Construction Risk Monitoring Method of Subway Foundation Pit Engineering Based on Simulated Annealing Neural Network

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Abstract. Traditional subway foundation pit engineering construction risk monitoring methods have slow convergence speed when solving large-scale practical problems, which affects the accuracy of monitoring. Therefore, a subway foundation pit engineering construction risk monitoring method based on simulated annealing neural network is designed. By identifying the accident risk sources of foundation pit engineering, understanding the accident causes and prevention mechanism among human, machine and environment, the classification of risk sources of foundation pit engineering is obtained, and the safety risk monitoring index system is constructed. The monitoring indicators are analyzed in detail, and the annealing neural network is optimized, and the process of double-layer simulated annealing algorithm is designed to realize risk monitoring. In the case simulation experiment, the designed monitoring method and the traditional method are used to monitor the project. The monitoring experimental results show that the proposed method can accurately predict the deformation of the subway tunnel through the monitoring data of the deep foundation pit construction adjacent to the existing subway tunnel.

Keywords: Simulated annealing neural network · Subway foundation pit · Construction risk monitoring

1 Introduction

With the rapid development of cities and the growth of urban population, the development and utilization of underground space is a more effective way to open up the living space of human beings. Urban underground railways, underground factories, underground garages, underground commercial streets, underground substations, underground shopping malls, underground warehouses, underground civil air defense projects, municipal underground engineering, and military underground engineering have increased [1].

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Whether it is the construction of the subway project of municipal engineering or the construction of the deep foundation of high-rise buildings, all of them involve the excavation of the foundation pit project, of which the foundation pit project of the subway station is one of the main manifestations. In view of the frequent occurrence of subway construction accidents, it is one of the effective measures to ensure the smooth progress of subway construction to use information-based monitoring equipment to grasp construction data and take corresponding measures through analysis. Therefore, in the process of subway construction, it is very necessary to analyze the uncertain factors that cause construction accidents by using risk management tools and implement key risk monitoring, and take preventive measures in advance to avoid losses. The research on construction risk monitoring includes the risk assessment model of deep foundation pit construction of metro station based on dea-ahp and BP neural network [2]. WBS-RBS is used to identify the risk factors in the construction process, and a two-level risk evaluation index system is established by AHP to determine the evaluation matrix. On the basis of the above, data envelopment is used to calculate the index weight, and the index weight value is used as the input of BP neural network to predict the construction risk of deep foundation pit of subway station and finally determine the risk level. However, in the process of construction risk monitoring, the traditional method often has the problem of slow convergence when solving large-scale practical problems, which affects the accuracy of monitoring. Therefore, a method of construction risk monitoring of Metro Foundation Pit Based on simulated annealing neural network is designed. By identifying the accident risk sources of foundation pit engineering and understanding the accident causes and prevention mechanisms among people, machines and environment, the classification of the risk sources of foundation pit engineering is obtained. Based on this, the safety risk monitoring index system is constructed, and each monitoring index is analyzed in detail. The annealing neural network is optimized, and the double-layer simulated annealing algorithm flow is designed to realize the project construction risk monitoring. The experimental results show that the absolute error and relative error of this method are kept below 0.01% and 0.14% respectively. It shows that this method can accurately predict the deformation of the subway tunnel through the construction monitoring data of the deep foundation pit adjacent to the existing subway tunnel.

2 Research on Risk Monitoring Method of Metro Foundation Pit Construction Based on Simulated Annealing Neural Network

2.1 Identify Risk Sources of Foundation Pit Engineering Accidents

In the research of risk source identification of foundation pit engineering accident, the occurrence of construction engineering quality accident has both technical and management reasons. There are four conditions for building accident: object, objective aspect, subject and subjective aspect. The man-made sources of risks in building deep foundation pit projects can be divided into the limitations of survey and design, the temporary nature of the foundation pit support project, the dynamic nature of the implementation process and the complexity of the organization, environmental sensitivity and the social hazard and the project There are five categories of manager's blindness [3]. The environmental sources of foundation pit engineering risks are mainly divided into four categories: geological factors, hydrological factors, surrounding environmental factors and construction factors. Classification by man, machine, and environment is a rational model for examining the cause of accidents and accident prevention mechanisms. The relationship between the cause of accidents and prevention mechanisms between man, machine, and the environment with management as the boundary is as follows:

