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Research on Aided Reading System of Digital Library Based on Text Image Features and Edge Computing

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ABSTRACT With the rapid development of library informatization level, traditional text information retrieval service methods have been difficult to meet the needs of users. Therefore, personalized assisted reading technology attracted wider attention, which can discover hidden associations by mining user information, book information, and user operation logs, and recommend the acquired knowledge to users. In order to improve the service quality and experiences of users, this paper presents a digital library assisted reading system that combines text image features and edge computing. Firstly, the digital library reading assistance system framework is proposed based on edge computing technology, which will improve the service quality and information transmission level of the digital library. And the auxiliary reading model of the digital library is presented based on text image features and RBF neural network. Detailed simulation results verify the applicability and efficiency of the proposed scheme.

INDEX TERMS Digital library, edge computing, assisted reading, text image features, RBF neural network.

I. INTRODUCTION

Since the 1990s, computer, network and communication technologies have developed rapidly [1]. In order to meet the requirements of processing massive digital information resources, improve the orderly release, organization, processing and delivery of network information resources, and improve the efficiency of user retrieval and acquisition of required information resources [2]. The theory and technology of digital library came into being and became the development direction of traditional library. The United States is the first country in the world to start research, development and construction of digital libraries, and it is also the country with the highest level of digital library construction and the widest range of applications in the world [3], [4]. The construction of digital libraries in the United States first began in the late 1980s. At that time, some scientific research institutions, academic libraries and urban public libraries began to research and explore the construction of digital libraries. In September 1993, the National Science Foundation, the National Aeronautics and Space Administration and the Advanced Research Center Program Agency of the United States Department of Defense jointly issued the ''Digital Library Initiative'', which kicked off the comprehensive construction of digital libraries in the United States [5].

As a provider of network information services, libraries have undergone profound changes in the information needs of users under the network environment, so the library's information services have also undergone profound changes. Among them, the main obstacle for users to obtain information in the network environment has changed from a spatial obstacle to a selective obstacle [6], [7]. The development of the network requires that libraries can strengthen cooperation, break through the limitations of time and region, and realize resource sharing. Users require libraries to provide accurate and personalized information services, etc. These factors have affected the information services of university libraries from traditional common services to personalized services. In short, the development of personalized information services can not only help teachers and students obtain accurate information for teaching and scientific research. Moreover, it promotes the development of libraries and information

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service industry, is an effective way to improve the network information environment, and at the same time points out the direction for the development of information service industry [8], [9]. Recommendation systems based on various library-assisted reading recommendation algorithms, although they have been used in some applications, still have problems [9], [10]. Some of them also hinder the healthy development of recommendation services. In the past research on auxiliary reading, there are many problems such as resource description characteristics, sparse matrix problems and scalability [11].

Aiming at the above shortcomings, how to design an auxiliary reading system for digital libraries with excellent performance is of important practical value for optimizing the development of digital libraries [12], [13]. This article analyzes the existing library assisted reading technology and its research status. In terms of innovation, this article uses edge computing technology to construct a digital library reading assistance system. This framework will improve the service quality and information transmission level of digital libraries. In addition, an auxiliary reading model of the digital library is established through text image features and RBF neural network algorithm. This model will provide a certain reference and reference for the research of auxiliary reading system in digital library. This model will provide a reference for the study of auxiliary reading systems in digital libraries.

The Section II of this paper describes the digital library text image characteristics and the related technology overview of edge computing. On this basis, Section III presents the auxiliary reading based on text image features and the auxiliary reading system architecture based on edge computing. The experimental results are provided in Section IV to verify the effectiveness of the proposed scheme paper.

II. RELATED WORK

A. TEXT IMAGE FEATURES

As a special image with textual meaning, text image has become more and more popular on the Internet with the rapid development of its storage and acquisition technology [14], [15]. Such as e-contracts, e-documents, e-files, advertising pictures of shopping malls or streets, images of bus stations, etc. that are ubiquitous on the Internet [16], [17]. This kind of information digitization has brought great convenience advantages to the society.

However, for the massive text image data, how to find the image or images that users are interested in is a very difficult task. HOG feature is a description operator used to express the local structural features of an image [18], [19]. The general idea of this feature extraction is to divide the image into regions of the same size and regularly distributed, calculate the gradient histogram of each region, and finally connect the gradient histograms of all regions on the entire image according to certain rules to form the HOG feature Vector. The specific process of this method is shown in Figure 1.

