Study of Digital Character Recognition
Based on BP Neural Networks

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**Abstract.** A digital character recognition method is presented based on BP Neural Network. This paper preprocesses the digital character image and extracts character feature, then uses BP Neural Network to recognize digital character. Back Propagation algorithm seeks network weights to minimize training error in the solution space. A network with hidden layer is created at first, then an input sample vector is sent to network input terminal and the square error \(E\) between output values and training sample object output values is calculated. Above process is repeated for input samples of training sets until the error is reduced within the limits of the threshold. The results show that the method presented has good accuracy, quick speed and strong robustness for realtime application.

**Introduction**

Digital character recognition belongs to research field of pattern recognition, which has been widely applied for ID, automobile license detection and bank bill identification.

Many recognition algorithms have appeared recently which are based on wavelet transforms, contour structure, statistic characteristics, neural network, support vector machine or template matching. Among these algorithms, neural network has high concurrency, good fault tolerance and self-learning ability [1].

This paper studies digital character recognition based on BP Neural Network. Test results show that the method has good accuracy, quick speed and strong robustness for realtime application.

**BP Neural Network Design**

BP Neural Network adopts multilayer forward neural network based on BP algorithm. Fig. 1 shows the typical structure of three-layer BP Neural Network. It is composed of input layer, hidden layer and output layer. All layers are fully connected between each other, but nerve cells have no interconnection in the same layer [2].

![Three-layer BP Neural Network structure](image)

Fig. 1 Three-layer BP Neural Network structure
BP(Back Propagation) algorithm adopts gradient descent method, which aims at the minimum square error between actual network output values and object network output values as given below [3].

$$E(\omega) = \frac{1}{2} \sum_{d \in D} \sum_{k \in \text{outputs}} (t_{kd} - o_{kd})^2.$$  \hspace{1cm} (1)

Where, outputs are the sets of network output layer, $t_{kd}$ and $o_{kd}$ are output value of the $k$-layer output cells when the training sample $d$ is used as network input, and error $E$ is considered as the function of connection weights between network layers depending on these weights jointly.

Back Propagation algorithm seeks network weights to minimize training error in the solution space. A network with hidden layer is created at first, whose nerve cells weights are assigned a little real number value. Then, an input sample vector is sent to network input terminal, and network output values are computed to calculate the square error $E$ between this output values and training sample object output values. The hidden layer can be disposed by adjusting the weights of output layer cells with the help of error values. Above process is repeated for input samples of training sets until the error is reduced within the limits of the threshold.

**Digital Character Recognition Experiment Design**

Visual C++.NET 2003 is adopted as the development environment. Fig. 2 shows four sample images with the resolution value of 64×32 pixels are used as sample sets for every digit.

![Fig. 2 Training samples](image)

**Image Preprocessing.** RGB images with noise are inputted and converted to grey level images. Target characters are separated from background region after image binaryzation. Based on connected region, normalization and alignment are realize by eliminating noise, adjusting gradient and splitting charters. Training and test sample are saved at last.

**Feature Extraction.** If all pixels of character image are taken to extract the input feature directly, a lot of input weights will be introduced because the dimension of characteristic vector is the product of the image pixels height value and width value. Sample image must be resampled to at the unified low resolution value of 64×32 pixels. Every low resolution value pixel is figured out according to the mean grey value of corresponding local high resolution value pixels.

**Network Structure Definition.** Ten network output cells are set up for ten digits. Every output corresponds to a kind of class label. The $i$ th output cell is assigned a high value and other cells are assigned low valued for target output, when the $i$ th class sample is trained. Maximum output cell number is used as the predictive network value for test. This coding scheme provides more free degree for target function, and offers reliable information about classification decision.

Training data have more free degree and convergence rate are quicker with more hidden layer cells. But too many hidden layer cells will result in over fitting and reduce discrimination and noise immunity [4]. After comparing several groups of actual test parameters, thirty hidden layer cells are selected.

**Digital Character Recognition Experiment Design**

**Training.** Maximum training times is set as 8000, error threshold is 0.001, learning rate is 0.1, hidden layer cell number is 30 and training begins after choosing training samples.

When gradient descent method is iterated to 522th age, the training lasts nine seconds and ends, the error is 0.001 and the training configuration file is saved. Fig. 3 shows the training result.
Test. After loading the previous training configuration file and selecting the test image, test begins. Fig. 4 shows the recognition result. Ten test samples are recognized successfully.

Conclusions
This paper realizes automatic recognition of digital character based on the BP Neural Network. The system has evolutionary global criterion and accuracy, quick convergence rate and high discrimination which can be applied for ID, automobile license detection and bank bill identification.
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