

A Financial Handwritten Digit Recognition Model Based on Artificial Intelligence

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Abstract: Handwritten digit recognition is a kind of image information classification problem through optical character analysis. Its essence is to represent the pixel points of digital images as gray values and then replace the pixel matrix with a numerical matrix. The computer can deal with numerical problems converted from handwritten Arabic numeral recognition problems through feature extraction and classification. With the rapid development of science and technology, this technology has dramatically reduced the cost of identification and human consumption, making identification more efficient and having a specific use value. However, the current handwritten digit recognition technology will cause problems such as abnormal recognition and recognition errors, reducing recognition accuracy. This will not only increase the cost of human recognition but also increase unnecessary risks. Based on the broad application prospect of handwritten digit recognition in finance, this paper focuses on the research and analysis of the handwritten digit recognition model for its insufficient accuracy, low performance, and other problems. Based on traditional data analysis, this paper adopts deep learning and control variable methods to conduct multiple groups of experiments to explore the impact of different parameters on the accuracy of experimental results. Summarize the best recognition accuracy and achieve the best model performance.

Keywords: Handwritten digit recognition; Artificial intelligence; Machine learning; Deep learning; Financial applications.

1. Introduction

With the rapid development of artificial intelligence, China's technology in this field continues to mature and achieve self-reliance. Still, social needs are changing, human costs are increasing, and technology needs to be constantly optimized and innovated. In recent years, China's research on artificial intelligence has focused on three areas: finance, medical care, and cities. With the development of AI, there are still many defects to be solved for AI in the financial field. The literature analyzes the actual application and risks under the economic area and AI combination. It proposes risk prevention strategies using intelligent protection, information encryption, and law improvement. Many problems, such as data standardization, data exchange, policy supervision, and algorithm theory, have become increasingly prominent in the medical field. Literature, based on data-driven in-depth learning, studied the challenges faced by medical AI and the direction of future development. Artificial intelligence and machine learning methods have gradually matured in urban life, bringing people many conveniences.

Based on this, literature focuses on analyzing AI applications in intelligent medicine, intelligent transportation, gait recognition, and face recognition. Figure 1 and Figure 2, respectively, show the proportion of China's AI technology sources and patent concentration fields from 2018 to 2021. Figure 1 shows the specific sources of China's AI technology in the three years from 2018 to 2021. Among them, China's AI technology accounts for a large proportion (63%), indicating that China's AI technology has developed rapidly. For other countries, the United States accounts for about 20%. In contrast, the rest of the countries account for a relatively small proportion (Japan, South Korea, and the European Patent Office account for 8%, 6%, and 2%, respectively).

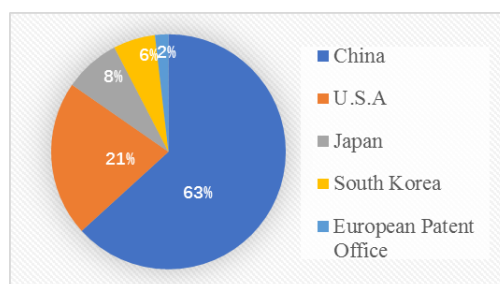


Figure 1. Source Distribution of Artificial Intelligence Technology in China from 2018 to 2021

Figure 2 further shows the statistical distribution of essential fields of AI research in China in the three years from 2018 to 2021. Among them, image recognition and transmission account for a large proportion (41%), while data processing, information, and machine learning account for about 20%, indicating that research in these three fields is relatively popular in China. In contrast, research in other areas accounts for relatively few (robot control, AI supervision, and natural language processing account for 10%, 8%, and 4%, respectively).