People's visual interest in document images is concentrated on the text and images, and the background and noise will not and should not be overly prominent. In fact, the sharper the text strokes and patterns in the document image, the weaker the background and noise interference, the more prominent the text in the document [20], [21]. The overall effect of the document image is better. Compared with other images, a text image is a special digital image with a specific meaning of text information, and its text information plays a key role in the understanding of the entire image. The text image has the characteristics of fine texture but uniform distribution and flat background area.

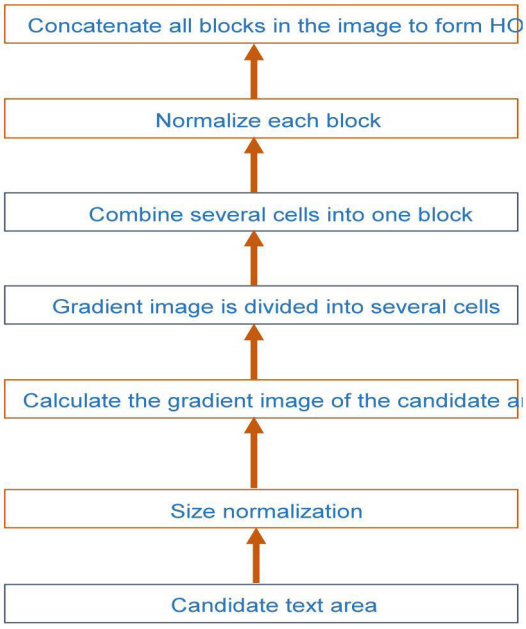

FIGURE 1. HOG feature extraction flowchart.

At present, there are few researches on the classification of text images, and the research on the classification of text images mainly focuses on the recognition of text images. Identify various types of text images in order to make better use of text images.

B. EDGE COMPUTING

Edge computing is a new computing model, which refers to the migration of some computing tasks from the original cloud computing center to the vicinity of the data source to reduce the pressure of cloud computing [22]. Many existing resource allocation algorithms for mobile edge computing focus on minimizing delay or energy consumption as their optimization goals. Literature [23] proposes a solution to minimize the calculation processing delay by allocating the computing resources in a cell base station cluster without using the core network. In literature [24], the author considered a multi-user mobile edge computing architecture based on wireless networks.

The service model of cloud computing cannot satisfy real-time feedback. In this mode, after the data source obtains the data, the data needs to be uploaded to the cloud.

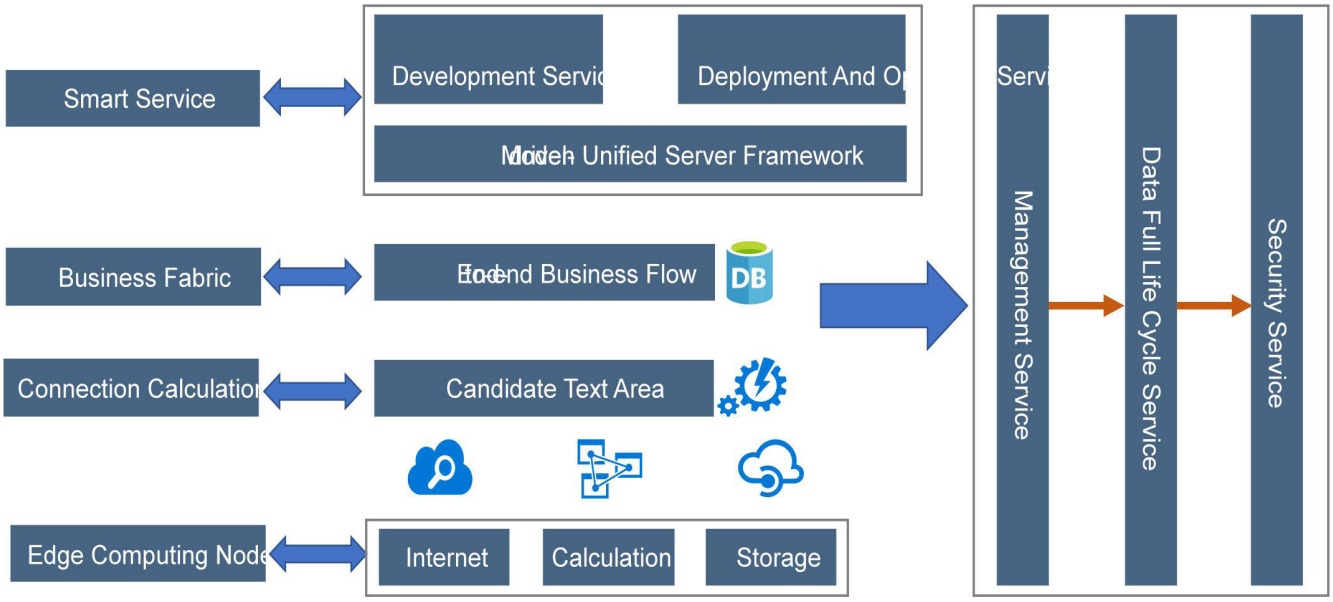

FIGURE 2. Reference example framework of edge computing.

