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SPECIAL SECTION ON GIGAPIXEL PANORAMIC VIDEO WITH VIRTUAL REALITY

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Research on Information Management Based on Image Recognition and Virtual Reality

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ABSTRACT Information management is an important part of national economic and social life. With the rapid rise of new technologies such as the Internet, more and more industries are seeking to integrate with informatization. At the same time, many problems have arisen due to the immaturity of information management technology. Therefore, improving the level of information management technology plays an important role in improving the efficiency of informatization. In view of the above problems, this paper builds a new information management model based on the original information management technology, combining image recognition and virtual reality technology. First, a text data collection model based on image recognition is designed in the information collection link. Secondly, based on the existing information management technology, virtual reality technology is used to visually display the image and text information. Finally, the case analysis and performance test results illustrate the superiority of the implemented information management technology. This method can provide scientific reference and basis for modern information management using image recognition technology.

INDEX TERMS Information management, image recognition, virtual reality, visualization.

I. INTRODUCTION

Informatization is a very popular special vocabulary at present, and it brings huge development opportunities to all sectors of society. More and more industries are seeking to combine with informatization, hoping to quickly improve industrial efficiency and management level [1], [2]. With the development of computer network technology, image recognition and virtual reality technology, the realization of three-dimensional visualization information management system has a solid theoretical and technical foundation. In the process of understanding the outside world, 80% of information is provided by human vision [3]. The visual system is closely related to many advanced functions of the brain. The virtual world created by the three-dimensional visualization technology based on virtual reality can express information more intuitively and accurately. Combining virtual reality technology with other computer technologies opens up a new way of information management [4].

Driven by the development of science and technology, many scholars have studied modern information management technology in many ways [5]. Mireille analyzed the functions of the management information system from the perspective of quality management, and believed that the quality management modules in the system were all composed of ISO9001 templates [6]. Scholars such as Paul Wheatley studied the information management life cycle of digital protection from the perspective of cost accounting under the OAIS framework, and contributed to the research on the long-term preservation of information [7]. In order to achieve effective management of engineering documents, Dr. Zhang *et al.* combined engineering texts with building information models and developed a web-based engineering text management information system using Revit API technology [8]. Y. Fujita conducted research on the authenticity and completeness of OAIS system research document information resources and reached certain conclusions [9].

Through the above research, it has been found that the development of computer graphics has enabled digital image processing technology to be applied in multiple fields, while in the field of engineering, complex engineering management information can be displayed in the form of images that are more easily recognized and analyzed by managers [10], [11]. Virtual reality technology is an emerging technology that combines computer technology and simulation technology. It uses computers to generate a simulated environment.

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With its multi-perception, interactivity, and immersion, it can simulate real environments or things and present them to users [12]. In teaching, virtual reality technology can provide users with a virtual learning environment, provide rich sensory stimulation and natural interaction, and bring an immersive learning experience.

This research integrates image recognition technology, virtual reality technology and other technologies to the visual information management platform [13]. The images collected by the high-definition camera perform image processing, and collect, update, organize, and analyze various data in real time. Relying on virtual reality technology, these data are expressed in the form of three-dimensional models and virtual scenes, and the utility of information is excavated to a greater extent to facilitate decision makers to obtain relevant data. The research will be able to improve the industry's overall production efficiency and management level, and achieve the best economic and social benefits.

II. INFORMATION MANAGEMENT TECHNOLOGY

With the continuous development of the economy of the times, information management plays an extremely important role in government, enterprise and social management. With the increasing number of traditional physical file management, its storage costs and management costs are also getting higher and higher [14]. With the passage of time and continuous use, physical files will be damaged and eventually cause losses. Therefore, with the development of modern information technology, the physical files are gradually converted into electronic files through digitalization. These electronic files are easy to permanently save and the preservation cost is low, and will not cause damage and loss. How to save, use and manage electronic files is the main problem we need to solve at present. We need to build an information resource management platform to scientifically collect, use, and save information resources, and at the same time ensure that this information can maintain its authenticity, reliability, and complete availability as long as possible.

Therefore, in the situation where management documents are becoming more and more important, the OAIS reference model emerges. OAIS is an open information management system. It uses reference models and conceptual frameworks to provide informational means for the long-term storage and utilization of digital information in file resource systems. Storage and management.

A. OAIS INFORMATION MODEL

An important component of the OAIS framework is the information model for storing metadata, and it is independent of digital object types and specific technologies. In order to achieve the long-term storage characteristics of archive information, OAIS divides information objects into content information, preservation description information, packaging information and bibliographic information and three types of information packages [15]. The submission information package is sent by the information generator to the archive information management platform. The archive information package is the information package actually stored by the archive information management platform, and the distributed information package is the information distributed by the archive information resource management platform in response to the user's utilization needs and distributed to the user package [16]. Among them, the archive information package is a long-term preservation information package. In order to save digital objects or physical objects, these three types of information packets are processed in the OAIS architecture to connect them as a whole. The OAIS information model is shown below.

