

Utilizing Intelligent Vector Image Technology to Graphically Display Network Monitoring

Yao Zhang*

School of Intelligence and Electronic Engineering, Dalian Neusoft University of Information, Dalian 116023, Liaoning, China

Traditional network monitoring graphic display methods have the problems of poor display effect, difficulty in manual identification and tracking of targets, and poor real-time performance. In this study, a network monitoring graphic display system was designed based on intelligent vector image technology to solve the problems in traditional image display methods. An adaptive histogram equalization algorithm was used to denoise and sharpen an image, and remove image distortion to improve the graphic display effect. Then, the Faster R-CNN target detection model based on convolutional neural network was used to achieve automatic target detection and tracking. The real-time image was processed through an image processing pipeline, and finally the target object in the monitoring image was converted into a vector graphic using intelligent vector image technology. Through experiments, the network monitoring graphics display system designed in this study was compared with traditional monitoring systems and raster image display systems in terms of performance, stability, image compression rate, and user experience. In terms of performance testing, the proposed system outperformed traditional monitoring systems in terms of image quality, rendering efficiency, real-time performance, loading speed, and display delay. In regard to stability, the proposed system performed the best in terms of data integrity, reaching 96.7%, which was significantly higher than the other two types of systems, with a failure rate of only 4.3%. Regarding system image compression rate, the average compression coefficient of the proposed system was 89.7%, which was higher than 56% of traditional monitoring systems and 72.7% of raster image display systems. In terms of user satisfaction scores, the proposed system performed best. The experimental results showed that intelligent vector image technology can significantly improve the effectiveness and performance of network monitoring graphics display, offering new ideas and methods for the improvement of network monitoring systems and has broad application prospects.

Keywords: Intelligent Vector Image Technology; Network Monitoring; Graphic Display; Feature extraction; Image Quality

1. INTRODUCTION

Network monitoring systems have been utilized extensively in many different businesses and fields as one of the key tools for security and prevention. However, typical monitoring systems have issues such as inadequate real-time performance, difficulty of target recognition, requiring manual tracking, and unsatisfactory graphical display. These problems have made data analysis, decision-making, and real-time monitoring more challenging. Therefore, there is an urgent need for an advanced network monitoring system that can achieve automatic target detection and tracking, improve graphical

presentation effects, and have high real-time performance. Such a system would improve security and management effectiveness by offering more intelligent, dependable, and efficient network monitoring solutions.

Network monitoring graphical display plays a crucial role in real-time monitoring, security protection, decision-making assistance, and other fields. For thorough monitoring, quick response, and effective management, it is a crucial visual information presentation and analysis technique. Tsai proposed a method for visualizing network topology based on correlation and popularity. In order to better illustrate network structure and connection patterns, this technique depicted network nodes as graphical icons and adaptively

*Corresponding Author. Email: dz201903011218@163.com

changed the icons' size and placement based on node popularity and association [1]. Aboulain adopted a network monitoring graphical display method based on clustering and multidimensional scaling. By clustering, and reducing the number of network nodes, large-scale network data can be presented in a visual manner, helping users understand and analyze network conditions [2]. Parjuangan used readings from three sensors and transmitted them in the form of short message services through a universal business mobile communication network. The read data was sent to the server through the internet data communication network and displayed as a webpage [3]. Yuan proposed a low-power wide area network information monitoring method based on the Internet of Things, and adopted a communication method of one main node and multiple sub nodes to meet the needs of large-scale information monitoring, greatly reducing the operating cost of the wide area network information monitoring system [4]. Dhingra proposed a network monitoring method based on spatiotemporal data mining and visualization, which visualized a large amount of network traffic data as dynamic graphics and conveyed network traffic characteristics through visual encoding methods such as color and shape, helping users detect abnormal behavior and security threats [5]. However, to some extent, the research conducted by these scholars has issues such as poor graphics display performance, manual operation required for object recognition and tracking, and poor real-time performance. They did not consider using intelligent vector image technology to achieve the graphical display of network monitoring.

Intelligent vector image technology can be used to display network monitoring graphics, providing clearer and more efficient image display. John proposed a machine-learning-based image processing algorithm that can automatically analyze target objects in monitored images and generate real-time vector graphic display results [6]. A novel deep learning and edge detection-based image processing technique was proposed by Wang; it can successfully extract an object's contour from a monitoring image and generate precise vector graphics display results. The proposed technique can greatly enhance user experience and the performance of the graphics display of network monitoring systems [7]. Sheng introduced a deep learning-based monitoring graphic display technique that has significantly advanced picture processing and identification. Intelligent image analysis, object detection, and tracking technologies are among his research accomplishments. These technologies have been successfully integrated into network monitoring systems, enhancing the presentation effect and precision of monitoring graphics [8]. In the networked monitoring systems based on vector intelligent imaging technology, the above-mentioned solutions still face problems of being unable to adapt to complex environments and meet real-time, accurate, and high-density monitoring needs.

In response to the above issues, this study designed a networked monitoring image display system based on intelligent vector image technology. A Faster R-CNN model based on convolutional neural networks was applied to detect and track moving targets. Finally, utilizing the image processing process and intelligent imaging technology, the objects on the image were transformed into vectorized graphics to improve

the display effect of the image. By means of experiments, the network monitoring graphics display system designed in this study was evaluated in terms of performance, stability, image compression rate, and user experience, and compared with traditional monitoring systems and raster image display systems to verify its effectiveness. The experimental results showed that the system designed in this study has low storage requirements, fast transmission speed, and good image quality effects that can meet the requirements for real-time image display in network monitoring scenarios.

2. METHOD OF ACHIEVING NETWORK MONITORING GRAPHIC DISPLAY

2.1 Enhancement of Graphic Display Effect

Before enhancing the image display effect, data collection is first necessary. In this study, the data collection steps include data source, data collector, data receiver, data processing, storage, and data display. The specific collection process is shown in Figure 1. Firstly, data sources are the monitored images and corresponding data collected by network monitoring equipment, cameras, etc. The data collector obtains and processes the data, and transmits it to the data receiving end. The data receiving end receives the data, processes and analyzes it, and extracts the feature information of the image. Secondly, by preprocessing the collected data, which involves image denoising, sharpening, and distortion removal, the image quality and data validity are improved. By storing processed data into a database, the data can be stored for a long time and accessed conveniently. Finally, the stored data is presented to the user in the form of an image.

After obtaining relevant data, this study adopted an adaptive histogram equalization method to denoise, sharpen, and reduce image distortion, thereby improving the display quality of the image. At the same time, certain details and boundaries in the image were enhanced and sharpened to further improve image clarity and visual quality. By correcting possible distortions, more precise and clear results can be achieved. These processes generate higher-quality images for display, thereby assisting network monitoring systems in identifying targets more accurately and quickly analyzing and assessing important information.

