Design of Handwritten Numeral Recognition System Based on BP Neural Network

Jianghai Liu and Jie Hong
College of Electronic Information Engineering, Wuhan East Lake College, Wuhan, Hubei, China
E-mail: 258155559@qq.com

Abstract. In the case of pattern recognition, handwritten numeral recognition is an important research topic in pattern recognition, and it has a very wide application in today’s information society. However, the research on numeral recognition is still in the development stage, and the recognition effect is not ideal. A handwritten numeral recognition method based on BP neural network is proposed. Firstly, the image is grayed, binarized, smoothed, denoised and normalized to extract the pixel value; Then the designed BP neural network is trained, compared with the expected results and expected structure, and the BP neural network is adjusted and modified; Finally, the trained neural network is obtained. Experiments show that the accuracy of this method for handwritten digit recognition is 85.88%.

Keywords. Handwritten digits; BP neural network; digital recognition; the simulation test.

1. Introduction

Handwritten numeral recognition is one of the important research topics in the field of image processing and pattern recognition. Due to the factors of the writer, the randomness of the digital image of handwritten numeral is very large, such as the difference of font size, stroke thickness and font inclination will directly affect the final recognition result of digital characters. Therefore, handwritten numeral recognition is one of the most challenging topics in the field of pattern recognition [1].

The research on handwritten numeral recognition not only has great practical significance, but also has a very broad application prospect. Nowadays, with the rapid development of economy and the accelerating process of financial marketization, the bill business is developing rapidly, and the number of bills is also increasing day by day. Personal vouchers, checks, invoices, receipts and other bills need to process a lot of information. At present, many human information is text images recorded on paper. It is cumbersome and inefficient to input these information into the computer. If the handwritten character recognition technology is used to realize the automatic input of information, it will undoubtedly effectively solve the problems of large workload, high cost, low efficiency and poor timeliness in the traditional manual processing methods. In addition, the application fields of handwritten numeral recognition include mail sorting, statistical reports and so on [2, 3].

This paper designs the system according to the general process of “data input data processing feature extraction BP neural network training neural network recognition”: (1) Data preprocessing stage: graying, binarization, image gradient sharpening, removing discrete noise, gradient adjustment, character segmentation, normalization, digital compression and rearrangement.
(2) The secondary training of the network normalizes the character pixels of each pre-processing data, and the value of the characteristic pixels forms a characteristic function matrix, which is fed to the network for secondary training.

2. Overview of Neural Network
Artificial neural network (hereinafter referred to as human brain neural network) has many basic functions similar to other neural network systems of modern human brain. It includes two basic processes: fast forward propagation of learning signal and reverse reversal of signal error.

From figure 1, we can clearly see that the forward vector is mainly obtained from two input hidden layers, so as to obtain a signal with small error, from which we can accurately calculate and obtain the actual output device capacity and regulator capacity of the input layer. For the height error vector signal, the node error vector signal is obtained by the value of each hidden node of the hidden layer, and the node weight vector adjustment value of each hidden layer can be used as the basis for calculation.

![Figure 1. Signal flow diagram of BP algorithm.](image)

3. Design of Digital Recognition System Based on BP Neural Network

3.1. BP Neural Network Design
The learning process of BP network is mainly composed of the following four parts:

1. Input mode forward propagation;
2. The output error is back propagated;
3. Cyclic memory training (the process of cyclic alternation or repeated calculation of the forward propagation and error backward propagation of the model): because the output error of the network is often very small, and for each group of training models entering the BP network, it usually requires hundreds of thousands or tens of thousands of regular training times, so that the network can effectively remember this training model. This kind of regular memory training method is to repeat steps 1 and 2 over and over again;
4. Discrimination of learning results (to determine whether the global error tends to the minimum or reaches the maximum training times): after each cycle memory training, the discrimination of learning results should be carried out. The main purpose of discrimination is to check whether the output error has been small enough to be allowed or whether the training times have reached the maximum training times. If it is small enough or reaches the maximum number of training times, the whole learning process can be ended, otherwise, the cycle training will be carried out.

Determination of neuron number in BP neural network

1. The number of nodes in the input layer

The number of each node in the input layer of BP neural network is the output feature dimension after image preprocessing. In this paper, the pixel is normalized by 816, the standard feature extraction method of each pixel is widely used in standard feature extraction, and the pixel value of each point is
directly used for feature extraction. Therefore, we can see that the number of nodes in the input layer is about 128. The neuron diagram is shown in figure 2.

![Neuron diagram](image)

**Figure 2.** Neuron diagram.

(2) Number of hidden layer nodes

The function of hidden nodes is the only way to extract and store data from samples. Each hidden node has multiple weights, and each weight is a parameter to improve the network mapping function.