To build an information resource management platform based on the OAIS reference model, the file content information can be free from time, quantity and space restrictions, and the service target can be expanded in a wide range and in many fields [17]. At the same time, the allocation and optimization of information file resources, overall planning and sharing have been completed, so that the work has developed qualitatively, and the impact and role in sustainable development have been further improved. Compared with the messy management in the traditional office form, the information resource management in the paperless office is easy to professionally manage, at the same time save costs, improve work efficiency, and realize the transformation of management from storage serviceability to resource release and utilization [18]. The information resource management platform realizes the centralized and unified management of various resources, so that the meaning and value of management work can be maximized, so as to maximize the preservation of valuable information resources, and realize the basic functions and historical responsibilities of work management.

The document information resources are consolidated, and the long-term storage and utilization of the document information resources within the enterprise is completed [19]. Through the construction of the document information resource management platform, the document information resources will be enriched and improved to provide corresponding reference materials and basis for enterprise decision-making and daily office work. Process and save data on a basis to achieve long-term and effective storage of file resources, thereby facilitating the use of files. The research has far-reaching significance for the enterprise's document management and enterprise construction and development.

B. IMAGE ACQUISITION DESIGN

The image acquisition system realizes the function of acquiring images located on any side of the express, and is composed of six cameras, a four-degree-of-freedom robot arm, and three photoelectric sensors. The cameras are divided into two groups, and each group has three cameras, which are respectively installed on the upper side and the two sides of the conveying equipment, and are used to collect the images of the express twice [20]. The three photoelectric sensors are respectively installed on the front side of the first group of

cameras, the second group of cameras and the turning robot arm relative to the running direction of the conveyor belt, and are used to provide them with signals that the documents arrive. The DOF mechanical arm is installed on the back side of the first group of cameras with respect to the running direction of the conveyor belt, and decides whether to reverse the document based on the photoelectric sensor signal and computer processing signal on its front side. Among them, the mechanical arm that completes the flip action requires at least four axes, so the four-axis mechanical arm is selected as the flip arm.

Based on the hardware structure, the computer processes the collected document images and the information returned by the photoelectric sensor, and sends instructions to the robotic arm, so as to ensure that the images are collected without the assistance of humans. First, the three cameras of the first group are installed in three directions of the conveyor belt 1. When the photoelectric sensor returns information 1, the first group of cameras takes a picture. At this time, the photo taken by the camera is the picture information on the three sides of the express number 1, 2, 3, and then the computer searches the collected three pictures and transmits instructions to the robotic arm according to the result. The turning manipulator decides whether to act according to the command information transmitted from the first step and the information returned by the photoelectric sensor PS2. When the photoelectric sensor PS2 detects the shipment and returns message 1. If the two-dimensional code is not found in the image returned by the first set of cameras, the robot arm 1 flips the document in the positive X-axis direction. If text is found in the image returned by the first set of cameras, the robot arm 1 does not move. Then the express enters the conveyor belt 2 perpendicular to the conveyor belt 1. Similar to the first group of cameras, the three cameras of the second group are placed above the conveyor belt 2, in the left and right directions, and when the photoelectric sensor returns information 1, the second group of cameras takes photos. In the first step, a total of six images were collected, and at least one of the six images contained text images. If none of the text images were found, it was determined to be a problem.

III. VIRTUAL REALITY TECHNOLOGY

Virtual reality technology (referred to as ''VR''), is an important direction of simulation technology. It combines a variety of technologies: computer technology, multimedia technology, image processing technology, simulation technology, etc., thus forming a new technology involving the field of simulation and computer. Virtual reality technology (VR) mainly includes aspects such as simulated environment, perception, natural skills and sensing equipment [21], [22].

The simulated environment is a computer-generated, real-time, dynamic three-dimensional realistic image. Perception means that an ideal VR should have the perception that all people have. In addition to the visual perception generated by computer graphics technology, there are perceptions of hearing, touch, force, movement, and even smell and taste, also known as multi-sensing. Natural skills refer to the rotation of human head, eyes, gestures, or other human behaviors. The computer processes the data suitable for the participant 's movements, responds to the user 's input in real time, and feeds back to the user 's facial features. The sensing device refers to a three-dimensional interactive device. Virtual reality technology is mainly composed of three aspects: virtual reality, virtual reality, and computer processing high-performance technology. Among them, physical blur refers to mapping a multi-dimensional information space through the real world. The key technologies are: virtual space modeling, sound localization, visual and space tracking, sensory feedback, voice interaction, etc. The use of these key technologies can make the virtual space produced by virtual reality technology have a stronger sense of realism, and the user 's immersion the interaction is better.

