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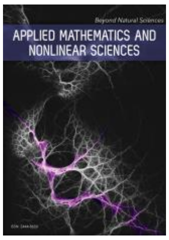

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The Planning & Designing of Urban Building Water Supply and Drainage Engineering in AI Era

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Abstract

To explore how to improve the quality of urban building water supply and drainage engineering and further promote the economic construction of urban buildings, this paper combines artificial intelligence with water supply and drainage engineering of urban buildings. A detailed analysis of water supply and drainage engineering is unfolded, and the combination of BP neural network algorithm and particle swarm algorithm is used to improve the convergence accuracy of the algorithm and network generalization ability to optimize the BP neural network algorithm and construct the artificial intelligence algorithm model. Through experiments in the artificial intelligence algorithm model, the actual output quality parameter is 82, and the difference with the desired output quality parameter of 81 is 1, while in the ordinary design, the actual output quality parameter is 70, and the difference with the desired output quality parameter is 11, get in the artificial intelligence model the desired output and the expected output close. It shows that combining artificial intelligence with urban building water supply and drainage engineering can improve the quality of the project, which is more accurate and superior to the ordinary design and reduce the project cost.

Keywords: Urban building; Water supply and drainage design; Engineering planning; BP neural network; Particle swarm algorithm.
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1 Introduction

In recent years, with the architectural planning and design of urban commercial complexes, water supply and drainage design occupies a very important position and role in urban planning [1-2]. It is very important to meet the basic life of urban residents and the construction of water supply and drainage systems for industrial and agricultural production [3-4]. In the overall planning of the city, the relevant departments of the municipality should grasp the key and difficult points of water supply and drainage design [5]. And taking it as the fundamental starting point, we strive to develop a scientific and reasonable urban water supply and drainage design scheme to further promote the economic construction and future development of the city [6-7].

The existing design has been developed over a long period of time, but there are still many problems [8]. With the booming development in the fields of artificial intelligence, materials, and construction, there are more, newer requirements for water supply and drainage engineering. The field of artificial intelligence and robotics are now being actively studied worldwide in combination with realistic physical engineering, thus greatly improving the convenience and feasibility as well as the accuracy of engineering [9-10]. Therefore, this paper analyzes the feasibility of the design of existing water supply and drainage engineering by combining the field of artificial intelligence and urban building water supply and drainage engineering [11].

The literature [12] describes the ventilation practices, foam pressure of drainage pipes, energy dissipation of drainage risers in high-rise buildings, the setting method of overflow outlets, the application range of siphon rainwater, and the water discharge and water testing of automatic sprinkler systems in water supply and drainage and fire protection design. The literature [13] describes that in today's practice of ecological and environmental protection, the green development concept of resource conservation has become an important task in architectural design. The energy saving and emission reduction of buildings are mainly reflected in the energy saving design of water and electricity resources, and how to realize the energy saving and emission reduction design of buildings without affecting the use function and comfort of buildings has become an important research direction in the current construction industry. The literature [14] analyzes the application of artificial intelligence in engineering. The development of engineering applications of artificial intelligence and its background is characterized by the explosion of human technology and innovation in this century, in which, in general, the theoretical systems of various scientific and technological disciplines have been enriched and improved. In the literature [15], the BP neural network algorithm BP is proposed for a more reasonable and convenient integration with urban water supply and drainage. The literature [16] the existing water conservancy infrastructure is planned through the simulation of the future city model, and the water conservancy construction project is constantly changing with the changes of the city. In the literature [17], In order to realize the reuse of water resources, it is proposed that urban water supply and drainage design should be considered from many aspects, such as future population and climate change.

This paper analyzes the design of urban building water supply and drainage engineering in the context of artificial intelligence in three parts to explore the superiority and accuracy of the design. The first part analyzes the design of water supply and drainage engineering, which focuses on the water supply system design for remote urban areas and high-rise buildings, as well as the monitoring of sustainable development and urban wastewater discharge in the drainage system. In the second part, through the introduction of BP neural network algorithm and particle swarm algorithm, it is found that the traditional algorithm has many drawbacks, so the two algorithms are combined to optimize BP neural network and build AI algorithm model to combine with a water supply and drainage engineering. In the third part, the optimized algorithm and this engineering design are tested, and the optimized algorithm is found to be accurate and convenient through two tests. Also in the quality parameter output is found to be more superior and accurate in the design of AI combined with a water supply and drainage engineering, which can meet the demand for engineering design in the present society.

