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Railway construction site safety hidden danger identification method based on machine vision

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Abstract: *In order to achieve accurate identification of safety hazards at railway construction sites, taking a railway engineering project as an example, machine vision technology was introduced to design a method for identifying safety hazards at railway construction sites. In this study, the images of key monitoring areas are first collected, input into the computer, and preprocessed. Then, the scene model of the construction site is constructed through the camera and infrared thermal imaging acquisition equipment, and the image background model of the dangerous area is established by referring to the Gaussian model. Finally, the image carrying the background is input, and the image is matched with the time series. The identification conditions of construction site dangerous areas are set up to realize the identification of hidden danger points in the background of dangerous point image. Comparative experimental results show that this method can improve the identification rate of safety hazards in railway construction sites.*

Keywords: *Machine vision; Railway engineering; Scene model; Identification method; Hidden danger; Construction site*

1. Introduction

In the in-depth investigation of a construction project site, it is found that there are a large number of potential safety hazards in most engineering construction, which involve many dangerous entities such as site workers, large machinery and equipment, engineering materials, as well as physical attributes of external characteristics such as distance and weight, as well as complex time and space relationships between various dangerous entities and their attributes. The site construction environment is characterized by complexity and crisscross [1]. Because of this, it is easy for the site management personnel and technicians to be distracted or negligent in their work, and it is difficult to realize the overall control on the site, thus increasing the hidden dangers of the site construction, such as high fall, blow damage, mechanical damage, etc. The safety risks mentioned above are highly professional and sudden. In addition, more than 90% of the safety risk information on the construction site is obtained through visual information. Most of the newly entered construction safety management personnel and construction site staff lack a large amount of knowledge reserve and practical work experience, even if the hidden dangers found on the site, It is also easy to neglect due to subjective factors, or turn a blind eye to hidden security risks. The inability to effectively investigate or accurately identify potential safety hazards at the construction site undoubtedly lays a time bomb for onsite construction operations. Once an uncontrollable safety accident occurs, it will not only affect the earnings of the construction party, but also pose a threat to the personal safety of onsite construction workers. In response to this issue, this article will take a railway engineering project as an example and introduce machine vision technology to design a safety hazard identification method for railway construction sites. The purpose of this design is to achieve high precision screening of onsite safety hazards and reduce the occurrence of safety accidents caused by onsite safety hazards.

2. Global scanning of railway construction site and image processing of key monitoring areas

In order to realize accurate identification of safety risks on the construction site and railway construction site in this process, global scanning of the construction site should be carried out first [2]. In this process, the construction site of railway engineering project should be regarded as an environment with complex scene characteristics. In order to realize the collection of details in the environment, mobile cameras are used to shoot moving targets in the scene. In the shooting process, considering that there is a certain relative movement behavior between the camera and field workers and technicians, the foreground and background targets in the images collected by this method have the characteristics of relative movement [3]. In order to realize the delineation of the key monitoring area in this process, it is necessary to find the moving target of interest in each frame of the monitoring picture in a continuous video sequence and collect the image of the key monitoring area through the detection of the moving target.

After completing the global scanning of the railway construction site and image acquisition of key monitoring areas, the image is input into the computer, where the preprocessing of the captured image of the construction site is performed. This process is shown in the following calculation formula.

$$\mu_i(t)=\frac{\alpha_i(t-1)}{\alpha_i(t-1)+1}\cdot\mu_i(t-1)+\frac{1}{\alpha_i(t-1)+1}\cdot M_i(t) \tag{1}$$

In formula (1), μ represents the preprocessing of images collected at the construction site; t represents the image acquisition timing point; i represents the number of image frames; α represents model matching; M represents the construction scenario. After completing the above processing, motion compensation is performed for the scene in the image. During the compensation process, Gaussian filtering and median filtering methods are used to filter the noise in the preprocessing image. After filtering, a dynamic sequence of images is generated based on the motion speed of the movable camera and the time series of images collected [4]. During this process, attention should be paid to image registration, converting a dynamic background image sequence into a static background image sequence, and performing motion compensation on the converted image. In this way, global scanning of the railway construction site and image processing for key monitoring areas can be achieved.

