



# Intelligent Image Detection System Based on Internet of Things and Cloud Computing

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## Abstract

Images are the most intuitive way for humans to perceive and obtain information, and they are one of the most important sources of information. With the development of information technology, the use of digital image processing methods to locate and identify targets is widely used, so it is particularly important to detect the targets of interest quickly and accurately in the image. The traditional image detection system has the problems of low detection accuracy, long time consumption, and poor stability. Therefore, this paper proposes the design and research of artificial intelligence image detection system based on Internet of Things and cloud computing. The system designed in this article mainly includes three links, namely: image processing analysis design link in cloud computing environment, image feature collection module design link, and image integration detection link. The main technologies used in image processing and analysis in the cloud computing environment are virtualization technology, distributed massive data storage, and distributed computing. In the image feature collection module, before the image is input to the neural network, it is necessary to perform preprocessing operations on the distorted image and perform perspective correction; then use the deep residual network in deep learning to extract features. Finally, there is the image integration detection link. First, the target category judgment and position correction are performed on the regions generated by the candidate region generation network, and then the integrated image detection is performed through the improved target detection method based on the frame difference method. Through simulation experiments, compared with the traditional image detection system, the speed advantage of the artificial intelligence image detection system designed in this paper is obvious in the case of a large increase in the number of images. On images at different pixel levels, the accuracy of the image detection system proposed in this paper is always higher than that of traditional image detection systems, and the CPU usage and memory usage are at a lower level. In addition, within three months, the stability is also at a relatively high level of 0.9.

**Keywords:** Image Detection System Design, Internet of Things (IoT), Cloud Computing, Improved Inter-Frame Difference Method

## 1. Introduction

For human beings, 85% of the information of objects obtained in life comes from the eyes. The eyes produce an intuitive feeling for the objects and then recognize it through the brain [1]. In our daily life, image information is everywhere in every corner. Surveillance cameras, cameras, mobile phones, etc. have made us enter an era of image information. The growth of this information and the development of computer hardware technology have made great progress in image detection [2, 3]. As an important part of the new round of artificial intelligence revolution, image detection also has an increasingly important impact on our lives. In today's era, the rapid development of Internet technology and the interaction of massive data information have formed a huge Internet of Things [4]. At the same time, actual needs continue to spawn new technologies and new products, which greatly facilitates our lives. Artificial

intelligence technology sweeps through traditional industries, and our lives have undergone earth-shaking changes. With the explosive growth of image data information and the interweaving of the Internet of Things, higher requirements have been placed on the analysis and calculation capabilities and recognition accuracy of image detection systems. The design of artificial intelligence image detection system has become one of the hot topics of people's research.

In the field of image detection, many relevant practitioners or researchers have conducted research. In [5], to enhance the safety and stability of self-driving cars, the author proposes a deep learning-based video information sharing IoT framework that uses computer vision to highlight information captured by cameras, such as road edges, traffic lights, and zebra crossings. The semantics of the highlighted information is recognized by artificial intelligence. In [6], to realize the intelligent appearance inspection of railway infrastructure, the author proposed a new railway inspection system based on deep convolutional neural network and computer vision-based image comparison method to accurately find the facility and detect its potential defect. In [7], the author proposed a real-time automatic integrated circuit mark inspection system based on an embedded platform to identify the rotation and position of the IC chip. In [8], the author proposed an active binocular 3D visual inspection system for rapid measurement of sheet features. Metal parts use 2D feature extraction and partial 3D point cloud. In [9], for the quality inspection of leather, the traditional manual inspection of defects by experts is time-consuming and laborious. The author proposes the application of machine vision systems in capturing images of leather surfaces. A novel multi-level threshold algorithm is used to segment leather defects and non-defective regions, and then texture features are extracted to objectively quantify leather surface defects. In [10], the author developed a paper mill finishing line quality inspection system to enhance the surface quality assessment of parts assembly and functional performance. Even for small color differences or small roughness changes, developed machine vision and hue threshold methods can be used to detect contaminants in paper and its surface. This system has helped increase the productivity of high-quality paper in the paper industry. In [11], the author proposed an automatic inspection method of residual stress images based on the bending test of a flexible transparent conductive substrate. With a flexible characteristic inspection system with a one-way common path image interferometry, residual stress images can be automatically checked during bending test operations. In [12], the author proposes an automatic optical inspection system for solder quality classification of THT solder joints. The proposed visual system can control the entire robot system while providing automatic rework capability for defective solder joints with less user interaction. In [13], the author proposed an automatic machine vision system for drug injection particle detection, in which the particle vision inspection machine first used a high-speed image acquisition system to acquire image sequences. In [14], in the Sutong Gil utility tunnel project, the author proposed an intelligent inspection robot system, including a robot body, a communication distribution system, a rail system, and a complete monitoring platform system. The system solves the problems of high difficulty, low efficiency, and high safety risk in manual inspection. The above research has achieved good results, but there are still some deficiencies. First, traditional detection methods have limitations in application. For example, it is difficult to arrange sensors in a complex space. Second, the accuracy is not high, the structure with larger deformation can get better detection results, and the error is large for images with small displacement. Third, the performance and stability level of the image detection system directly affect the actual work. The existing image detection technology has problems such as difficult operation, high cost, and poor stability.