IV. VIRTUAL REALITY TECHNOLOGY

The first thing image recognition technology does is to obtain important clues and information from the environment and classify objects. That is, the computer can recognize each target category included in the image scene according to different weather and different scenes. To accomplish this goal, it is necessary to use a large number of different types of target images to train the perception model. After training and learning the perception model, the perception model will automatically recognize different types of target information in the scene according to the target features it has learned. The target needs the perception model to have a good recognition function, because even the same scene in the logistics information collection will affect the judgment segment due to the speed of the object, weather changes and other factors [23].

If all the vectors in the training set can be correctly divided by a hyperplane, and the distance between the closest heterodynes to the plane is the largest, then the hyperplane is the optimal hyperplane. The heterogeneous vector closest to the hyperplane is called a support vector (SV). A set of support vectors can uniquely determine a hyperplane. SVM is developed from the optimal classification surface under linearly separable conditions. The solid points and hollow points in the figure represent two types of samples, H is the classification hyperplane between them, H1 and H2 are the hyperplanes that are closest to the classification surface and parallel to the classification surface. The distance is called classification margin [24].

If the linear separable sample set is a category label, the general form of the linear discriminant function in the dimensional space is $(x_i, y_i), i = 1, 2, \cdots, n; x \in R^d, y \in \{+1, -1\}$. The general form of the linear function is $g(x) = w \cdot x + b$. Then the classification surface equation is $w \cdot x + b = 0$. The discriminant function is normalized so that all samples of the two classes satisfy $|g(x)| \geq 1$, so making the interval maximum is equivalent to minimizing $\|\omega\|^2$.

$$y_i [(\mathbf{w} \cdot \mathbf{x}_i) + b] - 1 \geq 0, \quad i = 1, 2, \cdots, n \tag{1}$$

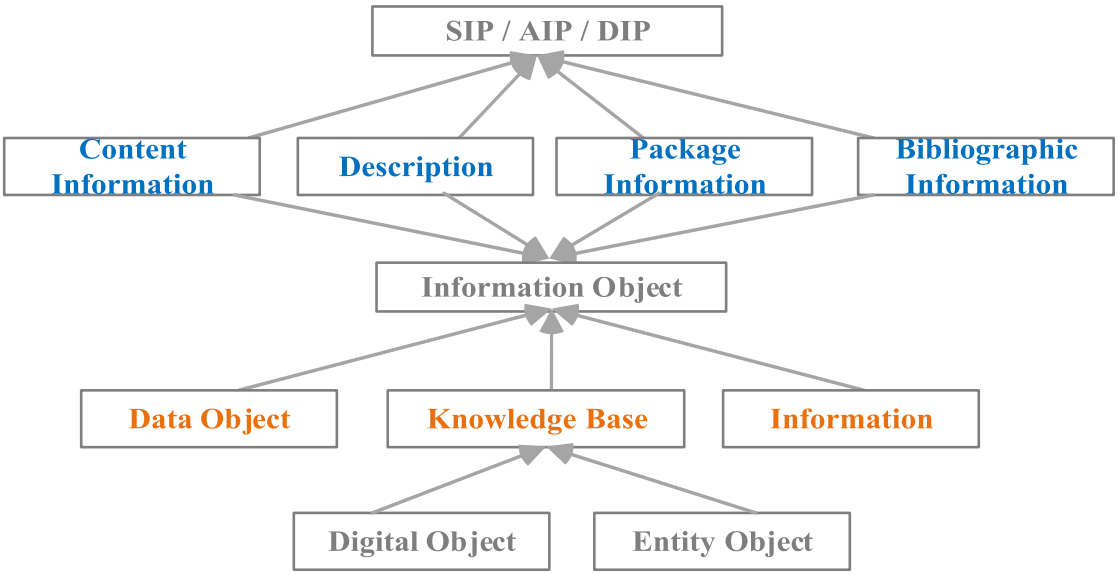

FIGURE 1. OAIS information management model.

