Application of computer image processing technology in oilfield underground mining machinery

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Abstract. With the rapid development of digital information and multimedia, image processing system is being widely used. Based on the basic theory of ferrography wear analysis, combined with computer image processing technology and pattern recognition theory, this paper extracts and analyzes the features of ferrography wear images caused by different oilfield underground mining machines. The evaluation index of foreign object detection accuracy is given to measure the accuracy of the detection algorithm. Through the analysis of connectivity, the eigenvalues of foreign particle targets in the collected images are obtained, and the eigenvalues of the targets extracted from the images basically have little change. By analyzing the wear failure formation mechanism and wear characteristics of typical oilfield underground mining machinery parts, it lays a solid theoretical foundation for the identification of abrasive morphology characteristics, the judgment of wear types and positions, and the determination of fault types.

Keywords: Computer Image Processing, Oil Field Underground Mining Machinery, Edge Detection

1. Introduction

Computer image processing refers to the process of converting image signals into digital signals and processing them with computers. It takes people as objects and improves people's visual effects. Commonly used methods mainly include image enhancement, image segmentation, edge extraction, morphological analysis, image compression coding and so on. Its main principle is to use the image acquisition card and camera to convert the external image into a digital image represented by the gray
values of red (R), green (G) and blue (B), and then use the corresponding software to analyze, process, process and output [1]. At present, the research and development of 3D optical digital imaging technology is quite active. It uses computer-aided coherent and incoherent optical methods and computer-aided geometric modeling technology to obtain a three-dimensional digital virtual model of real objects. It is a promising 3D data visualization technology.

In recent years, quantitative metallography has made gratifying achievements in theoretical research, test equipment development and production application, etc., and its application in materials science and engineering is becoming more and more common [2]. However, there are still many problems to be solved in stereology theory. With the continuous development of intelligent technology research, contactless measurement using computer vision technology is gradually developed at home and abroad. In this paper, the computer image processing technology is used to detect the mechanical properties of oilfield underground mining quickly and accurately.

2. Key technologies of computer image processing technology

In the practical use stage, computer image processing technology is particularly convenient and sensitive to operate, which is widely used in various image processing. At present, the measurement and calculation of quantitative metallography are mostly carried out under the optical microscope. With the development in recent years, it has been possible to measure and calculate the characteristic parameters of microstructure and macroscopic fracture structure of various electron microscopes. This process is related to the basic characteristics of X-ray. In a homogeneous object, the attenuation of X-ray is proportional to the traveling distance in the material. For the oil industry, the oil thickness uniformity test is one of the main contents to control and improve the oil quality. Generally speaking, digital images are mainly compressed, transformed, adjusted and segmented. With the continuous development of this technology, it involves multi-category theory. The image acquisition card inserted into the computer can convert the electrical signals collected by the camera into digital signals and digitize the images so that the computer can carry out various necessary processing [3].

Computer image processing technology is a technical process that is presented with ideal results after the image information that needs to be processed is converted or has some high-speed operation function through the computer-related image imaging and processing technology award. Image processing is to transform an image into a digital matrix and store it in a computer, and then use certain algorithms to process it. Its core technology protects analysis, coding, repairing image information mathematics and image enhancement. In addition, image processing technology is also applied to computer animation and model design. In life, computer technology is popular, image processing technology provides users with abundant information, and computers have powerful storage and fast processing functions. Then it is analyzed, processed, processed and output by using corresponding software. With the popularization and development of computers, image processing technology has been applied to industrial and agricultural production, military technology, scientific research and other aspects.

3. Image interpolation

Image interpolation is widely used in the field of computer vision. Image interpolation is the first step of image resampling, that is, transforming discrete digital image matrix into continuous images; The
second step is to resample the continuous images to obtain discrete images with higher resolution. In this paper, ferrography image is converted into digital form by video capture, and stored in computer for analysis. Abrasive particles are one of the important information sources for monitoring abrasive particles in oil fluid of oilfield underground mining machinery. Studying the composition, shape, size, surface morphology, physical properties and mechanical properties of abrasive particles can provide theoretical basis for determining the location of wear failure and wear failure mechanism of oilfield underground mining machinery.

3.1. Noise removal of image

The image of the underground mining machinery of the oil field to be detected captured by the camera is composed of the detected target and its image background. The reflection of the detected foreign object to the light source is the main target of the image display, while the background in the image is formed by various factors. Ensure that the normal direction of the measured hole at the top of the sphere is basically coincident with the axis of the objective lens. The rotating device of the sphere can rotate around two axes which are perpendicular to each other and pass through the center of the sphere, ensuring that all holes on the sphere can be transferred to the field of view below the objective lens of the photoelectric measuring head. The wear of mechanical parts of underground mining in oil fields during normal operation can generally be characterized by wear curves. In this subject, it is mainly the background segmentation of the image, and the abrasive particles are separated from the background in an appropriate way according to the characteristics of the abrasive particle image [4]. Image interpolation algorithm has become the research object. In the early days, simple algorithms such as nearest neighbor interpolation and linear interpolation were applied to resampling. Through the threshold segmentation method and the basic assumption that the path is a straight line in the calculation process, the path features are extracted.

