



The Application of Several Optimization Models Based on BP in the Deformation Prediction of Deep Foundation Pit is Reviewed

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Abstract

In this paper, based on the BP neural network, several main optimization models in the prediction of foundation pit deformation are analyzed, including GA-BP, PSO-BP, SSA-BP, ACO-BP prediction models. Several different models predict the deformation during the construction of the foundation pit, and clarify the advantages and disadvantages of different models and the advantages of integrating the algorithm into the deformation prediction of deep foundation pits in civil engineering.

Subject Areas

Operational Research

Keywords

Intelligent Optimization Algorithm, Civil Engineering, Geotechnical Engineering, Foundation Pit Deformation Prediction

1. Introduction

With the rapid development of technology, intelligent algorithms have shown their great potential in many fields. As an important industry involving infrastructure design, construction, maintenance and operation, civil engineering is also gradually introducing more intelligent algorithms to improve efficiency, reduce costs and improve safety.

A popular technology in recent years is artificial intelligence and its subset-intelligent algorithms. These algorithms have had a significant impact on the field of civil engineering, changing the way planners, designers and builders work. This paper will focus on the use of intelligent algorithms in civil engi-

neering, its effectiveness, advantages and limitations.

2. Deformation Monitoring of Traditional Civil Engineering Deep Foundation Pit

2.1. Traditional Deep Foundation Pit Deformation Monitoring Technology

The deformation prediction of deep foundation pit engineering occupies an important research position in the field of geotechnical engineering, especially in the context of China's rapid economic development and increasing investment in infrastructure. The traditional deformation prediction methods of civil deep foundation pit include grey GM (1, 1) model method, BP neural network model method and so on. Among them, the grey GM (1, 1) model method is a prediction method based on grey system theory, which can predict the future deformation of deep foundation pit equidistantly or non equidistantly. BP neural network [1] model rule is a prediction method based on artificial neural network, which can learn the relationship between data by training data set, so as to predict. In addition, some researchers have combined the grey system with the BP neural network to form a grey neural network combination model. This model shows reliability and practicability in the prediction of deep foundation pit deformation. In general, the choice of prediction method depends on the specific engineering practice and the characteristics of monitoring data.

2.2. The Disadvantages of Traditional Deep Foundation Pit Deformation Monitoring Technology

There are many drawbacks and shortcomings in the traditional deep foundation pit deformation prediction. The traditional methods usually rely on empirical formulas or simplified models, and cannot fully consider the complex factors such as geology and engineering materials, resulting in limited prediction accuracy. It is difficult to predict the deformation of deep foundation pit comprehensively and accurately due to the limitation of engineering geological conditions, foundation pit structure, construction methods and other factors. In terms of space and time, the traditional methods are mostly static analysis, lack of real-time monitoring means, unable to reflect the deformation of foundation pit in time, and it is difficult to take timely and effective control measures. In the calculation of construction period, the traditional method needs a long time to accumulate data and verify the model, and the prediction period is long, which cannot meet the rapidly changing engineering requirements. Finally, the traditional method is susceptible to interference from competent factors, such as subjective factors and insufficient data, resulting in unreliable prediction results.

3. Intelligent Algorithm Civil Engineering Deep Foundation Pit Deformation Prediction

3.1. Intelligent Algorithms

Intelligent algorithms refer to algorithms that can self-learn and adapt. Common

intelligent algorithms include machine learning, deep learning, genetic algorithms, etc. These algorithms can process and analyze a large amount of data, extract useful information from it, and use it to optimize decisions. They do this by analyzing patterns in the data, generating predictions, and improving the decision-making process over time. Intelligent algorithms are different from standard computer programs, which can improve their accuracy and efficiency without explicit human instructions.

3.2. Demands and Challenges in the Field of Civil Engineering

There are many problems in the deformation process of deep foundation pit. The fluctuation of groundwater level may lead to the change of soil force, which may cause the deformation and settlement of foundation pit. The inhomogeneity of the underground soil may lead to the uneven load of the foundation pit supporting structure, causing the deformation and failure of the foundation pit. The surrounding construction or traffic vibration may affect the soil around the foundation pit and increase the risk of foundation pit deformation. Improper design of foundation pit supporting structure, improper selection of materials or construction quality problems may lead to deformation or even collapse of foundation pit. The interaction between foundation pit and surrounding buildings or geological conditions will affect the stability of foundation pit and increase the difficulty of foundation pit deformation. At the same time, the failure of monitoring equipment and the untimely or inaccurate processing of monitoring data will also affect the monitoring and early warning ability of foundation pit deformation. Such as geological structure anomalies, earthquakes and other natural disaster factors may also lead to deep foundation pit deformation and safety hazards.