2 Design of water supply and drainage engineering

In urban planning, the design of water supply systems is particularly important. In urban economic construction and people's daily life, it is indispensable for water supply needs. If the city water supply system fails, it will lead to chaos in the city's economic construction and social environment. In the overall planning of the city, the drainage system corresponds to the design of the water supply system. Urban drainage system is mainly divided into production wastewater pipeline system and domestic sewage pipeline system. The design of the urban drainage system requires a comprehensive analysis of the demand for urban drainage and the construction of urban drainage pipes.

2.1 Design of water supply engineering

In the design of an urban planning water supply system, the first thing designers should consider is the basic needs of urban water supply. Urban water supply system is mainly to meet the city's industrial and agricultural production water, residential water, and all kinds of commercial water. Urban water supply system design should pay attention to the overall functional layout of the city, for the industrial and mining enterprise's more concentrated areas, to appropriately increase the number of water pipelines laid, and to anticipate the future prospects of the development of the area, in the design plan to reserve enough space to meet the industrial and mining enterprises to increase the need to build water supply system; for the design of urban residential water supply system, must ensure that the water supply system Stability and durability of the water supply system, if the residents of the water supply system failure, will certainly affect the daily life of residents, and may even lead to social instability and other problems. To fully consider the basic needs of urban water supply system design, to meet the requirements of the overall urban planning in the overall urban planning, drainage system and water supply system design corresponding. Figure 1 shows the design of the water supply project.

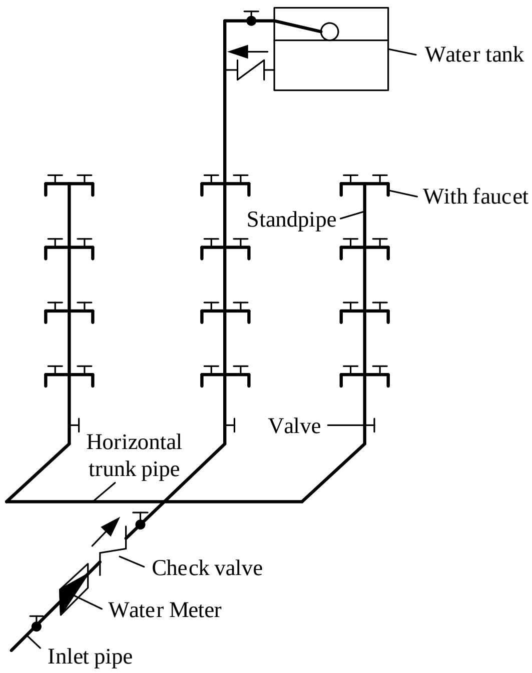

Figure 1. Design of water supply engineering

2.1.1 Water supply design for remote urban areas

In large and medium-sized cities, there are some areas in more remote locations that pose a problem for the design of urban water supply systems. Remote areas of the city due to the distance from the city water supply main road farther, less residential population, regional traffic congestion and other reasons for the design of urban water supply system has caused great difficulties. If the construction of water supply companies in remote areas will certainly require greater economic investment and personnel expenses, which does not meet the basic requirements of the city water supply system design to strictly control costs. Remote areas of the city water supply system to fully consider the cost of the project, but also to ensure that the residents of the area to the basic needs of water supply, designers can consider the design concept of water supply through the nearby or part of the area linked to the integrated water supply, which not only solves the problem of remote areas of water supply system design, but also in line with the requirements of saving project costs.

2.1.2 Water supply design for urban super high-rise buildings

With the rapid development of modern urban construction industry, more and more super high-rise buildings are being built or have been completed. The design of water supply system in urban planning must take into account the design of water supply system for super high-rise buildings. Super high-rise buildings have more floors and more people living in them, so the demand for water supply is also greater. At the same time, the height of super high-rise buildings is generally about 80m, and the pressure demand for water supply is also very large. In the design of water supply system for super high-rise buildings, the designers should combine the modern advanced water supply technology with the actual demand of system construction and make the corresponding design plan.

2.2 Design of drainage works

Urban drainage system is mainly divided into: production wastewater pipeline system and domestic sewage pipeline system. The production wastewater pipeline system mainly eliminates various types of wastewater produced in industrial and agricultural production, while the domestic wastewater pipeline system eliminates the sewage produced in daily life. The design of the urban drainage system requires a comprehensive analysis of the demand for urban drainage and the construction of urban drainage pipes. The focus of drainage system design in urban planning should be to meet the requirements of environmental protection in urban planning and the design of drainage system should have a long-term vision of development as shown in Figure 2.

