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Article

Single-Choice Aided Marking System Research Based on Back Propagation Neural Network

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Abstract: In the field of educational examination, automatic marking technology plays an essential role in improving the efficiency of marking and liberating the labor force. At present, the implementation of the policy of expanding erolments has caused a serious decline in the teacher-student ratio in colleges and universities. The traditional marking system based on Optical Mark Reader technology can no longer meet the requirements of liberating the labor force of teachers in small and medium-sized examinations. With the development of image processing and artificial neural network technology, the recognition of handwritten character in the field of pattern recognition has attracted the attention of many researchers. In this paper, filtering and de-noise processing and binary processing are used as preprocessing methods for handwriting recognition. Extract the pixel feature of handwritten characters through digital image processing of handwritten character pictures, and then, get the feature vector from these feature fragments and use it as the description of the character. The extracted feature values are used to train the neural network to realize the recognition of handwritten English letters and numerical characters. Experimental results on Chars74K and MNIST data sets show that the recognition accuracy of some handwritten English letters and numerical characters can reach 90% and 99%, respectively.

Keywords: Image preprocessing; BP neural network; handwriting recognition; marking system

1 Introduction

With the policy of enrolment expansion proposed in Colleges and Universities, the teacher-student ratio in some schools has declined seriously, and the task of judging papers has been aggravated, which has affected the teaching and scientific research work to a certain extent. The traditional manual scoring method has many drawbacks, on the one hand, teachers are required to review a large number of paper test papers at one time, Long-term mechanical correction work can easily leads to visual fatigue of the teacher and unavoidable human error, which affects the accuracy of marking; on the other hand, in the process of marking, frequent reviewing and correcting will result in a certain degree of paper damage, it is not conducive to the paper archiving and later references [1,2]. However, the automatic marking technology which relies on computer image processing technology is not only efficient and accurate, but also can realize the liberation of teachers' labor force.

2 The Introduction to the Auxiliary Marking System

2.1 Demand Analysis

At present, the automatic marking system based on OMR (Optical Mark Recognition) technology has been put into use, it needs to be supported by photoelectric reading machines and special answer

CARDS, and the cost is relatively high. After nearly 70 years of research and development, the character recognition has been the hot area of pattern recognition [3]. Developing the universality of automatic marking system in small-scale examination is a realistic demand of liberating the teacher labor force. In this paper, the auxiliary marking system based on image recognition is designed to meet the needs of teachers in small and medium-sized examinations, which can not only help teachers to mark papers, but also realize the security management of students' scores. The system collects test paper images through the camera, realizes the recognition of handwriting characters through image preprocessing, feature extraction and neural network model. Finally, the system will record the results and realizes the security protection of system login through the database.

2.2 System Goals

According to the actual requirements of the single-topic aided marking system, this paper applies the concept of "deep learning" to machine learning in the process of marking the objective questions and recording the identity of examinees, adopts the supervised learning model architecture to realize the recognition of target characters, and makes a modular design for the system.

First of all, locate and crop the area of interest and perform de-noise preprocessing, and then recognize analyze, displayed and stored the processed handwritten character images. At the same time, the system design should follow the principle of practicality, rationality and efficiency.

The flow chart for Single-choice Aided Marking System which is based on Back Propagation Neural Network is shown on Fig. 1.

