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Character Recognition Based on BP Artificial Neural Network

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Abstract—This paper provides a character recognition system based on the Back Propagation artificial neural network that is simplified. Trained with samples of the characters, the characters are recognized, using with VC++. Recognition rate reaches 96% ,which meets the design requirement.

Keywords- character recognition; artificial neural networks; BP algorithm

1. Introduction

Character automatic recognition has been researched for a long period to solve the question of character automatic recognition and make computer true intelligentized. Much work has been done and progress has been achieved. Generally,the realization of character recognition is by algorithm based on character structure and templates matching. Algorithm based on character structure is suitable to recognize alphabets and digits .Compared with Algorithm based on character structure, templates matching is easy to realize by computer, but the accuracy of recognition is lower. In order to improve the accuracy of recognition, new approaches must be found. In recent years, neural network technology has greatly developed and it posses the characteristics of storing information by distributed mechanism, parallel processing information, self-organization, self-learning and so on.

The paper is organized as follows. Section 1 introduces neural network . Section 2 describes the BP neural network, the simplified model and the training of BP. Section 3 describes how to realize character recognition by BP neural network on the VC++ platform. Section 4 mentions future work and draws conclusions.

2. Background

Neural network which has some virtues such as strong ability of anti-noise, fault tolerance, self-adaption and self-learning is thought much of. Thus, some methods of character recognition by neural network come into being. Generally, there are two methods of character recognition. The one method is to use the character of neural to send directly the whole image to the network. Due to the network which automatically attain the picture's character and recognize, it meets practical demands when the method is embed in hardware (neural network chip).But during the procedure, there is too much information to be processed. The other method is to train neural network Classifier by the character of picture acquired. The disadvantage of the method is that it takes long time to abstract the character's features and the speed of classification is very slow.

Currently the usual neural network includes BP network, Hpfield network and Kohonen network. Because of the complexity of neural network, it is difficult to use one kind of neural network. But BP model is widely

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used to information process, image recognition and model recognition because it is valid algorithm model and good approximation non-linear mapping. The study adopts BP network. .

3. Research Methodology

3.1. BP neural network

BP neural network comprises large amount of neurons connected with each other. Different connection forms among neurons, it is possible to constitute different structure neural network. But approximate structure of BP is shown in Fig.1.

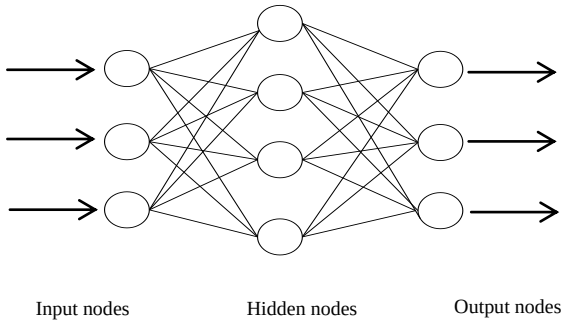

Fig.1. BP network

BP neural network not only concludes input nodes and output nodes, but also hidden nodes. For input information, it will be delivered to hidden nodes. Then by transformation function, output information from hidden nodes will be delivered to output nodes. Finally, the result is drawn.

3.2. Simplified BP neural network

To realize character recognition by computer, BP algorithm will be correspondingly simplified.The node function can be defined by the following formulas:

$$f(x)=\frac{1}{1+e^{-x}} \tag{1}$$

where x is input value, e is constant. Suppose there is random network which includes many nodes that the number of nodes is n, and each node's feature is Sigmoid. For simplicity there is only a output value named y in whole network. The output value of each node is O_k and the network includes N samples expressed as （x_i,y_i）(i=1,2,…,N).To one input named by x_i, the output of neural network is y_i. The equations of node (j) is described by the following.

$$net_{ji}=\sum_k w_{kj}O_{ki} \tag{2}$$

Square-type error function is determined by the following equations.

$$E_k=\frac{1}{2}\sum_{i=1}^{n}(y_k-\hat{y}_k)^2 \tag{3}$$

Where y_k is actual output of BP.

