Computer Big Data Technology in Internet Network Communication Video Monitoring of Coal Preparation Plant

Hao Chen, XinLi Zi, Qing Zhang, YuGe Zhu, JiaYin Wang *
China Coal Technology & Engineering Group Nanjing Design & Research Institute, Nanjing, 210000, China
*Corresponding author: jiayinwang@ccteg.cn

Abstract. The paper uses the control technology of computer big data and PLC, fieldbus communication technology and video monitoring technology to research, design and develop the monitoring system of the coal preparation plant's production process. In this plan, the coal preparation plant's video monitoring system, production centralized control system and other production support systems are fully integrated through network technology, to achieve the purpose of improving its safety guarantee function. The system improves the level of visual management, realizes unattended operation, and reduces potential safety hazards.

Keywords: Coal preparation plant; whole network; computer big data; digital video; network communication; video surveillance.

1. Introduction
In its development process, video surveillance has experienced three stages from the early analogy video surveillance to the current network video surveillance. The first stage is analogy video surveillance, which is composed of cameras, video switching matrix, monitors, and video recorders. It has a small application range, poor image quality, cannot exchange data with information systems, is not easy to expand, and has a short transmission distance, making it difficult to achieve remote access; the second stage Multimedia microcomputer platform (embedded system) digital video surveillance, composed of analogy cameras, various acquisition equipment, PC industrial computers, and acquisition cards. The front-end processing of the PC is relatively complex, high cost, complex wiring, poor environmental adaptability, and low reliability; The third stage is digital network monitoring based on embedded network video monitoring server technology, which is composed of network cameras, switches, aggregation switches, disk arrays, integrated platforms, and displays [1]. Compared with the first and second stages, it has obvious advantages: it can be realized Image transmission, remote control, ready-made signal acquisition, strong expansion capability, high reliability, strong environmental adaptability, convenient software expansion and upgrade, and simple use. This subject mainly studies the monitoring system of coal preparation plant that can intelligently judge whether workers around the equipment are in a safe area when certain large-scale dangerous equipment is turned on, and whether unauthorized personnel enter the control centre of certain important equipment, and so on. Therefore, the intelligent monitoring system for the staff of the coal preparation plant can to a large extent ensure the safety of the staff and the orderly progress of production.
2. System requirements
(1) The digital video surveillance system adopts the video surveillance technology based on TCP/IP network. The advantages are clear images, high pixels, 720P display, good network signal anti-interference, and suitable for places with strong interference in the factory. (2) The post driver can obtain the on-site image and sound information in a timely and accurate manner, and timely monitor and memorize the abnormal event process of emergencies, which is convenient for real-time monitoring of equipment operation and the working conditions of operators. (3) The construction is relatively convenient, cost-effective, and network expansion capabilities are strong. Camera points can be added at any time according to actual needs, and signal sharing and control can be easily realized. Managers can conveniently perform real-time monitoring and video inquiries in the office. (4) The storage capacity of the network hard disk video recorder is easy to increase, the storage image is high in definition, the operation is simple, and it is more convenient for post drivers and managers to inquire and browse. (5) The digital signal has the characteristics of high spectral efficiency, strong anti-interference, and low distortion. (6) The monitoring main screen has high definition, real-time and strong reliability, and supports single-screen multi-channel display, which is convenient for the operator to watch the real-time status of multiple devices at the same time.

3. System function design
3.1. Industrial control video linkage function
The industrial control video linkage mechanism focuses on improving the real-time monitoring efficiency of the video surveillance system. Its functions mainly include the following aspects. (1) The equipment in the production process of the coal preparation plant is started in sequence under the centralized control of the system. When the key equipment is started, the surveillance camera near the equipment will automatically turn to and aim at the equipment, and the centralized control room will display a large display [2]. The screen also automatically switches to the camera screen. (2) When a certain equipment fails during production operation, the host computer monitoring screen of the production centralized control system will send an alarm message, and the monitoring camera near the equipment will also automatically turn to the equipment and switch the screen to the centralized control system. Display on the large screen in the control room. (3) When an alarm occurs in other production guarantee systems of the coal preparation plant (such as a fire alarm system, an optical fibre temperature measurement system, and a gas monitoring system), the camera near the alarm point will also automatically turn to and aim at the alarm position, and related the screen is cast and cut to the large display screen in the centralized control room. Security deployment of key areas such as power distribution rooms, warehouses, and weighing rooms, the camera portrait detection function is enabled to capture detailed images of people entering and leaving, and record the time of entry and exit.

3.2. Post inspection and supervision
Specify daily production and regular inspection time for key equipment. If the camera does not detect personnel activity during the inspection time, an alarm record will be generated to supervise the post inspection personnel.

3.3. Light storage configuration
For non-movement monitoring scenes when the equipment is recording, a non-storage configuration is set to save storage space and reduce the retrieval time for subsequent queries.

