to some extent, its algorithm operated easily, and properly choosing relative variables can achieve better recognition effect of the system.

KEYWORDS

Digit recognition;
Neural network;
BP algorithm.

INTRODUCTION

As a branch of Character Recognition, Digit Recognition is highly functioned in managements of post, transportation and business tickets, such as the post codes, the statistic forms, the bank notes and so on. In China, the "Three Golden" Projects (Golden Bridge for satellite-monitored internet, Golden Custom for management of national taxes, Golden Card for credit card in exchange market) now largely rely on information technology, thus, the construction of information automatic register through digital technology will improve the development of these projects.

Neural Network is modeled with basing on the knowledge on natural neural system, generally speaking, it is a broad connected structure through a series of nodes that was simply functional to calculation and was called "neurons". The weight values of net-connection continuously adjusted the outside in-put study regulations and finally acquired the network with some expecting out-put features. That is, with the function of learning following the in-put samples, Neural Network is quite fit for solution of model recognition which includes digit recognition itself.

In the paper, the basic theory of BP Neural Network and the application of it are illustrated, and the simulating experiment is operated on digit recognition.

BP NEURAL NETWORK

BP (Back Propagation) Neural Network is a type of one-way directed multilayer forward network, it can be regarded as a nonlinear reflection from input to output, and that is, through the collection of samples with BP Neural Network, complex nonlinear functions will be achieved similarly. Manual neural network is similar to complex functions, with which the capability of information dealing system is completely determined with the weight values of various neurons in networks. Since network is large-scaled, various weight values can not be conformed one by one, consequently, network itself required some learning ability which means it can gradu-

ally adjust weight values from the study of sample models.

Back Propagation algorithm is one of the most usual study methods in neural networks, the algorithm analyses the error with the sample values calculated through the natural networks. With continuous correction of weight values in neural networks, the output of networks will be near with the expecting values, the final error will be confined in the acceptable area and the learning process is completed and the weight values have be acquired. Since the error calculation is from the output back to the input side, the algorithm is calling Back Propagation.

As the diagram 1 showed that a model of neuron with its transfer function f may usually be differential monotone increasing function, such as logarithm Sigmoid, function log Sid tangent Sigmoid function tan sig an linear function purling etc.

The features of last layer neuron restricted the features of output, when the last layer neuron be chosen as the Sigmoid function, the output of the whole network will be confined into a relatively small area, if the it would have be chosen as purling function, the entire network output can be an arbitrary value.

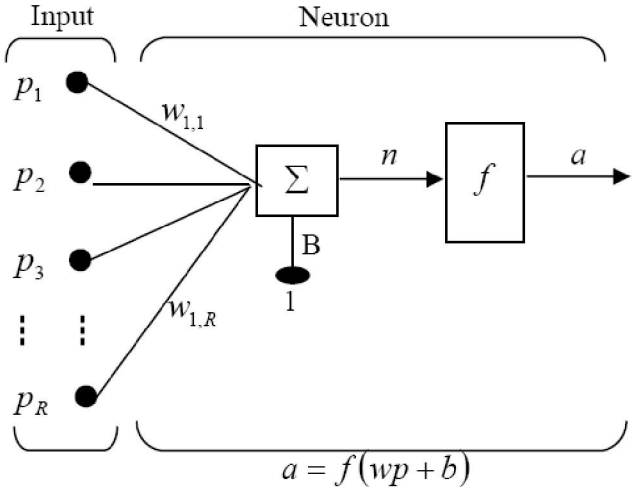

Figure 1 : BP neuron model

As illustrated in Figure 2, typical BP network structure applied the structure of BP neuron-based multilayer forward networks as the common ones.

The BP network usually has one or more invisible layers, and the invisible neuron will apply the sigmoid transfer function. It has been proved that the BP network can be near with any arbitrary linear functions when the invisible neurons are efficient.

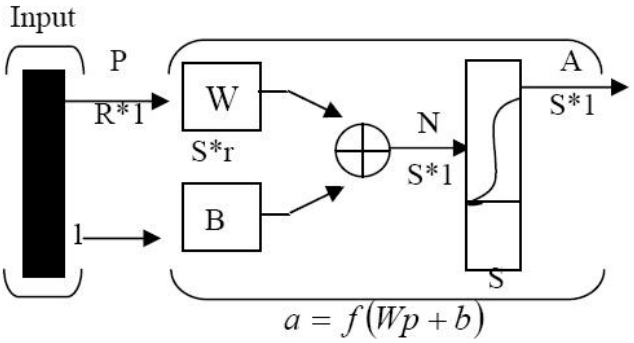

Figure 2 : BP neural network structure

REALIZATION OF DIGITAL REORGANIZATION BASED ON BP NEURAL NETWORKS

In computer, both character and image can describe with bitmaps. Given a BP neural network design with the ability of 10 number recognizing, once a trained network as an input of numbers, the network can recognize the right number. When we digitalize every number for the structure of input sample, we use the matrix of 5×7 for construction of input samples.