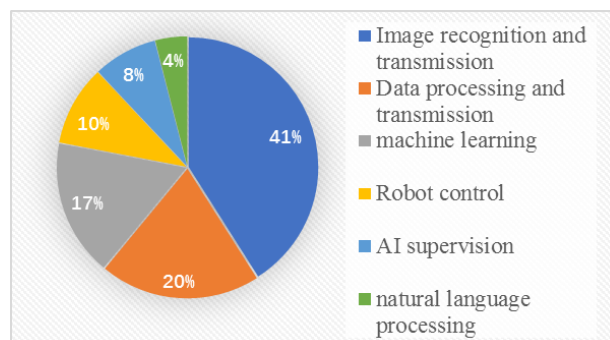


Figure 2. Necessary Fields of Artificial Intelligence Research in China from 2018 to 2021

The progress of artificial intelligence has driven the development of the financial field. The transformative force and the pace of intelligence are constantly increasing, bringing convenience, speed, and security to people's lives. Financial technology is widely used in banks to verify identity information. Based on in-depth learning, literature uses image processing technology and pattern recognition methods to identify and analyze license information, effectively combining artificial intelligence and financial identity recognition. However, in today's developed network, there are many hidden dangers behind the advantages of the Internet. In order to further improve the security performance of the network system, literature designed a network security protection system from both hardware and software aspects, in which BP neural network algorithm was used in the software design to extract and process the characteristics of network abnormal information, send intrusion alerts, prepare for more efficient defense and subsequent repair processing, and ensure the security of the network system. In addition, to avoid the emergence of new types of telecommunications fraud, illegal fund-raising, flight with money, and other problems, literature established an anti-fraud credit scoring model using machine learning methods and conducted research on anti-fraud risk early warning.

Among them, the handwritten digit recognition technology in artificial intelligence has a significant application value. It is an essential component in pattern recognition in computer optical character recognition. Fast, efficient, and accurate recognition determines technical performance. This method is to preprocess the original digital image and extract features, and then through pattern recognition from coarse classification to subdivision, finally output the results of model recognition. Figure 3 shows the digital image recognition process of inputting the original digital image, preprocessing, feature extraction, pattern recognition, rough classification, subdivision, and outputs of the recognition results.



Figure 3. Digital Image Recognition Process

Traditionally, handwritten digit recognition can be divided into online recognition and offline recognition due to different data forms. Based on deep learning and nonsegmentation methods, Zhang innovatively used a skeleton method to fuse offline and online samples and then conducted joint training under the DBLSTM-HMM recognition system to obtain better experimental results in handwritten English recognition. Online handwritten digit recognition is a relatively simple way to recognize the real-time written character data of the handwritten person through physical devices; Offline handwritten digit recognition is to scan and analyze the collected handwritten text data through image capture equipment. The difference between the two is that the former can analyze and obtain stroke features, writing speed, point coordinate information, and other data, while the latter cannot identify valuable details, which leads to low accuracy of offline recognition and cannot meet the number recognition process with different writing methods. The recognition rate and accuracy of handwritten digit recognition can be improved by using elastic BP algorithm [1], PCA dimension reduction improved KNN algorithm [9], neural network improvement applied to handwritten digit recognition [10], as well as Alex Net model improved convolutional neural

network [11].

Handwritten digit recognition has gradually expanded its application scope in the robot automation environment and has become a promising field of handwritten digit recognition applications in the financial field. With the rapid growth of China's economic strength, the demand for manual processing of statistical statements, financial statements, bank bills, postal codes, payments, and other operations is also growing, so we hope to introduce handwritten digit recognition technology under machine learning algorithms. The combination of artificial intelligence and machine learning technologies with handwritten digits will help to analyze better and recognize digital information; It can not only improve the overall work efficiency, and reduce labor costs but also enhance algorithmic transactions through machine continuous learning and summary, avoid financial risks caused by errors in manual operation, moreover improve the quality of customer service. So there is enormous potential for applying artificial intelligence to handwritten digit recognition.