The adaptive histogram equalization algorithm is a commonly-used image processing technique that can improve the graphics display effect by enhancing the contrast of the image [9–10]. Therefore, this study used a mean filter to remove high-frequency noise in the image, while maintaining image details and achieving image smoothing. The mean filtering algorithm is a simple and practical linear filtering algorithm that is used to average each pixel near a certain pixel, thereby smoothing the image. The corresponding denoising formula for the image is:

$$L_{denoised}(o, p) = \frac{1}{N} \sum_{i=1}^N L(o_i, p_i) \quad (1)$$

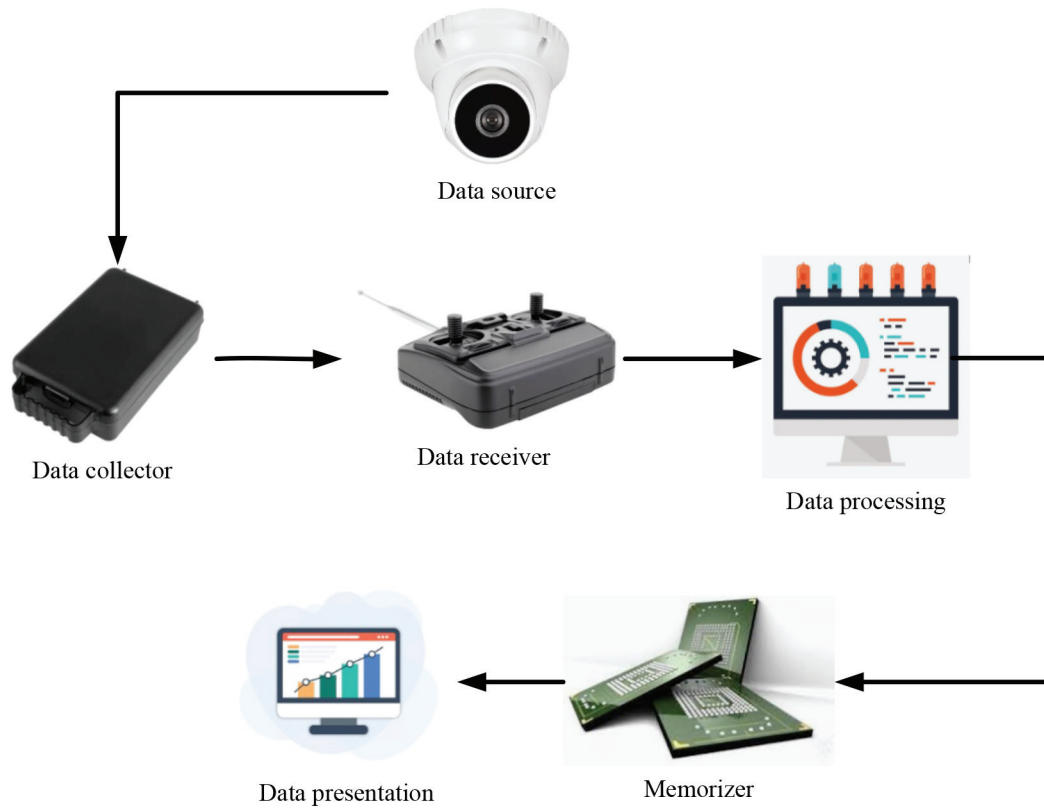


Figure 1 Data collection process.



Figure 2 Image denoising and feature extraction.

where (o_i, p_i) represents the pixel coordinates in the neighborhood, and N represents the number of pixels in the neighborhood.

The formula for sharpening images is:

$$P_{sharpened}(r, t) = P(r, t) + \gamma \cdot \Delta P(r, t) \quad (2)$$

where $\Delta P(r, t)$ represents the Laplace operator of the image, and γ represents the degree of enhancement.

To remove distortion in the image, mathematical Formula (3) can be used.

$$U_{restored}(n, m) = g(U(n, m)) \quad (3)$$

where $g(U(n, m))$ represents the image restoration algorithm used to restore the distorted part.

For the processed images that require feature extraction, this study used the FAST (Features from Accelerated Segment Test) feature extraction algorithm. This algorithm is

a fast and stable corner detection algorithm that can extract key feature points in images, determining the position of key points by comparing the grayscale values of pixels [11–12]. The FAST algorithm extracts features in four steps: grayscale threshold, circular neighborhood, fast comparison, and key point judgment. Formula 4 can be used to calculate the grayscale difference between pixels and pixels within the neighborhood [13–14].

$$diff(j, k) = |P(j) - P(k)| \quad (4)$$

where A represents the grayscale value of pixels, and B represents the grayscale value of pixels within the neighborhood. The image obtained after the above processing process is shown in Figure 2. The adaptive histogram equalization method adopted in this study can effectively solve the problem of poor graphics display in traditional monitoring systems.

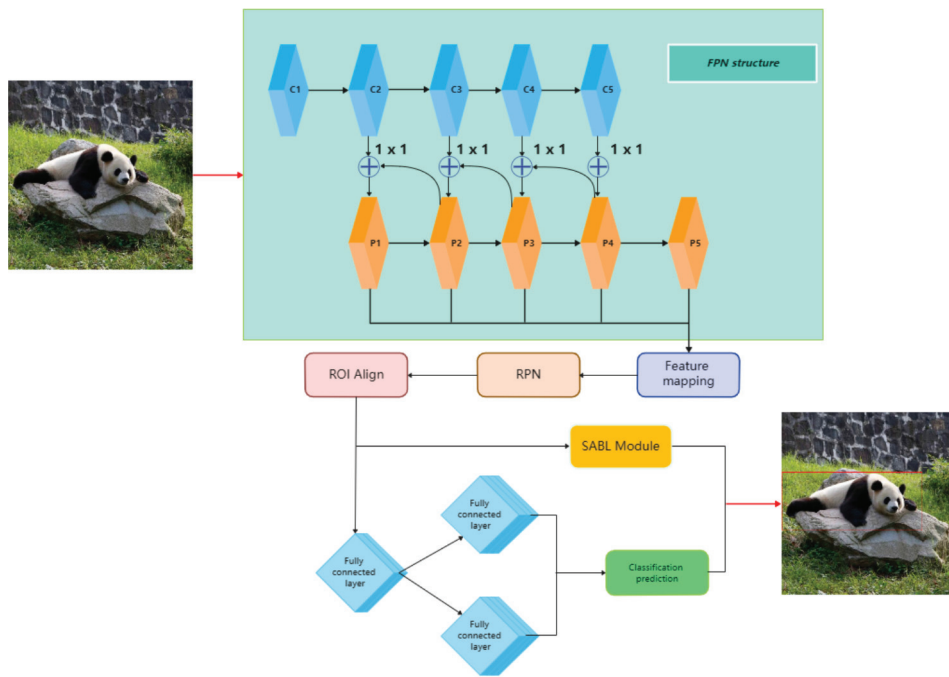


Figure 3 Faster R-CNN object detection algorithm framework.