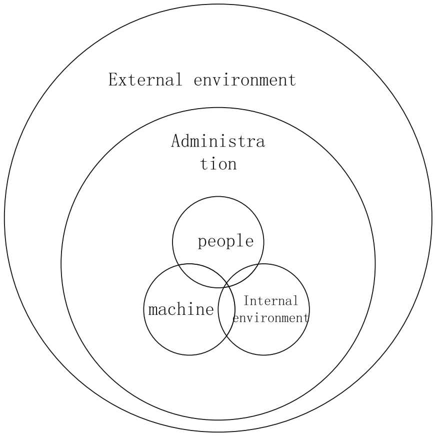

Fig. 1. Man machine environment management diagram

This section first finds out the accident classification standards and related literature summary according to relevant regulations. Based on the risk occurrence mechanism of subway station foundation pit engineering, as shown in the figure above, summarizes the previous team's research on risk sources and summarizes the foundation pit engineering from "The 37 risk sources" under the man-machine-environment-management model are as follows (Fig. 1 and Table 1):

Table 1. Risk sources of foundation pit engineering under the model of "man, machine, environment and management"

Risk source classification	A detailed description	
Actor risk source	1. Professional skills	2. Operation violation
	3. Work experience	4. Improper emergency handling
	5. Physical condition	6. On-site monitoring errors
	7. Safety awareness	8. Insufficient personnel
	9. Construction project supervision and construction contractors have insufficient experience or human error	

(*continued*)

Table 1. (*continued*)

Risk source classification	A detailed description	
	10. Malicious damage to engineering buildings or facilities by contractors or third parties	
Risk sources of construction tools	1. The quality of the equipment is unqualified	
	2. The appliance is damaged during installation	
	3. The quality of equipment maintenance is not up to standard	
	4. The appliance is damaged due to external force	
	5. Violation of the operation of the appliance (such as the damage of the mechanical shaft caused by the error of the lifting operation)	
Environmental risk sources	1. Geological conditions	2. On-site production environment
	3. Layout of underground pipelines	4. On-site space layout
	5. The surrounding ground subsidence	6. Stratum subsidence and horizontal displacement
	7. Climatic conditions during the local construction period	8. Groundwater and adjacent river water level
	9. Ground transportation	10. Rebound of foundation pit
	11. On-site security measures setting	12. Surrounding ground buildings
Organize and manage risk sources	1. Purchase of safety equipment	2. Drain of key talents
	3. The group has no cohesion	4. Unreasonable organizational structure
	5. Reward for safe work	6. Distorted information communication
	7. Safety awareness of managers	8. Managerial skills
	9. Management makes employees feel unfair and dissatisfied	
	10. -8 Management safety training and education (corporate management, project management personnel)	

Reasonable and comprehensive use of risk source identification methods provides method support for finding the risk sources of foundation pit engineering. Through the introduction of the scope of application of risk source identification methods and the advantages and disadvantages, the expert investigation method, safety checklist and risk breakdown structure (RBS) The method has been further applied in identifying the risk sources of foundation pit engineering accidents and determining the types of foundation pit engineering construction accidents [4].

2.2 Establish a Safety Risk Monitoring Index System

According to a large number of literatures, this paper summarizes the key problems in the construction process of deep foundation pit project, which are foundation pit support safety, foundation pit excavation safety and groundwater control [5, 6]. The construction of deep foundation pit adjacent to the existing subway is often more complicated than that of the general deep foundation pit construction. The above three problems affect the deformation of adjacent existing subway tunnel. (1) The impact of foundation pit support on adjacent existing subways. The supporting project of deep foundation pit plays a pivotal role in the construction of deep foundation pit. The supporting construction of deep foundation pit can play a role in retaining soil and water, ensuring the balance of stress on the overall structure of the entire foundation pit. Stable and safe. The type, thickness, insertion depth and type of supporting system, spacing, pre-loading size and back pressure soil reservation of the foundation pit retaining structure will all affect the ability of the foundation pit retaining system to resist deformation. In addition, the interaction between retaining wall and soil will also affect the displacement of retaining wall and soil outside the pit. (2) The influence of excavation of foundation pit on adjacent existing subway. In the construction process of deep foundation pit adjacent to the existing subway, the selection of excavation scheme will also affect the deformation of subway. Different geographical location, adjacent to the existing subway deep foundation pit in the excavation process will have different impact on the deformation of the subway. Earthwork excavation of foundation pit engineering is a unloading process. In this process, the change of ground load will affect the deformation of subway. (3) The impact of groundwater on neighboring existing subways. During the construction of a deep foundation pit, the change of the groundwater level will affect the deformation of the foundation pit, as well as the structural deformation of the adjacent deep foundation pit subway. The construction process of the foundation pit needs to control the height of the groundwater level, which requires precipitation of the foundation pit or recharge of groundwater. During the precipitation process of the foundation pit, the pore water in the stratum will dissipate, causing the subway to undergo vertical displacement and settlement. Similarly, the recharge of groundwater will cause subway.

