Object Detection on Underground Low-quality Images

Qi Mu¹, Zhiqiang He²*, Yankui Liu³ and Yu Sun⁴

¹ Collage of computer science and technology, Xi’an University of Science and Technology, Xi’an, Shaanxi, 710054, China
² Collage of computer science and technology, Xi’an University of Science and Technology, Xi’an, Shaanxi, 710054, China
³ Collage of computer science and technology, Xi’an University of Science and Technology, Xi’an, Shaanxi, 710054, China
⁴ Collage of computer science and technology, Xi’an University of Science and Technology, Xi’an, Shaanxi, 710054, China

*Corresponding author’s e-mail: nnkajima@163.com

Abstract. Because of the insufficient illumination and dark environment, the underground image has little difference between the object and the background, and there will be irregular high-light spots, which will have a huge impact on the object detection. The commonly used methods for underground object detection are frame difference method, background difference, etc [1-3]. Both the frame difference method and the background difference method cannot accurately detect the object due to the influence of noise and image quality. This paper uses image enhancement technology to improve the quality of underground image, and proposes a comprehensive object detection method that is more robust to noise, and our algorithm can eliminate the influence of high-light point and improve the detection accuracy.

1. Introduction

Underground object detection is the basis of the current underground video security supervision. At present, the object detection method for underground mainly adopts the frame difference method and the background difference method. The frame difference method performs differential operation on two adjacent frames, and the difference result indicates the amount of gray value change of the corresponding position in the two frames. By setting an empirical threshold, the region with large change of gray value is extracted as the detected object. The frame difference method is sensitive to non-object grayscale changes in the image, such as illumination changes and image noise effects. The background difference method is to extract the object in the object frame by using the difference result between the object frame and the background frame. This method needs to establish a reliable background and consider the selection and update of the background. In the underground video, the difference between the object and the environment is not great, and affected by the underground environment, the image noise changes are obvious, and the illumination changes are not estimable. Therefore, the frame difference method or the background difference method cannot detect the object completely.

We now review existing work on object detection of coal mines. Due to the characteristics of underground video, there are two traditional methods. One is background difference, and another is establishing a more accurate object expression. Zhang Xiehua [4] proposed an adaptive background...
modeling and updating method based on clustering technology, through statistical methods, according to a certain period of time. The change of the pixel value of a point to determine whether the point is the background, this method can adapt to the background change, but it is easy to judge the background pixel as the foreground for the scene with large variation of the underground image noise. Zhang Chen [5] proposed one object detection method based on robust fuzzy kernel clustering. The background and foreground are distinguished by judging the distance between the pixel feature vector and the background subclass. However, this method cannot adapt to sudden spot changes. It is easy to detect an area with a large change in pixel value such as a spot as a foreground object. Cai Limei [6] proposed the idea of checking the position of the person in the well according to the helmet. The helmet is a prominent feature of the miners. This feature can better distinguish the object. And the background, but this method can only find the helmet in the video frame, but not detect the whole body, and the individual helmets are relatively small and easily occluded, and the helmet would not be positioned by the helmet after the occlusion.

Aiming at the particularity of the underground environment, the combination of underground image enhancement and traditional object detection is used to weaken the influence of underground noise on object detection, and multi-threshold segmentation method is used to eliminate the illumination changes around the object to achieve accurate object detection.

2. Proposed approach

Firstly, the frame difference method is used to determine the region of interest, and the interference of illumination variation is reduced. Then the region is compared with the background model. Because the spot is relatively bright relative to the object, the differential image is doubling thresholded to eliminate the interference of the spot. The algorithm flow fig is as follows:

![Algorithm Flow Diagram](image)

Figure 1. The framework of object detection on underground low-quality images

2.1. Image enhancement

The underground image is affected by the illumination, contains a lot of salt and pepper noise and Gaussian noise, the noise is randomly distributed, and presents an unpredictable change state, so it is impossible to design a targeted filtering method. Wavelet transform has the characteristics of low entropy, multi-resolution, decorrelation and flexibility of selecting wavelet base [7]. It has good localization characteristics in the process of processing images. By using different parameters, it can focus on any detail of the object [8]. Therefore, in the process of processing underground image noise, wavelet transform is used to denoise, which weakens the influence of noise on object detection to some extent.

The artificial lighting method causes the underground image to be extremely uneven and bright. The brightness of the part close to the light source is close to 255, the brightness is close to 0 from the far side, the overall brightness is dark, the contrast is poor, the imaging is uneven, and the details are
blurred. Poor image quality results in increased difficulty in mining useful information from images. In order to obtain high-quality images, improve video readability, and improve the accuracy of subsequent processing algorithms, it is necessary to enhance the underground image to highlight its usefulness. In order to improve the difference between light and dark in the image, the histogram equalization is used to evenly distribute the gray value of the image, to brighten the darker region, and to limit the influence of the highlight point with large gray variation on the local region.