There are still many challenges in applying handwritten digit recognition in financial fields. Although there are only ten types of Arabic numerals, the machine recognition process is complicated due to various digital differences, nonstandard images, unclear handwriting, and different writing methods caused by writing habits. In addition, the accuracy requirements for digital recognition in the financial field are often more significant than the recognition of other characters and pictures. Therefore, more excellent methods are needed to research and improve the handwritten numeral model, improve the recognition accuracy and speed of the model, and reduce errors. We can only have more opportunities to apply this technology to accurate handwritten numeral recognition in the future.

To better realize the integration of handwritten numeral recognition and financial numerals, this paper will conduct a large number of experiments through the improved handwritten numeral recognition algorithm model, test the influence of the learning rate and the number of rounds of the model on the accuracy of the experimental results, get the best model time consumption, improve the overall accuracy of the model, and finally select the best scheme to try to apply it to finance reasonably. The main contributions are: (1) Emphasize the potential application value of handwritten digit recognition in the financial field. (2) This paper summarizes the improvements or solutions to handwritten digit recognition proposed by different literature and explains them. (3) The experimental results show that the model proposed in this paper achieves better performance on open-source datasets.

2. Related Work

Artificial intelligence has been increasingly widely used in finance in recent years. Moreover, the machine learning technology revolution in these fields is also increasingly valued by people. Among them, Lin discusses the specific analysis and application of artificial intelligence technology combined with big financial data, what's more, provides more valuable measures to improve the ability of financial data management; Guan discussed the application status and impact of artificial intelligence in the financial industry, as well as the future needs and prospects of artificial intelligence. In addition, many scholars have studied the application of AI to other aspects, such as the research on the innovation of the

"smart finance" model in the era of AI, the research on the application of AI in banking and securities investment, and the research on enabling inclusive finance AI is still in the early stage of development in the financial field; many aspects can develop potential, make rational use of AI, and achieve intellectualization.

In the application of the financial field, handwritten digit recognition technology has high requirements. The accuracy of model results, recognition rate, and speed will determine the risk level of machine handwritten digit recognition. Many scholars at home and abroad have conducted in-depth research on the application of this technology in different ways and proposed improvement plans to seek the best way to improve the accuracy of the technical model. They found that machine learning and deep learning can not only mine the potential value from a large number of data but also make prediction models and imitate human thinking and learning to bring people much convenience. Therefore, the research on handwritten digit recognition has some practical value.

Researchers at home and abroad have made many contributions to the research of handwritten digit recognition based on machine learning and depth learning. In the field of neural networks, WANG [10] designs and applies the convolutional neural network model to handwritten digit recognition and improves two single-hidden layer neural network training algorithms to obtain a training model with excellent performance proposes to locate and recognize deformed handwritten digits for correction automatically. Based on different directions of the convolutional neural network, XIE et al. [11] also made other improvements to the convolutional neural network. They introduced the Inception res net module, used batch-specific scaling processing methods, and reduced the number of convolution cores to optimize the final model accuracy. Literature [1] put forward a different point of view for handwritten digit recognition realized by the improved neural network method. An elastic BP algorithm based on the MATLAB platform will result in low-noise handwritten digit recognition.

Among other research methods, HU et al. [9] improved the handwritten digit recognition realized by the traditional KNN nearest neighbor classification algorithm by using distance weight statistics to reduce the time and space complexity when calculating the distance, thus improving the accuracy of handwritten digit recognition. In addition, there are also many types of research on the improvement of traditional methods applied to handwritten digit recognition: handwritten digit recognition method based on improved C-support vector machine optimizes the feature extraction process to improve accuracy [12], and support vector machine tree hybrid learning model based on the sensitivity value of boundary to feature selection to improve accuracy [18].

In the field of handwritten digit recognition in finance, some pioneers have done relevant research on handwritten digit recognition. Zhang [19] applied handwritten digit recognition to the layout analysis of financial instruments, compared the topological structure-based method of handwritten digit recognition with the process based on contour segmentation, and then improved the existing handwritten digit recognition model using multiple classifier technology to optimize the processing system of financial instruments. In addition, Lu et al. used the improved BP algorithm of a neural network to solve the problem of handwritten digit feature recognition in financial bills. Finally, the results obtained a relatively good recognition effect.