The rise of the structure. This kind of influence of groundwater on the subway will seriously threaten the normal and safe operation of the subway. Therefore, the change of groundwater is one of the non-negligible factors that cause the deformation of subway tunnels. (4) The index of the influence of the construction of deep foundation pit adjacent to the existing subway on the subway deformation is established. According to the influence of the deep foundation pit construction on the deformation of the adjacent existing subway and the influence of each construction process on the adjacent existing subway deformation in the construction process [7, 8], combined with the research method adopted in this paper, the data obtained from the monitoring of the foundation pit in the construction process and the data obtained from the subway monitoring are analyzed, so as to analyze the future of the foundation pit Therefore, the safety risk control measures can be formulated in advance to control the deformation of foundation pit and subway.

According to the analysis results and monitoring conditions, a safety risk technical monitoring index system is constructed for the safety risks of deep foundation pit construction, as shown in Table 2.

Table 2. Safety risk monitoring index system of metro tunnel deep foundation pit

Primary indicators	Secondary indicators	Level three indicators
Safety risk monitoring index system for deep foundation pit of metro tunnel	Foundation pit safety	Maintain the horizontal displacement of the pile (wall) body
		Maintenance pile (wall) top horizontal displacement
		Vertical displacement of maintenance pile (wall) top
		Vertical displacement of ground wall
		Steel support axial force
		Anchor cable tension
		Uplift at the bottom of the foundation pit
		Excavation depth of foundation pit
		Distance between foundation pit excavation and subway tunnel
		Groundwater level
	Subway tunnel safety	Horizontal displacement of tunnel structure
		Vertical displacement of tunnel structure
		Tunnel section convergence

The support system of the deep foundation pit can maintain the force balance of the overall structure of the entire foundation pit, can effectively ensure the stability and safety of the foundation pit during the construction process, and prevent the occurrence of safety accidents. (1) Pile (wall) horizontal displacement: the deformation of the diaphragm wall can most intuitively reflect the safety status of the foundation pit, which is a problem that needs to be paid attention to during the construction of the foundation pit. The diaphragm wall is under pressure from groundwater and soil [9, 10]. As the construction progresses, the underground conditions of the foundation pit are constantly changing, and the underground diaphragm wall and various piles are also in a constantly changing dynamic environment. Therefore, we should always pay attention to the horizontal displacement of the pile (wall) and monitor it from time to time to prevent the excessive horizontal displacement of the pile (wall) from being damaged, which may cause risks or safety accidents. The horizontal displacement of the pile (wall) is generally monitored and measured with a total station and an inclinometer. (2) Vertical displacement of pile (wall): in addition to the influence of groundwater and soil on the displacement of ground connected pile (wall), the friction resistance at the wall side and the bearing capacity at the bottom of wall also have certain influence on the vertical displacement of pile (wall). As a part of the foundation, diaphragm wall should bear not only horizontal lateral load but also vertical bearing capacity. The vertical displacement of pile (wall) in retaining structure will also affect the safety of deep foundation pit project. The vertical displacement of pile (wall) is generally monitored by geometric level or hydrostatic level. (3) Axial force of steel support: the change of axial force of internal support always reflects the state of supporting structure of deep foundation pit. The setting of axial force of steel support should ensure the stability of supporting structure, so as to ensure the stability of the whole deep foundation pit. It is necessary to pay attention to the change of axial force of steel support and find out the abnormal situation in time, so as to take measures to prevent the occurrence of risk accidents of deep foundation pit. The axial force of steel support is usually monitored by axial force meter or reading instrument. (4) Uplifting of the bottom of the foundation pit: During the excavation of a deep foundation pit project, the unloading of the soil in the pit will change the pressure at the bottom of the pit, causing the soil to rebound and deform, which will lead to the uplift of the bottom of the foundation pit. If the bulge at the bottom of the foundation pit is too large, it may cause risks during the construction of the deep foundation pit project. Under normal circumstances, as the excavation of the foundation pit continues to advance, the rebound of the bottom of the foundation pit will continue to increase, resulting in an increase in the uplift value of the bottom of the foundation pit. Therefore, the monitoring of the uplift at the bottom of the foundation pit is also an important risk indicator. Generally, a level gauge is used to monitor the uplift at the bottom of the foundation pit, and it should be performed immediately after each excavation is completed. (5) Anchor cable tension: the setting of anchor cable plays a role in strengthening the surrounding strata of deep foundation pit. The setting of anchor cable can control the deformation of diaphragm wall, reduce the displacement of supporting structure and ensure the stability of foundation pit. (6) Excavation depth of foundation pit: during the excavation of foundation pit, the balance of stratum will be destroyed, resulting in upward uplift of soil at the bottom of pit, lateral deformation of retaining structure of foundation pit and changes of surrounding stratum of foundation pit, which will lead to ground settlement and deformation of adjacent subway tunnel. Therefore, the influence of excavation depth of deep foundation pit construction on subway deformation is very important. (7) The distance between the excavation of the foundation pit and the subway tunnel: the impact of the construction of a deep foundation pit adjacent to the existing subway tunnel on the deformation of the subway tunnel is related to its relative position. The different positional relationship between the two makes the degree of impact on the existing subway tunnel different, which is related to the distance between the excavation position of the foundation pit and the subway tunnel. Generally speaking, the closer to the subway tunnel, the greater the impact on the deformation of the subway tunnel. Therefore, different distances have different effects on subway tunnels, and different distances require different protection measures. (8) Groundwater level: in the construction process of deep foundation pit, the treatment of groundwater is a very important link. The groundwater level will affect the stress change of foundation pit and the vertical displacement of adjacent existing subway tunnel. However, in the construction process of deep foundation pit, the groundwater level should be reduced reasonably to make the construction smooth. The influence of the change of groundwater level on the deformation of subway tunnel needs to be monitored according to the change of water level and the change of subway tunnel. At the same time, reasonable subway protection measures should be formulated to control the safety of subway tunnel and the safety construction of foundation pit. (9) Vertical displacement of the tunnel structure (including differential settlement): Due to the complexity of hydrogeology in the stratum, unloading of foundation pit excavation, groundwater control, and other construction processes will affect the vertical displacement of the subway tunnel structure. The sinking or floating of subway tunnels will have a certain impact on the safe operation of the subway. To monitor the vertical displacement of the existing subway tunnel structure, a level, a total station or an automated monitoring method is generally used. (10) Horizontal displacement of tunnel structure (including differential horizontal displacement): in the process of deep foundation pit construction and reinforcement of subway surrounding, the horizontal displacement of subway tunnel will change due to the change of soil lateral pressure. The change of horizontal displacement of existing subway tunnel structure is also an important factor affecting the safe operation of subway. In the process of deep foundation pit construction, it is necessary to strengthen the frequency of monitoring and find out the law between it and the construction process of deep foundation pit, so as to predict the subsequent safety situation of subway, and formulate relevant safety control measures in advance. (11) Tunnel clearance deformation: Tunnel clearance deformation, also known as clearance convergence, refers to the phenomenon that the rock and soil near the subway tunnel rush into the subway tunnel space after the excavation of the subway tunnel. Generally, it refers to the relative position between two points on the side of the tunnel. The changes that have occurred. Excessive tunnel clearance will affect the operation safety of subway trains, which is an important indicator in subway safety monitoring.