2.2 Faster R-CNN Object Detection

To address the difficulty of manually identifying and tracking targets in traditional monitoring systems, this study adopted the Faster R-CNN (Region based Convolutional Neural Networks) target detection model based on convolutional neural networks to achieve automatic target detection and tracking. Faster R-CNN has been improved on the basis of R-CNN and Faster R-CNN to replace the selective search (SS) algorithm, and has introduced a regional candidate network (RPN) [15–16]. Recent studies on smart sensor networks have emphasized that reliable target coverage and target retention are critical for improving the effectiveness and stability of intelligent monitoring systems [17].

Figure 3 presents the proposed target detection algorithm framework: the Faster R-CNN. In this framework, the ResNeSt31 (Residual Neural Network with Squeeze and Extinction and Stochastic Depth-31) was used as the backbone network, which extracted comprehensive feature information of monitoring targets through cross-channel information exchange. Then, FPN (Feature Pyramid Networks) was used as the basic network architecture for feature extraction, and the Regions of Interest Align (ROI Align) method was applied. After ROI Align, a side aware boundary localization (SABL) module was introduced. This module can perform regression on the predicted bounding box. Traditional bounding box regression focuses only on the predicted center point and the size of the bounding box, while the SABL module's regression focuses more on each edge of the bounding box, making each edge of the bounding box correspond to the target boundary, thereby more accurately locating the position information of the target. In addition, in the case of multiple feature points in network monitoring, this study reduces the confidence of detection boxes that do not meet

the specified values to preserve the detection information of adjacent targets. The object detection framework designed in this way can significantly improve the accuracy and stability of object detection.

2.3 Image Processing Pipeline

In order to resolve the problem of poor real-time performance in network monitoring, this study adopted an image processing pipeline for real-time image processing. Recent studies have shown that artificial-intelligence-assisted cloud computing architectures can significantly improve the operational efficiency and real-time management capability of large-scale intelligent monitoring systems [18].

The pipeline consists of multiple parallel processing units, each responsible for a specific image processing task [19]. Each processor adopts effective computational methods and techniques to ensure the processing of a massive amount of image data in a relatively short period of time. Real-time collection of network monitoring devices is carried out and transmitted to each processor in a pipelined manner. Each processing department processes image data in a specified order to ensure real-time performance. Finally, the processed image data is presented, and the system can display the processed image on the monitor, facilitating real-time observation by operators. These image processing pipelines enable the real-time processing of network monitoring images, and an effective and reliable monitoring system can be achieved to meet the real-time requirements [20–21]. The formula for the linear transformations is:

$$y(i, j) = a \cdot x(i, j) + k \quad (5)$$

The formula for histogram equalization is:

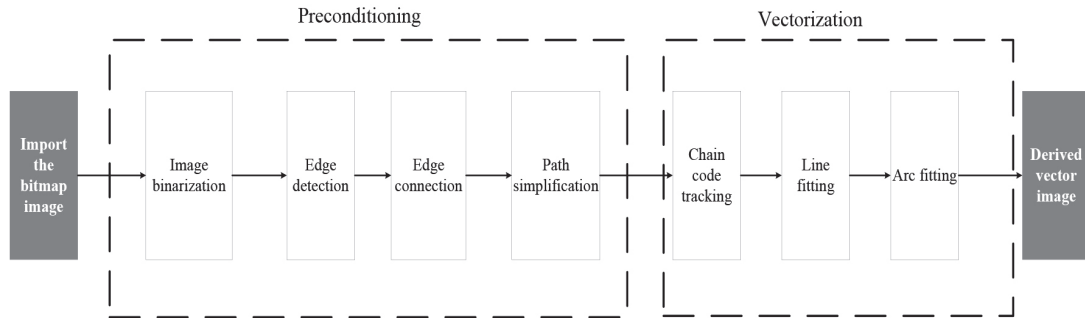


Figure 4 Image vectorization process.

$$y(i, j) = \frac{W-1}{HL} \sum_{u=0}^i \sum_{v=0}^j o(u, v) \quad (6)$$

In formulas (5) and (6), $x(i, j)$ represents the pixel value of the original image, and $y(i, j)$ represents the pixel value of the enhanced image; a and k represent the parameters of the linear transformation, and W represents the range of pixel values; H and L represent the width and height of the image, respectively, and $o(u, v)$ represents the histogram of the original image.

2.4 Intelligent Vector Image Technology

Intelligent vector image technology is a technique that converts bitmap images into vector images and expresses the image using geometric entities and attribute descriptions. During image vectorization, edge detection algorithms play a crucial role in detecting edges or contours in the image and converting them into vector form [22–23]. Two popular edge detection techniques are the Sobel operator and the Canny operator. By determining the gradient of pixels, the gradient-based technique known as the Sobel operator finds edges [24]. By applying convolution operations to the image, gradient values are obtained in both the horizontal and vertical directions. These gradient values are then combined to create the final edge image. The Canny operator is a multi-stage edge detection approach that incorporates dual threshold processing, non-maximum suppression, gradient computation, and Gaussian filtering [25]. For image vectorization, the mathematical formula for the Sobel operator is:

$$f(p, q) = \sqrt{(F_p(p, q))^2 + (F_q(p, q))^2} \quad (7)$$

The mathematical formula for the Canny operator is:

$$f(p, q) = \begin{cases} 0, & \text{if } f(p, q) < R_{low} \\ f(p, q), & \text{if } R_{low} = f(p, q) = R_{high} \\ 255, & \text{if } f(p, q) > R_{high} \end{cases} \quad (8)$$

In formulas (7) and (8), $f(p, q)$ represents the pixel value of the output image; $F_p(p, q)$ and $F_q(p, q)$ represent the gradient values of the image in the p and q directions; R_{low} and R_{high} are thresholds for edge strength.

The Canny operator is more effective than the Sobel operator at reducing noise, honing edges, and maximizing the benefits of a single edge. In order to improve the

accuracy and dependability of image analysis and processing, this study used techniques such as threshold segmentation and boundary stitching to produce more precise, lucid, and vectorized results that are closer to real boundaries. Gaussian filter denoising and non-maximum suppression were used to eliminate fine boundaries.

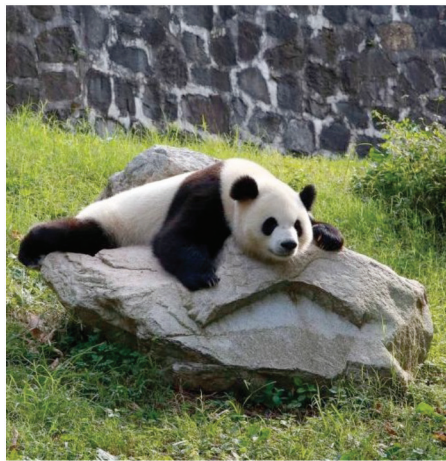
There are two steps to image vectorization: 1) the image is preprocessed, and 2) the image is vectorized. In the preprocessing step, the bitmap image is first binarized to render it as a black and white binary image, preparing for the next step of boundary extraction and boundary stitching. Next, using edge detection algorithms, the boundary of an image is extracted from the binary image [26–27]. Then, the extracted boundaries are concatenated to form a continuous line or segment, effectively removing redundant points in the vector graph. Afterwards, in the vectorization stage, a chain code tracking algorithm is used to convert the connected edges into path representations. By using chain code tracking technology, the boundary is transformed into a path comprising multiple points. Secondly, using the linear fitting method, a straight-line segment is matched with this line to reduce the number of points in the line. In order to better express the shape of the curve in the curve segment, a set of arc-fitting algorithms is used. Finally, the vector graph is processed and an ideal vector graph is obtained. In this way, the dot matrix image can be converted into a vector image with good scaling and editing effects. The image vectorization process is shown in Figure 4.