Data transmission takes a certain amount of time and cost. Therefore, cloud computing is suitable for processing long-term data and depends on different application scenarios. On the other hand, edge computing plays an irreplaceable role in scenarios such as real-time, short-period data, and local decision-making. Compared with cloud computing, edge computing is not a replacement, but a supplement and extension to cloud computing, providing a better computing platform for mobile computing. Edge computing is a distributed computing architecture. Under this framework, edge computing nodes themselves compute, store, and transmit data close to the edge of physical data. These edge computing nodes scattered on the terminal have replaced the original cloud computing-based central node processing large-scale services, making computing faster. Edge computing puts more emphasis on the physical edge, that is, the device terminal closer to the data generation. The edge computing model has more real-time and faster data processing capabilities.

In this paper, the author has completed the task of joint task allocation and resource allocation with the goal of minimizing the energy consumption of the mobile terminal under a certain delay requirement, and demonstrated the effectiveness of its algorithm in the simulation. Dong *et al.* [25] and others proposed a reference architecture for edge cloud, which extended the computing power of the central cloud to end users in homes or enterprises by using edge nodes provided by edge users and operators to support the operation of edge applications. The above research has done some research on the multi-terminal optimization of edge computing, but has not yet involved in-depth research on the direction of library auxiliary reading. Therefore, this paper focuses on the optimization technology of library auxiliary reading direction.

Edge terminal equipment must have corresponding configurations in terms of network, computing, storage, etc. to complete part or all of the processing tasks of data. As a distributed and open platform, edge computing provides intelligent services to the surroundings, connecting the data, physical data world and the digital world. This technology has key applications in real-time business, data optimization, data security and privacy protection. Edge computing is a distributed computing architecture. Under this framework, edge computing nodes themselves compute, store, and transmit data close to the edge of physical data. These edge computing nodes scattered on the terminal have replaced the original cloud computing-based central node processing large-scale services, making computing faster. Edge computing puts more emphasis on the physical edge, that is, the device terminal closer to the data generation. The edge computing model has more real-time and faster data processing capabilities [26]. Because the intermediate data transmission process is reduced, the data processing speed is also faster.

III. THE PROPOSED SCHEME

Local binary mode has the characteristics of gray invariance, simple and efficient calculation, and is widely used in artificial intelligence fields such as pattern recognition and machine vision. In the image, the pixel is selected as a 3×3 neighborhood, the center pixel is defined as the threshold, and the other eight pixels in the neighborhood are binarized.

Starting from the upper left pixel, in a clockwise direction, the size is compared with the center pixel in turn. If it is greater than or equal to the threshold, it is marked as 1, otherwise it is marked as 0. Arrange the marked numbers from high order to low order in the order of comparison to form an eight-bit binary number. Converted into a decimal

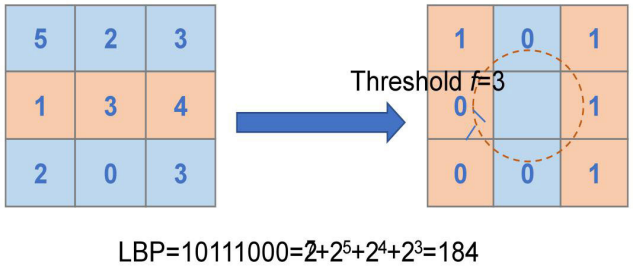

FIGURE 3. Local binary mode transformation process.

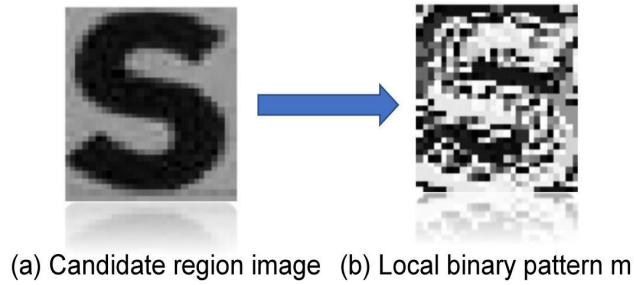

FIGURE 4. Candidate text area image and local binary pattern map.