The number of target groups in the image detection system is gradually large and complex, and the traditional detection technology is no longer competent for related tasks. The Internet of Things and cloud computing technology are the fruits of technological development. Using the massive resources on the Internet of Things and the powerful computing and processing capabilities of cloud computing can solve many difficult problems. The Internet of Things and cloud computing have been applied in many aspects and have achieved fruitful results. In [15], the author applied cloud computing in conjunction with the Internet of Things to the data center, and the results showed that delay-sensitive applications were better handled. Despite the huge amount of data, the real-time performance of the system is satisfied. In [16], the author integrated the Internet of Things and designed a new IoT programming paradigm for coordination of IoT application composition and data processing across heterogeneous computing infrastructures (cloud, edge, and things). In [17], the author applied cloud computing and the Internet of Things to precision agriculture, realized precise monitoring of remote equipment and crops, and improved the growth environment of crops. In [18], the author combined the Internet of Things with edge computing and cloud computing to extract accurate information from the raw sensor data of IoT devices deployed in complex environments. In [19], the author

builds a heterogeneous Internet of Things. In each network unit, smart devices use appropriate communication methods to integrate digital information and physical objects, providing users with exciting new applications and services. In [20], the author defined the security model in the cyber physical system and the Internet of Things system to improve its security. In [21], the author used cloud computing in the education industry, which not only reduced the burden of educational institutions to deal with complex IT infrastructure management and maintenance activities, but also saved a lot of costs. In [22], the author used cloud computing to monitor the boiler flow in industrial piping systems, providing customers with quality services. In [23], the author combined high-efficiency and energy-saving ant colony systems in cloud computing to minimize the number of active physical servers, thereby scheduling underutilized servers to save energy. In [24], the author applied cloud computing to the optimization of the transportation network of dangerous goods and established a network optimization model that minimizes the total cost considering the network capacity and the maximum risk limit. In [25], the author applies cloud computing to enterprise operations, which improves the company's operating efficiency, reduces service costs, and provides new services and value at a faster rate. In summary, the Internet of Things and cloud computing show high efficiency, speed, accuracy and other characteristics when facing complex and diverse tasks. Therefore, the Internet of Things and cloud computing technology are used to design artificial intelligence image detection systems.