After the video signal is collected by CCD camera, it is transformed into programmable video data by video acquisition card. After image preprocessing, edge detection operator, contour curve positioning and other algorithms, we can compare the actual contour curve with the standard curve, obtain deviation data, and then judge whether the quality of parts is qualified [5]. The software flow of image processing is shown in Figure 1.
Figure 1. Software flow of image processing

By analyzing the extracted characteristic parameters of wear particles, the judgment method of wear particle type is obtained. The wear rate is very large at first, then gradually decreases and then enters a stable state. Running-in is very important for the friction pairs of many oilfield underground mining machines, which causes great wear and heat on the friction surface, and changes the geometric characteristics of the friction surface and the mechanical and physical properties of the surface and surface layer. After image data acquisition, the host computer reads CCD data and raster data from SRAM of the acquisition card through data bus, and synthesizes them into a gray image, which is displayed on the interface of the host computer. Then the gray image is processed by computer image processing technology. Impulse noise, also known as Gaussian noise and salt and pepper noise, may appear in improper system operation, which is the most important noise in foreign body detection system [6].

3.2. Image segmentation

The so-called image segmentation refers to dividing an image into several meaningful regions which are irrelevant to each other according to features such as gray scale, color, spatial texture and geometric shape, so that these features show consistency or similarity in the same region, but show obvious differences among different regions. These parasitic effects may be produced in transmission or in the process of quantization. The main goal of image smoothing processing is to eliminate these parasitic effects without blurring the edge contours and lines of the image. In many cases, the measured physical signals are very low voltage and sensitive to noise. In this case, the measured signals need to be amplified and filtered before being converted into the digital format used by computers [7]. Because different shapes of the selected templates will have different effects and influences on denoising efficiency, templates should be selected according to different images and different image processing requirements.

The preprocessing process of ferrography image is generally as follows: firstly, filtering the wear particle image to remove the noise generated in the process of image acquisition and processing, smoothing the image, then separating the wear particle image from the image background, and then preliminarily extracting the wear particle parameters. The specific pretreatment steps are shown in Figure 2.

Figure 2. Flow chart of ferrography image preprocessing
There are many forms of data acquisition hardware, and the selection of data acquisition hardware should be based on the specific application situation and consider the existing technical resources. However, there is a strong correlation between the background region and the gray level in the target region, so the gray level uniformity can be taken as the basis of image segmentation. Specifically, after the neighborhood is determined, a weighting coefficient is set for the points in the neighborhood, and the setting of the coefficient can refer to the distance between the neighborhood point and the center point. However, it will still bring great adverse effects. The main disadvantage of linear interpolation algorithm is its incomplete suppression of high frequency part of image and confusion caused by putting high frequency data above cut-off frequency into low frequency part [8].

For oil field underground mining machinery, the first task is to identify the fruit from the background, determine its three-dimensional spatial position, and then harvest it. When samples of different volumes enter the capacitor at a certain speed. The capacitance of the polar plate will change, so that the unevenness of the density of the oilfield underground mining machinery can be obtained. The data produced are in different forms. The optical processing produces hard copy photos. The digital image processing produces digital tapes. Due to the influence of objective environment, the captured image inevitably loses some original information of objects, which makes it difficult to extract and match the features of the image, so it is necessary to preprocess the image in the early stage. Surface model and parametric feature model use digital samples instead of real objects, which provides a bridge for applying measurement modeling method to data compression and surface smoothing of digital samples.

4. Edge detection

4.1. Image edge detection operator

After filtering ferrography images, median filtering can be applied to ferrography images because of its good suppression effect on pulse interference and better preservation of details. If the threshold value is too high, some image points of abrasive objects will be classified as background image points, and the target area obtained by segmentation is smaller than the actual area; On the contrary, if the threshold value is too low, some background image points will be classified as abrasive object image points, and the obtained target area is larger than the actual area. It completes a data acquisition according to the commands and parameters input by the user and returns the test results to the user. This filtering method has a good effect on removing many noises, and can guarantee the edge detail values of image pixels in the process of removing random noises, mainly because this method does not deviate greatly from the main values. If the target area in ferrography image is large enough compared with the background area, and there is a certain difference in gray level between the target area and the background area, then the gray level histogram of the image will have bimodal characteristics. The most commonly used value is the intermediate value, and sometimes the maximum value and the minimum value are used.