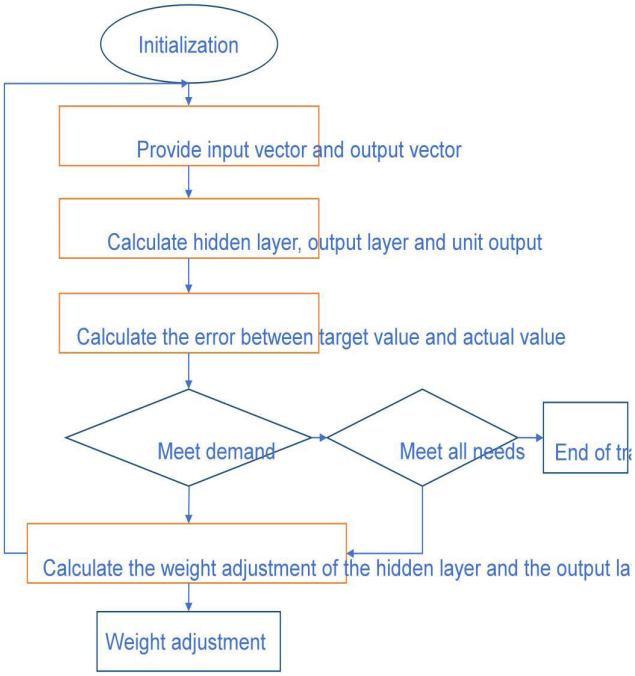

FIGURE 5. RBF neural network learning flowchart.

number is the local binary mode operator of this central pixel. The above transformation process is shown in Figure 3. From a visual point of view, the text information of the text image occupies most of the information of the image. The text information contained in the general digital image only involves the image file name, file size, file format, image width, height, etc. But the text image not only includes these text features, but also contains text information that reflects the meaning of the image. This kind of text information that reflects the meaning of images is the focus of text image research [27].

As artificially extracted features, LBP has been widely used in face recognition and pedestrian detection, and the calculation of LBP features is simple, mainly used to describe the local texture features of the image, and the effect is good. This paper mainly analyzes text images, so the LBP feature operator is used. The calculation principle of LBP is to select any pixel in the image as the center point, take the gray value of the center point pixel as the threshold value and compare the gray values of its eight neighboring pixels one by one. After the comparison, the point greater than the threshold is set to 1, and vice versa, to obtain a set of 8-bit binary numbers. This set of numbers is calculated to get an LBP value [28].

The RBF neural network learning process is shown in Figure 5, and the detailed description of the algorithm is as follows to initialize the RBF neural network model. The connection weight, and threshold, in the neural network are respectively assigned values in the interval.

RBF neural network can reflect the different division of sample data in space. Choosing an inappropriate center point position will have a great impact on the mapping result, that is to say, the neural network training result is very sensitive to the choice of the center point position. The width of the hidden layer of the RBF neural network is also an important factor affecting its classification and prediction ability. The width of the center point determines the range of response to the input variable, and the weight between the hidden layer and the input layer is the key to the final realization of the entire network. The symbol explanation used in the application of RBF neural network is shown in Table 1.

TABLE 1. Notation definitions.

Notation	Description
v_{jt}	K-th input variable
γ_t	RBF neural network hidden layer
μ_j	RBF neural network output layer output value
ε_j	The width of the hidden layer neuron basis function
V	Weight connection matrix from hidden layer to output layer
W	Weight connection matrix from hidden layer to output layer
Z	The weight connection matrix between the input layer and the output layer

Calculate the input and output of the hidden layer neural node in the RBF neural network, that is,

$$u_j = \sum_{i=1}^{n} w_{ij} x_i - \theta_j \tag{1}$$

$$h_j = f(u_j) = \frac{1}{1 - \exp(-u_j)} \tag{2}$$

Calculate the input and output of the neural nodes in the output layer of the RBF neural network, that is,

$$l_t = \sum v_{jt} h_j - \gamma_t \tag{3}$$

$$y_t = \frac{1}{1 + \exp(l_t)} \tag{4}$$

Calculate the weight error of the RBF neural network connected to the neural node of the output layer.

$$\varepsilon_i = (c_t - y_t)\, y_t\, (1 - y_t) \tag{5}$$

Calculate the weight error of the RBF neural network connected to the hidden layer neural node.

$$\varepsilon_j = \sum_{i=1}^{q} \varepsilon_i v_{jt} h_j \left(1 - h_j\right) \tag{6}$$

Update the connection weight and threshold of the RBF neural network.

$$w_{jt}\,(N+1) = w_{jt}\,(N) + \partial \varepsilon_j x_i \tag{7}$$

$$\theta_j\,(N+1) = \theta_j\,(N) + \beta \varepsilon_j \tag{8}$$

Calculate the error between the output value and the expected value, if it meets the set accuracy requirements, it will be learned through network training. The learning is over, otherwise go to the step to continue training and learning [29].