$$E_k=(y_k-\hat{y}_k)^2 \tag{4}$$

$$net_{ji}=\sum_k W_{kj}O_{ki} \tag{5}$$

$$\delta_{ji}=\frac{\partial E_i}{\partial net_{jk}} \tag{6}$$

Then the following equations is deduced.

$$\frac{\partial E_i}{\partial W_{kj}}=\frac{\partial E_i}{\partial net_{ji}}\frac{\partial net_{ji}}{\partial W_{kj}}=\frac{\partial E_i}{\partial net_{ji}}O_{ki} \tag{7}$$

1. When j is the output node, then $O_{ji}=\hat{y}_k$

$$\partial_{ji} = \frac{\partial E_k}{\partial \hat{y}_k}\frac{\partial \hat{y}_k}{\partial net_{ji}} = -(y_k - \hat{y}_k) f^{'}(net_{ji}) \tag{8}$$

2. Where j is not the output node,

$$\partial_{ji} = \frac{\partial E_i}{\partial net_{ji}} = \frac{\partial E_i}{\partial O_{ji}}\frac{\partial O_{ji}}{\partial net_{ji}} = \frac{\partial E_i}{\partial O_{ji}} f'(net_{ji}) \tag{9}$$

$$\frac{\partial E_i}{\partial O_{ji}} = \sum_m \frac{\partial E_i}{\partial net_{mi}}\frac{\partial net_{mi}}{\partial O_{ji}} = \sum_m \frac{\partial E_i}{\partial net_{mi}} W_{mj} = \sum_m \delta_{mi} W_{mj} \tag{10}$$

At last the following equations is deduced.

$$\begin{cases} \delta_{ji} = f^{'}(net_{ji}) \sum_m \delta_{mi} W_{mj} \\ \dfrac{\partial E_k}{\partial W_{kj}} = \delta_{ji} O_{ji} \end{cases} \tag{11}$$

Suppose that there are L layers in BP network, the L layer includes only output nodes and the first layer is input nodes. Thus the algorithm of BP is simplified as follows.

(1) Select initial Weights.

(2) Following process is repeated until the output value is convergent.

a)When value of i is from one to N, if there is fore propagation process, the value of O_{ki},net_{ji} and y_i are calculated. If there is back propagation process, the value of δ_{ji} is calculated in each layer from the M layer to the 2 layer.

b) The modified weights will be attained by using the following formula.

$$W_{kj} = W_{kj} - \mu \frac{\partial E}{\partial W_{kj}} \tag{12}$$

$$\frac{\partial E}{\partial W_{kj}} = \sum_{k=1}^{N} \frac{\partial E_i}{\partial_{kj}} \tag{13}$$

where μ is step.

The simplified BP algorithm is to turn a group of samples of input and output problem into a nonlinear optimization problem and use gradient descent method that is the most universal optimization method. The more accurate solution can be attained through adding hidden nodes to BP network which increases adjustable parameter in optimization problem.

3.3. Training BP neural network

It is a key problem to select the amount of data in complex character recognition, because the relationship between input and output is included the samples selected. Thus, the amount of data used is more and the result of learning and training more exactly reflect the relationship of input and output. However, too much data will crease the expense of gathering data, analyzing data and training BP. Of course, exact result will not be attained if there is too little data. In fact the amount of data is decided by many factors such as network scale, the need of network test and the distribute of input and output. An experiential rule of confirming network scale is that the number of training samples is five times to ten times as that of connective samples. According to the rule, training will be implemented between standard character and practical character abstracted from image, especially the confused character. Detailed steps are as follows.

Step 1: Select a pair of training samples from cases set being trained and use input vectors as network input.

Step 2: Calculate output vectors of network.

Step 3: Compare error between network output vectors and objective vectors being trained.

Step 4:Adjust network weights in the direct of reducing error from output t layer to the first middle layer.

Step 5:Repeat above steps for every case of case gather being trained until the error of the whole of case gather is minimum.