3. Establishing a scene model of railway construction site based on machine vision

On the basis of the above design content, machine vision technology is introduced to construct the scene model of the construction site through cameras and infrared thermal imaging acquisition equipment [5]. The scene image entry process of railway construction site based on machine vision is shown in Figure 1 below.

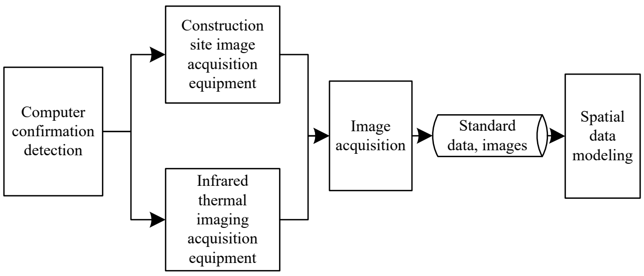

Figure 1: Image input of railway construction scene based on machine vision

In the modeling process, machine vision is used to collect image information in three different directions, establish spatial parameter points, which are expressed as (x,y,z), extract information in three directions of (x,y,z) based on machine vision, and establish spatial data model, as shown in the following calculation formula.

$$V_x=\frac{\sum_{i>1}^{n}x_i\times ms_i}{\sum_{i>1}^{n}ms_i} \tag{2}$$

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$$V_y = \frac{\sum_{i>1}^{n} y_i \times ms_i}{\sum_{i>1}^{n} ms_i} \tag{3}$$

$$V_z = \frac{\sum_{i>1}^{n} z_i \times ms_i}{\sum_{i>1}^{n} ms_i} \tag{4}$$

In the formula: (V_x, V_y, V_z) represents the spatial coordinate point of the railway construction site scene; m represents a nonlinear continuous function representation of visual information; s_i represents the mapping of data in space. Set the interface center point within the visual perception range, and establish a railway construction site scene model based on machine vision according to the visual convergence accuracy. The model expression is shown in the following calculation formula.

$$J = \sum_{i>1}^{n} \sum_{j>1}^{l} \left\| \phi(r_i) - \phi(v_j) \right\| \tag{5}$$

In Formula (5), J represents the scene model of railway construction site; l represents the farthest distance of visual perception; j stands for minimizing distance objective function; ϕ represents group annotation clustering area; r represents radius of visual perception range; v is the speed of observation data movement. According to the above methods, the railway construction scene model based on machine vision is completed.

4. Identification of hidden danger points in the background of the image

Based on the above content and referring to the Gaussian model, a background model of dangerous area images is established, and parameters are trained according to the background color distribution. In this process, the image carrying the background is inputted and matched with the time series. To reduce the computational complexity of image background modeling, the inputted image is divided into $N \times N$ grids, in which the security risk warning boundaries for different objects and observation objects are set. The relevant content is shown in Table 1 below.

Table 1: Hazardous Area Identification Conditions at the Construction Site

Order number	Hazardous areas	Identification conditions	Hazard type
(1)	Railway foundation pit	Extension length of foundation pit>2m	Caving in
(2)	Railway tunnel	External expansion of outer edge of tunnel portal>0.5m	Falling from height
(3)	Railway border	Altitude>2m	Falling from height
(4)	Construction machinery	Working status (set according to the specific situation on site)	Collision or impact damage
(5)	Tower crane	Rotation state radius>2m	Collision or impact damage
		Contour expansion in suspended state>2m	Mechanical collision damage

When the realtime collected image feedback information is consistent with the identification conditions, a terminal warning is triggered. In this way, the identification of hidden danger points in the image background of dangerous points is realized, and the design of a machine vision based safety hazard identification method for railway construction sites is completed.

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5. Comparative experiment

From the above three aspects, completed the railway construction site safety hidden danger identification method design based on machine vision, in order to realize the identification effect of the method in practical application test, the following will take a large railway engineering project in a region as an example, using the way of design comparison experiment, to test the method.