In view of the characteristics of low detection accuracy, long time consumption and poor stability of traditional image detection systems, this paper proposes the design of artificial intelligence image detection system based on Internet of Things and cloud computing. The system designed in this article mainly includes three links, namely: image processing analysis design link in cloud computing environment, image feature collection module design link, and image integration detection link. The main technologies used in image processing and analysis in the cloud computing environment are virtualization technology, distributed massive data storage, and distributed computing. In the image feature collection module, before the image is input to the neural network, it is necessary to perform preprocessing operations on the distorted image and perform perspective correction; then use the deep residual network in deep learning to extract features. Finally, there is the image integration detection link. First, the target category judgment and position correction are performed on the regions generated by the candidate region generation network, and then the integrated image detection is performed through the improved target detection method based on the frame difference method. Through simulation experiments, the two sets of images are selected to be 100 and 1000 respectively. Compared with the traditional image detection system, the speed of the artificial intelligence image detection system designed in this paper is obvious when the number of images is greatly increased. On images at different pixel levels, the image detection accuracy of the artificial intelligence detection system designed in this paper is always higher than that of traditional image detection systems. The CPU usage and memory usage of the system proposed in this article are at a very low level. In addition, within three months, the stability is also at a high level of 0.9.

## 2. Design of artificial intelligence image detection system based on Internet of Things and cloud computing

According to the requirements of the image intelligent detection system and the characteristics of the Internet of Things and the cloud computing model, when constructing an artificial intelligence image detection system based on the Internet of Things and the cloud computing, this article mainly considers three links: Image processing analysis design link, image feature collection module design link, and image integration detection link. Image processing and analysis in the cloud computing environment is mainly to complete the analysis, processing, storage and retrieval of massive information in the cloud. The image feature collection module is mainly used to obtain image feature information and provide valuable information for subsequent image detection. The image integration detection link is to complete the final image detection and output the results by gathering the information from the previous links. Through the above three links, an artificial intelligence image detection system based on the Internet of Things and cloud computing is constructed.

### 2.1 Image processing analysis and design in cloud computing environment

Cloud computing comes along with the development of personal computers. Through Internet, people can share the information and materials in their computers, in addition to finding the information they need. Cloud computing is to use large-scale and low-cost computers to form a computer cluster, and build a computing system through computer

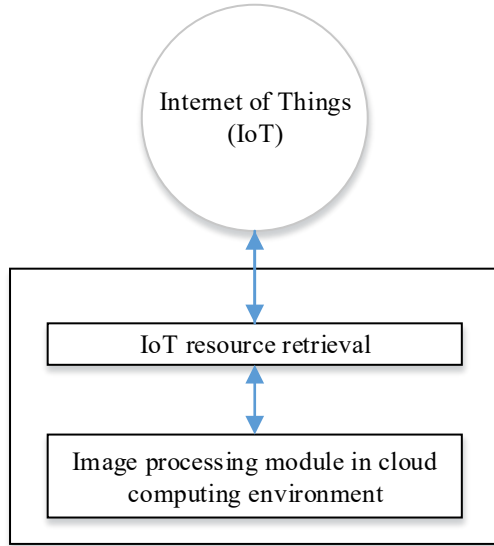
network connections to provide computing services. It has the characteristics of strong computing power, strong scalability, and low cost. Therefore, it is a good solution to the growing storage and calculation of network information. This can not only save costs, but also obtain powerful data processing and computing capabilities. The key technologies of cloud computing are as follows:

(1) Virtualization technology. Virtualization is the foundation of cloud computing. In cloud computing, computing, storage, applications, and services have all become resources, which are stored in the "cloud". Cloud computing requires unified management of these resources. Virtualization technology enables resources to achieve the purpose of dynamic sharing, and ultimately the utilization rate of resources is further improved.

(2) Distributed massive data storage. Cloud computing systems need to meet massive data storage and processing capabilities, and the data storage technology used must have distributed characteristics. Cloud computing uses distributed storage technology, which not only can abstract storage and unified management of storage resources, but also ensure that data has a safe read and write operation process. A cloud computing system is a resource pool composed of multiple servers or ordinary computers. The purpose of distributed storage is to meet storage requirements that cannot be met by a single server. The method is to use redundant storage, make full use of the storage resources of multiple servers or ordinary computers in the cloud environment, and store multiple backups of the same data on different cell nodes of the cloud environment.

