Advancing Production Operation Safety with Virtual Reality Solutions and AI-Driven Computer Vision

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Abstract. Artificial intelligence computer vision has always attracted much attention in the global academic community, and their method of analyzing security issues is mainly through simulation experiments. This article will conduct research based on human-computer interaction technology image processing and other related theories. First, this article introduces the principles of production operation cockpit. Then, this article elaborates on the computer vision algorithm and its mathematical derivation method and illustrates the feasibility and practicability of the research through examples. Finally, this article proposes an instrument panel safety design strategy based on the results of artificial intelligence computer vision research and conducts a safe driving simulation experiment. The experimental results show: (1) Security model testing: In terms of stability function testing, the wall display module is 0.857, the management prediction core module is 0.895, the operation management service database is 0.883, and the enterprise resource planning module is 0.837; in terms of throughput, the wall display module is 7478849, the management prediction core module is 7889587, the operation management service database is 895890, and the enterprise resource planning module is 742689; in terms of the number of concurrent users, these four modules are all 5,000; in terms of recovery failure time, the wall display module is 4 seconds, the management prediction core module is 3 seconds, the running management service database is 8 seconds, and the enterprise resource planning module is 4 seconds; the security performance of its model wall display module is 94%, the security performance of the management prediction core module is 97%, the security performance of the operation management service database is 99%, and the enterprise resource planning module has a security performance of 96%; in terms of page loading speed test, its wall display module is 4m/s, management prediction core module is 5m/s, operation management service database is 8m/s, and enterprise resource planning

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module is 6m/s. (2) In terms of computer vision algorithm performance: the accuracy of the computer vision algorithm is between 0.907-0.996, the recall rate is between 0.768-0.897, and the number of frames is 122HZ and 144HZ; the regression error range of the computer vision algorithm is between 0.047-0.79; the processor utilization of the algorithm is between 2% and 5%.

Keywords: Artificial Intelligence, Computer Vision, Driving Operation, Driving Safety, Virtual Reality Solutions
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1 INTRODUCTION

Artificial intelligence computer vision is an emerging science and technology that uses the human brain as the object of information processing and analysis and performs simulation and simulation based on this. Countries around the world attach great importance to the safety issues of machine vision, and China is also working hard to develop intelligent, automated, and other technologies to solve these problems [8][16]. At the same time, we must recognize the tremendous convenience and social and economic benefits that artificial intelligence computer technology brings to mankind.

Foreign scholars started research on artificial intelligence computer vision earlier and have now formed a relatively complete and mature theoretical system. The United States, Japan, and other countries have also made progress in security research. Domestic literature has conducted in-depth discussions and analyses on artificial intelligence computer image processing technology, related algorithms, and models based on human eye neural networks. By establishing the relationship between face recognition and machine learning, some scholars proposed using fuzzy mathematical methods to implement a multi-dimensional stereoscopic vision model of the simulated environment [20],[10]. Some scholars have discovered that humans have multiple perceptual abilities by analyzing the relationship between different position, posture, and orientation features in user input data. These characteristics directly affect the accuracy of computer vision technology in processing complex scenes, and also limit the performance of artificial intelligence recognition systems and the effectiveness of security protection measures to a certain extent [4][12]. Based on this, this article designs a production operation cockpit safety model based on artificial intelligence computer vision.

This article proposes an intelligent algorithm based on artificial intelligence computer image security system model. This method applies neural networks to research on driving simulator data collection, human-computer interaction interface design, and vehicle simulation control systems, which has practical significance. Experiments have proven that this method plays a positive role in improving the efficiency of production operations and can effectively improve decision-makers' judgment on production operations.