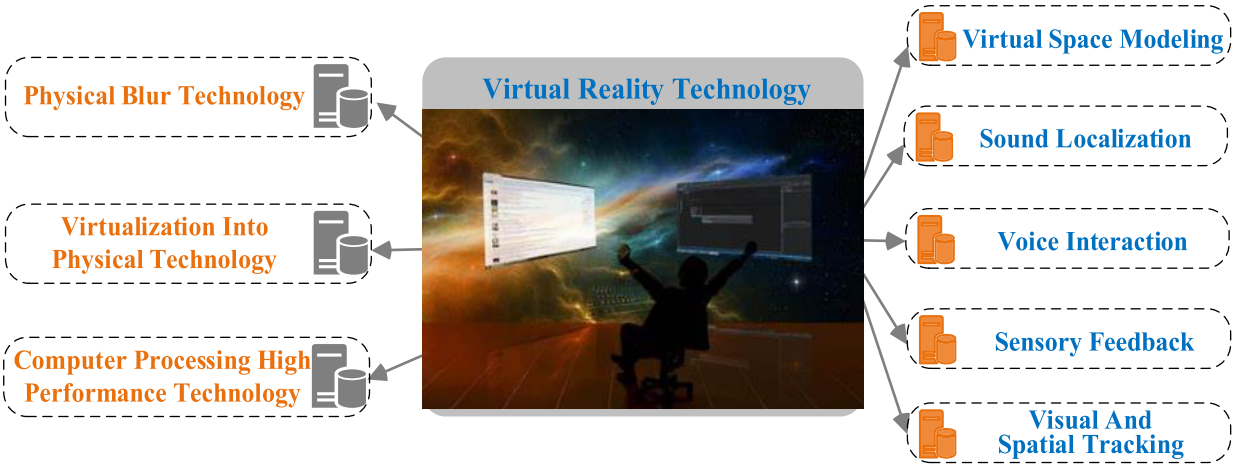

FIGURE 2. Schematic diagram of multi-technology integration of virtual reality technology.

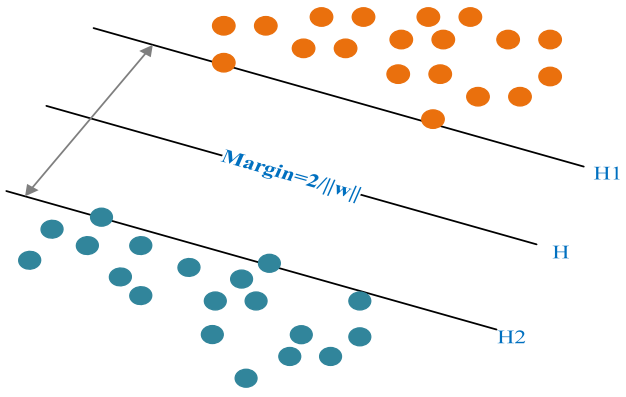

FIGURE 3. Basic principles of SVM.

Therefore, the classification surface that minimizes is the optimal classification surface. The training samples on the hyperplanes H1 and H2 that are closest to the classification surface and parallel to the optimal classification surface among the two types of samples are the samples that make the equal sign. In the case of linear separability, the optimal hyperplane problem under the structural risk minimization criterion is an optimization problem that minimum as the objective function. Therefore, the Lagrange function shown can be defined, where $a_i \geq 0$ is the correspondence of each sample Lagrange coefficient.

$$L(\omega, b, \alpha) = \frac{1}{2}\|\mathbf{w}\|^2 - \sum_{i=1}^{n} a_i y_i (\mathbf{w} \cdot \mathbf{x}_i + b) + \sum_{i=1}^{n} a_i \quad (2)$$

When solving the minimum time, make the functional partial derivative of w and b, and make them equal to 0. You can transform the above problem of finding the optimal classification surface into a simple dual problem. If α_i^* is the optimal solution, the the weight vector of the optimal

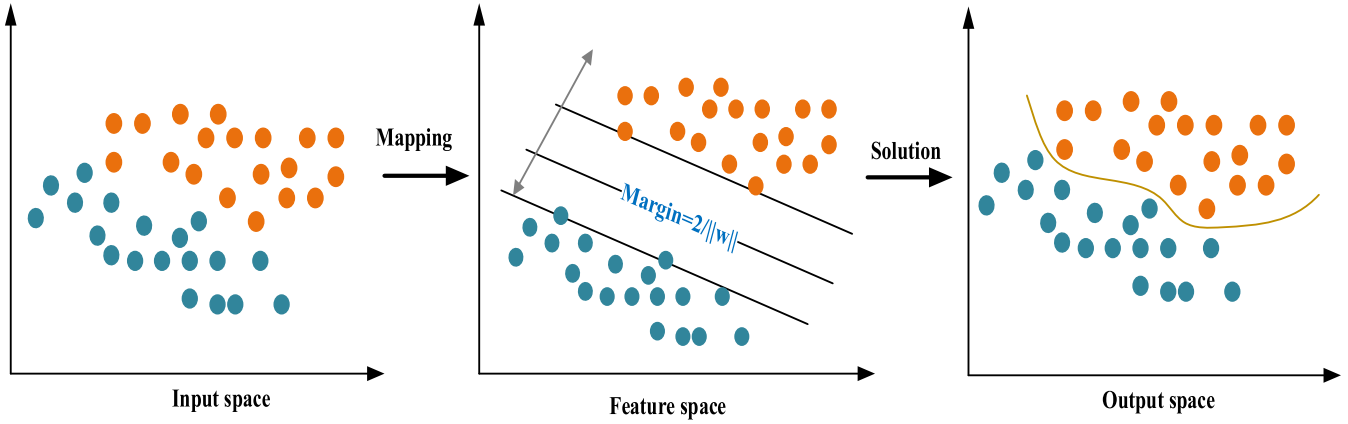

FIGURE 4. The solution of SVM to nonlinear problems.