On the other side, for the target vector expecting the position of 1 among the 10 inputting numbers for the right order, thus the other position will be occupied by the number 0. So, the target matrix will be a unit matrix within10×10 through the diagonal line. At same time, the disturb-proof ability of network should be concerned, that is, the designed network can recognize the right number even under some situation of irregular input.

$$\begin{bmatrix} 0 & 0 & \oplus & 0 & 0 \\ 0 & 0 & \oplus & 0 & 0 \\ 0 & 0 & \oplus & 0 & 0 \\ 0 & 0 & \oplus & 0 & 0 \\ 0 & 0 & \oplus & 0 & 0 \\ 0 & 0 & \oplus & 0 & 0 \\ 0 & 0 & \oplus & 0 & 0 \end{bmatrix}$$

Figure 3 : Matrix of the number 1

Exchange the above matrix into a linear one; we can get the number 1 with the form of column vector as

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following,

1=[0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 1 0 0]

It can be the characteristic vector for recognizing the number 1, using the same method; we can define all the numbers with the characteristic vectors as the recognizing measure for the neural networks.

The result of reorganization through the neural network for the output with 10 numbers vectors can be illustrated with a 10 dimension column vector, such as number 1 and 7, the model vectors respectively as following,

Target-_1= [0 1 0 0 0 0 0 0 0 0]

Target_7= [0 0 0 0 0 0 0 1 0 0]

And we can find an analog for any other numbers.

All number has the ideal characteristic vectors and model vectors which consist the collection of training samples, as following,

Number =

```
[0 0 1 0 0 0 0 1 0 0  0 0 1 0 0  0 0 1 0 0  0 0 1 0 0  0 0 1 0 0  0 0 1 0 0;
1 1 1 1 1  0 0 0 0 1  0 0 0 0 1  1 1 1 1 1  1 0 0 0 0  1 0 0 0 0  1 1 1 1 1;
1 1 1 1 1  0 0 0 0 1  0 0 0 0 1  1 1 1 1 1  0 0 0 0 1  0 0 0 0 1  1 1 1 1 1;
1 0 1 0 0  1 0 1 0 0  1 0 1 0 0  1 1 1 1 1  0 0 1 0 0  0 0 1 0 0  0 0 1 0 0;
1 1 1 1 1  1 0 0 0 0  1 0 0 0 0  1 1 1 1 1  0 0 0 0 1  0 0 0 0 1  1 1 1 1 1;
1 1 1 1 1  1 0 0 0 0  1 0 0 0 0  1 1 1 1 1  1 0 0 0 1  1 0 0 0 1  1 1 1 1 1;
1 1 1 1 1  0 0 0 0 1  0 0 0 0 1  0 0 0 0 1  0 0 0 0 1  0 0 0 0 1  0 0 0 0 1;
1 1 1 1 1  1 0 0 0 1  1 0 0 0 1  1 1 1 1 1  1 0 0 0 1  1 0 0 0 1  1 1 1 1 1;
1 1 1 1 1  1 0 0 0 1  1 0 0 0 1  1 1 1 1 1  0 0 0 0 1  0 0 0 0 1  0 0 0 0 1;
1 1 1 1 1  1 0 0 0 1  1 0 0 0 1  1 0 0 0 1  1 0 0 0 1  1 0 0 0 1  1 1 1 1 1];
```

Number=number1';

Targets=eye (10);

Among these, number for the collection of ideal letter characteristic vectors, targets for the counterpart of collection of model vectors.

As a result, recognition through neural network is a way of training neural network which can be accompanied with the character of statistics and getting the expecting model vectors in the process. However, in the process of real reorganization, the numerical characteristic vectors might be interfered with noises; for example, the Figure 4 illustrated a number 1 with interfered by noises.

Consequently, during the process of training and designing the neural network, noise-controlling capability must be concerned.

