Research Article

Construction and Application of Automatic Attendance Prediction System for Classroom Education Teaching Based on Random Matrix Theory

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Random matrix theory, as a theoretical tool for statistical processing of complex systems and high-dimensional data, has been more and more combined with big data technology and applied to automatic attendance prediction analysis of classroom education. Firstly, the basic definition of the random matrix is introduced. Secondly, the single ring theorem of the random matrix is introduced. Based on this, the random matrix model of data is established. However, few undergraduate or graduate students in physics have been exposed to this theory. By introducing the basic concept of random matrix theory, this paper analyzes the necessity and feasibility of introducing random matrix theory into automatic attendance prediction teaching in classroom education. As a biometrics technology, random matrix theory technology has been widely used in various fields of the identity verification system, and classroom attendance system is an important field of random matrix theory technology application. The traditional random matrix theory class attendance has the problem of slow recognition speed and low accuracy. With the popularity of deep learning, the random matrix theory based on deep learning has gradually replaced the traditional random matrix theory. In this paper, the SSD target detection algorithm, NB algorithm, and RF algorithm based on deep learning are used to improve and optimize the traditional random matrix theory class attendance system, which effectively improves the efficiency and accuracy of random matrix theory attendance. Then, aiming at the low recall rate and recognition rate of random matrix theory in low-pixel images, we try to apply the random matrix theory of single image resolution reconstruction method to face detection and random matrix theory and give a calculation method to deal with outliers and noise.

1. Introduction

In daily teaching management, it is necessary to strengthen supervision of students’ learning and life to maintain normal teaching order and improve the quality and effect of teaching. Classroom supervision is an important part of management work, and it is necessary to maintain good classroom order for students, teachers, and management departments. Attendance management is one of the more effective methods widely used at present. Empirical evidence shows that there is a significant correlation between students’ attendance and their academic performance [1]. It has also been suggested that students with poor attendance records are often associated with higher dropout rates [2]. The process of attendance can timely find the relevant clues and early intervention can avoid teenage students from going astray. Numerous studies have shown that students with good attendance are more likely to score higher on exams. Perfect attendance management can help students overcome their weaknesses, help them restrain themselves and manage themselves, participate in classroom teaching activities on time and regularly, so that students can timely understand what teachers teach in class, and make up knowledge points after class according to their own situation, so as to finish learning efficiently. Students with high attendance were more likely to pass reading and math tests than students with low attendance. Regular attendance also gives students who are learning a foreign language a...
chance to master the new language more quickly and accurately.

In recent years, with the rapid development of intelligent products, the study of attendance management systems based on fingerprints emerges in an endless stream. Combined with the use of scenarios, many researchers put forward related design and implementation. Literature [3] proposed a college teaching management system based on biometric recognition and Internet of Things technology. The system includes an ARM9-S3C2440 development board, fingerprint sensor, and SQLite database. In addition to fingerprint recognition, the system also adds the function of palm vein recognition. The main functions of the system include automatic attendance and score entry. With the help of Internet of Things technology, the system can carry out real-time monitoring and processing of attendance data on the web page, and all the information about attendance records can be obtained from the website. Based on fingerprint identification, literature [4] integrates global mobile communication technology (GSM) and Purple Bee technology into the system, and literature [5] integrates radio frequency identification technology (RFID) and global mobile communication technology into the system. The GSM module is used to send the students’ daily attendance reports and the start and end times of the course to the teaching administration, and the students’ guardians can also be informed of their performance in school by text message. At the same time, the attendance data is transferred from the classroom to the data through the ZigBee module for centralized storage and subsequent analysis. RFID is used in the system to determine the location of attendance personnel. Since the concept of “deep learning” was put forward, it has achieved unprecedented development in the field of computer vision. Facebook artificial intelligence lab used a deep convolutional neural network to obtain a 97.25% recognition rate on the LFW database [6, 7], and then FaceNet proposed by Google created a 99.63% accuracy rate on this data set [8]. A well-trained and deep convolutional neural network is used to optimize the whole neural network directly, instead of changing the convolutional layer of the middle bottleneck like other methods. In the process of training, the author used difficult alignment samples, three yuan minimum method, which makes the representative sample stronger, with more efficient training data; its core idea is found in the face of sample data P A and target A that most do not like the furthest (Euclidean distance) [9], found in all the negative sample data N A close to target the most sample; comparing the three, there is computational redundancy. The method achieves a 99.63% correct recognition rate in the LFW data set. Besides, to capture the useful value from the massive data, new techniques and technologies are in immediate need to collect, curate, and analyze them. Luckily, the rapid evolution of GPU architectures from graphics processors, new methods, such as random matrix theory, large-scale optimization, deep learning, and new machine learning systems can boost the development of big data techniques.