First define the following variables and independent variables:

Weight connection matrix between input layer and hidden layer $V = \left(V_1, V_2, \cdots, V_j, \cdots, V_m\right)$.

Weight connection matrix from hidden layer to output layer $W = (W_1, W_2, \cdots, W_k, \cdots, W_l)$.The weight connection matrix between the input layer and the output layer $Z = \left(Z_1, Z_2, \cdots, Z_p, \cdots, Z_q\right)$. According to the above steps, the following results are obtained. Weight connection matrix from hidden layer to output layer.

IV. PERFORMANCE TEST

A. TEST ENVIRONMENT ASSISTED READING SYSTEM ARCHITECTURE BASED ON EDGE COMPUTING

The edge node layer is mainly composed of a large number of distributed networks that exist in the physical environment and edge servers that serve cameras. Because the traditional camera does not have computing power, it is mainly responsible for collecting text image data collection. The edge server is mainly responsible for two tasks, storing and processing data from the camera and running video image processing tasks. The edge server is composed of three modules. Edge computing is a distributed computing architecture. Under this framework, edge computing nodes themselves compute, store, and transmit data close to the edge of physical data. These edge computing nodes scattered on the terminal have replaced the original cloud computing-based central node processing large-scale services, making computing faster. Edge computing puts more emphasis on the physical edge, that is, the device terminal closer to the data generation. The edge computing model has more real-time and faster data processing capabilities.

The data processing module consists of two parts: data cache and data extraction algorithm. The data cache part caches the original data from the camera. Therefore, how to map the recognized text feature data to each specific page in a distributed camera network has become a major challenge for the system. Realize different levels of personalized information services. Due to the high number of original video data frames and resolutions generated by some high-definition cameras, this will cause the efficiency of the extraction algorithm to decrease, and the system cannot guarantee real-time performance. Therefore, the module will provide a down-sampling algorithm to extract a video with a suitable frame rate according to the computing power of the system for data extraction algorithm. In a text image feature extraction system that spans multiple cameras, the system usually needs to obtain data such as image features of the book text. In addition, because the scene is usually more complicated in a real environment, multiple lines of text often appear in the same camera at the same time, or a page of text repeatedly spans multiple cameras. Therefore, how to map the recognized text feature data to each specific page in a distributed camera network has become a major challenge for the system. Realize different levels of personalized information services. The system provides different service pages and contents according to the different levels of service objects, so that users can obtain corresponding personalized information according to their needs, and realize different levels and targeted services. Realize active service. The system can push information according to the information settings customized in advance by the user without the user's participation. This information service is active and real-time. Break through the time and geographical restrictions.

B. EXPERIMENTAL CONDITION SETTING

Test the classification performance of candidate regions, and use the control variable method to test feature performance and classifier performance respectively. For testing feature performance, keep the classifier unchanged, and test the performance of each feature on the classifier separately. Select 3000 positive samples and 3000 negative samples as the training set, and 4000 positive samples and 4000 negative samples as the test set. The Gabor feature, LRBF feature, and HOG feature of the sample are extracted, and each feature is combined with the number of boundary corner points and the stroke area ratio to detect the classification performance. Load capacity test of auxiliary reading terminal in different

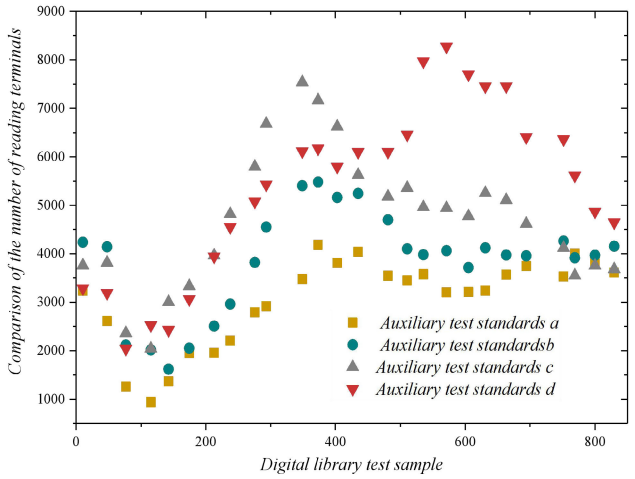

FIGURE 6. Load capacity test of auxiliary reading terminal in different environments.