Figure 5 presents the vectorization results of the image. By comparing Figure 5(a) and Figure 5(b), it can be observed that the proposed method effectively preserves the contour features of the original image while generating a smooth and clean vectorized image with only minor differences from the original one.

3. DESIGN AND IMPLEMENTATION OF A NETWORK MONITORING GRAPHICS DISPLAY SYSTEM BASED ON INTELLIGENT VECTOR IMAGE TECHNOLOGY

3.1 Overall System Architecture Design

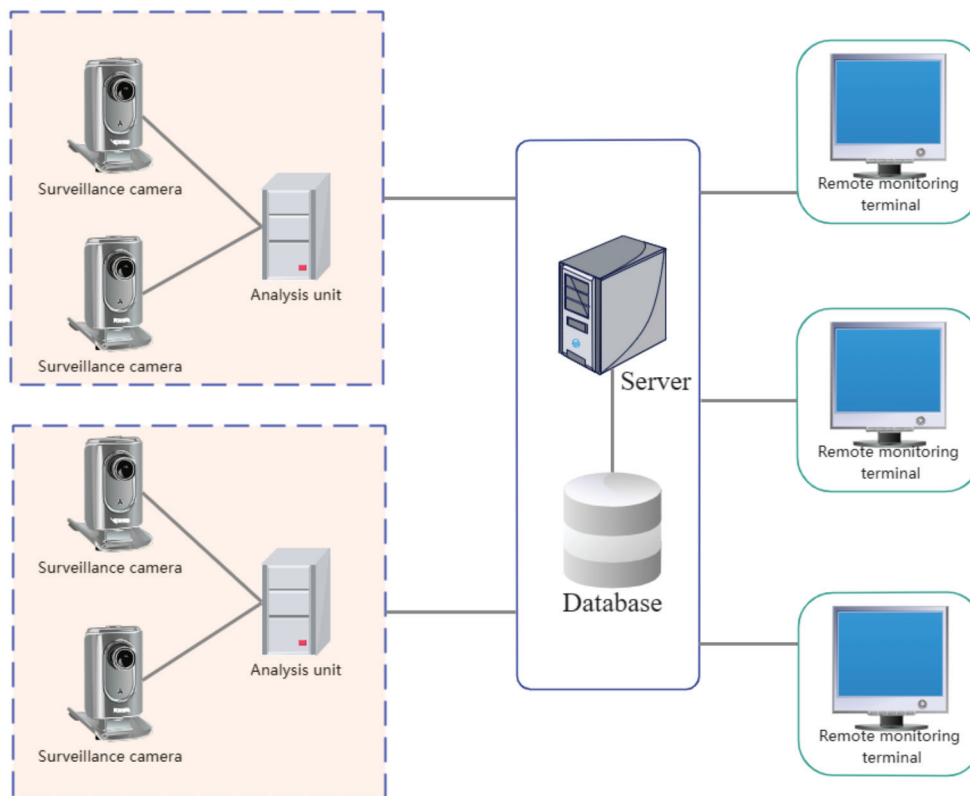
After clarifying the problems to be solved, this study designed a network monitoring graphic display system based on



(a) Original graphics



(b) Vectorized graphics

Figure 5 Vectorization effect diagram.**Figure 6** Structure diagram of network monitoring graphic display system.

intelligent vector image technology (as shown in Figure 6). It consists of four main parts: camera module, transmission module, control module, image processing and display module.

- ① Camera module: the main function of the camera is to convert the monitored image into a detection signal that is then transmitted to the control center through the system transmission module. After control and processing, the original image signal is restored [28–29]. When necessary, it can also record and store images. The camera is the most important part of a

network monitoring system, which is responsible for information processing tasks such as light, electricity, and magnetism.

- ② Transmission module: the function of the transmission part is to transmit the image signals (sometimes audio signals) emitted by the camera to the central computer room or other monitoring locations. At the same time, the control signal sent by the control center is transmitted to the site via the transmission unit, achieving control of the on-site camera, lens, pan head, protective cover, etc. At present, there are two main methods for

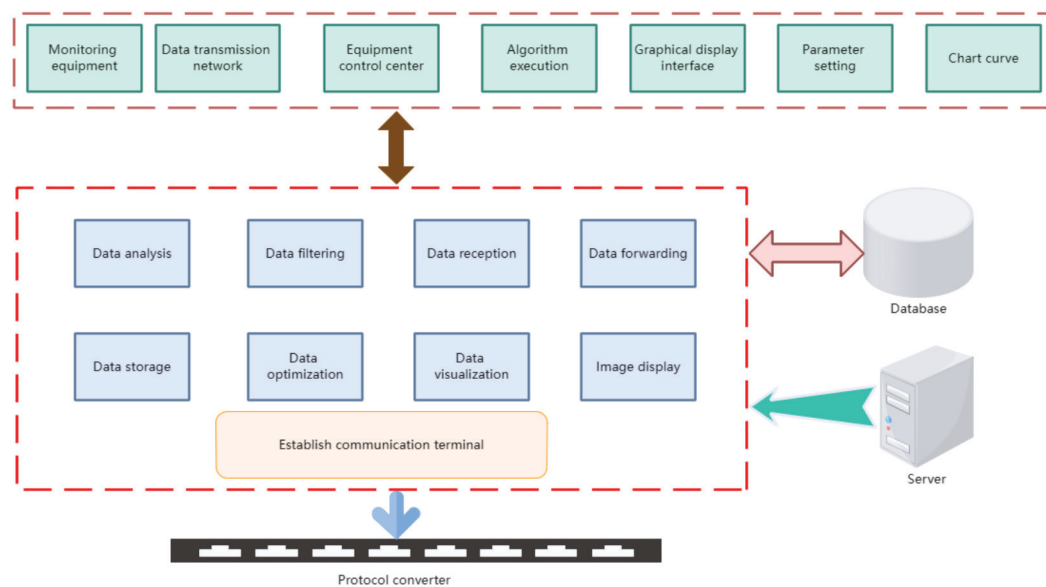


Figure 7 Detailed system structure.

transmitting television signals: one is wired, and the other is wireless. The latter is used in this study.