Using geometric diagonalization to reestimate the variance of samples [10], a new regularization discriminant classification method was obtained and applied to the analysis of high-dimensional genetic data. In recent years, the integrated study on high-dimensional data classification problems also has been widely used, especially the random forest algorithm [11] studied the use of random forests for classification tasks, and its classification performance and SVM are compared, and the results show that the random forest in terms of classification accuracy and the training time and the performance of the SVM as well are less than those required in SVM. The generation process of feature subspace in the traditional random forest algorithm is improved [12], and a high-dimensional data-oriented random forest algorithm is proposed. In addition, some algorithms that can be directly used for high-dimensional data clustering have also been studied. The proposed high-dimensional Gaussian clustering method based on the EM algorithm [13] and the proposed spectral clustering method based on iterative optimization [14] have both been used for high-dimensional data analysis. In the case that the covariance matrix is unknown [15], an optimal mean estimation method for shrinkage is proposed by minimizing the quadratic expected loss function. In the large-dimensional asymptotic framework, an optimal contraction estimate of the high-dimensional mean vector is also derived by using random matrix theory [16]. The estimation of the mean vector of the multivariate normal distribution with an unknown singular covariance matrix is also discussed [17], and a variety of shrink mean estimation methods are obtained. Eigenvalue contraction estimation is the most basic regularization estimation method of covariance matrix without specific assumptions about the structure of the covariance matrix. Its shrinkage methods mainly include linear shrinkage and nonlinear shrinkage. It is one of the most popular linear shrinkage estimation methods to uniformly shrink the sample eigenvalues to the vicinity of the central value [18] and obtain the optimal analytical expression of the shrinkage coefficient. In addition, two nonparametric methods were used to directly apply the contraction estimation to the estimation of the inverse covariance matrix [18]. However, when the eigenvalues of the population are dispersed, such as in a step structure, linear shrinkage can only slightly improve the estimation of the covariance matrix of the population. Random matrix theory research shows that the eigenvalue contraction problem is actually a very important nonlinear problem. The relevant tools of random matrix theory, especially the Marchenko-Pastur equation [19], are used to perform different degrees of contraction for each eigenvalue according to the nonlinear relationship between the overall eigenvalue and the sample eigenvalue. The estimation of the total covariance matrix is greatly improved.

This paper mainly analyzes the random matrix theory and measurement data modeling method and demonstrates the necessity of introducing the random matrix theory into automatic attendance prediction analysis of classroom education. The basic concepts of a random matrix, eigenvalue and eigenvector, distribution function, common matrix, and related theorems are introduced and discussed. Based on the measured data, the stochastic matrix modeling and data
processing method are proposed, and the simulation analysis is carried out based on the simulation model of automatic attendance prediction of standard classroom education. A human body perception framework combining face recognition and random matrix theory is proposed for dynamic attendance monitoring from two aspects of identity authentication and space-time trajectory. And the relevant methods in the framework are implemented to process the collected data. Finally, combined with the specific application scenarios, how to use the image and random matrix theory to achieve the function of a more comprehensive description is discussed. As a biometrics technology, attendance technology has been widely used in various fields of identity verification systems; classroom attendance system is an important field of face recognition technology application. Traditional face recognition class attendance has the problem of slow recognition speed and low accuracy. With the popularity of random matrix theory, face recognition based on random matrix has gradually replaced traditional face recognition.