Using the data collected by sensors, combined with machine learning algorithms, the health status of civil structures such as buildings and bridges can be monitored in real time. By analyzing the abnormal patterns in the data, the possible structural damage is predicted, so as to achieve timely maintenance and ensure the safety of the structure. In construction management, deep learning algorithms can be used to optimize project progress and resource allocation. By analyzing the historical construction data, the algorithm can predict the key time points of the project, and make recommendations on resource allocation to avoid waste of resources and ensure that the project is completed on time. In the field of traffic engineering, intelligent algorithms can optimize traffic flow and reduce congestion. For example, by analyzing multi-source data (such as traffic flow data, video surveillance, etc.), intelligent algorithms can adjust traffic lights in real time and optimize traffic flow. The intelligent algorithm can also be applied to the development and optimization of civil engineering materials. By analyzing the big data of various material properties, machine learning models can predict the influence of the mixing ratio of materials on their properties and help engineers choose the best material combination and manufacturing process.

Today, intelligent algorithms are widely used in various fields, and the prediction of deep foundation pit deformation gives us a new prospect and expecta-

tion. First of all, intelligent algorithms can identify potential safety hazards, reduce the risk of accidents on construction sites, and ensure the safety of workers and the public. Secondly, intelligent algorithms can help optimize processes, reduce costs, and increase productivity. This leads to faster project completion time and less resource usage. Finally, machine learning algorithms are used in quality-in-quality predictive maintenance and structural health monitoring to ensure that the structure maintains high quality, reduce failure rates, and extend the service life of infrastructure.

3.3. Analysis of Technological Innovation Points

Intelligent algorithms have been widely used in the civil engineering industry, including predictive modeling, data mining and optimization techniques. The most common applications are intelligent algorithms that have been used to monitor the health of structures such as bridges and buildings. Sensors are placed on the structure, and machine learning algorithms are used to analyze the collected data to detect defects or deterioration in real time. In the monitoring of construction sites, the use of drones to capture images of construction sites has become increasingly popular. Intelligent algorithms are used to analyze the collected images to identify potential safety hazards or structural defects. Intelligent algorithms are used to predict when equipment or machinery may fail, allowing scheduled repairs before costly failures occur. This improves efficiency and reduces maintenance downtime. Machine learning algorithms can help predict the potential environmental impact of proposed construction projects. This helps ensure compliance with environmental regulations and reduces the organization's environmental footprint.

3.4. Alternative Future Forecast

Although the intelligent algorithm has many advantages, its application in civil engineering still has some limitations. These include:

- 1) Dependence on data: The correct operation of intelligent algorithms depends largely on data. If insufficient or inaccurate data is used, it may lead to wrong predictions and suboptimal decisions.
- 2) Lack of transparency: The complexity of some machine learning algorithms makes them difficult to explain to stakeholders, leading to potential concerns about transparency and accountability.
- 3) Bias: Using machine learning algorithms will introduce bias in the decision-making process, especially when the data used does not represent a wider population.

4. The Specific Application of Intelligent Algorithm in Deep Foundation Pit

4.1. Genetic Algorithm

The genetic algorithm simulates the process of natural selection to iteratively op-

optimize the design scheme. In the structural design, the design parameters can be encoded like “genes”, and gradually optimized through selection, crossover and mutation operations in multiple generations to find the most suitable structural solution. (See **Table 1**)

Table 1. Application of genetic algorithm in civil engineering.

Document	Algorithm	Optimization object	Practically optimize application scenarios	Optimization problem classification
[2]	GA-BP	Minimum predicted deformation error	Nonlinear deformation of deep foundation pit	single-objective optimization
[3]	GA-BP + BIM	Minimum predicted deformation error	Nonlinear deformation of deep foundation pit	multi-objective optimization

4.2. Particle Swarm Optimization

Particle swarm optimization is a group-based optimization technique, which optimizes the design by simulating the behavior of birds hunting. In the structural design, each “particle” represents a design scheme, by tracking and imitating the surrounding optimal solution to update their state, so as to find the optimal design. (See **Table 2**)

Table 2. Application of particle swarm optimization in civil engineering.

Document	Algorithm	Optimization object	Practically optimize application scenarios	Optimization problem classification
[4]	PSO-BP	Minimum predicted deformation error	Nonlinear deformation of deep foundation pit	single-objective optimization
[5]	PSO-SVM	Minimum predicted deformation error	Nonlinear deformation of deep foundation pit	multi-objective optimization

4.3. Sparrow Algorithm

The sparrow algorithm is a heuristic optimization algorithm that simulates the behavior of sparrows foraging when solving problems. It has the advantages of strong global optimization ability, suitable for a variety of problem areas, fast convergence speed and so on. In the prediction of deep foundation pit deformation, the sparrow algorithm adopts a random search strategy, which is conducive to a comprehensive and effective exploration in the solution space, and can better avoid falling into the local optimal solution. The sparrow algorithm has faster convergence speed and improves the efficiency of the algorithm. The sparrow algorithm is not sensitive to the selection of initial values and has good robustness. It can better cope with the complex and changeable engineering environ-

ment when dealing with the deformation prediction of deep foundation pits. The sparrow algorithm is relatively simple and easy to implement, without too much parameter adjustment and complex calculation, which makes it highly operable in engineering practice. (See **Table 3**)

Table 3. Application of sparrow algorithm in civil engineering.