The above neural network can be illustrated as the following sentence:

```
S1 = 10;
[R, Q] = size (number);
[S2, Q] = size (targets);
P = number;
Net = Neff (minmax(P),[S1 S2],{'logsig' 'logsig'},'traingdx');
```

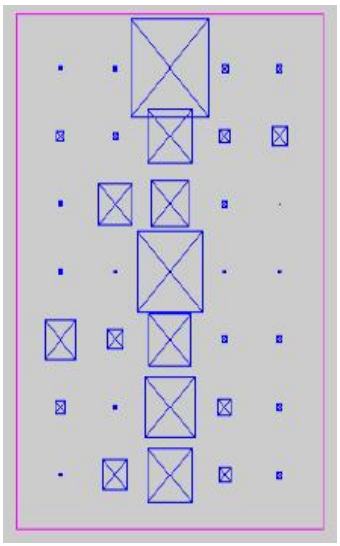

Figure 4 : Bitmap of number 1 with noises

For the purpose of improving the ability of controlling noise, we usually use the ideal sample compared with the noise-including samples, and by the end to analyses the training of networks, the process can be in the following three steps :

(1) The ideal sample trained neural network,

```
P=number;
T=targets;
net.performFcn='sse';
net.trainParam.goal=0.1;
net.trainParam.show=20;
net.trainParam.epochs=5000;
net.trainParam.mc=0.95;
[net,tr]=train (net,P,T);
```

(2) The noise-including sample trained neural network:

```
Netn=net;
net.trainParam.goal=0.006;
net.trainParam.epochs=6000;
T= [targets targets targets targets];
For pass=1:10
P= [number,number,...
(number+randn(R,Q)*0.1),...(number+randn(R,Q)*0.2)];
[netn,tr]=train (netn,P,T);
End
```

(3) The twice trained network with the ideal sample:

netn.trainParam.goal=0.1;
netn.trainParam.epochs=500;
netn.trainParam.show=5;
P=number;
T=targets;
[Needn't]=train (net,P,T);

As a result, the following Figure 5 showed the curve of the movement of error changing, as we can see that when the train process in the 133 steps, the network achieve its goal.

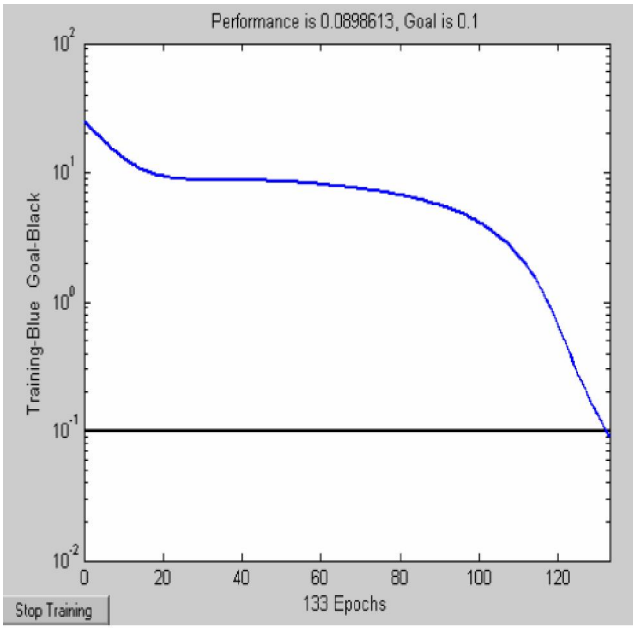

Figure 5 : Error changing curve

After the training of network, the output number of network may not be simply 0 or 1 as the model vectors required the elements, because of the effect of noise, so we calculate the net output with the function compete, thus the standard model vector can be achieved and near to the network out put.

Using the input mode with mean square deviation white noise, the input mode can be simulated the man-constructed neural networks, according to the rate of recognizing error, the system can confirm the function of network.

We simulated the system model with the setting of noise as 0 and the mean square deviation successively as 0:0.05:0.5[4]. For every white noise with different square deviation, based on the original ideal sample, they all produce 100 groups of sample with the original noise, then we use these samples to recognize the model of network, and got the error rate of 100 groups through the result of simulating. Consequently, we finally get the relative changing curves as the Figure 7 showed below:

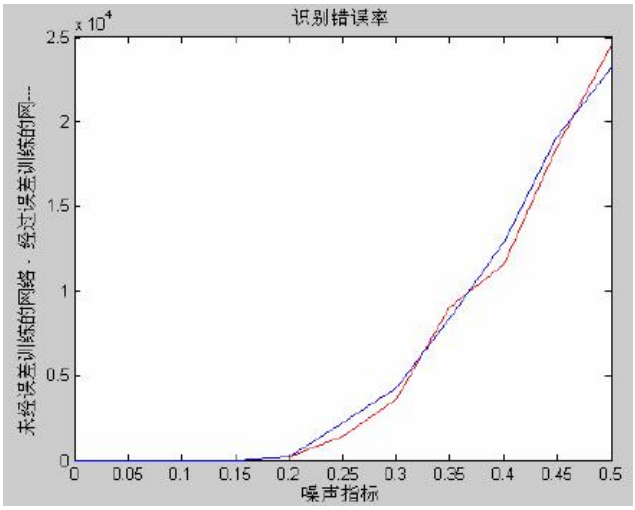

Figure 6 : Relation of recognizing error rate and noise square deviation change

In Figure 6, the curve is for the error rate of network recognizing. Using the noise-including sample, the raining of network can improve the recognizing rate largely. With the diagrams, the situation are illustrated, as the enlarging of noise deviations, the net recognizing error ascends, while the mean square deviation is under 0.15, the recognizing error will be slim.