2.3 Optimize Annealing Neural Network

Although the traditional simulated annealing algorithm can not solve the problem of slow simulated annealing based on the idea of the traditional neural network simulated annealing, it can not solve the problem of optimal solution based on the idea of neural network simulated annealing Quasi annealing optimization is called network algorithm. The first layer of simple annealing is a similar simulated annealing idea. It first sets a larger learning rate $\eta(0.5 - 0.9)$ and momentum term coefficient $a(0.5 - 0.9)$, and gradually reduces the learning rate and momentum term coefficients, so that the error accuracy quickly drops to a smaller value. When the error accuracy drops to a preset target accuracy value, you can jump out of the training neural network. The second layer of deep annealing, after the simple annealing of the first layer reaches a small error, on this basis, the simulated annealing algorithm is used to find the global optimal solution. The use of double-layer simulated annealing to optimize the BP neural network reduces the training time of the BP neural network, improves the training speed of the neural network, and solves the problem that the training of the BP neural network cannot obtain the global optimal solution. On the basis of the traditional BP algorithm, adding learning rate η and momentum coefficient a, using the idea of simulated annealing, a similar simulated annealing algorithm is proposed, called the first-level simple annealing. The algorithm starts to set larger $\eta(0.5-0.9)$ and a, and then after training each batch of samples, η and a are gradually reduced in the following way:

$$\begin{cases} \eta = \eta - \dfrac{0.01}{10^q} \\ a = a - \dfrac{0.01}{10^q} \end{cases} \tag{1}$$

The initial value of q is set to 0, and after each batch of sample training, q becomes $q+1$ until the calculated error accuracy reaches the preset target error accuracy or the maximum number of iterations reaches the preset value.