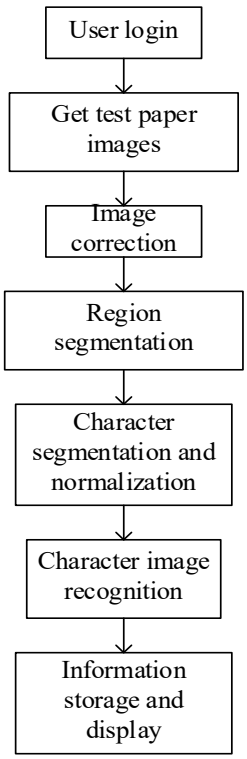


Figure 1: System flow chart

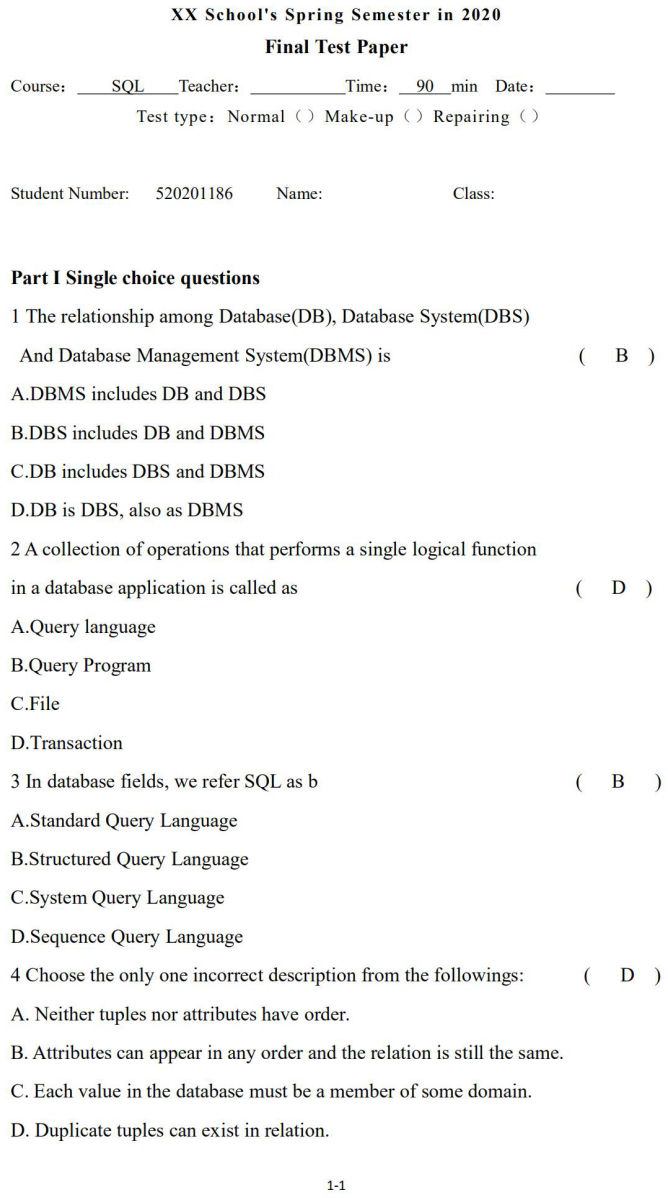
3 The Related Technologies

3.1 Image Acquisition of Test Paper

This system uses the program to call the network camera [4] as the image input device to directly

collect test paper image. Using the combination of traditional camera and network video technology, the image of test paper is captured from video stream and then to save and edit them.

The video stream image captured from the graphical interface of the system is shown in Fig. 2.



XX School's Spring Semester in 2020

Final Test Paper

Course: SQL Teacher: _____ Time: 90 min Date: _____

Test type: Normal ( ) Make-up ( ) Repairing ( )

Student Number: 520201186 Name: Class:

Part I Single choice questions

1 The relationship among Database(DB), Database System(DBS)
And Database Management System(DBMS) is (B)

A.DBMS includes DB and DBS

B.DBS includes DB and DBMS

C.DB includes DBS and DBMS

D.DB is DBS, also as DBMS

2 A collection of operations that performs a single logical function
in a database application is called as (D)

A.Query language

B.Query Program

C.File

D.Transaction

3 In database fields, we refer SQL as b (B)

A.Standard Query Language

B.Structured Query Language

C.System Query Language

D.Sequence Query Language

4 Choose the only one incorrect description from the followings: (D)

A. Neither tuples nor attributes have order.

B. Attributes can appear in any order and the relation is still the same.

C. Each value in the database must be a member of some domain.

D. Duplicate tuples can exist in relation.

1-1

Figure 2: Examination paper image with graphical interface

3.2 Image Preprocessing

When obtaining test paper images by IP camera, there are some problems in the test paper images taken due to subjective or objective factors. For example, the location and angle of the mobile phones are not appropriate, and the paper position manually placed by the examiners is not in the area or is unfair, which will lead to the visual angle skew or the shift of the paper captured by photographing. At the same time, when the mobile phone camera is used to shoot the image of the test paper, it will also be affected by the light and shadow, resulting in obvious bright and dark color difference and perspective distortion in the test paper. Therefore, after intercepting the image, the correction and preprocessing of the image should be carried out.