2 DISCUSSION ON PRODUCTION OPERATION COCKPIT SAFETY MODEL BASED ON ARTIFICIAL INTELLIGENCE COMPUTER VISION

2.1 Basic Concepts of Safe Cockpit

The production operation cockpit refers to a management tool that provides decision makers with real-time, accurate, and comprehensive production operation information through data analysis and visual display. It integrates comprehensive data indicators and key performance indicators to help management gain an in-depth understanding of operations, monitor key business processes, and analyze and make decisions on problems [3],[1]. The basic concept of the production operation cockpit is to visually display the production operation status in the form of charts, dashboards, etc., through the collection, integration and analysis of data, complex production and operation information is transformed into intuitive and easy-to-understand visual images, providing managers with a reference for decision-making. The core function of the production operation cockpit is data integration and integration. It can summarize and organize data from different departments and different systems, realize the integration of diverse data sources, and ensure the accuracy and consistency of data. This helps to gain an in-depth understanding of the situation in each link of the production operation process and identify potential problems and opportunities in a timely manner. Its functions are as follows:

1. The production and operation cockpit has powerful data analysis capabilities. Through the visual display of data, managers can clearly see the production operation status, including key performance indicators such as production efficiency, resource utilization, and quality indicators. At the same time, it can also perform advanced data analysis such as trend analysis and anomaly detection to help managers discover potential problems and trends and take corresponding measures in a timely manner [5],[15].

2. The production and operation cockpit has real-time monitoring and early warning functions. Through the collection and analysis of real-time data, it can monitor the production operation status in real time and provide early warning prompts based on set rules and indicators. This helps managers discover and solve problems in production in a timely manner to avoid possible risks and losses.

3. The production and operation cockpit supports multi-dimensional data query and analysis. Managers can filter and analyze production operation data according to different dimensions through flexible query methods, such as slicing and pivoting data according to multiple dimensions such as time, region, and product [18],[11]. This helps to gain an in-depth understanding of production operations at different levels, identify problems and carry out refined management.

2.2 Production Operation Cockpit Safety Assessment

The safety assessment criteria for enterprise production and operation cockpits need to consider the following aspects to ensure the effectiveness of safety management and the improvement of the overall level.

1. Alarm supervision and management. This requires the introduction of information such as internal process alarms, interlocking cutoff alarms, flammable and toxic gas alarms, fire alarms and video surveillance into the safe cockpit, and a dedicated person responsible for monitoring the handling of production alarms 24 hours a day. In this way, the problem of untimely alarm or failure to deal with the alarm can be solved, thereby ensuring that timely response measures can be taken in an emergency.

2. Intelligent early warning and hierarchical push are another important aspect. According to the level of alarm, it is necessary to implement smart early warning and hierarchical push mechanism to push alarm information of key parts and important indicators to relevant persons in charge of the enterprise in a timely manner. The establishment of this mechanism can effectively ensure that alarm information is processed in a timely manner, thereby better ensuring production safety.

At the management level, on-site follow-up management of leading cadres plays an important role. Enterprises should set up on-site follow-up modules for leading cadres, formulate monthly follow-up plans and prepare alarm analysis and judgment results. By fully monitoring the on-site follow-up process of leading cadres, and recording the follow-up route, time, hidden dangers discovered and the rectification of hidden dangers, it also includes summary analysis and assessment reports of hidden dangers. Such follow-up management can enable leading cadres to go deep into the production line and further enhance their safety awareness and sense of responsibility [7][2].

This supervision mechanism can promptly discover problems and potential safety hazards in operations, and take corresponding measures to solve them to ensure the safe conduct of special operations.