2. Regularization Discriminant Analysis of Automatic Attendance Prediction in Classroom Education Based on Random Matrix Theory

2.1. High-Dimensional Covariance Matrix Estimation Method. In the rotation invariant estimation method, the spectral decomposition form of the total covariance matrix is assumed as follows:

\[ T = \sum_{j=1}^{n} \lambda_j \beta_j \beta_j^T. \]  

(1)

Similarly, the sample covariance matrix \( \mathbf{P} \) can also be decomposed into \( \mathbf{u} \):

\[ \mathbf{P} = \sum_{j=1}^{n} \alpha_j \mu_j \mu_j^T. \]  

(2)

The kernel method can be used to obtain the kernel estimation \( h \) of the probability density function and Hilbert transform \( k \):

\[ d(k) = \frac{1}{P} \sum_{j=1}^{m} k \frac{\lambda_j}{b_{nk}}. \]  

(3)

The advantage of random matrix theory lies in its detection of small motion and sensitivity to changes in position, but the unique identification of identity is not its advantage at present. And for the actual classroom scenarios used in attendance work, we also need to determine the identity of the target, in the framework for this level, and put forward combined with the existing automated attendance predicted perception technology of random matrix theory and considering the convenience degree of application decides to use the image way to determine the identity of the attendance. The use of images to determine personal identity does not require remapping of personal biometrics such as gait and random matrix theory signal change features to train the classifier to determine identity, and the image conforms to people’s cognitive laws. The proposed framework combines the advantages of two different types of random matrix theory automated attendance prediction perception technology to make up for the disadvantages of any single technology, so as to perceive the human body existing in the environment, so as to complete the tasks related to attendance and behavior analysis. See Figure 1.

The above frame is presented from two dimensions of image and random matrix theory to perceive the human body in the environment. Each part of the framework is described in detail below.

On the one hand, a photo containing a face is taken from the image to determine its identity. First of all, the method of image collection is described above—automatic collection by cameras installed in the classroom or manual collection by hand-held cameras. The difference is that the automatically collected images are of high quality. The resulting original image also contains pixels other than the human face. Next, the image needs to be processed to get only the area containing the face; pretreatment and face detection are often used in this step; after this step, we will get all faces contained in the image. Finally, the algorithm compares the distance between the detected face and the prestored face in the database and outputs the result through the classifier. The above three main steps are all completed in the image of the identity of the person contained in the complete confirmation.

On the other hand, the distance, angle, and velocity data are obtained according to the random matrix theory, and their spatial positions, motion states, and geometric quantities are determined. First, raw data is collected through sensors capable of sending and receiving random matrix theory. The raw data obtained is in the form of a series of points, each point carrying its own state information such as distance, angle, and speed. Next, points carrying state information are input into the clustering algorithm to generate clusters representing targets. Finally, the trajectory of the target is generated by associating the clustering with the tracker predicted by the filtering algorithm. After the above three main steps are completed, the position, track, and quantity of the human body in the environment can be obtained; thus, the existence of the human body can be perceived under the dimension of random matrix theory.

By integrating the results of the above two aspects, we can perceive the human body in the environment from the aspects of identity, position, track, and quantity, respectively, under the two dimensions of the image and random matrix theory, thus supporting the analysis of students’ attendance and learning behavior.

2.2. Construction of the Random Matrix Model for Automatic Attendance Measurement Data in Classroom Education. The measured data at sampling time \( T \) is

\[ x(t) = x_1(t), x_2(t), \ldots, x_n(t). \]  

(4)
In order to meet the needs of real-time calculation, the measured data are sequentially intercepted by the sliding time window for analysis, and the width of the sliding time window is set to $T$; that is, while collecting the data of the moment, the historical data of $T-1$ before the moment is fully utilized, and the random matrix is constructed from all the data in the time window as follows:

$$Y = [Y_1, Y_2, \ldots, Y_{N-T+1}].$$

(5)

The selection of time window should meet the following conditions: it should not be too wide to ensure that the calculation speed can meet the needs of real-time detection, but it should not be too narrow and should try to contain all the measured data of all partitions. It also needs to be basically the same to ensure that the analysis and calculation results of different partitions can be compared. It should be pointed out that in order to meet the asymptotic convergence when analyzing the spectral distribution of a high-dimensional random matrix, the dimension of the random matrix should be close to infinity in theory, but it is obvious that the infinite amount of data cannot be obtained in practical application. The asymptotic convergence is also observed in the moderate-scale random matrices with tens to hundreds of dimensions, which makes it possible to apply the random matrix theory to practical engineering problems.