3.4. Safety start-up monitoring of key process equipment
For belt conveyors, scraper conveyors, vibrating screens and other equipment, the smart "moving object detection" function of the smart camera is used to delineate the electronic boundary of safe start-up. When the equipment start command is issued, the relevant camera detects the movement of people in the area and issues a security alarm, and the production control system prohibits the equipment from
starting [3]. At the same time, the video surveillance system switches the relevant video screens to the large display screen in the centralized control room.

4. System Architecture
The coal preparation plant monitoring system includes a centralized control system and an industrial television monitoring system. The centralized control system is composed of a monitoring computer, a PLC control system, a power monitoring system, a single-machine automation system, and various process parameter detection instruments [4]. The structure diagram of the monitoring system is shown in Figure 1. The whole system has a three-layer structure. The first layer is the equipment layer, which is mainly composed of field-controlled equipment, field sensors and instruments; the second layer is the control layer, which is mainly composed of PLC systems. The third layer is the information (monitoring management) layer, which is mainly composed of industrial switches, monitoring computers, video servers, large-screen TV walls, and LED displays. Figure 1 shows the system architecture.

![Figure 1. Monitoring system architecture of coal preparation plant.](image)

1) Front-end monitoring resource collection, using stainless steel explosion-proof and waterproof network cameras and bolt-on camera technology to collect video signals, and fully cover the blind areas in the production area. The front-end camera signal is converted into an optical fibre signal through the network RG45 interface and connected to the hard disk video recorder, image decoder, and video server to complete the collection and collection of the original signal on the production site.

2) Intelligent image recognition is an important part of the machine vision system of the intelligent coal preparation system. It uses on-site installation of industrial cameras, light sources, internal boards (built-in analysis software) or machine vision sensors to replace on-site operators for on-site signal recognition. The Ivms-8700 intelligent video integrated platform remotely monitors and controls the operation status of the front-end monitoring equipment in the system, and displays it in real-time in the form of various charts [5]. The video image data stored in the disk array is retrieved, replayed, and main feature identification is performed. Intelligent analysis, decoding control, after secondary analysis and processing, output to the terminal display for alarm prompts.

3) By correlating the video collected signals of the field equipment with the equipment failures of the centralized control PLC system of the coal preparation plant, the corresponding video signal display of the related production equipment failures can help the dispatching station monitor personnel to quickly make judgments and ensure the production of coal preparation Go smoothly.
5. Personnel target tracking algorithm design in video surveillance

5.1. Principle of Gaussian Mixture Model

In the moving target detection, the Gaussian model is used to model the time series of the video image frame, and the Gaussian model uses the Gaussian probability density function (normal distribution curve) to simulate things [6]. Early researchers used a single Gaussian model, but later found that the single Gaussian model only has a better modelling effect for single-modal scenes. In daily life, there are often multi-modal scenes such as light changes and swaying branches. For this kind of scene, the single Gaussian model cannot be modelled well, so Chris Stauffer and others proposed a mixed Gaussian model, which uses multiple mixed Gaussian distributions to solve Modelling problems in multi-modal backgrounds. This method assumes that the statistical characteristics of each pixel of the video image in the time series conform to the Gaussian mixture distribution, then the probability distribution of the pixel $X_i$ at time $t$ is

$$P(X_i = \sum_{i=1}^{K} \omega_i \eta(X_i, \mu_i, \Sigma_i))$$

(1)

Where: $K$ represents the number of Gaussian distributions, generally 3 to 5; $\omega_i$ represents the weight of the $i$ Gaussian distribution at time $t$, $\sum_{i=1}^{K} \omega_i = 1$ $\eta$ Represents an n-dimensional joint Gaussian probability distribution; $\mu_i$ represents the $i$ Gaussian distribution at $t$ Mean value at time; $\Sigma_i$ is the covariance matrix of the density function of the single Gaussian model $\eta_i$ at time $t$. $\eta$ calculation formula is

$$\eta(X_i, \mu_i, \Sigma_i) = \frac{1}{\sqrt{(2\pi)^n |\Sigma_i|}} \exp \left[ -\frac{1}{2} (X_i - \mu_i)^T \Sigma_i^{-1} (X_i - \mu_i) \right]$$

(2)

If the image is RGB three-channel, then $\Sigma_{ij}$ represents the covariance matrix among the three channels of R, G, and B.

$$\Sigma_{ij} = \sigma_{ij}^2 I$$

(3)

In the formula, $\sigma_{ij}$ represents the variance of the $i$ Gaussian distribution; $I$ is the identity matrix.