3 EXPERIMENTAL PROCESS OF PRODUCTION AND OPERATION COCKPIT SAFETY MODEL BASED ON ARTIFICIAL INTELLIGENCE COMPUTER VISION

3.1 Safety Model of Production Operation Cockpit

The safety model of the enterprise's production and operation cockpit (as shown in Figure 1) mainly includes the following functions:

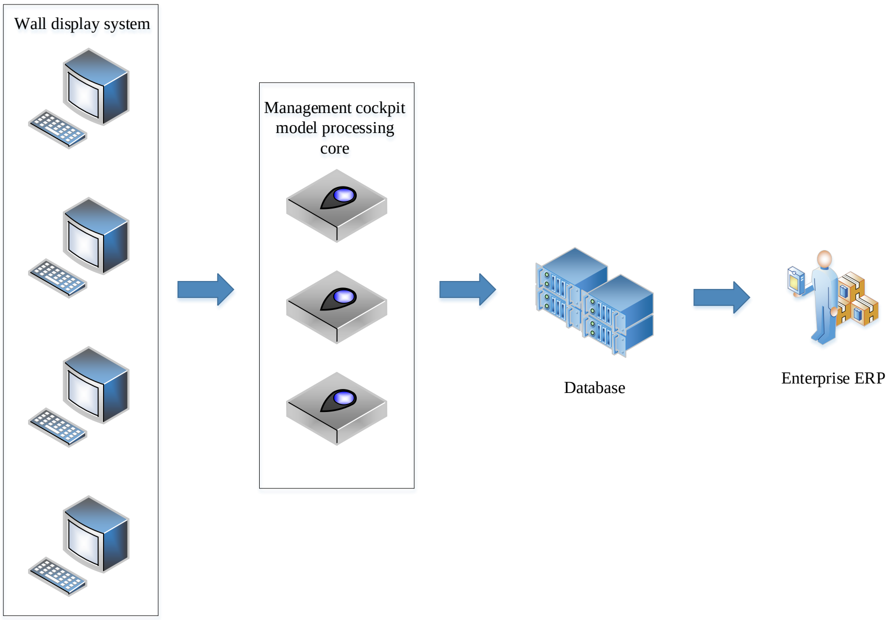

Figure 1: Composition of the production and operation cockpit safety model.

1. Management forecast core module: By comprehensively applying government data and social data, it can select micro-indicators that have an impact on macroeconomic changes. Then, artificial intelligence technology is used to build a forecast model to predict the changing trends of macroeconomic indicators, and to detect and provide early warning of macroeconomic changes and abnormalities. This module conducts a global, comprehensive and systematic analysis of the overall operation of the enterprise in order to take appropriate measures when threats may arise or have already occurred [17][9]. This module can also predict hazardous events that may occur or are about to occur in the future. By accurately predicting the changing trends and development trends of factors such as the macroeconomic situation and industry environment, the main indicators that affect the safety of the production and operation cockpit can be determined. In this way, targeted measures can be taken to ensure the safety of production operations.

2. Wall display module: It is divided into internal wall and external wall. The latest technological achievements developed by the company are usually hung on the internal walls. The external wall

can display data for staff, help them conduct in-depth analysis of the industrial structure, industrial chain ecology, corporate positioning and division of labor, and sort out the distribution of industrial chain links, upstream and downstream relationships and subdivisions. By drawing an industrial panorama from multiple angles and conducting visual analysis, we can comprehensively display the current status of industrial development, clarify regional differentiated positioning and industrial synergy, and promote the linkage and synergy of economic resources, infrastructure and industry policies.

3. Operation management service database: This database contains data records of problems and solutions generated by internal employees during their work. In addition to these, it also stores basic data for the operation of the platform. The system can also be functionally divided according to different situations.

4. Enterprise resource planning module: This module predicts possible risks based on changing trends in customer needs and proposes corresponding solutions to deal with crises and threats. During the design process, a comprehensive understanding of the resources provided by each component and the impact of each component on the overall performance is required to determine whether the optimized configuration of the production and operation cockpit is needed.