Specifically, the main categories of classroom data application include data processing at the data level (such as data acquisition, analysis, and visual processing) and data application at the teaching level (such as teaching evaluation and feedback, teaching interaction, and teaching decision adjustment). According to the data application in the classroom environment of information technology, this study further distinguishes the application methods of classroom data, including traditional data application and data application supported by information technology, as shown in Table 1.

The realization of a linear discriminant analysis algorithm requires the use of training data set. The prior mean and covariance matrix $E$ of each class are estimated. However, in the case of higher dimensions, the estimated covariance matrix million is usually ill-conditioned or even singular. Aiming at the estimation problem of high-dimensional covariance matrix in LDA, two covariance matrix estimation methods of nonlinear shrinkage and eigenvalue interception were applied to the LDA algorithm, respectively, by using the relevant research of random matrix theory. A Random Matrix Regularized Discriminant Analysis (RMRDA) algorithm for high-dimensional data classification is presented. The algorithm design is shown in Algorithm 1.

### 2.3. Implementation of Classroom Attendance Scene Based on Random Matrix Theory Algorithm

The flow chart of class attendance based on random matrix theory and algorithm is shown in Figure 2.

Implementation steps are as follows:

1. Firstly, the collected videos or pictures are input into the system, and the random matrix theory is used for
the 2-fold pixel reconstruction of pictures or video frames with a resolution less than 640 * 480

(2) Then, in the original image or reconstruction of the image input random matrix theory network face detection and facial features positioning, the algorithm output predicted face frame and facial features vector

(3) Grayscale of the obtained face frame, normalized processing, and all the face frame is modified into the same size as the data in the database, and all facial features form a data vector

(4) After the processing of the face frame input random matrix theory in turn for recognition, the facial feature vector used for face weighting calculates the global weighted similarity

(5) The global weighted similarity is less than the recognition threshold of the face as recognizable and face marking, the similarity is greater than the recognition threshold of the face as an unrecognizable face, and there will not be recognized face image output and marking

For better application of the student class attendance task, in this experiment, according to a certain class (37) experiments, the first is students face data collection; in this experiment, middle school students are still in a wide-angle view, but the state does not make the request to the student, there should be an acquisition of the status of two different period students, and 15 to 20 were randomly selected in the first section of the video frame image. The faces of students were made into 72 * 72 face samples, and the sensitive features of facial features were extracted for weighting. All the face samples collected were divided into 27 categories according to students, and 27 models were made to form the recognition and matching database, which contained 427 face photos in total. Figure 3 shows a sample of partial training data collected.

Before the formal classroom education teaching automation prediction, the researchers first explain to respondents classroom education teaching the “data” of college students in the automation, “including the student’s behavior data (such as the discipline and behavior) and the student’s work data (including student assignments and work evaluation)”, and explain the classroom education and teaching automation forecast recording matters and then the classroom education and teaching automation forecast outline formal classroom education and teaching automation forecast. Due to the method of automatic prediction of classroom education by telephone, it is difficult for the two parties to control the interaction rhythm through the nonverbal behaviors of the other party. Therefore, in addition to the outline of automatic prediction of classroom education and teaching, combined with the actual situation,
“tracking problem”, “exploratory problem”, “specific problem”, “direct problem”, “structural problem”, “explanatory problem”, and other methods are flexibly adopted to carry out automatic prediction of classroom education and teaching, and the problem expression is as clear and concise as possible.

2.4. Experimental Design. In this study, positioning, counting, trajectory, and speed tracking experiments were carried out on the targets in the experimental scene, and the experimental objects were still students in the laboratory. The position changes can be used to analyze which students are often in groups, who are used to sitting in the front row, and so on. In the experimental environment, students sit and stand according to the classroom scene, and make notes, turn books, and do other actions. Multiple tests were conducted for scenarios with 1–12 people in the environment, and a set of results are shown in Figures 4 and 5.