(3) Distributed computing. Distributed computing is a technology that makes full use of the idle computing resources of computers on the Internet to deal with large-scale computing problems. Cloud computing uses distributed computing technology, by decomposing a large computing processing program into many subprograms, which are much smaller than the original program. Then the obtained subroutine is distributed to the huge computer network system for analysis and calculation processing, and finally the processing result is returned. Using the technology of distributed computing, a huge amount of information data can be completed in a short time, and the computing performance can reach or even surpass the "supercomputer".

With the help of the massive information resources of the Internet of Things, and with the help of the powerful computing power of cloud computing, image information can be effectively processed and analyzed. There are two main tasks in image processing and analysis in the cloud computing environment. First, the most important task of setting up the cloud is to ensure that the image feature information collected by the design system terminal remains. In addition, this also requires that this information can be compared with the information resources on the Internet of Things at any time. Second, call the Internet of Things information resources. The cloud environment is the link connecting the Internet of Things. The cloud environment can call the internal data information of the Internet of Things and can compare the uploaded image feature data with the called data. If the above two parts of the work are successfully completed, it means that the cloud data architecture is basically completed. The workflow of image processing and analysis in the cloud computing environment is shown in Figure 1.



**Figure 1.** Workflow of image processing and analysis in a cloud computing environment

## 2.2 Design of image feature collection module

In the image feature collection module, considering the intelligence of the image detection system, the deep residual network in deep learning is used to extract features. First, before the image is input to the neural network, it is necessary to perform preprocessing operations on the distorted image and perform perspective correction. The essence of perspective transformation is to transform the target with distortion to a different view plane through mapping. The formula is:

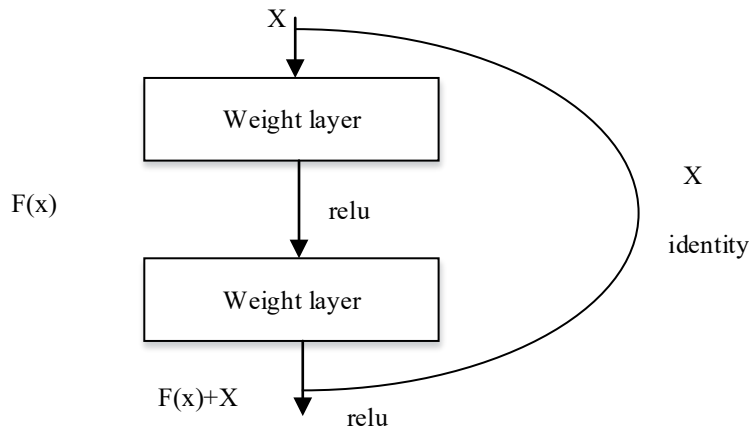
$$[x', y', w'] = [u, v, w] \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \quad (1)$$

Where  $(u, v)$  is the original coordinates of the pixels in the image, and  $(x = x' / w', y = y' / w')$  is the coordinates after the transformation. The perspective transformation matrix is

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} = \begin{bmatrix} T_1 & T_2 \\ T_3 & a_{33} \end{bmatrix} \quad (2)$$

The purpose of  $T_1 = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$  is to perform linear transformation, the purpose of  $T_2 = [a_{13} \quad a_{23}]^T$  is to perform perspective transformation, and  $T_3 = [a_{31} \quad a_{32}]$  represents the amount of parallel movement.

Here, ResNet-101 network structure is selected as the feature extraction network of the algorithm. The conventional CNN network will disappear when the number of layers reaches a certain level. The residual network solves this problem to a certain extent. Figure 2 shows the basic structure of a residual learning unit.



**Figure 2.** A residual learning unit

As shown above, the residual unit directly adds a channel between input and output. Suppose the input is  $x$ , and the mapping relationship between the original input and output is  $F(x)$ . After adding the residual unit, the output becomes  $F(x) + x$ , which adds an identity map to the gradient of the network. Many experiments have shown that this change in learning goals (from the original learning output to the difference between the learning output and input) makes the optimization of the network easier. This is necessary to increase the depth of the network while ensuring the effectiveness of training. The introduction of the residual structure makes the derivative of the error contain the identity term in the process of back propagation, effectively alleviating the occurrence of gradient dissipation. It also breaks the asymmetry of the network, reduces the degradation of the network that easily occurs with the increase of the number of layers, enhances the generalization ability of the network, and reduces the difficulty of learning.