3.2 Mathematical Description of Safe Operating Cockpit

The cockpit model uses artificial intelligence computer vision technology to simulate safe operations. This system is based on face recognition and image processing and analyzes data such as human physiological information and environmental parameters through human facial feature modeling. In practical applications, mathematical methods and related algorithms can be used to establish the relationship between virtual scenes and real objects, thereby accurately verifying the identity of real actors and actresses [13],[19]. In addition, computer vision technology can also be used to combine the human detection system with the safe operating status to form a complete simulation process. However, because the human eye is greatly affected by environmental factors and has a complex and changeable structure, it cannot quickly and accurately identify target objects and complete tasks. At the same time, affected by large changes in the external environment, it is difficult to control and detect the safe operation system in real-time, and there are security threats.

In order to meet the needs, image processing operations convert images into different sizes and shapes for operations such as classification, positioning and matching. According to different types of objects, the corresponding size and dimension attribute information are determined as input parameters, and the corresponding relationship matrix is calculated as a training set. Then, these data are analyzed and calculated to obtain the decision tree model. Before data compression, a large amount of noise and other information need to be removed from the original image to eliminate these noises [6],[14]. At the same time, attention needs to be paid to using the clear filtered results for subsequent analysis and calculations. The calculation principle is: assuming each dimension is $h^{\prime}$, $h^{\prime}$can be obtained by minimizing the loss, as shown in formula (1).

$$\varepsilon = \left\| \sum_{i=1}^{d} h^{l} * f^{l} - g \right\|^{2} + \lambda \sum_{i=1}^{d} \left\| h^{l} \right\|^{2} \tag{1}$$

Among them, h'represents the regularization parameter, g is the corresponding correlation output of f^{l}, and formula (3) is obtained by transforming formula (2) into the frequency domain.

$$H^{l} = \frac{\overline{G} F^{l}}{\sum_{k=1}^{d} \overline{F^{k}} F^{k} + \lambda} = \frac{{A_t}^{l}}{B_t} \tag{2}$$

In order to save calculation time and improve calculation speed, the calculations of A_t^l and B_t are approximately completed through the update strategy, see formulas (3) and (4) for details.

$$A_t^l = (1-\eta)A_{t-1}^l + \eta\overline{G}_t F_t^l \tag{3}$$

$$B_t = (1-\eta)B_{t-1} + \eta\sum_{k=1}^{d}\overline{F}_t^k F_t^l \tag{4}$$

Before an iterative cycle begins, two stages of initialization and image analysis are required. Next, we need to obtain data information such as rotation direction, speed and acceleration of the three stepper motors. Finally, we can enter the global optimization operation. The human visual system mainly relies on the information data obtained by external sensors for analysis and calculation, and makes judgments and interpretations based on the results. The interface characteristics formed between objects in different locations are also different. Under these characteristics, corresponding algorithms need to be implemented. Therefore, in practical applications, appropriate methods need to be used according to specific situations to obtain correct and effective images[21].

3.3 Security Model Testing Environment and Process

In order to ensure that the experiment proceeds smoothly, the equipment required in the laboratory needs to be configured before the experiment. These include equipment such as simulation training machines and digital cameras. First, we need to pay attention to the hardware environment. Artificial intelligence machine vision applications have high security protection requirements for computer systems, so computers and other intelligent equipment must be selected to suit these needs. Secondly, the software environment is also very important. It includes settings for simulation scenarios and virtualized scenarios. In terms of setup, it is necessary to consider the switching operation between the experimental bench and the laboratory, and ensure that the equipment required in the laboratory is properly configured. The hardware environment of this experiment is shown in Table 1.

Name	*Configuration*
Wall display	*FineReport*
CPU	*Intel CORE i5-8400*
Video storage	*16GB*
Enterprise resource planning(ERP)	*AR HUD Pro*

Table 1: Experimental hardware environment.

The experimental software environment includes computer simulation scenarios and security protection systems. The specific configuration is shown in Table 2. In the simulation scenario, users can obtain production operation information through cameras and use image processing software to analyze and extract the collected data. In addition, computer vision technology provides a new way of interaction during the model construction and testing process. The virtual reality succession system experimental environment also includes elements such as safety protection devices, simulation scenarios, and virtual reality construction.