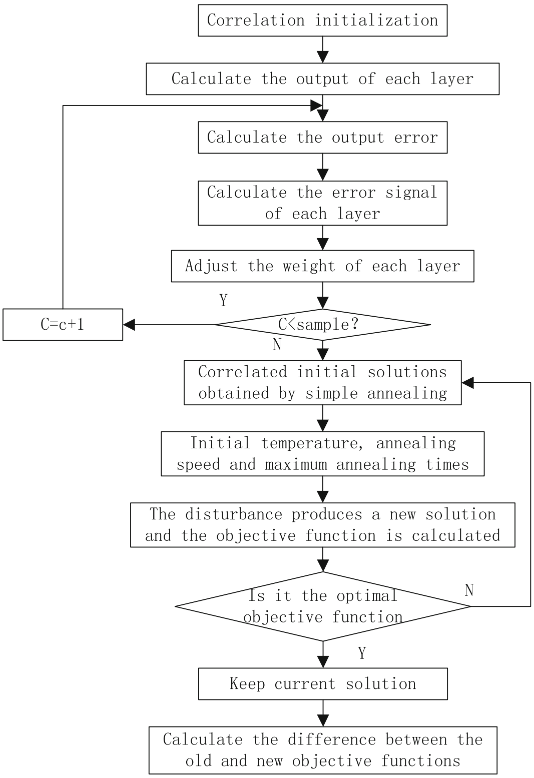

Fig. 2. Flow chart of two-layer simulated annealing algorithm

The main purpose of the first layer of simple annealing is to shorten the training time of BP neural network, improve the training speed, and make the error accuracy rapidly decline. If the error accuracy of the preset target can be achieved, the calculation will jump out. Otherwise, it will go into the second layer deep annealing. According to the first layer of simple annealing and the second layer of annealing, combined with the standard BP algorithm, a two-layer simulated annealing optimization algorithm is obtained (Fig. 2).

Deep annealing is modified on the basis of the traditional simulated annealing algorithm. Its main purpose is to search for the global optimal value. Based on the traditional simulated annealing algorithm, the main improvements of deep annealing are as follows:

(1) The error accuracy of each sample in the last error precision value obtained by the first layer simple annealing is taken as the initial value.

Finally, the total error accuracy value is used as the initial objective function value.

Disturbance neural network weights V (input layer to hidden layer weight matrix) and w (hidden layer to output layer weight matrix).

The objective function is the sum of the error precision values of each training sample.

(4) When recalculating the error accuracy value of each sample, the weight adjustment formula of traditional BP algorithm is still used to modify the weight matrix V and W of neural network. The learning rate and momentum coefficient used are the first layer of simple annealing, and the corresponding error of each training sample is taken as a new partition to realize risk monitoring. So far, the design of risk monitoring method for Subway Foundation Pit Construction Based on simulated annealing neural network is completed.

3 Case Simulation

3.1 Overview of the Actual Project

This example project is located at a railway station in a certain city in Central Plains. It is an underground transportation project of a comprehensive transportation hub (East Square), and is a typical underground project in my country that passes through an existing subway tunnel. The underground works on both sides of the subway tunnel are very close to the subway tunnel. In order to reduce the impact of the construction in progress on the subway tunnel, the periphery of the underground works is constructed by the reverse construction method, which requires extremely high technical requirements, and the crossing part is located below the operating line. The settlement and deformation control requirements are extremely high.

Considering the great difficulty of the project and the high control requirements, this project is taken as the research object of this paper, and the deformation control standard and technology of the existing subway tunnel are studied to ensure the construction safety of the new project and the safe operation of the existing line. The land use planning near the railway station is mainly for urban residential, enterprise office and commercial activities. To the east of the East Square is Putian West Road, the main road of the city. Under the road is a pedestrian passage. In the south is the reserved land for the bus terminal station. On the west side is the railway station. Underground in the south side are the transfer stations of Metro Line 1, line 5 and city line 3. The north side is the highway passenger station. There is a national road passing through the underground next to the project, and the two station section of Metro Line 1 in the city passes through the underground in the middle of the project.

The north-south structure of the square is 175 m east-west and 121 m north-south. Shunzuo District of the central island is 109 m east-west and 56 m north-south. The remaining part is the reverse cropping area; the structure of the south area is 176 m east-west and 117 m north-south. Shunzuo District of the central island is 118 m east-west and 66 m north-south. The remaining area is a reversed work area. The height of the commercial area on the first underground level is 6.1 m, and the ceiling height is 5 m after the decoration is completed; the second and third floor parking garages are 4.2 m in height, and the pipeline height is 2.4 mm after the garage is decorated; The three connecting passages connecting the north and south areas are 48 m long, with cross-sectional dimensions of 14.2 m × 3.557 m, 18.5 m × 3.557, and 14.2 m × 3.557 m. The passage connecting the north side with the bus station is 45.5 m long and 16.3 m wide. The positional relationship diagram between the civil air defense project and the section tunnel section is as follows (Fig. 3):