classification surface, that is, the weight vector of the optimal classification surface is a linear combination of the support vectors in the training sample.

$$Q(\alpha) = \sum_{i=1}^{n} \alpha_i - \frac{1}{2} \sum_{i,j=1}^{n} \alpha_i \alpha_j y_i y_j \left(\mathbf{x}_i \cdot \mathbf{x}_j\right) \tag{3}$$

According to the relevant theory of functionals, as long as a kernel function satisfies the Mercer condition, it corresponds to the inner product in a transformation space. The Mercer condition stipulates: for any symmetric function, it is a necessary and sufficient condition for inner product operation in a certain feature space.

$$\iint K\left(x, x'\right) \varphi\left(x'\right) dx dx' \geq 0 \tag{4}$$

The SVM classification function is a linear combination of a set of nonlinear functions with support vectors as parameters. The SVM classification function is only related to the number of SVMs, not to the dimension of space. Therefore, even if the dimensionality of the change space increases a lot, it does not increase too much time complexity when seeking the optimal classification function. The working principle of SVM to deal with nonlinear problems is shown in Figure 4.

From the function expression of the support vector machine as shown in the formula, it can be seen that the SVM transforms the original low-dimensional space into a new high-dimensional space through the inner product kernel function, and the classification and discrimination of the SVM only differs from the samples to be identified and the training samples Support vector related.

$$f(x) = \operatorname{sgn}\left(w^* \cdot x + b\right) = \operatorname{sgn}\left(\sum_{i=1}^{n} \alpha_i^* y_i K\left(x_i \cdot x\right) + b^*\right) \tag{5}$$

The Gaussian Radial Basis (RBF) kernel function is one of the most widely used kernel functions. The kernel function has only one kernel parameter called the kernel radius, and its expression is:

$$K(\boldsymbol{x}, \boldsymbol{y}) = \exp\left(-\frac{\|\boldsymbol{x} - \boldsymbol{y}\|^2}{2\sigma^2}\right), \quad \sigma > 0 \tag{6}$$

The polynomial kernel function is also a very common kernel function. The kernel function has only one kernel parameter that can only be an integer.

$$K(\boldsymbol{x}, \boldsymbol{y}) = (\langle \boldsymbol{x} - \boldsymbol{y} \rangle + p)^q, \quad q \in Z \tag{7}$$

The Sigmoid kernel function is derived from a neural network. The support vector machine implementation of the Sigmoid kernel can be equivalent to a two-layer neural network. Its expression is:

$$K(\boldsymbol{x}, \boldsymbol{y}) = \tanh(r \langle \boldsymbol{x}, \boldsymbol{y} \rangle + c) \tag{8}$$

In this study, RBF kernel function, polynomial kernel function and Sigmoid kernel function are used as a single kernel function for compounding. The compound kernel function is:

$$\begin{aligned} K(\boldsymbol{x}, \boldsymbol{y}) = {} & \rho_1 \exp\left(-\frac{\|\boldsymbol{x} - \boldsymbol{y}\|^2}{2\sigma^2}\right) + \rho_2 (\langle \boldsymbol{x} - \boldsymbol{y} \rangle + p)^q \\ & + \rho_3 \tanh(r \langle \boldsymbol{x}, \boldsymbol{y} \rangle + c) \end{aligned} \tag{9}$$

$$K(\boldsymbol{x}, \boldsymbol{y}) = 0.7 \exp\left(-\frac{\|\boldsymbol{x} - \boldsymbol{y}\|^2}{0.6}\right) + 0.3 \tanh(\langle \boldsymbol{x}, \boldsymbol{y} \rangle - 1) \tag{10}$$

Using the composite kernel function shown, training different sample points, and then comparing with a single kernel function, the performance of the optimal composite kernel function is more superior.

V. INFORMATION MANAGEMENT TECHNOLOGY FRAMEWORK BASED ON IMAGE RECOGNITION

Mathematical model refers to a model constructed with mathematical language using mathematical logic methods. The development of the Internet has resulted in a large amount of data accumulation. Massive digital logistics images have brought a wealth of "data food" to the researchers of logistics information collection. With the constant attention to data value mining, in recent years, there have been endless ways to study and analyze logistics information from the perspective of graphic images and mathematical statistics [25].

The access layer can also be referred to as the data collection layer, and its role is through various data collection methods (for example: analog cameras, various sensors, RFID

TABLE 1. System development environment and tools.