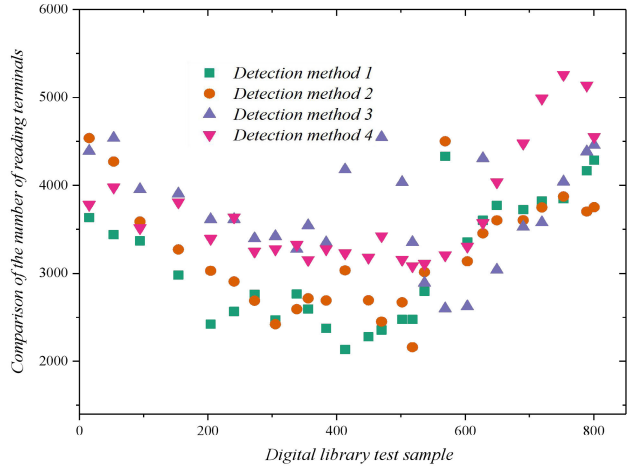

FIGURE 7. Auxiliary reading terminal carrying capacity test under different methods in the same environment.

environments is shown in Figure 6. Auxiliary reading terminal carrying capacity test under different methods in the same environment is shown in Figure 7.

C. AUXILIARY READING MODEL PERFORMANCE TEST

RESULTS It can be seen from Figure 6 and Figure 7 that when the number of positive samples is 3000 and the number of negative samples is 3000, the AUC area is the largest, that is, the classifier has the best performance. Edge terminal equipment must have corresponding configurations in terms of network, computing, storage, etc. to complete part or all of the processing tasks of data. As a distributed and open platform, edge computing provides intelligent services to the surroundings, connecting the data, physical data world and the digital world. More or less negative samples than positive samples will cause the performance of RBF neural network to decrease. The ROC curve shows that the performance of the classifier is difficult to distinguish with the naked eye. The performance is usually expressed by the value of AUC. The higher the value of AUC, the better the classification ability of the classifier, and its range is usually 0.51.0. We train the text image assisted reading model by choosing different sample sizes, and the corresponding ROC curve and AUC value are shown in Figure 6 and Figure 7. After completing the framework and model establishment process, the paper carried out the application test and case analysis process of the digital library assisted reading technology in the fourth chapter.

Therefore, this paper selects 3000 positive samples and 3000 negative samples, uses the combination of LRBF features, HOG features, border corner points and stroke area ratio to train the RBF neural network, and uses the trained model to classify.

By using the classifier and combining the underlying feature combination of the text image, the model of the text image training sample set can be obtained. Using the test sample set of text images to test the RBF neural network generated by the training sample set, the results can predict the document image very well. Although the other two types of images have a little error, they basically meet the actual requirements of the prediction accuracy. The classification results of text images are evaluated by recall and precision. Experiments show that the text image classification method proposed in this chapter is feasible, and the document images have 100% precision and recall. The performance of each feature on the AdaBoost classifier is shown in Figure 8 and Figure 9.

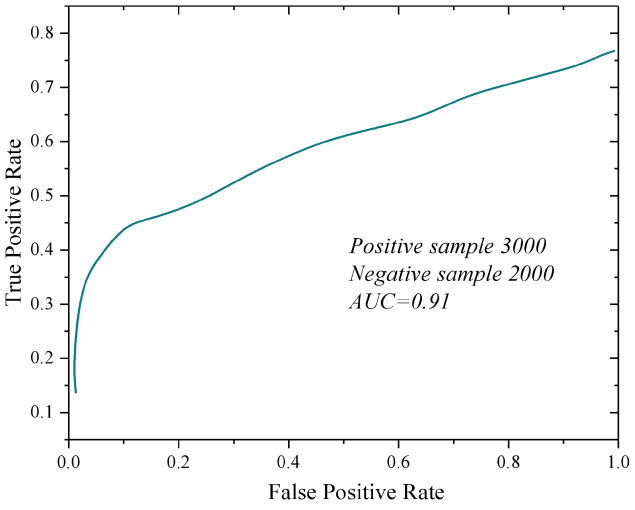

FIGURE 8. ROC curve of the classifier when the positive and negative samples are different.

As long as the user connects his computer to the network, he can use the personalized information service system to receive information without being restricted by time and region. Reduce search time. Based on the recorded user browsing and retrieval history, the system downloads resources that may be reused to the local resource library.