### 2.3 Image integration detection method based on deep residual network

#### (1) Optimization of target positioning network

This is mainly to judge the target category and correct the position of the area generated by the candidate area generation network. It selects the  $N$  proposals with the highest foreground probability for non-maximum suppression (NMS, searches for local maxima and suppresses non-maximum elements). When a target is detected by the pixel grid where multiple anchors are located, inputting each one to the classification network and outputting it will bring a large amount of calculation and complexity. When two or more bounding boxes have a high degree of overlap, the region with the highest recommended score is used as the output, and the others are filtered out to simplify the calculation. Considering the complexity and variability of the image, when two objects occlude each other, the bounding box of the object behind is likely to be filtered out by the NMS algorithm. To improve the detection performance in this case, this paper uses soft-NMS method instead of NMS in target positioning network to make target judgment and classification correction.

The form of the NMS algorithm is as follows:

$$s_i = \begin{cases} s_i, & iou(M, b_i) < N_t \\ 0, & iou(M, b_i) \geq N_t \end{cases} \quad (3)$$

Among them,  $M$  is the current area recommendation with the highest score,  $b_i$  is the current  $i$ -th area recommendation,  $N_t$  is the suppression threshold, and  $s_i$  is the current area recommendation score.

The main idea of Soft-NMS algorithm is to smooth this function, there are generally two kinds of smoothing functions: linear weighting function and Gaussian weighting function. This article uses a Gaussian weighting function.

Linear weighting function:

$$s_i = \begin{cases} s_i, & iou(M, b_i) < N_i \\ s_i(1 - iou(M, b_i)), & iou(M, b_i) \geq N_i \end{cases} \quad (4)$$

Gaussian weighting function:

$$s_i = s_i e^{-\frac{iou(M, b_i)^2}{\sigma}}, \forall b_i \notin D \quad (5)$$

## (2) Improved image target integration detection based on the inter-frame difference method

The traditional inter-frame difference method performs subtraction calculation on the image pixels of adjacent frames to determine whether the target is moving. This chapter uses the frame difference method to detect image targets for two main reasons:

1) The implementation of the frame difference method is very simple, the time interval between frames is small, and it is more adaptable to environmental changes. Compared with the background subtraction, the frame difference method is more suitable for the detection task of remote sensing video images.

2) The disadvantage of the inter-frame difference method is that it is greatly affected by the target movement speed. For the detected image, the object movement is generally relatively slow, which can avoid the occurrence of target re-examination or loss caused by the improper selection of the time interval between the inter-frame differences. For moving targets in an image, the general moving speed of the target is relatively slow, so the traditional frame difference method is not very suitable for extracting the interval between adjacent frames for subtraction. Because the direct displacement of two or three frames is small, the complete target area cannot be obtained by performing a differential operation. Therefore, this paper improves the inter-frame difference method. The improved process of moving target detection based on the frame difference method is as follows:

Step 1: Obtain the video that needs to be detected and cut the area where the moving target is located to get a more clear moving target area;

Step 2: Obtain each frame of the image video, arrange it into a sequence of image frames, and number them in sequence;

Step 3: Enhance the image of some images to make the detection effect more intuitive, easy to observe and subjective evaluation;

Step 4: From the beginning of the sequence, extract the 1+3k frame image to form the image sequence to be detected;

Step 5: For the new image frame sequence, perform differential operation between adjacent frames;

Step 6: Use a certain threshold set in advance to determine the value of the image obtained after the differential operation in step 5. Above a certain value, it is determined that the target is moving;

Step 7: Perform morphological processing on the detection results, mainly the dilation operation, which makes the visual effect of the detection results more intuitive and alleviates the problem of incomplete extraction of the target area caused by the principle of the frame difference method.

Through the improved detection method in this article, it can not only process conventional still images, but also recognize the image detection of moving objects in the video.