Selecting the number of hidden nodes is a very complex thing, which is directly related to the requirements of the problem and the number of input and output units. Therefore, in practice, we must make a decision based on the designer’s experience and many attempts. Generally, the more hidden nodes, the more accurate BP network, but the longer the training time. Too many hidden nodes should not be selected, otherwise the recognition rate will decline sharply, and the noise elimination function of the network will also decline. In fact, if the number of nodes hidden in the network is too small, the performance of the network from the information provided by these samples will be greatly reduced, and these data are not enough to summarize and reflect the sample law of the training set. If there are too many hidden nodes, the irregular nodes can be removed. The content of the sample (such as noise) will also learn to remember the so-called over matching problem, and irregular nodes can also be deleted [4].

3.2. Image Preprocessing Module

The image preprocessing module will adjust the input image according to the pixel level, adjust the slope so that the size of handwritten digits can be kept constant, so as to extract the sample and data after preprocessing.

(1) Graying of color image

Generally, 256 color images will appear. Because the content of 256 color geographic map palette is very complex and cannot perform many other algorithms, the color image usually needs to be grayed out. After grayscale, the grayscale image has the same RGB value, but the color brightness is different. Moreover, when the gray value is large, the pixels may become bright, while when the gray value is low, the color of the image will become dark [5-7].

(2) Binarization of gray image

After the graying of the color image, the two-dimensional value of each pixel is only one, that is, the two-dimensional value of gray. The two-dimensional digitization of three-dimensional image is divided into black and white images according to a specific standard. This system uses the given threshold method, the given threshold is 220. The rendering after binarization is shown in figure 3.
(3) Gradient sharpening

Due to the blur of the image font after binarization, it is necessary to carry out gradient sharpening. The gradual definition also has some influence on the noise removal.

(4) De discrete noise

Discrete noise must be eliminated. The specific method is: scan the whole image. If a black pixel is found, the black pixel is connected directly or indirectly. If it is greater than a certain value (a certain value depends on the situation), it can be regarded as a non discrete point. Otherwise, it will be treated as a discrete point and removed from the image [8].

The following steps describe the noise reduction algorithm of the system:

(1) Initialize to 0.

(2) Scan left rectangular pixel, right rectangular pixel, upper rectangular pixel, lower rectangular pixel, upper left rectangular pixel, upper right rectangular pixel, lower left rectangular pixel and lower right rectangular pixel in turn, and the average value of 8 rectangular pixels is reached. When the attribute values of a primary color pixel are 255, the number of primary attribute pixels identifying this point will increase. The maximum pixels of each picture in the first and last columns are reset to 255 [9].

After the above four steps, most of the image noise will be eliminated, and the text information will be well preserved. The image effect after denoising is shown in figure 4.

(5) Normalization adjustment

There may be some distortion in multiple images when reading, so you need to adjust them to keep them at the same physical level or position all the time [10]. It not only makes it convenient for users to segment and automatically recognize multiple characters, but also helps users to enhance the accuracy of character recognition. Due to the different sizes of scanned characters, the accuracy of recognizing images of the same size is very high, and normalization adjustment is needed, as shown in figure 5.
4. Simulation Experiment
Firstly, a large number of training samples are used in training network to obtain, save and transfer weights in document format. Training sample is a kind of carefully selected known data, which can well reflect the separability of training sample. They can extract the characteristics of training sample photos and send them to BP network for training. Some handwritten samples are shown in figure 6.

Secondly, BP network can be used to recognize unknown data after training. It must be preprocessed first, then feature extracted, and finally sent to BP network until the result is obtained. The MSE curve of digital identification system simulation is shown in figure 7.

The gradient sum check curve of digital identification system simulation is shown in figure 8.

Experiment shows that the accuracy of trained neural network for handwritten digit recognition is 85.88%. The neural network has high accuracy and reliability in the digital character recognition technology. Because the neural network provides a kind of information processing function with complex models such as self-learning, association and memory, it plays an important role in the multi process, nonlinear system and other aspects of model recognition.

5. Summary
In recent years, digital feature recognition and analysis technology has gradually become a hot topic in the academic research of China’s scientific community. It has a wide range of practical application and development prospects. It is also considered to be a major historical and challenging technical
problem. Traditional data analysis methods include data template method, statistical method and decision-making method. It has been unable to fully meet the higher requirements for analysis accuracy and calculation speed. The ability of parallel computing, the ability of fault-tolerant computing, the universality and reliability of artificial neural network, and any high-precision approximate estimation of unknown nonlinear objects and a group of attributes of objects provide us with a new method of handwritten numeral recognition. At the same time, it is closely integrated with all kinds of preprocessing technology in the pattern recognition technology, which also makes the handwritten digit recognition technology get further development.

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