Document	Algorithm	Optimization object	Practically optimize application scenarios	Optimization problem classification
[6]	SSA-Elman	Minimum predicted deformation error	Nonlinear deformation of deep foundation pit	multi-objective optimization
[7]	EMD-SSA-LSTM	Minimum predicted deformation error	Nonlinear deformation of deep foundation pit	multi-objective optimization

4.4. Ant Colony Algorithm

Ant colony algorithm solves various optimization problems by simulating the behavior of ants finding paths in the process of finding food. The basic idea of the ant colony optimization algorithm is to regard the ant's walking path as a feasible solution to the problem to be optimized, and all the paths of the entire ant colony constitute the solution space of the problem to be optimized. Ants with shorter paths will release more pheromones. As time goes on, the concentration of pheromones accumulated on shorter paths gradually increases, and the number of ants choosing this path is also increasing. Finally, the whole ant colony will be concentrated on the best path under the action of positive feedback, and the corresponding is the optimal solution of the problem to be optimized. (See **Table 4**)

Table 4. Application of ant colony algorithm in civil engineering.

Document	Algorithm	Optimization object	Practically optimize application scenarios	Optimization problem classification
[8]	Ant colony-BP	Minimum predicted deformation error	Nonlinear deformation of deep foundation pit	multi-objective optimization
[9]	ACO-BP	Minimum predicted deformation error	Nonlinear deformation of deep foundation pit	multi-objective optimization
[10]	Timeseries + ACO-BP	Minimum predicted deformation error	Nonlinear deformation of deep foundation pit	multi-objective optimization

5. Conclusion and Foresight

1、Although the application of intelligent algorithms in the field of civil engineering has brought many benefits, it also faces challenges such as data quality, algorithm transparency and interpretation ability. In addition, how to effectively integrate traditional engineering knowledge and modern algorithms is also a current research hotspot.

2、Starting from the optimization problem of foundation pit deformation prediction, the practical application of four kinds of algorithms, genetic algorithm, particle swarm optimization, sparrow optimization and ant colony optimization, is summarized. The technical challenges and development trends based on stochastic optimization algorithms are also discussed.

3、Developing robust and effective optimization algorithms is also a challenge. Strong global optimization ability and high computational efficiency are the two most important aspects of stochastic optimization algorithms. Among genetic algorithm, particle swarm optimization, ant colony algorithm and simulated annealing algorithm, only genetic algorithm has been widely used in industry, and the other three algorithms have not been studied in depth. Since many parameters in these algorithms will affect the global search ability and convergence speed, the sensitivity of relevant parameters should be studied first according to different situations. The expected results will provide general rules for the optimal parameter setting of these algorithms. The hybrid stochastic algorithm combines the advantages of different methods, such as the hybrid simulated annealing genetic algorithm and the differential evolution genetic algorithm, which can significantly improve the original method. However, the published literature on this study is limited. Many hybrid strategies have not been applied to morphing optimization, such as hybrid genetic algorithm-particle swarm optimization and genetic algorithm-ant colony optimization.

Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] 李伟, 邓乐平. 基于 BP 神经网络模型的基坑变形监测分析研究[J]. 测绘与空间地理信息, 2023, 46(7): 140-143.
- [2] 邱章龙. 基于 GA-BP 神经网络的深基坑变形最优化预测研究[J]. 山西建筑, 2022, 48(19): 143-146+194.
- [3] 杨大田, 范良宜, 刘畅. 基于 GA-BP 神经网络的深基坑变形预测与 BIM 技术的施工控制研究[J]. 施工技术(中英文), 2022, 51(20): 112-117+127.
- [4] 刘贺, 张弘强, 刘斌. 基于粒子群优化神经网络算法的深基坑变形预测方法[J]. 吉林大学学报(地球科学版), 2014, 44(5): 1609-1614.
- [5] 蔡群群. 基于粒子群算法改进支持向量机的深基坑变形预测研究[J]. 黑龙江交通科技, 2023, 46(5): 97-99+103.
- [6] 张媛凤. 基于人工神经网络和麻雀搜索算法的深基坑变形预测研究[D]: [硕士学位论文]. 广州: 华南理工大学, 2022.

- [7] 任哲. 基于 SSA Elman 和灰云模型的基坑变形预测与安全评估[D]: [硕士学位论文]. 大连: 大连理工大学, 2021.
- [8] 杨青, 吉文来, 石星照, 等. 基于蚁群-BP 神经网络的基坑变形预测[J]. 现代测绘, 2012, 35(6): 13-14+27.
- [9] 王霖东. 融合蚁群算法和 BP 神经网络的基坑变形预测应用研究[J]. 国防交通工程与技术, 2022, 20(6): 38-40+7.
- [10] 杨爱婷, 高正夏, 卞志兵, 等. 基于时间序列 ACO-BP 神经网络在基坑变形预测中的应用研究[J]. 路基工程, 2015(2): 58-62.