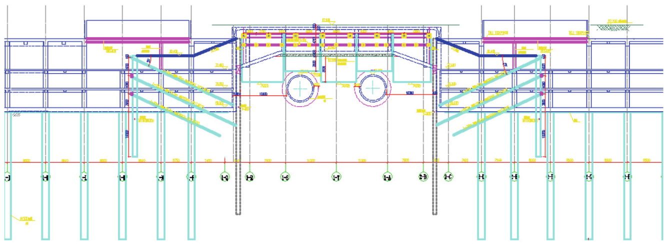

Fig. 3. The relationship between the air defense project and the section of the tunnel section

During the site survey of the East Square project, it was discovered that the interval between the station-Boxue Road station of the first phase of the Metro Line 1 project had been completed, and there was a large amount of soil above the tunnel. At the same time, the soil was within the scope of the East Square project. According to the measurement results, the length of the mound is 220 m along the longitudinal tunnel of the section, and the height of the mound is 14 m at the highest point. The engineering features of this project are as follows:

(1) The foundation pit has deep excavation, large excavation area and many retaining structures.

The foundation pit is rectangular, 269 m long and 176 m wide. The underground water level of the plot is high, and the requirements for foundation pit excavation, precipitation and protection are relatively strict; moreover, there is a bus station around the foundation pit which is about to be constructed, and there may be cross construction. At the same time, due to the limitation of construction site conditions, a large number of enclosure structures need to be constructed. Because of the complexity of the foundation pit project, SMW support method, diaphragm wall support method and deep mixing pile support method are used in the retaining structure of the foundation pit.

(2) It is difficult to protect the safety of operating subways.

The shield section of Metro Line 1 passes under the deep foundation pit project to connect the three connecting passages connecting the north and south foundation pits. During construction, it is necessary to ensure that Metro Line 1 can operate safely and normally. Reinforce the body, which makes the situation faced during the construction process more complicated and the difficulty of the construction greatly increases.

(3) Complex surrounding environment

There are railway stations, underpasses of National Highway 107, and long-distance passenger stations in the immediate vicinity of the project. The impact of construction on the surrounding environment must be considered, and protective measures must be taken; The passages cross; and the underground passages in the core area of the transportation hub to be built on the south side of the square are also likely to be constructed in parallel with the project. The consideration of various factors adds to the difficulty of the project. Therefore, the construction environment is complicated.

3.2 Safety Risk Assessment for Construction Management of Deep Foundation Pits Adjacent to Existing Subways

For the engineering risk occurred in the construction process of deep foundation pit adjacent to the existing subway tunnel, the formulation of risk control measures depends on whether the risk can be accepted and the acceptable degree. Therefore, before the risk assessment of the project management of the adjacent existing subway tunnel deep foundation pit project, it is necessary to formulate a clear risk occurrence probability level and risk acceptance criteria. In this paper, according to the situation of the project, the occurrence probability of risk factors is divided into five levels, as shown in the following Table 3:

Table 3. Probability level of risk factors

Grade	Description	Probability	Valuation
A	Rarely	<0.0003	0.1
B	Rarely	[0.0003, 0.003]	0.3
C	Occasionally	[0.003, 0.03]	0.5
D	Probably	[0.03, 0.3]	0.7
E	Frequently	≥ 0.3	0.9

The interval of each risk value corresponds to a specific level of safety risk level, as shown in the following Table 4:

Table 4. Safety risk classification

Grade	Value at risk	Acceptance	Security risk description
First level	0–0.25	Can be overlooked	The risk situation is extremely low, the safety status of the project is very good, and no treatment is required
Second level	0.25–0.5	Acceptable	The risk is low, the safety status is good, it needs attention, the possibility of serious injury is small, but there is the possibility of general injury accidents, and routine management review
Three levels	0.5–0.75	Acceptable after treatment	The risk is medium, the safety status is average, the general injury accident is more likely to occur, and rectification is required
Level 4	0.75–1.0	Refuse to accept	The risk probability of the project is high, and there is a large potential risk It is difficult to deal with the consequences of the risk, so we must adjust and pay attention to it continuously

The safety risk level is divided according to the probability and severity of safety risk events. Therefore, the safety risk interval is a comprehensive manifestation of the consequences of safety risk accidents. After determining the safety risk level of the project, the safety risk manager can determine the risk acceptance standard according to the maximum risk that the enterprise and the project can bear, and at the same time determine the safety risk control plan and measures according to the risk acceptance standard, so as to improve the project Carry out effective security risk control. The layout of the foundation pit water level monitoring is as follows (Fig. 4):

