Intelligent early warning of on-site safety of infrastructure projects based on dynamic risk factor identification

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Abstract. In order to realize the effective early warning of the site safety of infrastructure projects, it is necessary to carry out in-depth analysis of the early warning methods, so an intelligent early warning of the site safety of infrastructure projects based on the identification of dynamic risk factors is proposed. The dynamic risk factor identification method is used to analyze the mutual influence of risk factors on the site of infrastructure projects. The data attribute correlation analysis structure is constructed, and the on-site safety early warning information of infrastructure projects is analyzed digitally. On this basis, the risk event level standard is set to realize the dynamic risk early warning in the construction process of infrastructure projects. The experimental results show that the results of on-site safety intelligent early warning of infrastructure projects obtained by the proposed method are basically consistent with the real results, and the safety intelligent early warning results with higher accuracy and efficiency can be obtained, and the safety factor of the nearby environment can be effectively detected, and the early warning effect is good.

Keywords: Identification of dynamic risk factors; Infrastructure projects; Site safety; Intelligent early warning;

1 Introduction

With the acceleration of urbanization, infrastructure projects have become an important factor to promote social progress [1]. However, in the process of infrastructure construction, security has always been a key challenge [2]. Accidents may not only lead to casualties and property losses, but also have a negative impact on the progress of the project and social stability. In order to solve this problem, more and more countries begin to adopt intelligent technology to improve the safety early warning ability of infrastructure projects.

Reference [3] puts forward the early warning of safety in the construction site of capital construction projects by combining computer vision and semantic reasoning,

B. K. Kandel et al. (eds.), *Proceedings of the 2023 8th International Conference on Engineering Management (ICEM 2023)*, Atlantis Highlights in Engineering 23,
https://doi.org/10.2991/978-94-6463-308-5_30

and promotes safety management through semantic reasoning and corresponding mitigation. By comparing the visual information extracted from architectural images with the predefined SWRL rules, we can infer the dangers and corresponding mitigation measures. Taking falling from a height as an example, the theoretical and technical feasibility of the conceptual framework is verified. The results show that the proposed framework is similar to the thinking mode of safety managers, and the identification and prevention of on-site hazards can be promoted by semantic reasoning of hazards from images and listing corresponding mitigation measures. Reference [4] puts forward the research of building engineering safety early warning based on BP neural network. An adaptive learning algorithm with additional momentum is introduced to optimize and improve the model. Through the simulation analysis of 10 groups of sample data by MATLAB, it can be seen that the proposed construction engineering safety early warning model has good convergence and accuracy, and can be applied to specific engineering practice.

During the intelligent early warning of the site safety of capital construction projects, it is necessary to obtain and analyze various risk factors at the project site, and give an alarm in time to ensure the safety of staff. Through a comprehensive analysis of these factors, we can quickly and accurately warn the potential safety risks and take timely measures to avoid accidents. This paper puts forward an intelligent early warning method for site safety of infrastructure projects based on dynamic risk factor identification to further promote the combination of intelligent technology and infrastructure construction, which can effectively improve the safety and sustainable development level of infrastructure projects and create a safer, more convenient and more reliable environment for people.

2 Intelligent early warning of on-site safety of infrastructure projects based on dynamic risk factor identification

2.1 Coupling effects between dynamic risk factors

The occurrence of construction accidents in infrastructure projects is often caused by the mutual coupling of multiple risk factors. The dynamic risk factor identification method is used to carry out the on-site safety early warning of infrastructure projects and analyze the mutual influence of the on-site risk factors of infrastructure projects [5]. The details are as follows:

Assuming that A and B represent two risk factors in the field operation space of infrastructure projects [6], C_i represents the mutual influence between the two risk factors A and B in the matrix C, and n represents the number of factors, then the relationship between C and C_i can be expressed as: $C=\left(C_i\right)_{n\times n}$.

Normalizing the matrix C to obtain the normalized matrix C':

$$C' = A \times B \times \frac{C}{\sum_{i=1}^{n} C_i} \tag{1}$$

On the basis of normalized matrix, the coupling influence relationship between influence degree E and affected degree F is calculated as follows:

$$\begin{cases} E = \left(G_k + H_k\right) \times \sum_{i=1}^{n} u_i \times C' \\ F = \left(G_k - H_k\right) \times \sum_{i=1}^{n} u_i \times C' \end{cases} \tag{2}$$

In formula (2), G_k represents the mutual influence of other risk factors on risk factor k when they are influenced by k factor; H_k indicates the degree to which other risk factors are affected by the risk factor k at the site of the infrastructure project; u_i indicates the importance in the overall influencing factors; From this, we can infer the coupling influence between the dynamic risk factors of the infrastructure project site.