In order to ensure that the student number area and the answering area can be completely divided, the paper template:

(1) The test paper should adopt the standard A4 pages; should be designed based on the following three principles:

(2) The head of the test paper with basic information of school, test, candidate and the fixed area.

(3) Set the single-choice answer area at the end of the question line, and the question area must not exceed the bracket area for writing answers.

This paper uses tilt correction based on edge detection [5,6] into a fixed height to fit the threshold value of edge detection. The traditional edge detection algorithm is used to extract the edge, find the closed contour, and select the maximum area contour as the target edge. The four corner points are determined by polygon fitting, then the ladder diagram is obtained by mapping, and the original image is obtained by perspective transformation. According to the position information of the corresponding area in the test paper template, the region of interest is cut, and then the target character image is segmented according to the projection method, and finally the expansion operation is performed to de-noise [7], and then normalized to the subsequent standardized size image. The processing effect is shown in Fig. 3.

Figure 3: Renderings of image preprocessing

3.3 Character Feature Extraction

This paper uses the pixel distribution feature extraction method to operate on the image pixel distribution features, such as projection features. The pixel-by-pixel feature extraction method is to scan the image cyclically after gray-scale binary [8], count the number of white pixels, and return a one-dimensional feature vector matrix that is the same as the number of image pixels.

4 Neural Network Model and Related Algorithms

Artificial Neural Network [9] is a network model modeled after the biological nervous system. In general, it is used as an information processing unit to simulate the logical learning of human brain to process data, perform specific tasks or complete functions of interest. The neural network model is constructed by imitating the structure of biological neurons. There is a simple neuron model shown in Fig. 4.

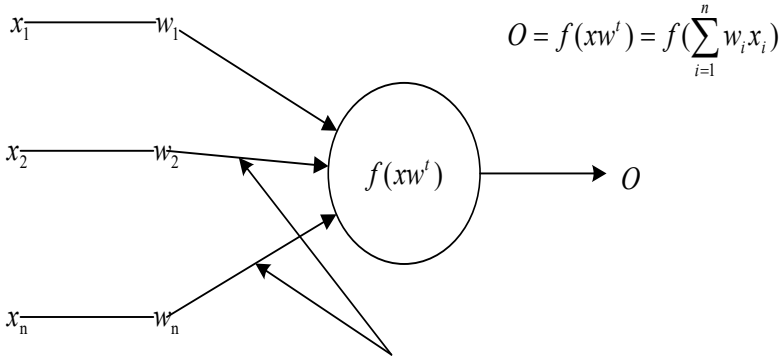


Figure 4: Neuron model

4.1 The Introduction of BP Neural Network

BP neural network is a network for model training often used in pattern recognition, and it is also called a multilayer feed-forward neural network [10]. In Fig. 5, it shows the topology of multilayer feed-forward neural network. It can be clearly seen in the model that there is no connection between neurons in the same network layer. Moreover, there is no feedback connection between different network layers, but there is a weight transfer connection between the neurons of adjacent layers. The input layer accepts the input signal and passes it forward to the hidden node. After the function of the hidden layer, the output signal of the hidden node is passed to the output contact, and finally the result is output in the output layer. The multilayer feed-forward neural network with BP algorithm is called BP neural network. It consists of one input layer, one output layer and one or more hidden layers [11–13]. The activation function uses sigmoid function [14].