According to the needs of relevant work, this experiment uses the Windows system as a support, and all operation images and construction images collected on site need to be entered into the computer for processing. To ensure that the experimental results meet the requirements, configure the experimental environment according to Table 2 below.

Table 2: Comparative Experimental Environment Configuration

Order number	Item	Parameter
(1)	Operating system	Windows 10
(2)	Data Image Acceleration Environment	CUDA10.1
(3)	Computer running memory	16G
(4)	Computer Programming Language	Python 3.8
(5)	GPU	RTX2070/GeForce
(6)	CPU	CPU @ 2.90GHz/Intel(R) Core(TM)i5-10400F

On the basis of the above content, the railway construction site images are collected. According to the statistics of the computer terminal, a total of 10,000 railway construction site images are collected, 8000 of which are used as the training set, and 2000 of which are used as the test set.

During the identification process, first conduct global scanning of the railway construction site and image processing of key monitoring areas, introduce machine vision technology, establish a scene model of the construction site, and complete the identification of safety hazards on the construction site through image background modeling and hidden danger point identification. After completing the above research, the identification method based on SBAS-InSAR technology and the identification method based on YOLO V5 were introduced. The two proposed methods were used as traditional method 1 and traditional method 2, and three methods were used to identify potential safety hazards at the construction site.

In order to measure the identification effect of the design method on the site security hidden danger in practical application, the security hidden danger targets in the test image set are identified. The identification rate is calculated by the following formula.

$$k = \frac{n_t}{n_a} \tag{6}$$

In formula (6), k represents the identification rate of potential safety hazards at the railway construction site; n_t represents the correctly identified quantity; n_a represents the total number of safety hazard targets in all images. According to the above method, the statistical comparison experiment results are shown in Figure 2 below.

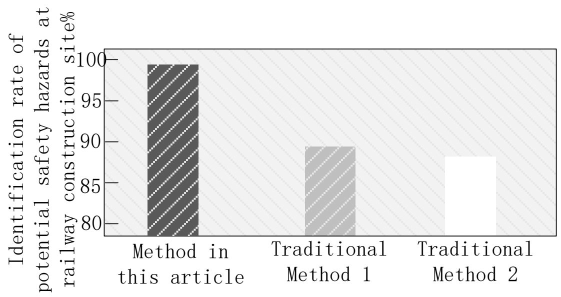

Figure 2: Identification Results of Safety Hazards at Railway Construction Site

From the experimental results shown in Figure 2 above, it can be seen that using this method to identify safety hazards on railway construction sites, the identification rate of safety hazards is about 99%, while using traditional method 1 and traditional method 2 to identify safety hazards on railway construction sites, the identification rate is less than 90%. Therefore, after completing the above experiments, the conclusion is as follows: Compared to traditional methods, the method for identifying potential safety hazards in railway construction sites designed in this paper based on machine vision has a good effect in practical applications. This method can improve the identification rate of potential safety hazards in railway construction sites. In this way, the occurrence of safety accidents in onsite construction can be controlled, providing safety assurance for onsite construction operations.

6. Conclusion

At the present stage, most of the safety hazard identification work of engineering projects is manually completed by managers with rich experience. However, according to a lot of feedback, the application effect of this identification method cannot reach the expectation at all, and even there will be a large deviation between the identification results and the real results, thus increasing the problem of site construction safety hazards. In order to solve this problem and realize accurate identification of safety risks on the site, this study takes a railway engineering project as an example, introduces machine vision technology, through the railway construction site global scanning and key monitoring area image acquisition and processing, construction of railway construction site scene model, dangerous point image background modeling and hidden point identification, to complete the design. After the comparison test, it is proved that this method can improve the identification rate of railway construction site safety hazards, and control the occurrence of safety accidents in the construction site in this way. Therefore, we can try to put the method designed in this paper into use in the subsequent work according to the specific needs of site construction management and risk control. In this way, we can realize the high-precision investigation of safety risks on the construction site.

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