Name	*Configuration*
Operating system	*Windows 11*
CUDA	*8.0*
Python	*3.6*
OTA（Over-The-Air）	*3.2.4*
DBeaver	*PostgreSQL*

Table 2: Experimental software environment.

The testing of the security model mainly includes the following steps:

1. Preprocessing experimental data includes collecting samples and constructing scenarios. This raw information needs to be converted into standard parameters by selecting an appropriate reference value to determine whether the system is operating properly.

2. Preprocessing computer vision sensor images is converting the data collected in the simulation environment into digital signals according to certain rules and recording the relevant information between the original samples and the recorded video clips. If a problem or error occurs, it needs to be fixed. If the correct result cannot be obtained after necessary processing, return to the initial state and re-enter new parameters.

3. Conducting video analysis and comparison of the simulation environment operation process to obtain data such as possible fault types and causes. Establishing a security model based on the set initial conditions and environmental variables, and conduct simulation experiments on the designed algorithm to verify its performance and effect by calculating the corresponding simulated human eye neural network.

4 EXPERIMENTAL ANALYSIS OF PRODUCTION OPERATION COCKPIT SAFETY MODEL BASED ON ARTIFICIAL INTELLIGENCE COMPUTER VISION

4.1 Functional Testing of Production Operation Cockpit Safety Model

The testing of the security model mainly covers four dimensions, namely system stability, throughput, number of concurrent users, and fault recovery time. This article tests these performances to test whether the system can operate normally. It is necessary to ensure that the test results are consistent with the actual situation. From the data in Table 3, it can be seen that in terms of stability function testing, the wall display module is 0.857, the management prediction core module is 0.895, the operation management service database is 0.883, and the enterprise resource planning module is 0.837; in terms of throughput, the wall display module is 7478849, the management prediction core module is 7889587, the operation management service database is 895890, and the enterprise resource planning module is 742689; in terms of the number of concurrent users, these four modules are all 5,000; in terms of recovery failure time, the wall display module is 4 seconds, the management prediction core module is 3 seconds, the running management service database is 8 seconds, and the enterprise resource planning module is 4 seconds.

Test module	*Stability*	*Throughput*	*Number of concurrent users*	*Failure recovery time(s)*
Wall display system	*0.857*	*7478849*	*5000*	*4*
Manage the cockpit processing core module	*0.895*	*7889587*	*5000*	*3*
Data base	*0.883*	*895890*	*5000*	*8*
Enterprise ERP	*0.837*	*742689*	*5000*	*4*

Table 3: Security model functional testing.

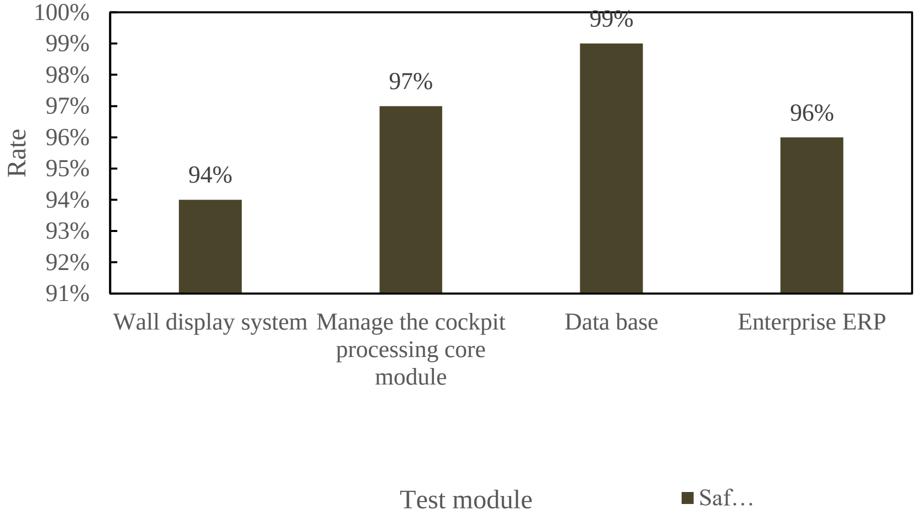

Figure 2: Security testing of security models.