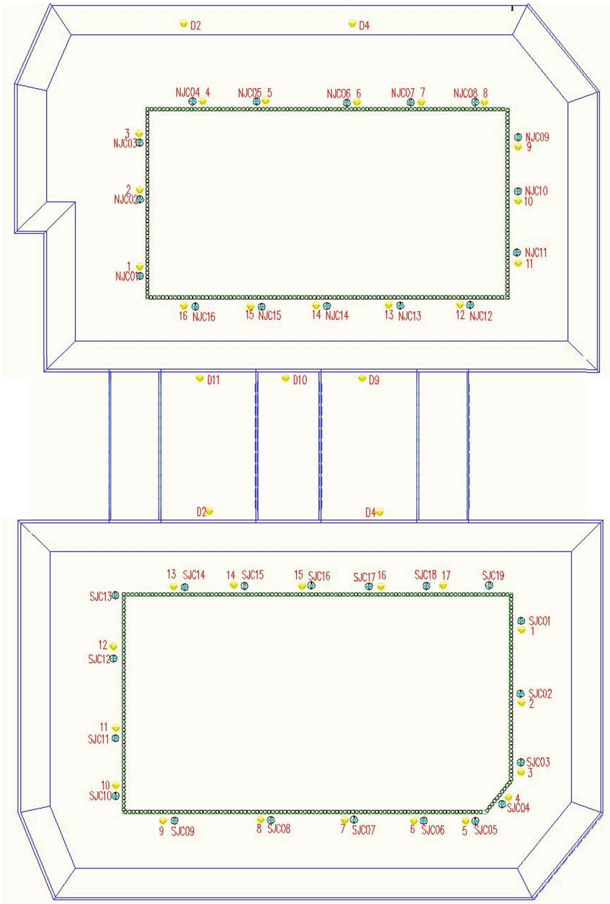

Fig. 4. Layout of foundation pit water level monitoring

In this data collection process, due to the large number of foundation pit monitoring points and subway monitoring layout points, the monitoring data at NJC 16 and NJC 21 were selected for analysis of the monitoring data at NJC 16 and NJC 21 during the initial model establishment. The monitoring data source of the body selects No. 13 monitoring point, the monitoring data of anchor cable tension selects the anchor cable No. 6 monitoring point; the subway monitoring selects the monitoring data of the monitoring point within the scope of channel 1#. According to the actual monitoring situation of the project, the interval of each set of data is 4 days. The monitoring data of the deep foundation pit during the construction process is used to fit and train the various indicators of the subway, and then a dynamic method is used to predict. That is, with the continuous advancement of construction, the data information obtained by monitoring gradually increases. These new data are continuously added to the training samples during the network model prediction process, and the neural network is dynamically trained, adjusted and updated, and the monitoring error is counted..

3.3 Experimental Results and Analysis

On the basis of the above experimental preparation, the detection model based on simulated annealing neural network is established. The NNTool toolbox in MATLAB software is used to replace the data into the compiled program and run it. The results obtained for the first time are as follows (Fig. 5):

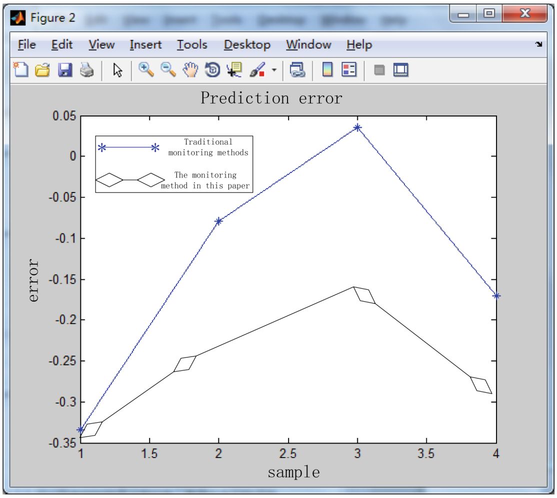

Fig. 5. Comparison of monitoring errors of the first training of the two methods

As shown in the figure above, although the simulated annealing neural network has a high degree of fitting ability, there are still certain errors in the prediction results of the network verification, and some sample points have large errors, so the dynamic method is used to predict, and the new collection is organized. The data is added to the training sample to dynamically train, adjust and update the network model.

Taking 16 groups of sample data as training data and 6 groups of sample data as test data, the results obtained are as follows (Fig. 6):

As can be seen from the above figure, with the increase of the number of training samples, the prediction accuracy of the two detection methods is improved. In the training and testing of traditional monitoring methods, the maximum absolute error is 0.45, the maximum relative error is 7.35%, but the rest of the absolute error is kept below 0.05, the relative error is below 0.7%. In the training and inspection of the monitoring method designed in this paper, the maximum absolute error is 0.14, the maximum relative error is 2.08%, the remaining absolute error is kept below 0.01, and the relative error is kept below 0.14%. Therefore, it can be concluded that the subway foundation pit construction risk monitoring method based on the simulated annealing neural network designed in this paper can accurately pass the adjacent existing The deformation of the subway tunnel can be predicted by the monitoring data of the deep foundation pit construction of the subway tunnel, so that the safety risk control measures of the subway tunnel can be formulated in advance to ensure the safety of the subway in the construction process.