### 3. Simulation experiment of artificial intelligence image detection system

The artificial intelligence image detection system based on Internet of Things and cloud computing designed in this paper is tested by simulation experiments. Compare and analyze the test results with the results of traditional image detection functions to determine the performance and efficiency of the artificial intelligence image detection system based on the Internet of Things and cloud computing in image detection.

The computer configuration of the simulation platform is: Inspur rack server, the CPU model is Xeon Silver 4110, the memory is DDR4 64G, and the system is 64bit windows10 professional edition.

The deep learning framework uses TensorFlow 1.12, and the training hyperparameters are shown in Table 1.

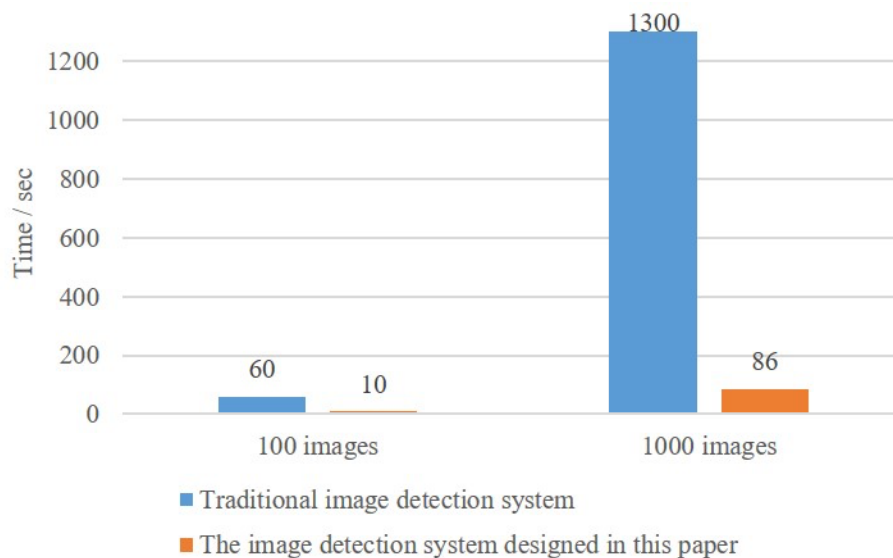
**Table 1.** Training hyperparameters

| Training hyperparameter       | value  | Training hyperparameter          | value |
|-------------------------------|--------|----------------------------------|-------|
| Basic learning rate           | 0.002  | Learning rate change parameter   | 0.13  |
| Weight decay term             | 0.0006 | The maximum number of iterations | 23000 |
| Learning rate change strategy | Step   | Momentum                         | 0.85  |

### 4. Results and discussions artificial intelligence image detection system

(1) Comparison of image detection speed between traditional image detection system and artificial intelligence detection system designed in this paper

In many image detection application scenarios, the detection speed is very high. This means that the designed image detection system has high real-time performance. Therefore, this article compares the designed artificial intelligence detection system with the traditional image detection system and compares the differences in image detection speed between the two. Two sets of images with several 100 and 1000 were selected and tested by two systems, and the time spent was counted. The detection time of the two image detection systems is shown in Figure 3.