Figure 4 is a polar histogram, representing the number of human bodies in different experimental order environments (part of which is selected to show), and clockwise is the direction of increasing experimental number. The positions marked by blue dots in Figure 5 are the positions of human

Figure 3: Sample of partial training data: (a) a video frame from the training sample and (b) human face images captured in multiple video frames.
bodies in the actual environment in the experiment, and Figure 5 corresponds to the number of people marked 150 and 330 in Figure 4, respectively. Experimental results show that the proposed method can accurately locate and count human bodies in the environment.

3. Results and Analysis

The movement of teachers and students in the classroom: teachers are often seen walking back and forth alone on the platform or patrolling the classroom; students often move between rows of seats, back and forth in aisles, in groups, or with each other. Therefore, on the basis of accurate positioning and counting of objects in the environment, this study also designs experiments for moving objects in the environment using random matrix theory and carries out tracking experiments of moving objects’ trajectories and velocities. The subjects of the experiment are people moving in the laboratory. The human body moves back and forth in the laboratory to record its trajectory and speed. The experimental results of moving human targets in the laboratory by using the proposed method are shown in Figure 6.

The speed at the corresponding time point in Figure 6 shows that the speed of two people overlaps well. This suggests that two people are moving sideways closer together and that they are moving at similar speeds at the same point in time. Therefore, it is concluded that they may have communicated during the movement.

In order to prove that the regularization discriminant analysis algorithm can improve the classification performance of high-dimensional data, several real high-dimensional data are verified experimentally. Table 2 shows the ACCR and SD of three real data in different classification algorithms. Each experimental result is obtained by averaging the results of 50 experiments. According to the experimental results, it can be seen that the random matrix
theory algorithm after the mean increase performs better than the DLDA algorithm in the classification of real data. The influence of sample number $N$ in classroom teaching automatic attendance data set and variable number $P$ in microarray data set on classification results was also verified. As shown in Figure 7, for the classroom education teaching automatic attendance data set, with the gradual increase of sample $N$, the average classification accuracy of the random matrix theory algorithm also gradually increases, which is higher than that of the DLDA algorithm, but the improvement is not obvious.

### 4. Analysis of Experimental Results

As can be seen from Table 3, the average degree of satisfaction of students in the experimental class for the application of different classroom data tools is between 4.1 and 4.4, indicating that students have high overall satisfaction with the application of these tools, and the differences among the three are small. Among them, the highest level of satisfaction is the application of the "Questionnaire Star" in-class test of learning mastery, 21 students (47.9%) choose "very consistent", 18 students (37.2%) choose "consistent", 22 students (50.9%) chose "very consistent", and 15 students (30.2%) chose "consistent" in recording their learning performance with "class optimization master". "Class optimization master" was used to randomly select students with the lowest satisfaction with their questions, but there was little difference. 22 students (45.7%) chose "very consistent", and 15 students (34.8%) chose "consistent".

When the light intensity in the environment drops to a certain extent, the face recognition algorithm can no longer perceive the human body in the environment. If we still rely solely on face recognition at this time, attendance and student behavior analysis can hardly be completed. However, the fusion model of face recognition and random matrix theory proposed in this paper can rely on the data from the random matrix theory to perceive the environment.

#### Algorithm 1: Regularization discriminant analysis algorithm based on random matrix theory.

Input: Training data, test data  
Output: Average correct classification rate (ACCR)  
Step 1: Divide the labeled samples in $X$ into $K$ categories  
Step 2: Calculate prior and mean value, variable $k = 1, 2, ..., K$  
Step 3: Calculate sample covariance matrix $S$  
Step 4: Reestimate the sample covariance matrix using the nonlinear shrinkage method or eigenvalue interception method  
Step 5: Substitute a new sample vector $X$ in the test data into the prior and mean values  
Step 6: Partition $x$ into the class that maximizes $Gz(x)$  
Step 7: Repeat steps 1–6 to calculate the average classification accuracy

![Figure 6: Transverse trajectory and velocity diagram.](image-url)
in this case, because the illumination conditions have almost no influence on the random matrix theory and create a dark or no light environment by closing the curtains. At this time, the image collected by the image acquisition equipment without night vision function is completely dark. For human face recognition in this environment, no label is returned. The position of each target, the total number of targets in the environment at the corresponding time point, and the speed of each target are shown in Figure 8.