In order to improve the recognizing ability of network further and reduce the error rate, we achieve this goal with the method of noise-including samples training mode, by increasing the noise samples, we finally enlarge the collection of noise or enlarge the recognizing network.

Figure 7 and 8 illustrated the final recognizing mode of number 1, as the diagrams showed that, the network recognize the number 1 correctly.

Noise-included number 8 and final recognition are showed in the bitmap 9 and 10 respectively, as a result, the network recognize number 8 correctly.

As all of the recognizing system, the digital recognition might be evaluated by certain series of statistics and parameters.

We check the system through 2 types of index illustrating the functions,

(1)Right recognizing rate A= (correct recognized samples/ totality)*100%

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(2)Error rate S= (missing recognized samples /totality)*100%

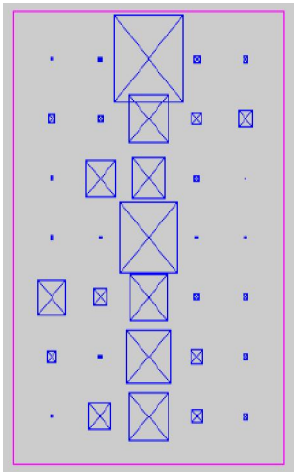

Figure 7 : Number 1 with noises

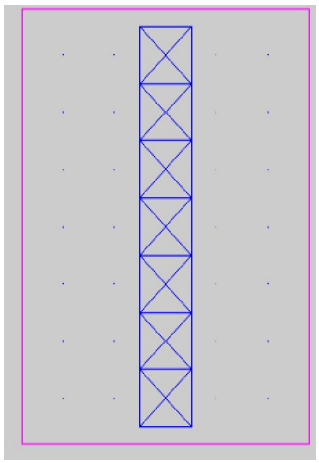

Figure 8 : Recognizing result of 1

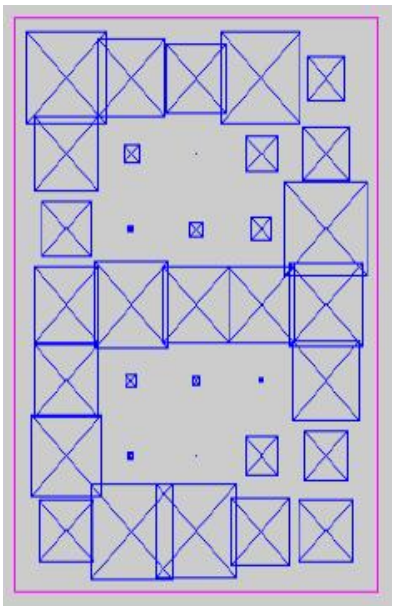

Figure 9 : number 8 with noises

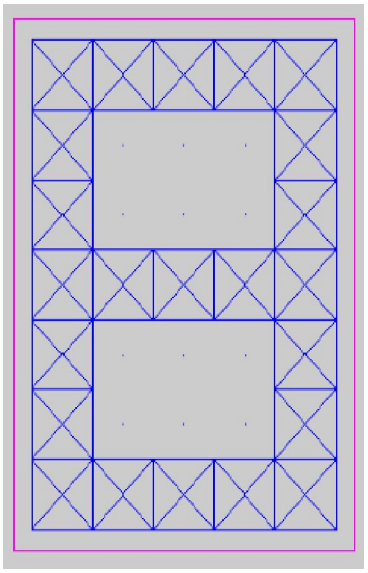

Figure 10 : Recognition result of number 8

The relation showed: A+S=100%

As a consequence, an ideal system will be with the minimum of S and maxim of A, in a practical system, the recognizing rate A will improved through the descend of error rate.

CONCLUSION

BP networks acquired nonlinear ability, automatic learning ability, automatic adapting ability, generalizing ability, error containing ability and sparsely information-reserving ability etc. All of these feature made BP neural network a big success in the application of mode recognition. The program of study BP is developing fast and attracts the scholars' interest in it.

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