2.2 Data analysis of on-site safety early warning information of capital construction projects

Before the safety early warning information of the construction site is digitized, in order to ensure the accuracy of the digitized results, the collected data information is analyzed. Considering that there are many links in the infrastructure project site, the construction project is complex, and the attributes of different projects are quite different, it is necessary to analyze the attributes of the collected data in the construction site to ensure that the key attributes of the collected data are not disturbed by other factors, and reduce the calculation pressure of the subsequent early warning algorithm [7]. At the same time, the correlation between the collected data with different attributes needs to be kept low enough to provide as much effective early warning information as possible with as little calculation as possible.

Collecting construction samples, establishing a risk data sample set U of the infrastructure project site, setting the possibility of accidents as λ [8], the frequency of danger of construction workers as η, and the consequences as κ, obtaining the risk evaluation index of the infrastructure project site through evaluation, and analyzing the early warning information according to this index, the data attribute correlation analysis process is shown in Figure 1.

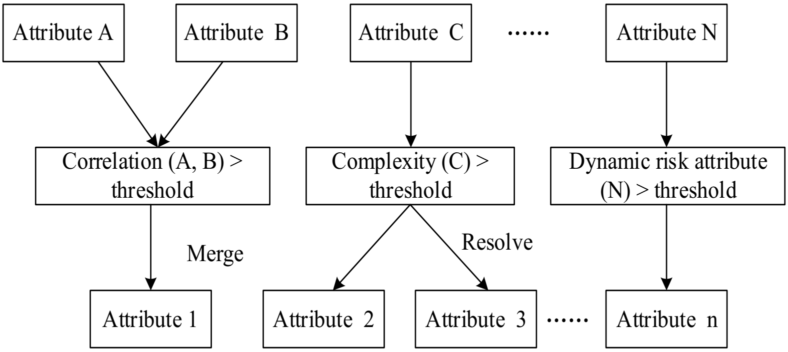

Fig. 1. Structure diagram of data attribute correlation analysis

According to Figure 1, the correlation degree of any two data attributes in the collected data is detected, and if the detected correlation degree is greater than the threshold, the data can be merged; If the complexity of the data is greater than the threshold, the data attribute needs to be decomposed; If the dynamic risk attribute is greater than the threshold, the corresponding attribute value is directly output. Through the above decomposition and merging processing, the final attribute vector is combined.

2.3 Realize the dynamic risk early warning in the construction process of capital construction projects.

Based on the complex site environment of capital construction projects, construction accidents are usually caused by the interaction of multiple dynamic risk factors. The coupling of dynamic risk factors causing accidents is called occurrence coupling, and the probability of accidents caused by occurrence coupling is calculated [9-10]. Assuming that the risk entropy of event z is M_z and the occurrence probability is N_z, the relationship between M_z and N_z can be expressed by formula (3):

$$M_z = \ln N_z \times E \times F \tag{3}$$

Using Formula (3) to calculate the risk factors in the risk assessment system, combining with the expert opinions and the relevant regulatory documents of engineering construction risk assessment, according to the property losses and casualties caused by risk entropy and the probability of risk accidents, the construction risk accidents of infrastructure projects identified by multi-risk factors are classified into five grades, and the specific rating standards are shown in Table 1.

Table 1. Standard Table of Risk Event Level

Risk level	Probability of occurrence/%	Qualitative description content
1	0-1	Negligible
2	2-40	To be considered
3	41-60	serious
4	61-80	Very serious
5	81-100	disastrous

According to the classification of risk levels in the construction process of infrastructure projects, effective monitoring of site risk accidents of infrastructure projects can be completed, and real-time early warning of potential safety hazards in the construction of infrastructure projects can be issued to avoid the occurrence of potential accidents.

On the basis of the above-mentioned risk event grading, the intelligent early warning of on-site safety of infrastructure projects is realized, and the specific calculation formula is shown as follows:

$$K=\frac{k\times\left(p_i-q_i\right)}{M_z} \tag{4}$$

In formula (4), K represents the output warning value, k represents the warning coefficient[11], p_i represents the expected output, and q_i FF represents the predicted output. Through the above formula, the intelligent early warning value of on-site safety of infrastructure projects is obtained. According to the early warning value, the situation of the infrastructure project site is judged, and the dynamic risk early warning in the construction process of the infrastructure project is realized.

3 Experimental analysis

In order to verify the effect and effectiveness of the intelligent early warning of the site safety of infrastructure projects based on dynamic risk factor identification, an experimental test was carried out. Build a virtual environment of infrastructure project site through reasonable layout, and simulate the real infrastructure project site, including buildings, equipment, personnel and other elements. Install sensors and monitoring equipment to collect data of risk factors such as temperature, humidity, PM2.5 concentration and noise, and monitor and record them in real time; Then the relevant experimental parameters are set, and the specific settings of the experimental parameters are shown in Table 2.