Attributes	*Specific environment and version*	*Attributes*	*Specific environment and version*
Operating system development	macOS、CentOS 7	Project management tools	Git 2.10
development tools	Atom、phpStorm	Front-end construction and management	Atom、phpStorm
Operating environment and server	CentOS 7、Nginx 1.8	Operating environment and server	FIS 3
database	MySQL 5.7.9、MolaDB	Design Tools	PhotoShop CC 2015

radio frequency identification, two-dimensional codes, alarm detectors, temperature sensors, vehicle positioning systems, etc.) get data. The dynamic information that can be collected through the access layer, through continuous data collection, realizes data accumulation and lays the foundation for big data mining.

The data layer is an important part of logistics information collection. The access layer uses image recognition technology to collect massive unprocessed data and transmit it to the data layer through optical fiber network cables. The data is processed and classified into different databases for storage management. In addition, the use of data exchange technology to achieve data exchange and sharing, thereby enriching the accumulation of database data. The data layer also uses a variety of advanced cloud computing data processing technologies to dig deep into the data and pave the way for data decision-making applications.

The platform layer mainly completes system integration and data processing. The platform layer needs to use technical means to integrate the existing information systems of various departments, and perform deep self-configuration processing of the data collected by various subsystems, and complete deep processing and storage of data through database servers and large enterprise-level databases. The platform layer combined with the data layer can complete the main data processing of the information platform, and can achieve data filtering, exchange, analysis, and mining between various systems to support the application needs of different users at the application layer. At the same time, this layer is responsible for the regular maintenance of the system, data encryption and security protection.

VI. INFORMATION MANAGEMENT TECHNOLOGY FRAMEWORK BASED ON IMAGE RECOGNITION

The above describes the design and implementation of information management. In order to verify the feasibility and efficiency of the information management based on image recognition and virtual reality technology proposed in this paper. We will conduct performance tests on the technology and analyze and verify the practicability and efficiency of the technology.

A. TECHNICAL TEST ENVIRONMENT

The development of the system server mainly uses the ODP framework based on PHP, and the front end is mainly developed based on React. js and Redux framework. At the same time, Git is also used for code management, and the front-end part uses the FIS3 framework for front-end code preprocessing, compilation, and packaging operations, which promotes the team's efficient iterative development and collaborative work. The development environment and tools of the system are shown in Table 1.

This system test includes server-side test and front-end page test, and is responsible for various test tools. Unit test: mainly includes the correctness verification of each minimum unit of the system. Server-side unit testing uses Python's unit test module, and front-end unit testing uses the Jasmine testing framework. Functional testing: mainly includes QA verification of various functions of the system, using Python's Selenium framework for various functional tests. Performance testing: As long as the automated testing tools are used to simulate the performance of the system under normal conditions, peak conditions and abnormal conditions, the system uses the siege framework for performance testing and the Noah platform to monitor the performance status of offline machines. Automated testing: Mainly through automated tools and simulate the various operations of the system under preset conditions, using the new automated testing of the Selenium framework [26].

B. DATA TRANSMISSION TEST

During the system design, multiple data security mechanisms are adopted to ensure reliable data transmission [27]. On the one hand, while the logistics information data is transmitted in real time, the data is stored locally for a short period of time. On the other hand, when a small amount of data loss occurs, the instant retransmission mode can be started. That is, when data packet loss occurs, the system starts the

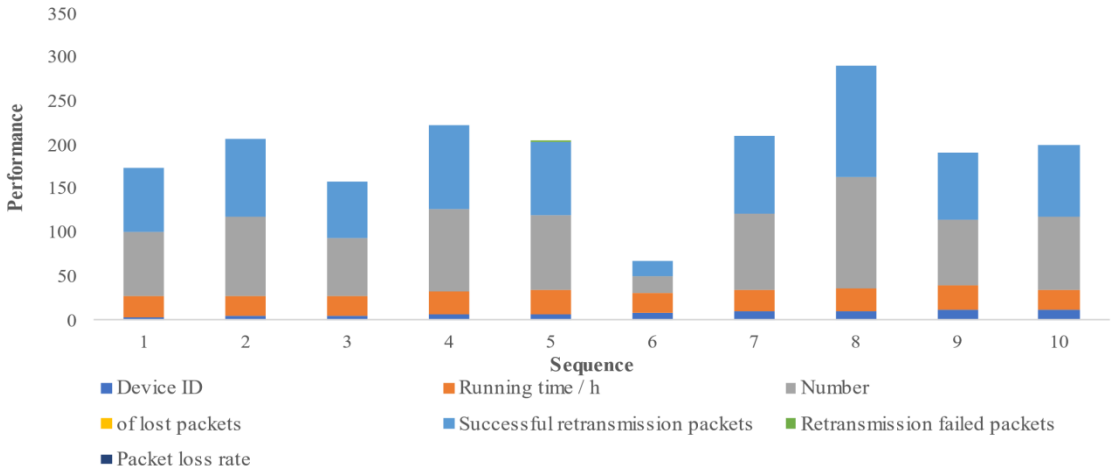

FIGURE 5. Data transmission reliability test results.