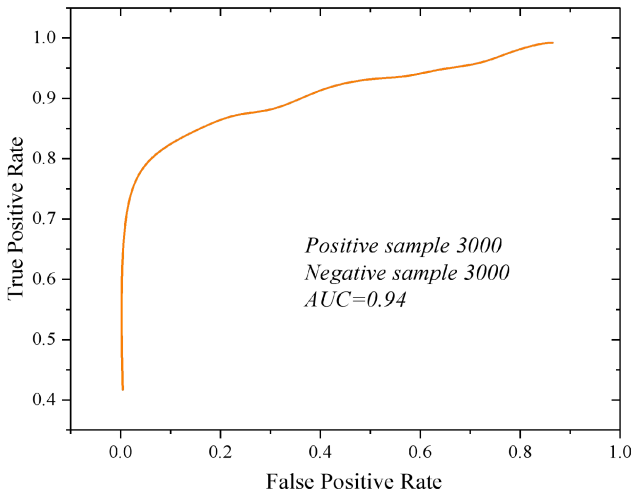

FIGURE 9. ROC curve of the classifier when the positive and negative samples are equal.

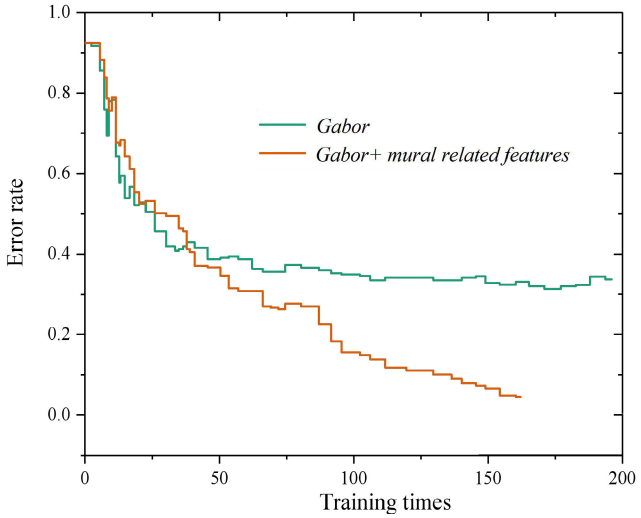

FIGURE 11. Gabor feature and combined feature comparison.

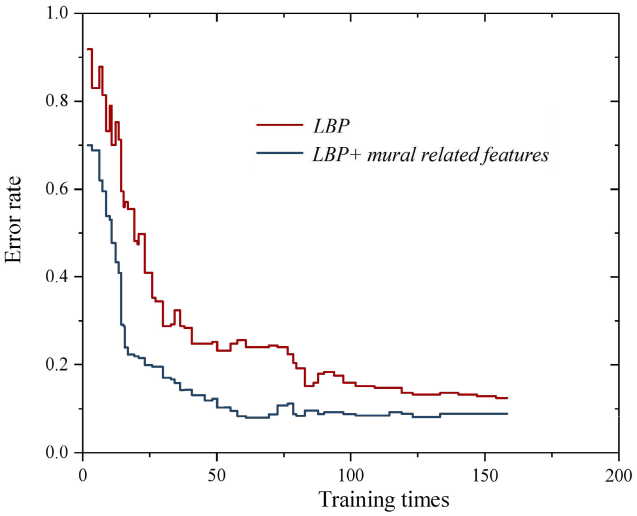

FIGURE 10. Comparison of LBP features and combined features.

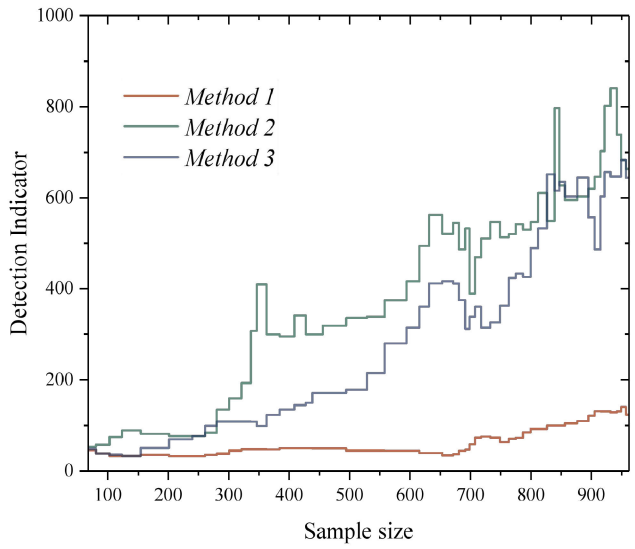

FIGURE 12. Comparison of text recognition under the same category in digital libraries.