Table 2. Experimental Parameter Settings

Serial number	Experimental parameters	Parameter setting
1	processor	Intel Xeon E3-1220v53.0GHz
2	internal storage	8G
3	hard disc	1*Intel SSD,1*SATA 1T
4	Tester CPU	Intel Xeon E53.0GHz
5	operating system	Windows 10
6	Development tools	Visual Studio Code 1.51.1
7	Experimental platform	Spark architecture

As shown in Table 2, under the setting of the above experimental parameters, according to the possible risk factors of infrastructure projects, a certain number and types of risk factors are set, and corresponding thresholds are specified for each factor. At the same time, an intelligent early warning mechanism is designed to judge whether to trigger early warning according to the collected risk factor data and the set threshold; The experiment compares the proposed method, the method of reference [3] and the method of reference [4] to carry out experimental tests and determine different levels of early warning.

Whether the early warning result is correct or not is an important basis to decide whether the on-site safety intelligent early warning of infrastructure projects can be carried out smoothly. The experiment gives priority to analyzing the deviation between the intelligent early warning results of different methods and the real early warning level. The detailed experimental test results are shown in Figure 2.

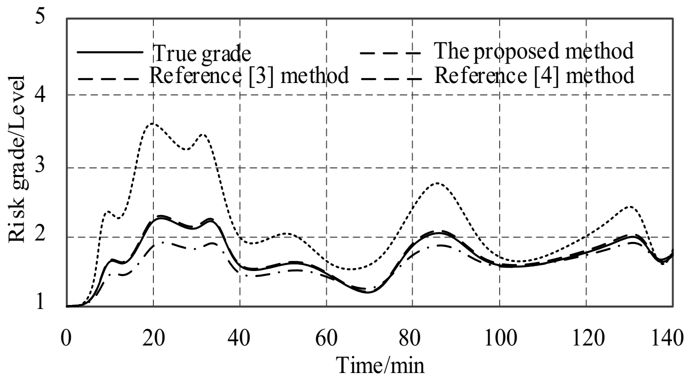

Fig. 2. Comparison results of deviation between intelligent early warning results and real early warning levels under different methods

From the analysis of Figure 2, it can be seen that the results of on-site safety intelligent early warning of infrastructure projects obtained by the proposed method are basically consistent with the real results; There is a certain deviation between the on-site safety intelligent early warning results of infrastructure projects obtained by the method of reference [3] and the real results, and the deviation is large within 10 to 40min minutes, which needs to be further improved; The method of reference [4] in the process of intelligent early warning of site safety of infrastructure projects, the obtained early warning result value is lower than the real result. To sum up, the proposed method can get more accurate and efficient intelligent early warning results of on-site safety of infrastructure projects.

In the process of on-site safety intelligent early warning of infrastructure projects, the safety factor of the nearby environment is set to, and the interval is [0,1]. The higher the safety factor, the better the effect of on-site safety intelligent early warning of infrastructure projects. The proposed method, reference [3] method and reference [4] method are compared with the actual environmental safety factor, and the test results are shown in Figure 3.

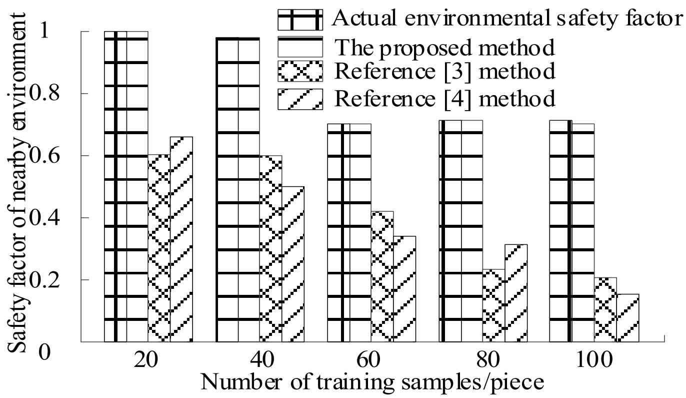

Fig. 3. Test results of safety factor in different identification methods

From the analysis of Figure 3, it can be seen that the safety factor of the nearby environment detected by the proposed method in risk early warning is basically consistent with the actual environmental safety factor. The other two reference methods are biased in early warning. To sum up, the proposed method can effectively detect the safety factor of the nearby environment during intelligent early warning, and the early warning effect is good.

4 Conclusion

This paper puts forward an intelligent early warning method for the site safety of infrastructure projects based on dynamic risk factor identification, which realizes real-time early warning of various risk factors on the site of infrastructure projects and provides strong support for the safety of staff. Through analysis, this paper draws a conclusion: the results of the on-site safety intelligent early warning of infrastructure projects obtained by the proposed method are basically consistent with the real results, and can obtain the safety intelligent early warning results with higher accuracy, and at the same time, it can effectively detect the safety factor of the nearby environment, and the early warning effect is good.

However, the intelligent early-warning method for site safety of infrastructure projects faces some challenges in the implementation process. These include technical issues such as sensor accuracy, data processing and algorithms, and solving these challenges requires the support of technology research and development. The future research trend is to further improve the stability of the method, improve the management mechanism, and promote the wide application of this method in the field of infrastructure construction.

Acknowledgments

The study was supported by "Research and application of key technologies of infrastructure integrated control and early warning based on knowledge reasoning(Grant No. 5700-202256191A-1-1-ZN)".

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