In this paper, we will use the depth learning method to compare the research schemes after different improved parameters, apply various techniques to handwritten digit recognition in finance, and explain. After many experiments, we can get a better recognition model and accuracy and a shorter recognition time, hoping to apply it to the financial field with the best model performance.

3. Experiment

This paper introduces the static and dynamic attributes of the data set, as well as the table description and network structure description of the data set. The experiment is based on the design of a handwritten digit recognition model of a neural network object. It uses the control variable method to preliminarily explore the impact of learning rate and rounds on the optimal accuracy rate to optimize the final recognition effect.

3.1. Introduction to Static and Dynamic Attributes of Datasets

The static attributes of a dataset refer to the unchanging file attributes collected under different requests; furthermore, generally do not change with access. The key to judging a dataset's static attributes is determined by factors such as the fixed time of the dataset attributes, whether they are updated regularly, and whether they are valid. It can better reflect the reference value and specific data set attribute time points. Although static attributes have good stability, their value is single and limited.

The dynamic attribute of a dataset refers to the changed file attributes collected under different requests. This indicates that the dataset's characteristics can be updated at any time, and the latest dynamic dataset attributes can be displayed as required, which has real-time value. However, collecting the newest dataset attributes requires costs. Furthermore, the value of dynamic characteristics is less trusted than that of static data.

The static attribute of the dataset is the mainstream of machine learning. This paper's static quality of handwritten digit recognition is Arabic numerals. In addition, the dynamic characteristics of data sets also have some value, even above the fixed points, in which the features and symbols of numbers are dynamic attributes of handwritten digit recognition.

3.2. Dataset Table Description

Table 1 shows the distribution of the ten numbers 0 to 9 in the training and test sets, respectively. The total number of samples is 60000. It can be observed that the distribution proportion of the ten numbers is relatively balanced. At the same time, it also shows the comparison between the number of training sets and the number of test sets for each number, as well as the digital visualization results and data set sources.

3.3. Network structure description











This paper uses the neural network model to extract features and try various architectures. For a more intuitive display, Figure 4 visualizes the most basic neural network structure, showing that this neural network has only three design layers, including an input layer, a hidden layer, and an output layer.

Input layer: import the data you want into the neural network.

Hidden layer: it abstracts the features of input data, realizes feature extraction, and increases the complexity of the network structure. The number of nodes is variable, and its neural network representation ability positively correlates with the number of nodes.

Output layer: output the final calculation results of the network structure, and the number of nodes is fixed.

Table 1. Dataset Description

Number	Distribution of numbers		Train/Test	Visualization	Dataset Source
	Number/Train	Number/Test			
0	5923/60000	980/10000	6.044		Survival Strategies for the Robot Rebellion (pjreddie.com)
1	6742/60000	1135/10000	5.940		
2	5958/60000	1032/10000	5.773		
3	6131/60000	1010/10000	6.070		
4	5842/60000	982/10000	5.949		
5	5421/60000	892/10000	6.077		
6	5918/60000	958/10000	6.177		
7	6265/60000	1028/10000	6.094		
8	5851/60000	974/10000	6.007		
9	5949/60000	1009/10000	5.896		

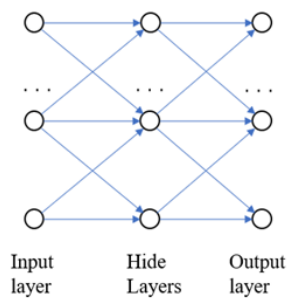


Figure 4. Schematic Diagram of Neural Network Structure

3.4. Explore the influence of different learning rates on the accuracy of experiments

Keep the optimal number of rounds at 50, and explore the change of the best total accuracy rate with the learning rate of 0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 2. The experiment shows that the accuracy rate is 36.45% when the learning rate is 0.0001, 36.45% when the learning rate is 0.0005, 71.65% when the learning rate is 0.001, 84.10% when the learning rate is 0.005, 87.62% when the learning rate is