The above results show that the fusion of the two methods is better than the single method, especially in some complex scenes, and their fusion makes the sources of student behavior data more diverse.

Based on the experimental results, it can be concluded that the proposed method when face recognition can accurately identify it with the random matrix theory fusion model can form an identity, location, quantity, trajectory, and speed perception of the human body, so as to complete the body’s attendance, behavior analysis, and environmental features such as task. And when the face recognition due to factors, such as light, shade and make the effect not beautiful, in this paper, the noncontact method combining image recognition and random matrix theory can perceive the presence of the human body from the position, quantity, trajectory, speed, and other dimensions by using random matrix theory, which makes up for the defects of a single method and enhances

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<th>Table 2: Classification accuracy of different algorithms in classroom teaching automation prediction.</th>
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<td>Algorithm</td>
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<tr>
<td>RF</td>
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<td>NB</td>
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<tr>
<td>DLDA</td>
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<td>Random matrix theory</td>
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<th>Table 3: Application satisfaction of classroom data tools.</th>
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<td>Item</td>
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<td>I am satisfied with the information technology teacher using the &quot;questionnaire star&quot; to test the learning and mastering of the situation in class</td>
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<tr>
<td>I am satisfied that the teacher uses the class optimization master to record learning performance</td>
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<tr>
<td>I was satisfied with the teacher using the class optimization master to randomly select students to answer the questions</td>
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information from two modes. In addition, the proposed method can also be used as an effective method to monitor human activity and aggregation in a certain area. For example, it can be used to monitor the activities of people in the laboratory, especially the use of sensitive resources. It can also provide a basis for analyzing the learning behavior of specific groups in the scenario of collaborative learning and a smart classroom. As the entry point of the specific work in the teaching activity of attendance, a model of human identity, position, quantity, and movement track perception in the environment is proposed by combining image recognition and random matrix theory. The face recognition algorithm, clustering algorithm, and Kalman filter in image recognition are used to process the collected basic data. In order to satisfy the asymptotic convergence when analyzing the spectral distribution of the high-dimensional random matrix, the dimension of the random matrix is required to be nearly infinite in theory, but it is obvious that the infinite amount of data cannot be obtained in practical application. The asymptotic convergence is also observed in the moderate-scale random matrices with tens to hundreds of dimensions, which makes it possible to apply the random matrix theory to practical engineering problems.

5. Conclusion

In terms of the concept of classroom attendance, the proposed random matrix theory perception model changes the traditional classroom attendance detection from active detection to passive detection, which can improve the user-friendliness of the process of attendance. In terms of technology, two random matrix theory methods of image recognition and random matrix theory are proposed for attendance checking, appropriate algorithms are selected for data processing according to the characteristics of data, and relevant algorithms are implemented, so as to realize identity recognition, human body positioning, counting, motion tracking, and speed tracking. In terms of educational data, the method proposed by integrating two random matrix theory methods can provide more data for education, thus providing basis and support for student behavior analysis. At the same time, the random matrix theory method proposed in this paper can avoid the health and safety problems of fingerprints and other contact methods. The research on the relevant theories of random matrix theory is of great importance to social security and economic development under special circumstances, and the random matrix theory method proposed in this paper is also an efficient method. As mentioned earlier, the method can also be used to monitor human activity in an area. For example, it can be used to monitor activities in the lab, especially the use of sensitive resources. The next step is to apply artificial intelligence to computer network technology, which can effectively improve the stability, security, and effectiveness of the computer system, and promote the plan. For the healthy development of computer network technology, in practical application, artificial intelligence can be widely used in “security management”, “data identification”, and other fields and improve the ability of computer systems to deal with mass data and to meet the basic needs of network users for data transmission, processing, and application.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.
Conflicts of Interest

The authors declare that they have no conflicts of interest or personal relationships that could have appeared to influence the work reported in this paper.

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