- ③ **Control module:** the main function of the monitoring module is to remotely control relevant equipment in the central computer system. The control system consists of a central controller and a microcomputer controller. They operate and control the monitoring system, as well as remotely controlling the monitoring device. By using a central controller or microcontroller, it is easy to control and adjust the camera, lens, pan head, and protective cover, meeting the requirements of monitoring.
- ④ **Image processing and display module:** the image processing module is responsible for allocating, switching, recording, replaying, processing, and copying image signals transmitted by the system. The display part uses devices such as displays and monitors for image display operations. The main equipment for image processing and display includes video controllers/switches, displays, monitors, and recorders. Through video control/switching, it is possible to allocate and switch image signals, thereby directing different image signals to different display devices to meet different monitoring needs. The display panel and monitor display high-quality and clear processed image signals for users to watch and monitor. Next, a video recorder can be used to record and store the image signal for future replay and viewing.

3.2 Detailed Structural Design of the System

The detailed structure of the network monitoring graphic display system designed in this study includes the following parts. The monitoring equipment monitors the

main indicators and parameters of the real-time monitoring system. The data transmission network transmits the data collected by the monitoring equipment. The equipment control center is responsible for managing and controlling monitoring equipment. The algorithm execution module processes and analyzes the collected data. The graphical display interface displays the processed data in a graphical form to users. The parameter-setting module: it is used to configure various parameters of the monitoring system. Chart curve module generates chart displays of monitoring data. The data filtering and analysis module filters and analyzes the collected data. The data reception, data forwarding, and data storage module is responsible for receiving, forwarding, and storing monitoring data. The data optimization module: it is used to optimize and clean data. The data visualization and image display module is responsible for presenting optimized data to users in a visual form. The communication end to protocol converter module converts and adapts the data between different communication protocols. The server and database provide support services and stores data. The structure is shown in Figure 7.

3.3 Main Process of System Work

The main process of a network monitoring system includes the following steps. Firstly, through an internet connection, the network monitoring system obtains real-time images or video streams captured by surveillance cameras. These data are transmitted through routers and undergo security screening through firewalls to protect the system from potential threats. Next, the image is transmitted to the image processing module for preprocessing, including denoising, brightness and contrast adjustments, and edge enhancement. After that, using remote monitoring technology, users can access the monitoring system through a remote browser to view and manage monitoring images in real time. The system uses object detection and tracking algorithms to analyze the

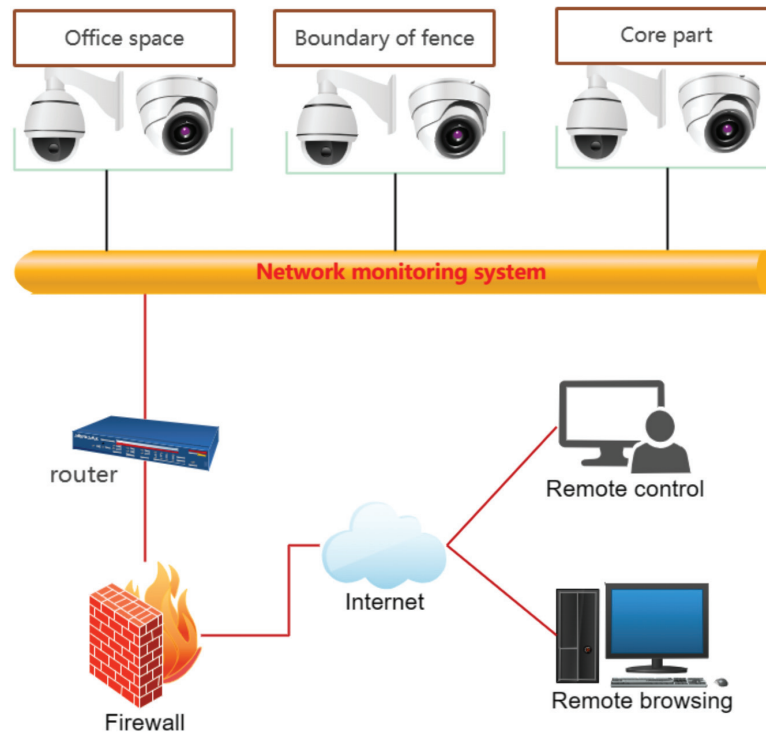


Figure 8 Network monitoring entity process.

Table 1 Scalability comparison of different technologies.

Technology type	Maximum number of cameras supported	Network bandwidth requirement (Mbps, Megabits per second)	Maximum storage capacity (TB, Terabyte)
Intelligent vector image technology	36	100	30
Traditional image display technology	20	150	16
Raster image display technology	28	120	20

processed image, identify the target objects in the image and track them for real-time monitoring. Finally, for real-time observation and analysis by users, the processed image is displayed on a remote browser through a graphical display module. The entire process is iterated to achieve efficient display and management of remote monitoring and browsing network monitoring graphics. The workflow is shown in Figure 8.

4. EXPERIMENTAL DESIGN AND RESULTS OF NETWORK MONITORING GRAPHICS DISPLAY SYSTEM

4.1 Comparison of Different Technologies for Implementing the System

In order to obtain a deeper understanding of the differences between traditional image display technology, raster image display technology and intelligent vector image technology,

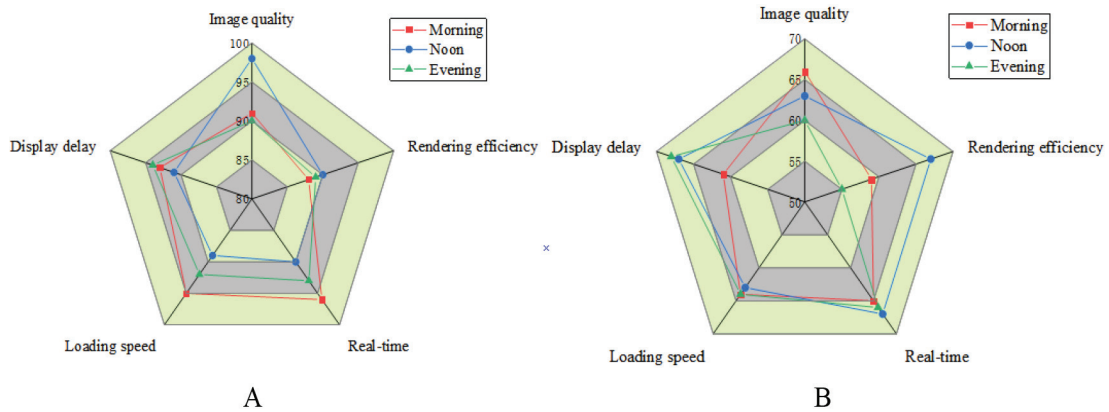
this study conducted a series of comparative experiments to evaluate their scalability and real-time performance (see Tables 1 and 2) to verify their application effectiveness and advantages and disadvantages in network monitoring graphic display systems.