Security models for artificial intelligence computer vision are an important application. In the computer production process, security issues have always received much attention. In order to ensure smooth and secure communication between the machine system and users, it is necessary to conduct testing analysis to confirm whether there are defects or deficiencies in the software. At the same time, we must also consider the possible accidents that may occur in the simulated environment and the possible consequences and losses caused by related dangerous events. Finally, the relationship between the various parts in the model can be verified through experiments and corresponding conclusions can be drawn. The security performance of its model is shown in Figure 2, in which the wall display module is 94%, the management prediction core module is 97%, the operation management service database is 99%, and the enterprise resource planning module is 96%.

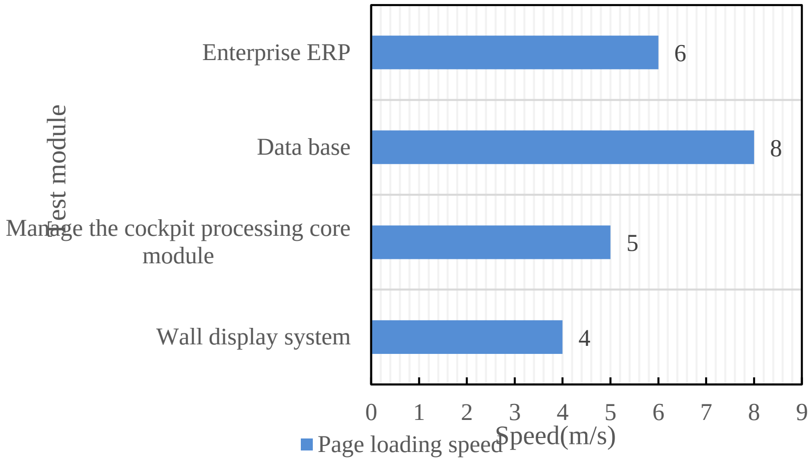

Figure 3: Page loading speed test for security model.

In the security model, page loading speed is a key parameter. When the user clicks the button, the system will generate corresponding results based on the corresponding operation. In order to assess possible systemic risk factors, a comprehensive risk assessment exercise is required. Then, combined with the actual situation, mathematical equations and specific numerical values are established to describe the characteristics and influencing factors of hazardous data, and relevant parameter values are calculated. After completing the above stages, system design and optimization solution selection need to be carried out. The page loading speed test results are shown in Figure 3. The wall display module is 4m/s, the management prediction core module is 5m/s, the operation management service database is 8m/s, and the enterprise resource planning module is 6m/s.

4.2 Computer Vision Algorithm Performance Test

This article tests the performance parameters of computer vision algorithms, namely real-time performance, accuracy, and frames per second (FPS). In practical applications, the speed and accuracy of image processing are key indicators to measure the operating status of the machine. In order to ensure that the task can be completed on time and achieve the expected results, the input data needs to be analyzed and calculated accurately, efficiently and with short response time, and output to the decision-making system. According to the data in Table 4, the accuracy of the computer vision algorithm used in this article is between 0.907-0.996, the recall rate is between 0.768-0.897, and the number of frames is 122HZ and 144HZ.

Test times	*Accuracy*	*Recall*	*FPS/Hz*
1	*0.907*	*0.785*	*144*
2	*0.957*	*0.897*	*144*
3	*0.982*	*0.865*	*120*
4	*0.993*	*0.863*	*144*
5	*0.980*	*0.768*	*120*
6	*0.996*	*0.798*	*120*
7	*0.965*	*0.874*	*144*

8	*0.978*	*0.856*	*120*
9	*0.952*	*0.838*	*120*
10	*0.979*	*0.784*	*120*

Table 4: Computer vision algorithm performance parameters.