0.01, 89.71% when the learning rate is 0.05, 89.76% when the learning rate is 0.1, 86.28% when the learning rate is 0.5, and 83.36% when the learning rate is 1, When the learning rate is 2, the accuracy rate is 80.02%. When the learning rate is 0.0001-0.05, the accuracy rate increases. When the learning rate is 0.05-0.1, the accuracy rate is stable but fluctuates. Due to the overfitting of the model, the accuracy rate decreases slowly from 0.1-2. Therefore, the best experimental result is that when the learning rate is 0.1, the accuracy rate is 89.76%. Figure 5 shows the effect of different learning rates on the accuracy of the experiment when the number of rounds is unchanged.

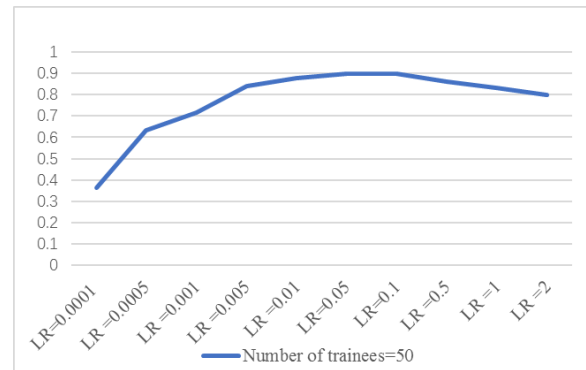


Figure 5. Effect of Learning Rate on Model Accuracy

Based on Figure 5, further explore the impact of the number of training rounds on the training set. This paper will conduct ten experiments with learning rates of 0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, and 2. Each group will compare the changes in the final accuracy rate of the experiment when the number of rounds is 15, 30, and 50. The investigation shows that the experiment's accuracy rate increases with the number of games of model training. However, when the learning rate is closer to the best (the best learning rate in this experiment is 0.05), the increase in the number of rounds has less impact on improving the accuracy rate. On the contrary, the greater the absolute value of the difference between the learning rate and the best learning rate, the more significant the impact of the increase in the number of rounds on improving the accuracy rate. Figure 6 shows the effect of different games on the accuracy of the experiment under each group of learning rates.

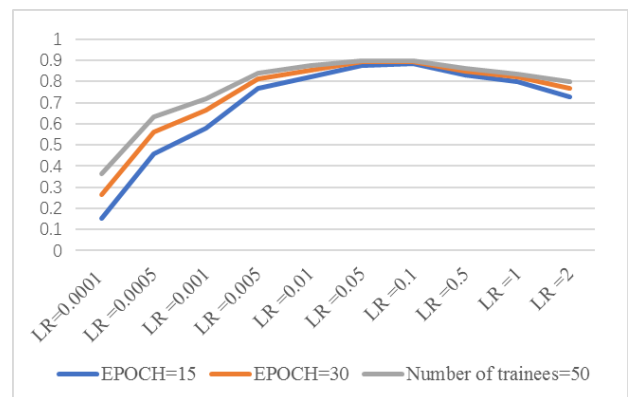


Figure 6. Effect of Number of Rounds on Accuracy under Each Learning Rate

4. Conclusion

This paper proposes a handwritten digit recognition model based on the financial system and trains the intelligent digit recognition model through deep learning, which replaces the

traditional complex artificial process. Through artificial intelligence, the analysis process in the financial system is accelerated, and the accuracy of the data is guaranteed. The economic system often has a large amount of data, and traditional data analysis methods need to rely on manual input. The model based on deep learning proposed in this paper can efficiently use training data and a large amount of data to learn better feature representation ability. The experimental results show that the intelligent model proposed in this paper has achieved good results on the open-source dataset MNIST and has practical application value.

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