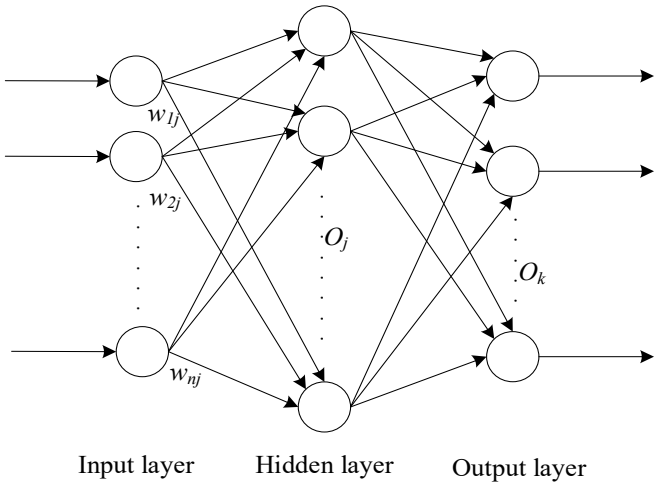


Figure 5: Topology of multilayer feed-forward neural network

4.2 BP Neural Network Algorithm

The basic idea of the BP algorithm is to input the training sample set in the input layer of the feedforward network, and then use the back propagation algorithm with supervised self-learning mechanism to repeatedly train the error of the neural network and adjust the neuron weights to make the output vector as close as possible to the desired vector. When the sum of squared errors of the network output layer is less than the specified error, the training is completed, and finally the weight and error of the network are saved.

The basic flow of the algorithm [15–17] is:

Step 1: Initialization, set each parameter: sample counter m (maximum M), training counter number n (maximum N), set up the weight matrix of random Numbers, error E zeros, and permissible error value for ε ;

Step 2: Input the collected training sample set, including the actual training sample X and the expected output sample x ;

Step 3: Calculate the output X and Y vectors of each layer, and the output error is shown as the formula (1):

$$e = x - y \tag{1}$$

Step 4: Calculate the error signal of each layer and the local gradient δ of the error, determine whether the error is within the allowable range, if it is satisfied, skip to Step 6, otherwise skip to Step 5;

Step 5: If the operation times reach the maximum value during the training period, jump to Step 6

directly; otherwise, use the back propagation calculation principle to continuously adjust the weights of each layer;

Step 6: Check the sample counter m to determine whether the sample training is completed. If it is completed, it will end directly, if it is not completed, skip to Step 2 to continue.

Selection of the number of nodes in each layer.

The theory has proved that a network with deviation and at least one S-type hidden layer plus a linear output layer can approximate any rational function [18]. In this paper, a three-layer BP neural network with a hidden layer is adopted [19,20], where the node of the input layer is determined by the eigenvalue. After adjusting the image of handwritten English letters (A~D) to 28 × 28 pixels in the same format as the Chars74K image of the training set, the number of nodes in the input layer is determined to be 784. The number of hidden layer nodes is determined by the training experience value as the best 300. The number of output layer nodes is determined to be 4 by the number of expected output values.

4.3 Open Source Artificial Neural Network Library Keras

Keras is an advanced neural network API based on Python. This paper uses the MNIST data set as the training set to train a network model for handwritten character recognition based on the Keras library. Use the core data structure-model, and Sequential order model, the model is stacked by the function called add. Finally, configure the learning process by a function called compiled [21–25].

5 Database Design

To ensure the security of the system, MySQL database is adopted in this paper to set the basic information table of user objects for login verification. Tab. 1 shows the basic information of teachers.

Table 1: The basic information of teachers

Id	Username	Password
1	10107001	123456
2	10107002	123456
3	10107003	123456
4	10107004	123456
5	10107005	123456
6	10107006	123456

6 Testing and Analysis

This system is completed on a 64-bit Win10 system computer. The configuration of the computer is:

CPU: Intel Core (i5-6200U), Frequency with 2.3 GHz

Memory: 8.0 GB

GPU: NVIDIA GeForce 930 M

The realization of handwritten character recognition is divided into two parts. The first part is English character recognition, by building a three-layer BP neural network, and selecting the Chars74K data set as the training data set. Among them, 56 kinds pictures are standardized to 28 × 28 pixels. Labels are added for different types of character images, and the picture data is stored in a matrix. The second is digit character recognition. Using the Keras library that comes with python, select the MNIST data set which contains 60,000 training examples and 10,000 test examples as the training set.

6.1 Processing Steps

Student id area:

(1) Use the cv2.findContours function for each number character to find the edge, and return the upper left and lower right corners of the frame;

(2) According to the frame, process each picture into the picture format of the MNIST data set;

(3) Import the network model trained and stored with the MNIST data set to predict the result, and return the recognition result to the list for storage.