Wavelet analysis is used to filter image noise. Firstly, the image signal is decomposed into multiple scales by wavelet transform. At each scale, the wavelet coefficients belonging to noise are removed and the wavelet coefficients belonging to signal are retained. Because the noise is mainly distributed on the high frequency components of the image, only the high frequency coefficients can be processed to filter out the noise.
Generally, three high-frequency components decomposed from each layer can be processed by soft threshold, and the specific method is as follows.

\[
W_j^\prime(x, y) = \begin{cases} 
0 & \|W_j^\prime(x, y)\| \leq T \\
W_j^\prime(x, y) - T & \|W_j^\prime(x, y)\| > T 
\end{cases}
\] (1)

The research object can be separated from the background by setting the threshold between the color value of the background point and the color value of the research object. Usually, only the threshold value of one color in RGB can be used to separate the research object. For images with complex color distribution, RGB can be used for segmentation. \(F(x, y)\) represents any one of \(R(x, y), G(x, y), B(x, y)\), and the segmentation is carried out according to formula 2).

\[
f(x, y) = \begin{cases} 
1 & F(x, y) \geq T \\
0 & F(x, y) < T 
\end{cases}
\] (2)

According to the validity of edge detection and the reliability of location, Canny studied the characteristics of the optimal edge detector and deduced the mathematical expression of the optimal edge detector. However, this method is greatly affected by the environment, and the different temperature and humidity of the underground mining machinery in the same oilfield will cause great differences in the detection results; Image feature extraction is to measure, recognize or understand the object through the image, and rely on some features that can over-characterize the image object, such as lines, edges, regions, colors, textures and so on. In order to suppress noise and improve image quality, it is necessary to smooth the image. These signals can be converted into required electrical signals by CCD driving circuit (usually adding line and field synchronization signals to convert them into full TV signals), and then output to analog display or image acquisition card to be converted into digital signals for computer processing. The median value of the gray value obtained after the above two steps replaces the gray value of the far pixel in the middle position in the original frame.

4.2. Parallel edge detection

Different images have different gray scales, and there are obvious edges at the boundary, which can be used to segment images. Therefore, it is very important for support vector machines to solve nonlinear problems. There are many types of selected templates mentioned, such as square, curve and cross. A learning machine developed from the linear separable optimal classification plane, its purpose is to separate the training samples of the two categories to the greatest extent through the obtained linear classification hyperplane, and at the same time make the edge of the hyperplane as large as possible and minimize the expected risk. Projection imaging from three-dimensional to two-dimensional will inevitably lose some information; In addition, the illumination and noise in the imaging process are also inevitable and important factors. In the two-dimensional case, the directional property of Canny operator makes the performance of edge detection and location better than that of M-H operator, has better edge strength estimation, and can generate two information of edge gradient direction and strength, which provides convenience for subsequent processing.

In this paper, the cross median filter is used to remove stripes, and the 5×5 window is the best through the smoothing test of the moving seed image. After cross filtering, the output result is:
\[ g(x, y) = \left( \frac{1}{10} \sum_{m=-2}^{2} f(x-m, y) + \sum_{n=-2}^{2} f(x, y-n) \right) \]  

In which, \( g(x, y) \) is the gray value of the processed image; \( f(x, y) \) is the gray value of the image before processing;

This paper presents an improved method based on the traditional Prewitt algorithm for image enhancement. Through the analysis and comparison of this algorithm, it shows that this algorithm is an effective enhancement algorithm for low contrast noise images, and it is easy to meet the requirements of real-time processing. The improved algorithm is

\[ g(x, y) = \begin{cases} \Delta x / 3 & |\Delta x| \geq |\Delta y| \\ \Delta y / 3 & |\Delta x| < |\Delta y| \end{cases} \]  

Testing the uniformity of oilfield underground mining machinery by image texture analysis mainly uses image processing and pattern recognition technology to automatically analyze and judge the uniformity of blackboard image, so that the classification of blackboard can be automatically executed. The purpose of image enhancement is to improve the visual effect of the image or transform the image into a more suitable form for analysis and processing by machines. In addition, the independent image processing software package can realize all the functions of the traditional image card. In this way, an image acquisition card which makes full use of the above technology came into being, and it became a multimedia card. The method of filtering masking simulation is used to determine the average gray value of pixels in the image to replace the gray value of each pixel in the image, so that the gray value of the image is presented smoothly and the abnormal gray value of the image is reduced. Histogram is used in finding the best lighting conditions for capturing images, changing gray scales and segmenting images into objects and backgrounds. The same histogram may correspond to several images.

5. Conclusion

In this paper, the ferrographic wear particle image and its shape feature vector parameters are taken as the research object, and the pattern recognition is carried out by using computer image processing technology and support vector machine method, so as to judge the cause of mechanical failure. In this paper, image smoothing, median filtering, edge detection and other technologies are organically combined to effectively reduce the influence of noise in the original ferrography image. The Canny algorithm is used to extract the contour of oil field underground mining machinery parts, and a specific algorithm is designed to locate the contour curve, which completes the image processing and detection functions of oil field underground mining machinery parts. Pretreatment can reduce the workload of image segmentation and analysis on the premise of retaining useful information of images. The optimal threshold segmentation method can accurately segment images and automatically identify two kinds of defects.

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