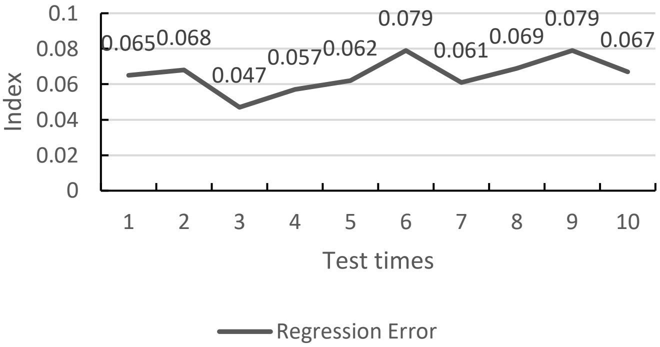

Figure 4: Regression error of computer vision algorithms.

Regression error refers to the presence of many uncertain factors in the data generated by artificial intelligence algorithms, which leads to biased model parameter estimates, thereby reducing the accuracy of the model. In practical applications, due to the nonlinear, time-varying and self-organizing characteristics of human brain neural networks, as well as the high requirements of computers for information processing speed, it is easy to fall into local optimal values. However, applying it to image recognition systems can solve the above problems and obtain satisfactory results, using artificial intelligence algorithms for image classification, feature extraction and screening, thereby improving the accuracy of the model. As can be seen from the data in Figure 4, the regression error range of the computer vision algorithm is between 0.047-0.79.

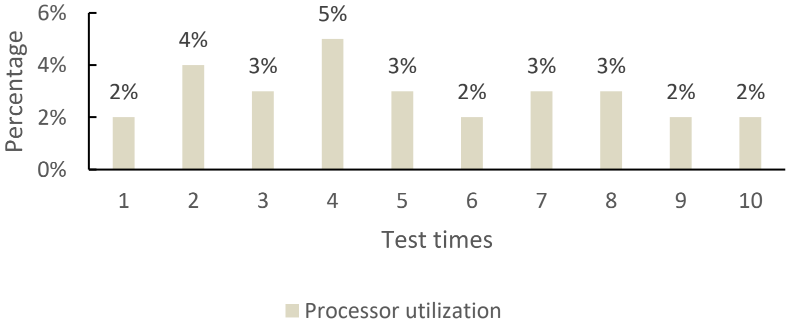

Figure 5: Processor utilization of computer vision algorithms.

The processor of the computer vision algorithm performs analysis through processes such as image processing and data acquisition. In actual production, computer cores are usually used to complete this function. The user's job is to obtain the corresponding information and store it for purposes such as decision-making operations or customer service. To improve the operating performance and reliability of artificial intelligence computer systems, it is necessary to strengthen the construction of hardware facilities and the development of software technology to improve the application effect of computer vision algorithms in data collection, transmission, and analysis. According to the data in Figure 5, it can be seen that the processor utilization of this algorithm is between 2% and 5%.

5 CONCLUSION

The rapid development of artificial intelligence technology has brought great convenience to people's lives. In order to ensure the safety and reliability of the system, this article makes full use of artificial intelligence computer algorithms to analyze and study human faces and establish corresponding models. At the same time, in order to develop effective preventive measures, this article considers factors such as whether the system can operate normally when an accident may occur, takes measures to reduce the false alarm rate and avoid errors caused by incorrect input information, and strengthens data verification to reduce safety hazards and risks. According to the test results of this article, the production operation cockpit safety model based on computer vision algorithms has excellent performance in terms of model function and algorithm performance. This shows that the model can meet the needs of users.the fusion of Virtual Reality (VR) solutions with AI-driven Computer Vision marks a groundbreaking advancement in bolstering safety protocols within production operations. The amalgamation of these technologies presents a multifaceted approach to risk mitigation and proactive safety measures.

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