5.2. Background modelling process

First, assign initial values to the parameters. The setting of initial values does not have much effect on the final model, but in order to quickly build the model, it is necessary to set a smaller initial mean value and as large a variance as possible. When a new frame $X_i (t = t+1)$ appears, first arrange the multiple Gaussian distributions in descending order of $\omega / \sigma$, in order to put the Gaussian model that is most likely to match to the front. If each Gaussian model arranged in order does not satisfy the condition: $X_i - \mu_i < 2.5\sigma_i$, then the pixel is the previous scenic spot. At this time, the Gaussian distribution with the smallest $\omega / \sigma$ is discarded, and a new Gaussian distribution is established with $X_i$ as the mean. The new Gaussian distribution should be set with a small weight and a large initial variance. If $X_i - \mu_i < 2.5\sigma_i$ is true for each Gaussian model, then stop the matching of subsequent Gaussian distributions [7]. Assuming that the currently matched Gaussian model is the $b$, if $b>B$, then $X_i$ is the previous scenic spot, otherwise $X_i$ is the background point, and B is defined as follows:
In the formula: $T$ is a preset threshold, the larger the $T$, the more pixels are judged as background points. After the foreground detection is completed, the background model parameters need to be updated, which is the key to the algorithm. The update formula of Gaussian distribution weight is

$$\omega_{k,t} = (1 - \varepsilon)\omega_{k,t-1} + \alpha M_{k,t}$$

In the formula: $\alpha$ is the learning rate, which reflects the speed of each parameter change in the distribution process; for the matched Gaussian distribution, $M_{k,t} = 1$ for the unmatched Gaussian distribution, $M_{k,t} = 0$.

5.3. Experimental verification

In order to test the effectiveness of the improved human target tracking method for the tracking of moving human targets, this paper selects a 1min video from the monitoring video of the coal preparation plant for testing. The video frame rate is 25 frames/s and the pixel is $352 \times 288$. In the experiment, the image of the tracked target area is first converted into the HIS colour space, and the colour value $H$ in the colour space is used as the tracking feature, and the image colour value $H$ is quantized into 45 bins (each bin as the feature $u$). The Panucho kernel function is used as the kernel function of the Gaussian filtering algorithm, and the Bach coefficient is used as the similarity function. The number of iterations of the Gaussian filtering algorithm is set to 20 times. The initial target is obtained by the moving human detection method. The experimental results are as follows as shown in Figure 2.

Figure 2. Tracking effect of improved human target tracking method.

It can be seen from Figure 2 that the improved human target tracking method has a better tracking effect, combined with the Kalman filter algorithm can well eliminate the influence of similar colour areas in the background. Since this article uses the colour value $H$ in the HIS colour space to track the target, when the three component values in the RGB colour space are equal, the colour value $H$ in the HIS colour space is undefined currently, which causes the tracking target to shrink to Hard hat area.
6. Conclusion
The system designed in the thesis has data collection and processing capabilities, production process monitoring capabilities, information query capabilities, decision-making assistance capabilities, and office automation capabilities. At the same time, the paper combines the environment of the coal preparation plant and selects the background subtraction method based on the Gaussian mixture model to realize the detection of moving targets. This system provides reliable, fast, convenient, and scientific modern methods for coal preparation plant managers, and creates necessary conditions for realizing modern management of coal preparation plants.

References
[1] Fan, Y., Ma, X., Dong, X., Feng, Z., & Dong, Y. Characterisation of floc size, effective density and sedimentation under various flocculation mechanisms. Water Science and Technology, 82(7) (2020) 1261-1271.
[2] Gvozdyakov, D. V., Zenkov, A. V., & Kuznetsov, G. V. Ignition of coal-water fuel droplets with addition of isopropyl alcohol. International Journal of Energy Research, 45(2) (2021) 1535-1549.
[3] Syrodoy, S. V., Kostoreva, J. A., Kostoreva, A. A., & Asadullina, L. I. Ignition of wood and coal particle mixtures in conditions of steam and water boiler furnaces. Journal of the Energy Institute, 93(2) (2020) 443-449.
[4] Bogomolov, A., Valiullin, T., Vershinina, K., Shevyrev, S., & Shlegel, N. Igniting soaring droplets of promising fuel slurries. Energies, 12(2) (2019) 208-219.
[5] Vershinina, K., Shabardin, D., & Strizhak, P. Burnout rates of fuel slurries containing petrochemicals, coals and coal processing waste. Powder Technology, 343(5) (2019) 204-214.
[6] Kuznetsov, G. V., & Yankovskii, S. A. Conditions and characteristics in ignition of composite fuels based on coal with the addition of wood. Thermal Engineering, 66(2) (2019) 133-137.
[7] Is’yomin, R. L., Kuz’min, S. N., Mikhailov, A. V., Milovanov, O. Y., Klimov, D. V., Nebyvaev, A. V., & Khaskhachikh, V. V. Fluidization of a Multicomponent Bed in a Reactor for Co-Torrefaction of Waste Coal and Biomass. Journal of Engineering Physics and Thermophysics, 93(3) (2020) 750-756.