2.2. Object location determine

The frame difference method can be used to roughly determine the position of the moving object in the image, which is the first step to achieve accurate object detection. The frame difference method makes the difference between two adjacent frames or multiple frames in the video sequence, the background regions substantially cancel each other, and the regions where the moving objects appear are greatly different, and the position of the moving object can be detected. The basic formula for the two-frame difference is as follows:

\[
D_k(x, y) = |I_k(x, y) - I_{k-1}(x, y)|
\]

\[
T_k(x, y) = \begin{cases} 
1, & D_k(x, y) \geq Y \\
0, & D_k(x, y) < Y 
\end{cases}
\]

\[
(1)
\]

\[
(2)
\]

\(T_k\) is differential foreground image, \(Y\) is differential threshold. A reasonable threshold is set according to the amount of change in the pixel value of the image target area, thereby dividing the image foreground object.

The frame difference method yields a binary image that generally contains non-object regions that cause grayscale changes due to environmental factors. These regions are erroneously detected during this process, so it is also important to exclude these erroneous regions. By image etching, a better binary image is created.

2.3. Double threshold background difference

After getting the approximate position of the object, we need to get a more complete representation of the object. In general, the background difference method is a more effective object detection method. This method is simple to calculate, easy to implement, can detect object in real time, and can detect relatively complete moving object.

In the special environment of underground mines, a large amount of artificial illumination is used, and the position and height of the light source are changing. The change of light and dark caused by the change of the light source is difficult to be eliminated. The spot is brighter, the gray value is basically above 240, the underground object is generally dark, and the gray value is lower, so the difference between the spot and the background model is greater than the difference between the object and the background model.

The original image is distinguished from the background image to obtain a difference image, and the difference image is judged using a double threshold. Therefore, the improved background difference method is called a double threshold background difference method. Set two thresholds, the former to distinguish between the object and the background, and the latter to distinguish between the object and the spot. The double threshold method can be used to eliminate the interference of the spot on the object detection, which is expressed by the following formula:

\[
W(x, y) = \begin{cases} 
1, & T_i \geq D(x, y) \geq T_0 \\
0, & Other 
\end{cases}
\]

\[
D(x, y) \text{ is background difference image, } T_0 \text{ and } T_i \text{ are threshold, } W(x, y) \text{ is binary image.}
\]

\[
(3)
\]
3. Experiments
In this section, we present and discuss the result of our algorithm. We use our algorithm in some underground videos that contain moving objects and spot changes, and we find that our algorithm detection results are more accurate than traditional algorithmic results.

![Figure 2. Experimental results](image)

Experimental results are divided into three parts. (a)(b), input image and fixed background. (c)(d), the image enhancement results of the input image. (e)(f), the result of the initial positioning of the object. (g)(h), the final results of traditional algorithms and our algorithms.

4. Conclusion
In this paper, we apply image enhancement algorithms to precise object detection tasks for underground low-quality images, and reduce the impact of image noise and illumination on object detection. During the experiment, it was found that the spot change caused by artificial illumination had a great influence on the object detection. Therefore, the double threshold background difference method was used to eliminate the influence of the spot, and the experimental results performed well on some images. However, since the gray level change of the spot area approximates a continuous process, simply introducing multiple thresholds does not completely eliminate the spot. Therefore, the
spot elimination and filling need to explore a better algorithm to further improve the accuracy of the underground object detection algorithm.

Acknowledgments
This work is supported by Scientific and Technology Program Funded by Xi’an City (Program 2017079CG/RC042(XAKD003))

References
[1] Chen, J.C., Zhang, J.H., Liu, S.J. (2011) Improved object detection algorithm based on background modeling and frame difference. Computer Engineering, S1: 171–173.
[2] Xue, L.X., Luo, Y.L., Wang, Z.C. (2011) Adaptive moving object detection method based on frame difference. Application Research of Computers, 04 : 1551-1552+.
[3] Shen, Y., Wang, X.X. (2017) Video moving object detection method based on background subtraction and frame difference method. Automation & Instrumentation, 04 : 122-124.
[4] Zhang, X.H., Zhao, X.H. (2016) Research on Moving Object Detection in Coal Mine Intelligent Video Surveillance. Industry and Mine Automation, 04: 31-36.
[5] Zhang, C. (2013) Research on Object Detection and Tracking in Underground Environment. China University of Mining and Technology.
[6] Cai, L.M. (2010) Research on Human Detection and Tracking in Underground Coal Mine Video. China University of Mining and Technology.
[7] Zhang, X., Zhang, D.H., Zhang, X.X., Zhang, J.P. (2006) Image Denoising Based on Wavelet Transform. Chinese Journal of Scientific Instrument, S3: 2284-2286.
[8] Donoho, D.L., Johnstone, I.M. (1994) Ideal spatial adaptation by wavelet shrinkage. Biometrika, 81: 425-455.