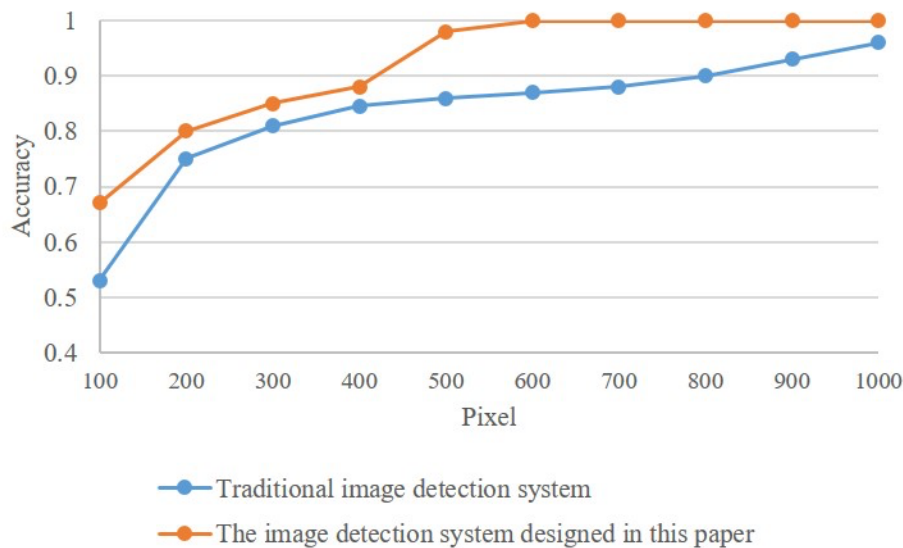


**Figure 3.** Comparison of image detection speed

It can be seen from Figure 3 that when detecting 100 images, the traditional image detection system takes 60 seconds, while the artificial intelligence system designed in this paper takes only 10 seconds, which is only one sixth of the former. When the number of images detected is 1000, how long does the traditional image detection system take 1300 seconds. The artificial intelligence system designed in this article takes only 86 seconds. In the case of a substantial increase in the number of images, the speed advantage of the artificial intelligence image detection system designed in this paper is obvious.

(2) Comparison of image detection accuracy between traditional image detection system and artificial intelligence detection system designed in this paper

The accuracy of image detection is one of the important indicators to measure the usability of the system. Different pixel levels of the image will affect the accuracy of the image detection system. Here, the images at different pixel levels are detected using the traditional image detection system and the artificial intelligence detection system designed in this article to observe the detection accuracy of different systems. The change of detection accuracy with pixel level is shown in Figure 4.

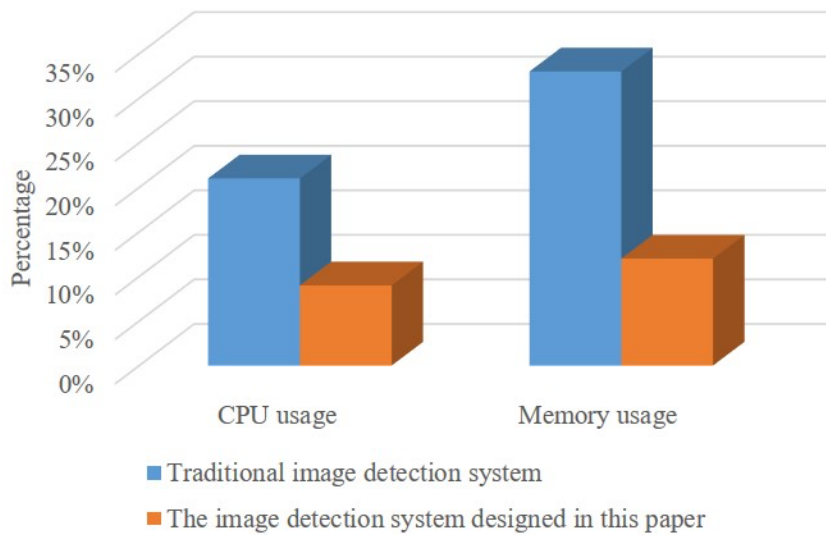


**Figure 4.** Change in detection accuracy with pixel level

As can be seen from Figure 4, on any pixel-level image, the image detection accuracy of the artificial intelligence detection system designed in this paper is always higher than that of the traditional image detection system, showing absolute advantages. The reason for this analysis is that the artificial intelligence image detection system based on the Internet of Things and cloud computing utilizes the massive resources of the Internet of Things and improves the processing and analysis capabilities of data information by drawing on the resources of the Internet of Things, thereby greatly improving the accuracy.