TABLE 2. Concurrent number = 200 Cycle times = 100 Stress test result table.

Test item	*Operation result*	*Test item*	*Operation result*
Transactions	5237 hits	Response time	1.10 secs
Availability	100 %	Transaction rate	122.68 trans/sec
Elapsed time	42.69 s	Throughput	13.75 MB/sec
Data transferred	586.96 MB	Concurrency	135.51
Successful transactions	5237	Longest transactions	3.62
Failed transactions	0	Shortest transactions	0.69

instant data retransmission mechanism. Without affecting the real-time data transmission, the real-time transmission gap will be lost the data is sent back to the data server. When the network is disconnected for a long time or the network signal is poor resulting in a large amount of lost data that cannot be transferred in real time, the system will issue an alarm prompt [28].

In the process of system performance testing, the two indicators of system response time and packet loss rate are used to test the concurrent performance of the system and the performance of responding to customers. Limited to the network environment and server performance have a greater impact on performance indicators, the network environment during the test is selected as the internal network, the server is a stand-alone server with a brand-new system and a cluster with two stand-alone servers [29]. It can be seen from the test results that the packet loss rate of wireless data transmission is $<0.1\%$, and 99% of the packet loss data can be retransmitted successfully. After the device is turned on next time, the data can still be retransmitted successfully, thereby ensuring the integrity of the data.

C. TECHNICAL PERFORMANCE TEST

In order to test the reliability of the information management technology in the actual use of parameters, we have organized various types of system tests. In the case that the function meets the business, the system also needs to meet the requirements of performance indicators such as response speed and server concurrent affordability [30]. This system uses the siege framework to perform performance tests and uses Noah to monitor various performance indicators. Recognize the test scene of the graph result page, use the siege test tool to simulate 200 users to cycle 100 concurrent requests to obtain the following experimental results, as shown in Table 2.

From the experimental results, it can be seen that the number of successes in 5237 sessions is 5237. Under this test condition, a transmission rate of 100% is guaranteed. The total session lasts 42.69 seconds, a total of 586.96 trillion data is transmitted, and the average response time is 1.10. Seconds, the transmission rate is 112.68 times/second, the longest transmission is 3.62 seconds, and the shortest transmission is 0.69 seconds. From the success rate, the stability of the system is very high, but from the perspective of access time,

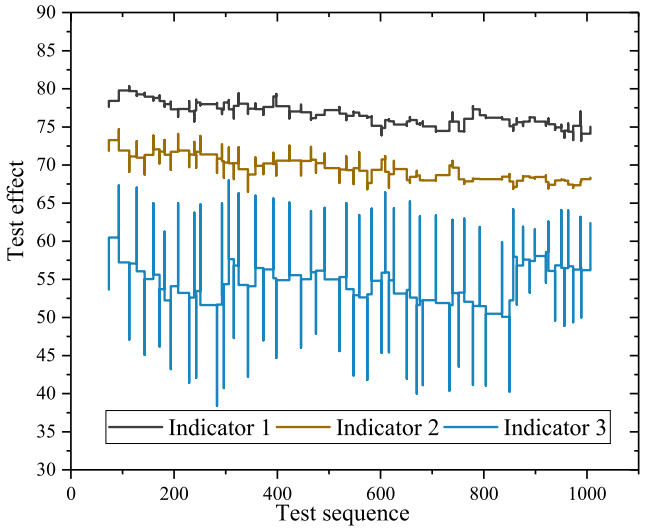

FIGURE 6. Information management technology performance test results-CPU_IDLE.

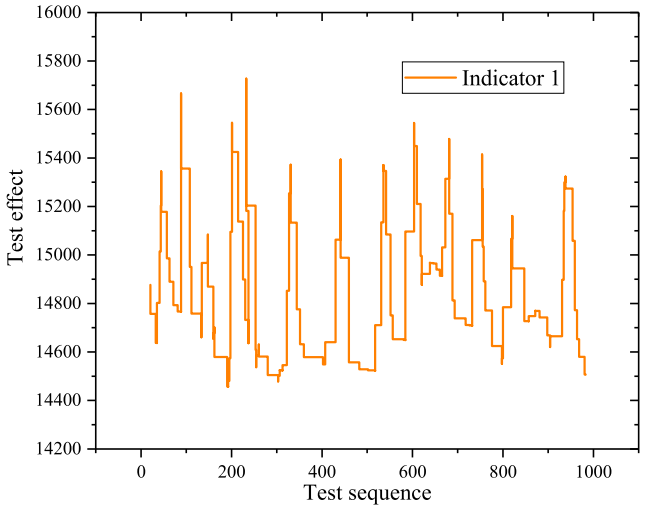

FIGURE 7. Information management technology performance test results-MEN_USED.