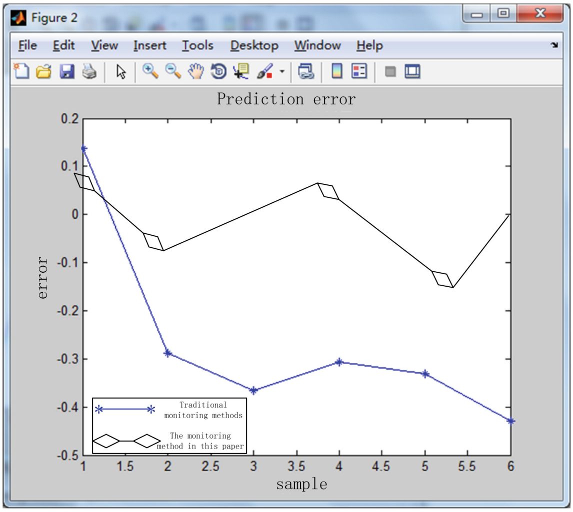

Fig. 6. Comparison of monitoring errors of the two methods after multiple training

4 Concluding Remarks

At present, China's subway projects are at the peak of construction. Not only is the construction scale large, but the complexity of engineering construction is far greater than in the past. In addition, the development of the subway construction market is not perfect, the behavior of market subjects is not standardized, and engineering quality and construction casualty accidents occur from time to time, which greatly increases the risk factors of the project. Because there are many factors affecting the project risk, and some factors affect each other, it is difficult to evaluate the project risk, This paper carries out construction risk monitoring based on simulated annealing neural network. By identifying accident risk sources, understanding accident causes and prevention mechanisms, classifying risk sources, building a safety risk monitoring index system, and analyzing the indicators, optimizing annealing neural network to achieve project construction risk monitoring. However, in the process of project construction risk monitoring, due to the complexity of the algorithm, the monitoring time did not achieve the expected effect and the monitoring efficiency was reduced. In the next study, the algorithm will be improved to shorten the calculation time and improve the monitoring efficiency of subway foundation pit construction risk.

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References

1. Zhong, X.: Simulation of building construction safety early warning model based on support vector machine. Comput. Simul. **36**(08), 459–462 (2019)
2. Cao, Y.: Optimization of adaptive signal control using simulated annealing algorithm. J. Transport. Eng. Inf. **59**(01), 53–59+64 (2018)
3. Jiang, M.: A predication model of bp neural network based on genetic simulated annealing algorithms. Softw. Eng. **021**(007), 36–38 (2018)
4. Hu, Z., Li, W., Qiao, J.: Frequency conversion sinusoidal chaotic neural network based on self-adaptive simulated annealing. Acta Electron. Sin. **47**(03), 613–622 (2019)
5. Gong, S., Liu, J., Mei, L., et al.: Loss optimization model for multi-hop HF radio transmission on sea surface based on BP simulated annealing algorithm. New Industr. Strareg. **4**, 17–21 (2019)
6. Yao, J., Hu, H., Bai, Y., et al.: DOA estimation method based on SAPSO-BP neural network. J. Chongqing Inst. Technol. **380**(05), 189–194 (2018)
7. Li, L., Zheng, H., Ding, C., et al.: Terrorist attack classification based on improved bp neural network. Softw. Guide **18**(05), 21–26 (2019)
8. Luo, Z., Zeng, L., Pan, H., et al.: Research on construction safety risk assessment of new subway station close-attached undercrossing the existing operating station. Math. Probl. Eng. **2019**(1), 1–20 (2019)
9. Srinivasan, G., Venkatesh, M.P.: Risk assessment of construction project in India. IOP Conf. Ser. Mater. Sci. Eng. **993**, 012044 (2020)
10. Park, K., Lee, H.W., Choi, K., et al.: Project risk factors facing construction management firms. Int. J. Civil Eng. Trans. A Civil Eng. **17**(3), 305–321 (2019)
11. Liu, W.: Risk source analysis and identification method of shallow buried bias tunnel construction. Sichuan Archit. **40**(3), 320–322 (2020)
12. Lv, H.: Research on construction safety risk management of new subway projects adjacent to existing subway lines. Doors Windows **011**, 152–153 (2021)