From Table 1, it can be seen that intelligent vector image technology had the highest support for the maximum number of cameras, reaching 36, which allowed the system to access multiple surveillance cameras simultaneously, thus better meeting the requirements of large-scale monitoring. Moreover, the requirement for network bandwidth was 100Mbps, which was lower than that required by the other two technologies and had strong adaptability. In terms of maximum storage capacity, it was much higher than the other two technologies, with a capacity of up to 30TB, which was suitable for long-term storage of large amounts of monitoring data. Overall, the intelligent vector image technology chosen for this study had strong scalability.

Table 2 shows that the intelligent moderate image technology had the fastest response speed, only 10 ms, which was lower than the 18 ms of conventional image display technology and the 16 ms of raster image display technology.

Table 2 Real time performance comparison of different technologies.

Technology type	Average response time (milliseconds)	Maximum response time (milliseconds)	Average frame rate
Intelligent vector image technology	10	14	60
Traditional image display technology	18	24	30
Raster image display technology	16	20	45

**Figure 9** System performance comparison chart. (A) Results of the network monitoring graphic display system designed in this article. (B) Results of traditional monitoring systems.

The maximum response time of intelligent vector image technology and raster image display technology was relatively low, at 14 milliseconds and 20 milliseconds, respectively. The maximum response time of traditional image display technology was 24 milliseconds, which was slightly higher than the other two technologies. The lower maximum response time indicates that these technologies can process and display image content faster. Intelligent vector image technology performed best in terms of average frame rate, reaching 60 frames per second, which was higher than traditional image display technology's 30 frames per second and raster image display technology's 45 frames per second. Higher frame rates can provide smoother and more natural image playback and animation effects.

4.2 System Performance Comparison

In order to understand the performance of the network monitoring graphics display system designed using intelligent vector image technology, experiments were conducted to compare five aspects of the system designed in this study with those of traditional monitoring systems: image quality, rendering efficiency, real-time performance, loading speed, and display delay. The experiment specifically compared the various indicators of these two systems in the morning, noon, and evening. By evaluating and analyzing these five aspects, the performance and applicability of these two systems at different time periods can be evaluated and analyzed, providing reference basis for the optimization of network monitoring graphic display systems. The comparison results are shown in Figure 9.

Utilizing the five-dimensional radar image data provided in Figures 9 (A) and 9 (B), it is possible to compare and analyze the traditional monitoring system and the system designed

in this article. The image quality of traditional monitoring systems was 66, 63, and 60 in the early, middle, and late time periods, which was far inferior to the 91, 98, and 90 designed in this article. This fully demonstrated that the system described in this article performed better in terms of image quality, especially during the noon period, with an image quality of 98, which was much higher than the traditional system's 63. In terms of rendering efficiency, real-time performance, loading speed, and display delay, the proposed system was also superior to traditional monitoring systems.

Comparisons with traditional monitoring systems alone are often not convincing enough and have a certain degree of randomness. Therefore, in this study, a system was designed based on raster image display technology for comparison. In this study the three systems were compared in terms of resource utilization in CPU (Central Processing Unit), memory, bandwidth, and other aspects. The comparison is shown in Table 3.

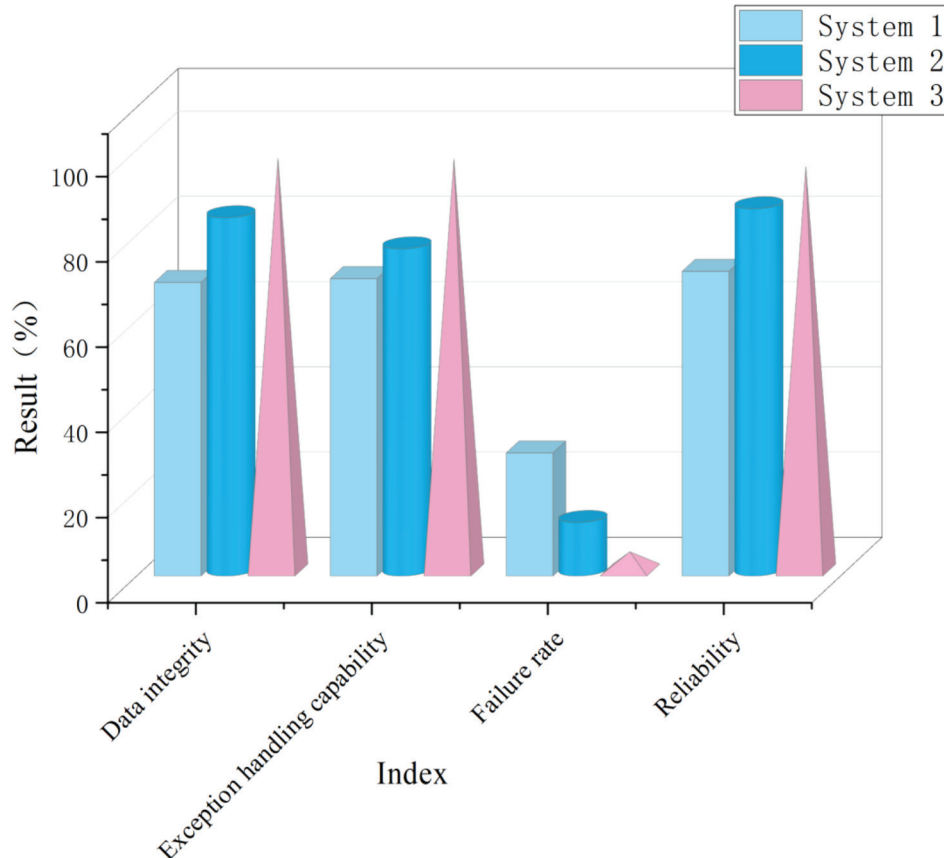
According to Table 3, compared to raster image display systems and network monitoring graphic display systems, traditional monitoring systems have higher CPU usage, memory usage, and disk space usage, indicating poor resource utilization in traditional systems. Overall, the network monitoring graphic display system has the highest energy efficiency and the lowest disk space occupation, surpassing the other two systems in all aspects.

4.3 System Stability Comparison

This article compared the four stability indicators of traditional monitoring systems (System 1), raster image display systems (System 2), and the network monitoring graphic display system designed in this study (System 3): data integrity, anomaly handling ability, fault rate, and reliability.

Table 3 Comparison of system resource utilization.

Parameter	Traditional monitoring system	Raster image display system	Network monitoring graphic display system
CPU usage(%)	25	23	20
Memory footprint(Megabyte, MB)	250	220	160
Disk space usage(Gigabyte, GB)	6	5	3
Energy efficiency index ((operand/energy consumption) *1000)	130	160	180

**Figure 10** System stability comparison.

By comprehensively comparing scores for various indicators, stability evaluation can be conducted on these three different systems, and the optimal monitoring graphic display system can be selected according to actual needs. The specific stability comparison results of these three different systems are shown in Figure 10.