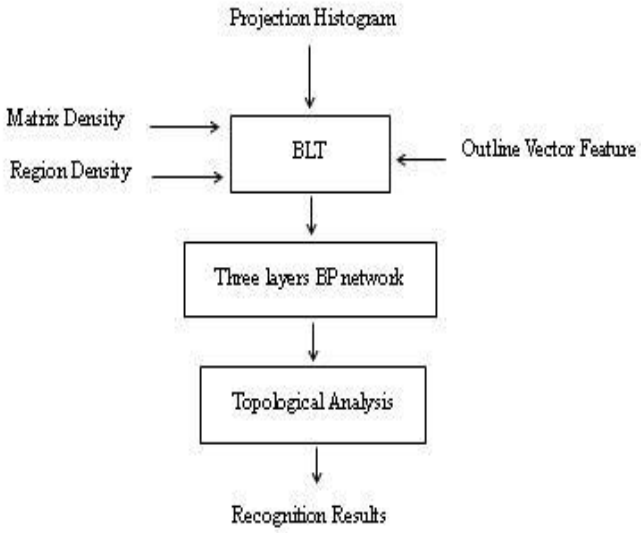

Fig.3. Topological Structure

The calculation of the first step and the second step is implemented layer by layer. The end of learning is that error between actual output vectors and objective vectors is so little that it is acceptable and the weights do not need to be adjusted. As a result, when neural network trained is used to recognize character, the process only need to use the first step and the second step. The third step and the forth step begins from output layer and iteration method is used.

4. Experimental result and analysis

It is very easy to realize character recognition on the VC++ platform using simplified BP algorithm. The flow chart of character recognition is shown in Fig.2.

Character recognition is based on three layer BP neural network and it is important to abstract the feature of character vectors. It will obtain good effect if each aspect feature of binarization character such as projection distance, projection histogram, region density and outline feature coefficient are abstracted and sent to neural network. While the single features are sent to neural network, its effect is not good.

In order to quicken the recognition speed and meet the demand of input vector, BLT which is Binarization Linear Transform is needed to reduce input vectors. For some shape alike character such as Q and D,B and 8, neural network cannot correctly recognize, thus, the following topological analysis which is shown in fig.3. is needed.

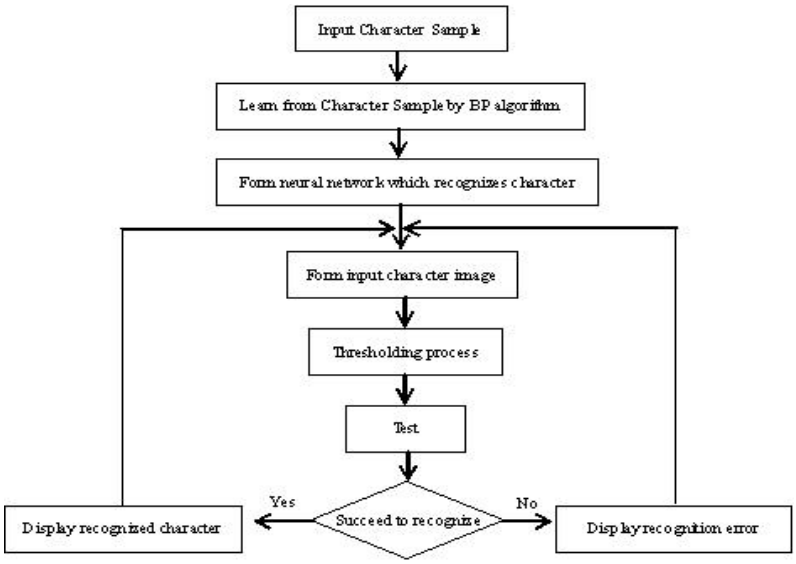

Fig.2. The flow chart of character recognition

5. Discussion

Using the system the whole recognition ratio can reach ninety-six percent, which includes that the recognition ratio of letter and number is ninety-eight percent and that of Chinese Character is ninety-four percent in good environment. Even in bad environment which means that the whole image is very dim the whole recognition ratio can also reach over ninety percent.

In experiment, two thousand characters will be recognized and the result of recognition is shown in Table I.

TABLE I RECOGNITION RESULT

	The total of character	In good environment		In bad environment	
		Right recognition	The ratio of recognition	Right recognition	The ratio of recognition
letter	560	549	98%	532	95%
number	800	791	98%	768	96%
Chinese Character	960	921	96%	883	92%

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