The answer area:

(1) Normalize handwritten English characters and process them into 28 $\times$ 28 pixels;

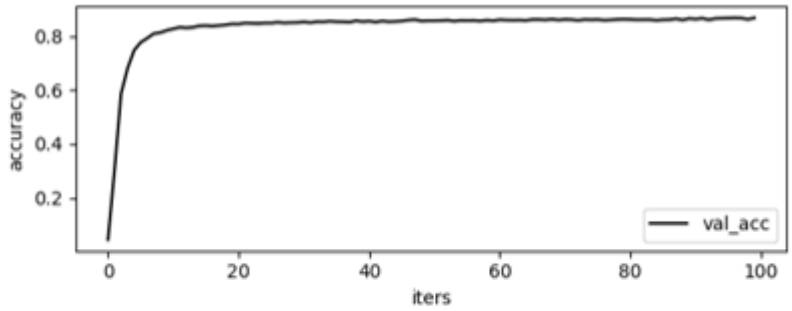
(2) Convert the picture to a vector or matrix. Use the image graying function "img. convert ('L')" to open the image, and each pixel is represented by 8 bit. The image is converted into an array, and the pixels are converted between 0 and 1. After binary, converting the image matrix into a one-dimensional array and storing it in a random matrix with a size of $(1,256 * 256 * 3)$ [26]. Set the number flags from 0 to 3 for the four letters A to D. Converting a one-dimensional array into a matrix and store it in the datatest.txt file, and use it as data for character recognition;

(3) Process the images in the data set and convert them into a matrix and store them in a text document named data;

(4) The data set data.txt was imported for neural network training to obtain the prediction model. Then predict the test data obtained in Step (2), which is stored in the file Datatest.txt, and get the results.

6.2 Analysis of Experimental Results

Different network models are selected for training and recognizing of different handwritten characters. Fig. 6 shows the recognition accuracy of handwritten characters, where Fig. 6(a) represents the recognition accuracy of English characters, and Fig. 6(b) represents the recognition accuracy of Numbers characters. Fig. 7 shows the recognition result of the test. It should be noted that in the recognition of handwritten English characters, the label number in this paper represents the recognition result. For example, the letters A, B, C and D are represented by the Numbers 0, 1, 2 and 3.



(a) English character recognition accuracy

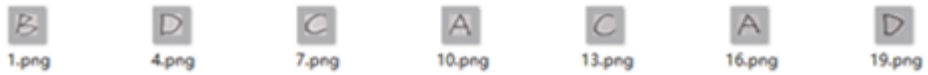
```
 9600/10000 [===========================>..] - ETA: 0s
 9920/10000 [============================>.] - ETA: 0s
10000/10000 [==============================] - 2s 164us/step
The accuracy of Numerical character recognition is acc 0.991100013256073
```

(b) Numerical character recognition accuracy

Figure 6: Character recognition accuracy


```
{0: '2', 1: '0', 2: '1', 3: '6', 4: '3', 5: '8', 6: '6', 7: '6'}
dict_values(['2', '0', '1', '6', '3', '8', '6', '6'])
=======Student ID is successfully recognized=======
```

(a) recognition result of Student ID area




```
27th example is number3, we predict it as 3
['1', '3', '2', '2', '0', '3', '2']
===Multiple-choice answer recognition successfully!===
```

(b) recognition result of answer area

Figure 7: Sample test results

The test results show that handwritten character recognition based on image recognition can achieve more ideal recognition results.

7 Conclusion

The realization of the auxiliary judging system is the cross integration of multiple fields, including deep learning, pattern recognition, image processing and other aspects [27–31]. The realization of this system is conducive to the implementation of automatic marking methods in small-scale examinations in primary and secondary schools and even colleges. It can liberate teachers from the arduous task of marking papers, improve the level of teaching and researching, and reduce unfairness due to subjective factors.

The system designed in this paper realizes the collection of test paper images and accurately divides the region of interest. After de-noise the image, the individual characters are segmented. Normalize them to convert the handwritten characters into input formats suitable for their neural network models, and compare the recognized results with the standard answer database. After the final score is obtained, the student information and grade information are displayed and stored.

With the rapid development of science and technology, although this article has realized the recognition of handwritten characters, there are still some shortcomings. First of all, the fault tolerance of the system should be improved. For example, for hyphenated characters in the writing process, the segmentation technology should be improved to facilitate subsequent processing and recognition; Second, the image preprocessing should be refined and more handwritten character images should be collected as a training set to improve the recognition accuracy of the neural network. These two aspects are also further research directions.

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Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

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