Figure 10 shows the test evaluation results of these three systems according to four indicators: data integrity, exception handling ability, fault rate, and reliability. Further analysis showed that the proposed System 3 (the network monitoring graphic display system designed in this study) performed the best in terms of data integrity, reaching 96.7%, which was significantly higher than that of System 2 (raster image display system)'s 84.1% and that of System 1 (traditional monitoring system) which was 68.9%. This fully demonstrated that System 3 could effectively store and transmit monitoring data, and the integrity of the data was highly guaranteed. System 3 also scored high in terms of exception

handling ability and reliability, reaching 96.5% and 94.8%, respectively. This meant that System 3 can effectively handle errors and abnormal situations in the monitoring system, improving the stability and reliability of the system. System 3 also performed the best in terms of fault rate, only 4.3%, which fully demonstrated that the proposed system had a low frequency of faults and high stability.

Overall, System 3 performed well in terms of data integrity, exception handling ability, and fault rate, and had high stability. However, System 1 and System 2 performed relatively weakly in these aspects.

4.4 System Image Compression Rates Comparison

Image compression is a crucial image processing technique that has been extensively used for digital images. Image

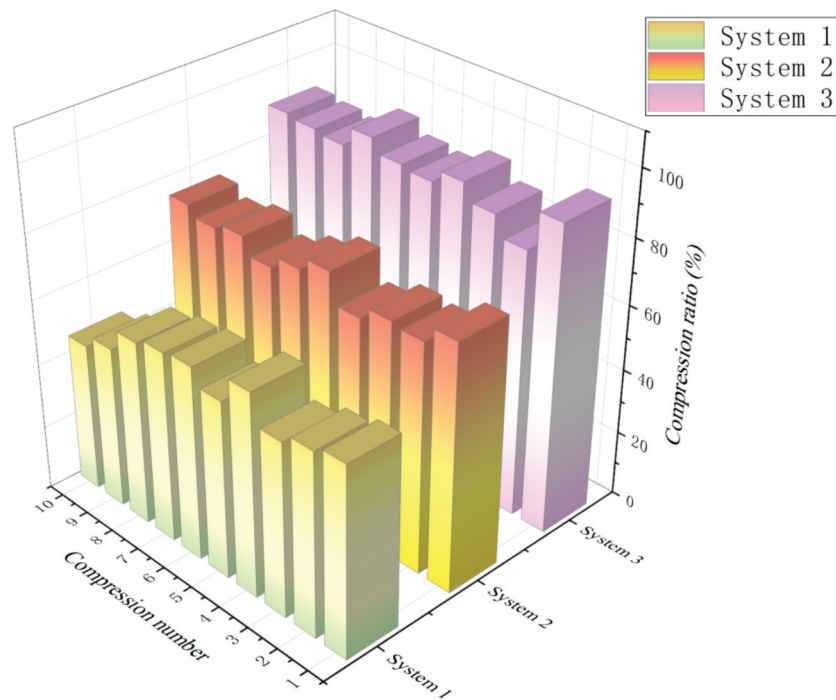


Figure 11 Comparison of system image compression rates.

compression technology can increase data transmission bandwidth, save storage space, and shrink image files. The use of diverse techniques to compress images leads to notable variations in both compression rate and image quality. Determining the compression rates of various systems allows for the evaluation and comparison of their respective picture-compression performance. This study conducted experiments to determine the picture compression rates achieved by System 1, System 2, and System 3. The comparative analysis results are shown in Figure 11.

Figure 11 shows that for the first measurement, the image compression coefficient of System 1 was 59%, while in subsequent measurements, it fluctuated between 46% and 63%, with an average compression coefficient of 56%. The image compression coefficient of System 2 was 76% for the first measurement, and then fluctuated between 68% and 77% in subsequent measurements, with an average compression coefficient of 72.7%. Overall, System 2 has a higher and more stable compression rate compared to System 1. For the first measurement, the image compression coefficient of System 3 was 94%. In subsequent measurements, it fluctuated between 82% and 94%, with an average compression coefficient of 89.7%.

In summary, the image compression rate of System 3 was higher than that of the other two systems, which can better reduce the size of image files, effectively reduce storage space required and improve bandwidth utilization for data transmission.

4.5 User Experience Comparison

In order to evaluate the effectiveness of the proposed graphic display system in terms of user experience, a

satisfaction survey was conducted. The survey participants tried and compared traditional monitoring systems, raster image display systems, the system designed in this study. Questionnaire was used to measure user satisfaction.

The survey results are shown in Figure 12, where the horizontal axis represents 10 participants in the survey and the vertical axis represents the user's evaluation score.

According to the information analysis provided in Figure 12, the scoring range of System 1 was between 60 and 73, with an average score of 66.2. Whereas, the score of System 2 fluctuated between 70 and 84, with an average score of 77.6. The lowest score for System 3 was 89, and the highest score was 98; the average score was 94.1. From the perspective of user evaluation scores, System 3 had the best user reputation, the highest score, and less fluctuation in evaluation. Based on this analysis, System 3 performed the best in terms of user evaluation scores, and users had a high level of satisfaction with it. The evaluation score for System 2 was the second highest, while System 1 had the lowest evaluation.

5. CONCLUSION

In this study, intelligent vector image technology was applied to design and achieve a system for the graphics display of network monitoring. By converting monitoring images into vector graphics and using intelligent algorithms for image analysis and optimization, efficient display and accurate expression of monitoring graphics were achieved. The experimental results showed that the system designed in this study had significant advantages in terms of performance, image compression rate, stability, and user evaluation. In

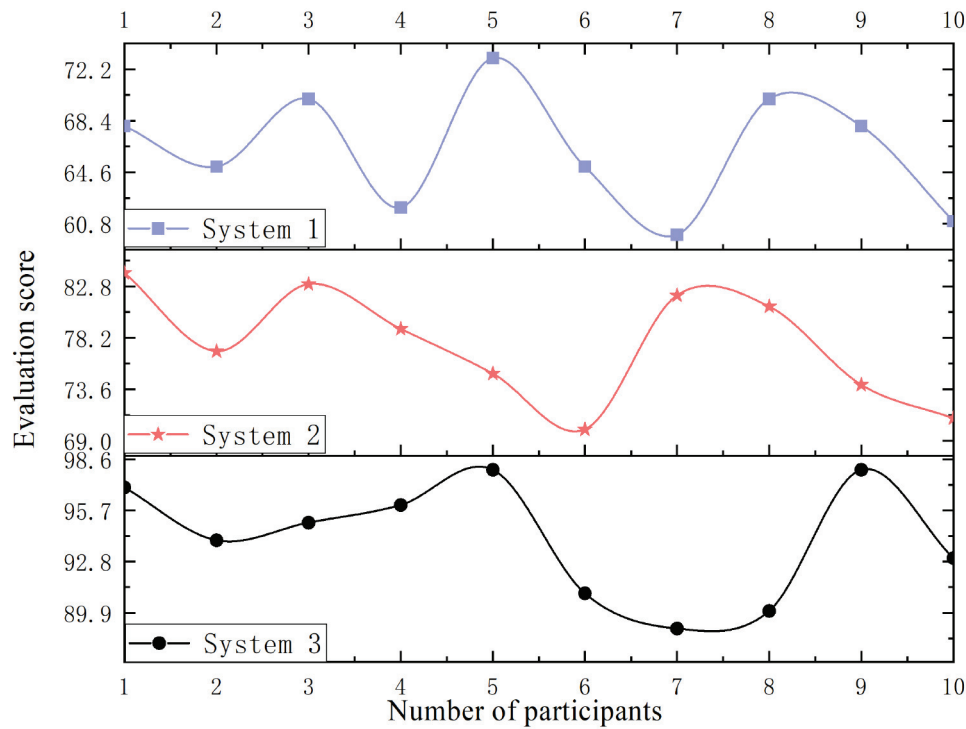


Figure 12 Comparison of user evaluation scores.

the future, more application fields of intelligent vector image technology can be further explored, and the performance and reliability of the methods can be further improved.