(3) Performance comparison between traditional image detection system and artificial intelligence detection system designed in this paper

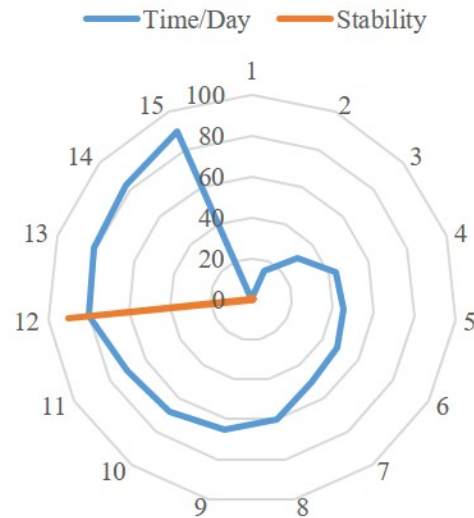
The performance of the image detection system directly affects the development of related work. Therefore, when designing an artificial intelligence image detection system based on the Internet of Things and cloud computing, performance testing of the system is indispensable. In this study, the system performance observation indicators include two aspects, namely the system's CPU usage and memory usage. CPU usage is the CPU resources occupied by running programs, which means that your machine is running programs at a certain point in time. The higher the usage rate, the machine runs a lot of programs currently, and vice versa. Memory usage refers to the memory overhead of this process. The high CPU usage of a certain program will affect the operation of other programs. If a certain program takes up too much memory, it will affect the overall performance of the machine. The performance index of the system in this paper is compared with the performance index of the traditional image detection system.



**Figure 5.** Comparison of CPU usage and memory usage of image detection system

As can be seen from Figure 5, in terms of CPU usage, the CPU usage of traditional image detection systems is as high as 21%. The CPU usage of the artificial intelligence image detection system based on the Internet of Things and cloud computing proposed in this article is only 9%, which is not yet half of the traditional system. In terms of memory usage, the memory usage of traditional image detection systems and the memory usage of artificial intelligence detection systems designed in this paper are 33% and 12%, respectively. This is enough to show that the artificial intelligence system designed in this paper shows great advantages in terms of performance. Analysis of the reasons revealed that the artificial intelligence image detection system based on the Internet of Things and cloud computing leveraged the massive resources of the Internet of Things technology and powerful cloud computing processing methods, which greatly reduced the operating pressure of the client. Therefore, the system's CPU usage and memory usage are at a very low level. The system design resource is small, and it can meet any configuration of the computer platform.

(4) Stability test of artificial intelligence image detection system based on Internet of Things and cloud computing  
The stability of the image detection system is one of the important influencing factors to ensure that the work can be carried out smoothly for a long time. The system is deviated from the normal state by some interference. When the interference is eliminated, the system can be restored to its normal state, and the system is stable. On the contrary, once the system deviates from its normal state, it can no longer return to the normal state, and the deviation becomes larger and larger, the system is unstable. With the strongest stability being 1, the stability of the system mentioned in this article is shown in Figure 6.



**Figure 6.** System stability over time

As can be seen from Figure 6, the stability of the system basically fluctuated around 0.9 over a period of up to three months. It shows that the system designed in this article has good stability and can stand the test of time.

The artificial intelligence image detection system based on the Internet of Things and cloud computing is significantly superior to the traditional image detection system in image recognition capability, image detection speed, image detection accuracy, and ability to reduce inspection cost. It can be concluded from the content discussed above that the artificial intelligence image detection system based on the Internet of Things technology has higher image recognition capabilities and image detection capabilities. It can reduce the cost of image detection while improving the efficiency and quality of image detection, and fully reflects the advantages of artificial intelligence technology. At the same time, the application of the Internet of Things technology has also effectively improved the speed and accuracy of the image detection system.

## 5. Conclusions

With the increasing economic level of society and the improvement of humanities and science and technology, the past pure textual information forms have gradually transformed into rich information carriers such as images. In many fields, with the emergence of massive data, the detection of images becomes particularly difficult. According to the shortcomings of the traditional image detection system, this paper designs an artificial intelligence image detection system based on the Internet of Things and cloud computing. However, in the design process, due to the strong complexity of this part, there may be many details in the problem. This also needs us to improve in the future research, and then provide help for the artificial intelligence image detection based on the Internet of Things and cloud computing.

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