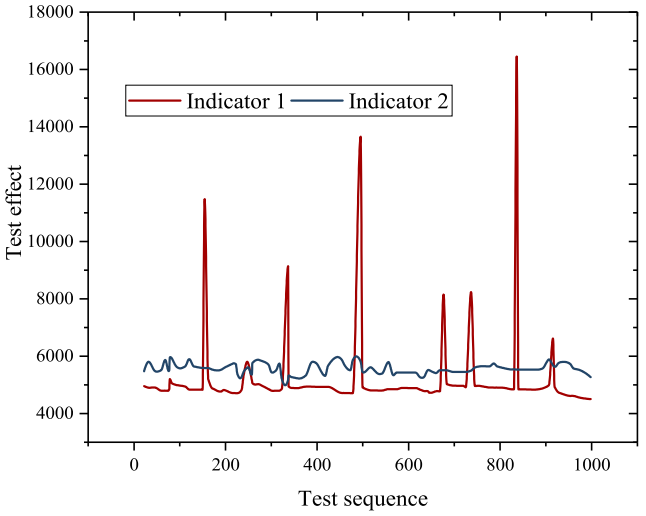

FIGURE 8. Information management technology performance test results-NET_TOTAL_BITPS.

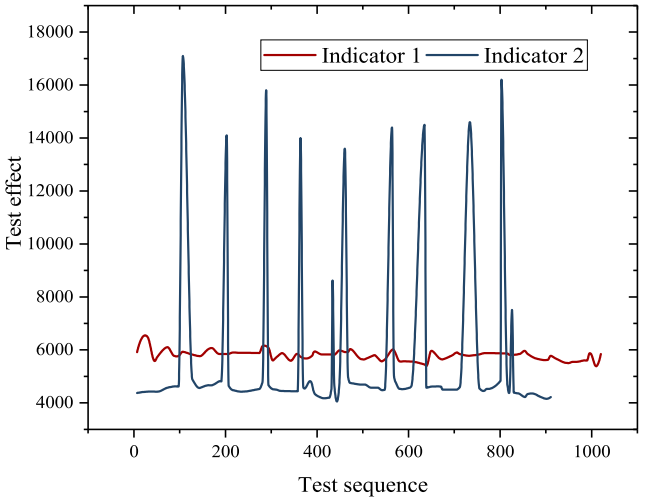

FIGURE 9. Information management technology performance test results-NET_TOTAL_OUT.

it still needs to be improved, because the server takes too long to process the request, and there is still room for optimization. The system passes the Noah system's monitoring server hour-level data, as shown in Figures 6, 7, 8, and 9.

It can be clearly seen from the figure 6 that the system's CPU, memory, network input and network output operation within an hour. The indicators of CPU and memory are running smoothly, basically maintaining fluctuations within a certain reasonable range. The network is irregularly fluctuating due to the instability of the request time, but the fluctuations are in line with the expected effect. After testing and analysis of the results in the above stages, it is found that the system meets the needs of business and users in terms of functions, and meets the conditions of server clusters in performance. From the overall observation, it is found that no system has achieved very good results in stability, which can basically ensure the accuracy of image recognition and precision. However, the system's access speed can obviously feel the loading is too slow. On the one hand, with regard to the requirements of the image recognition function, due to the variety of image recognition functions, the specific implementation of each function is different. In the end, the data of all functions need to be integrated and displayed together, and certain slower processing functions will inevitably slow down the overall progress. On the other hand, for the indicators of the servers, the differences between the servers themselves and the network conditions in different regions lead to certain differences in certain indexes of the server cluster. Although these differences are currently in a stable and better range, there are still aspects that can be optimized. In summary, the various modules of this system can still be targeted for improvement.

VII. CONCLUSION

This paper studies information management based on image recognition and virtual reality. The system uses the support

vector machine algorithm for file information and classification and identification, collects file images in real time, and processes and analyzes data through algorithms. The actual case test and analysis illustrate the good effect of the information management technology achieved, which can provide a scientific reference model and basis for establishing a remote real-time dynamic information management system using image recognition and other technologies. In addition, this paper mainly analyzes the application of support vector machines for big data analysis and other technologies, and mainly conducts shallow analysis. The application of information management needs to be deepened and studied at the data mining level. Focusing on the increasing and deepening needs of the industry for future social development, we will continue to tap and improve existing information management technologies to provide scientific assistance for improving the degree of industry informatization.

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