REFERENCES

1. Tsai P W, Tsai C W, Hsu C W. Network monitoring in software-defined networking: A review. *IEEE Systems Journal*, 2018, 12(4): 3958–3969.
2. Aboulan A, Green D H, Switzer J F. NILM dashboard: A power system monitor for electromechanical equipment diagnostics. *IEEE Transactions on Industrial Informatics*, 2018, 15(3): 1405–1414.
3. Parjuangan S, Ali R, Purnama A. Real-time monitoring and warning system in urban rivers. *TELKOMNIKA (Telecommunication Computing Electronics and Control)*, 2019, 17(3): 1521–1525.
4. Yuan C, Zhang W, Yue M. The design of accelerator control network analysis system and its application. *Radiation Detection Technology and Methods*, 2023, 7(2): 200–209.
5. Dhingra S, Madda R B, Gandomi A H. Internet of Things mobile–air pollution monitoring system (IoT-Mobair). *IEEE Internet of Things Journal*, 2019, 6(3): 5577–5584.
6. John J, Varkey M S, Podder R S. Smart prediction and monitoring of waste disposal system using IoT and cloud for IoT based smart cities. *Wireless Personal Communications*, 2022, 122(1): 243–275.
7. Wang S, Liu X, Liu S. Human short long-term cognitive memory mechanism for visual monitoring in IoT-assisted smart cities. *IEEE Internet of Things Journal*, 2021, 9(10): 7128–7139.
8. Sheng Y, Chen W, Wen H. Visualization research and application of water quality monitoring data based on ECharts. *J. Big Data*, 2020, 2(1): 1–8.
9. Paul A. Adaptive tri-plateau limit tri-histogram equalization algorithm for digital image enhancement. *The Visual Computer*, 2023, 39(1): 297–318.
10. Acharya U K, Kumar S. Image sub-division and quadruple clipped adaptive histogram equalization (ISQCAHE) for low exposure image enhancement. *Multidimensional Systems and Signal Processing*, 2023, 34(1): 25–45.
11. Mohameth F, Bingcai C, Sada K A. Plant disease detection with deep learning and feature extraction using plant village. *Journal of Computer and Communications*, 2020, 8(6): 10–22.
12. Hamout H, Elyousfi A. Fast depth map intra coding for 3D video compression-based tensor feature extraction and data analysis. *IEEE Transactions on Circuits and Systems for Video Technology*, 2019, 30(7): 1933–1945.
13. Zhou J, Liu L, Wei W. Network representation learning: from preprocessing, feature extraction to node embedding. *ACM Computing Surveys (CSUR)*, 2022, 55(2): 1–35.
14. Meng D, Wang H, Yang S. Fault analysis of wind power rolling bearing based on EMD feature extraction. *CMES-Computer Modeling in Engineering & Sciences*, 2022, 130(1): 543–558.
15. Xiong X, Zhu T, Zhu Y. Molecular convolutional neural networks with DNA regulatory circuits. *Nature Machine Intelligence*, 2022, 4(7): 625–635.
16. Xu, Z. Computational intelligence based sustainable computing with classification model for big data visualization on map reduce environment. *Discov Internet Things* 2, 2 (2022).
17. Hu S. Full target k-coverage retention at the boundary of smart sensor networks. *Engineering Intelligent Systems*, 2024, 32(2): 145–153.
18. Chen X, Tang Y. Data center energy management based on cloud computing and artificial intelligence. *Engineering Intelligent Systems*, 2024, 32(3): 257–266.
19. Schapiro D, Sokolov A, Yapp C. MCMICRO: a scalable, modular image-processing pipeline for multiplexed tissue imaging. *Nature Methods*, 2022, 19(3): 311–315.

20. Garcia L J, Timmermans M, Pozuelos F J. prose: A Python framework for modular astronomical images processing. *Monthly Notices of the Royal Astronomical Society*, 2022, 509(4): 4817–4828.
21. Choi D H, Liu H W, Jung Y H. Analyzing angiogenesis on a chip using deep learning-based image processing. *Lab on a Chip*, 2023, 23(3): 475–484.
22. Hou S M, Jia C L, Wanga Y B. A review of the edge detection technology. *Sparklinglight Transactions on Artificial Intelligence and Quantum Computing (STAIQC)*, 2021, 1(2): 26–37.
23. Sungheetha D A. Gtiki-gabor-transform incorporated k-means and fuzzy c means clustering for edge detection in ct and mri. *Journal of Soft Computing Paradigm*, 2020, 2(2): 111–119.
24. Wang X, Fang Y, Li C. Static gesture segmentation technique based on improved Sobel operator. *The Journal of Engineering*, 2019, 2019(22): 8339–8342.
25. Huang M, Liu Y, Yang Y. Edge detection of ore and rock on the surface of explosion pile based on improved Canny operator. *Alexandria Engineering Journal*, 2022, 61(12): 10769–10777.
26. Wang X, Wang S, Guo Y. Coal gangue image segmentation method based on edge detection theory of star algorithm. *International Journal of Coal Preparation and Utilization*, 2023, 43(1): 119–134.
27. Verma A, Dhanda N, Yadav V. Binary particle swarm optimization-based edge detection under weighted image sharpening filter. *International Journal of Information Technology*, 2023, 15(1): 289–299.
28. Nayak Seetanadi, G., Årzen, K. E., & Maggio, M. (2022). Control-based event-driven bandwidth allocation scheme for video-surveillance systems. *Cyber-Physical Systems*, 8(2), 111–137.
29. Dhaya D R. CCTV surveillance for unprecedented violence and traffic monitoring. *Journal of Innovative Image Processing*, 2020, 2(1): 25–34.



Yao Zhang was born in Shangrao, Jiangxi Province, China, in 1984. She received the bachelor's degree in electronic information engineering and the master's degree in circuits and systems from Northeastern University. Currently, she is a lecturer at the Dalian Neusoft University of Information. Her research directions include embedded systems, digital image processing, etc.

Email: dz201903011218@163.com