In the era of information explosion, only through the organization and arrangement of information resources can it be convenient for readers to inquire and retrieve. With the popularization of the Internet, the information resources of the library are not only tangible collection resources, but also one of the rich resources of the library.

In the above-mentioned test of text image recognition in digital libraries, we found that the auxiliary reading system based on text images and edge computing established in this paper has obtained relatively good test results. In order to horizontally compare the advantages of the model established in this paper with previous studies, we conducted a series of comparative simulation test procedures. In the comparison, we mainly compared the text recognition accuracy rate of digital libraries under different categories and the amount of text recognition under the same category of digital libraries. Figure 12 shows the amount of text recognition under the same category in the digital library. How to design an auxiliary reading system for digital libraries with excellent performance in response to the above-mentioned shortcomings has important practical value for optimizing the development of digital libraries. This paper discusses a digital library assisted reading system that combines text image features and edge computing. The digital library reading assistance architecture is constructed through integrated edge computing technology, which will improve the service quality and information transmission level of the digital library. By using the classifier and combining the underlying feature combination of the text image, the model of the text image training sample set can be obtained. Using the test sample set of text images to test the RBF neural network generated by the training sample set, the results can predict the document image very well.

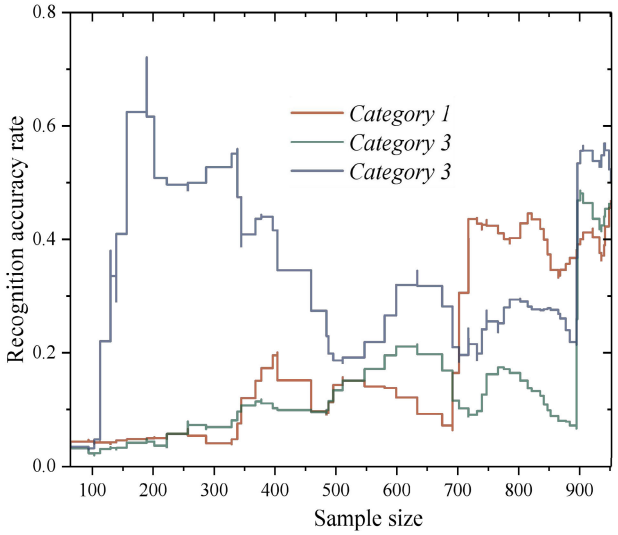

FIGURE 13. Comparison of the Correct Rate of Text Recognition in digital library under different categories.

Figure 13 shows the accuracy of text recognition in digital libraries under different categories. According to the comparison, we find that the assisted reading technology established in this paper has obtained better results than other methods.

The traditional concepts of classification and cataloging can still be applied to electronic and network information resources, but some methods need to be modified to adapt to the network environment and the characteristics of network information resources. We establish an auxiliary reading system by adopting text image recognition and edge computing. Through the organization of services, appropriate adjustments and adoption should be made to adapt to its future development direction. If you need to retrieve similar information, you only need to search in the local resource library instead of searching on the Internet.

V. CONCLUSION

Personalized assisted reading can deeply dig hidden information in digital libraries, and obtain results that users cannot obtain through information retrieval. Due to the intelligence and humanization of personalized service, its application fields are becoming wider and wider, and the recommendation technology adopted is becoming more reasonable and complicated. Comparing several recommendation algorithms that are currently widely used and considering the application environment of the library, they will have problems such as sparse scoring data and poor scalability. How to allow users to obtain the recommendation information of similar types of books and periodicals, to obtain the recommendation of new books, and the recommendation information of books and periodicals with higher recommendation value, has become a research hotspot of digital library recommendation services. In order to improve the above-mentioned recommendation effect, this paper proposes a specific improvement algorithm and verifies the improvement of the recommendation effect through system implementation.

This paper discusses a digital library assisted reading system that combines text image features and edge computing. After the above model and architecture are established, simulation test and system trial results verify the applicability and efficiency of the model. This model will provide a certain reference and reference for the research of auxiliary reading system of digital library. Through this improved algorithm, the recommendation system can obtain information that users are more interested in from a large amount of data information, which not only further improves the quality of recommended information, but also improves the overall utilization of library resources. In the future, we will continue to devote ourselves to the research of digital library assisted reading, and provide certain scientific support for the development of library digitalization.

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