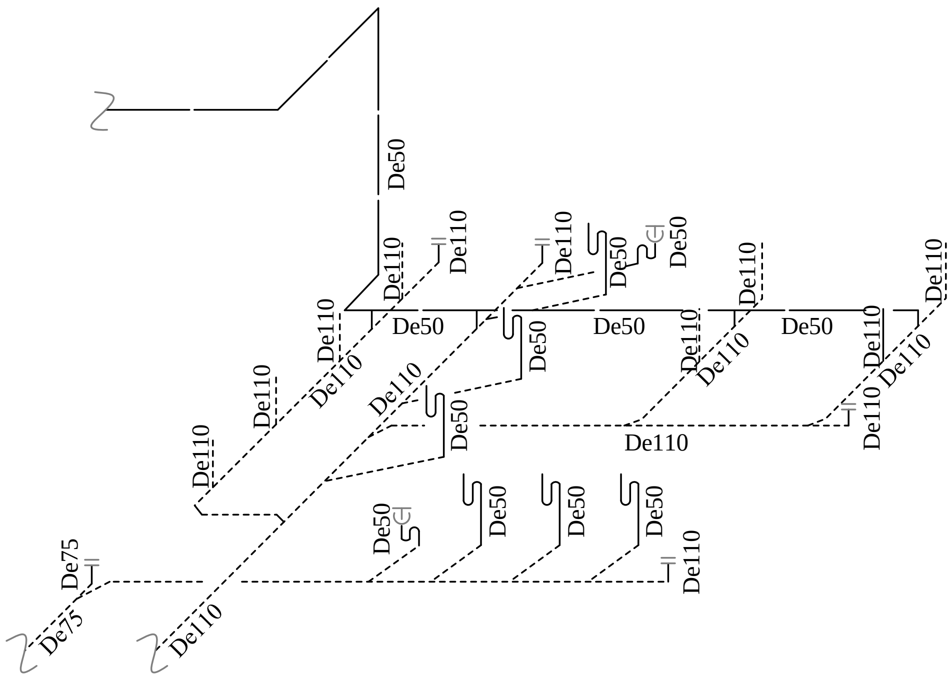

Figure 2. Design of drainage engineering

The main focus of drainage system design in urban planning is to meet the requirements of environmental protection in urban planning. Secondly, the drainage system should be designed with a long-term development vision, mainly the design of urban drainage pipes and the monitoring of industrial production effluent.

2.2.1 Design of drainage pipes

In the design of urban drainage system, there are many design problems with drainage pipes. The design of drainage pipes should take into account the overall layout and construction of urban planning and make full use of the existing drainage pipes in the city. The design of urban drainage pipes should be carried out on the basis of renovation and maintenance of the existing drainage pipes, and the existing drainage pipes should be used as much as possible, and the pipes that are difficult to continue to use should be updated in time. The design of urban drainage pipes should not only adhere to the requirements of cost control but also meet the requirements of urban planning for the quality and service life of drainage pipes.

2.2.2 Monitoring of industrial production effluent

In urban planning, elements of environmental protection are increasingly being applied to the design of drainage systems. The industrial wastewater volume standard is the average volume of wastewater discharged per unit of product produced or per unit of raw material processed. In urban drainage system design, industrial wastewater can be monitored by referring to the data of existing industrial enterprises with similar production processes. When the standard information on industrial wastewater volume is sometimes not easily available, the industrial water volume standard can be used as a basis to estimate the wastewater volume. The design of urban drainage system is not just a scheme for laying drainage pipes, but also effective monitoring and control of industrial wastewater based on the urban planning requirements for environmental protection.

3 AI model based on BP neural network and particle swarm algorithm

BP neural network can deal well with non-smooth, non-time series of urban construction and drainage water supply engineering data, the more widely used in urban construction and drainage water supply engineering quality evaluation. However, BP neural network itself has some problems, such as low learning efficiency, and easy to fall into local minima resulting in the inability to find the global optimal solution, which limits its application in the evaluation of seawater quality urban building drainage water supply project quality evaluation. This paper adopts the combination of BP neural network algorithm and particle swarm algorithm, using particle swarm algorithm to optimize the connection parameters of neural network, avoid the algorithm into local minima, and improve the convergence accuracy and network generalization ability to optimize the BP neural network algorithm and build the artificial intelligence algorithm model.

3.1 BP neural network algorithm

The structure of a common BP neural network is schematically shown in Figure 3. The algorithm is based on the gradient descent method, which corrects the gradient of the network weights and thresholds by calculating the objective function.

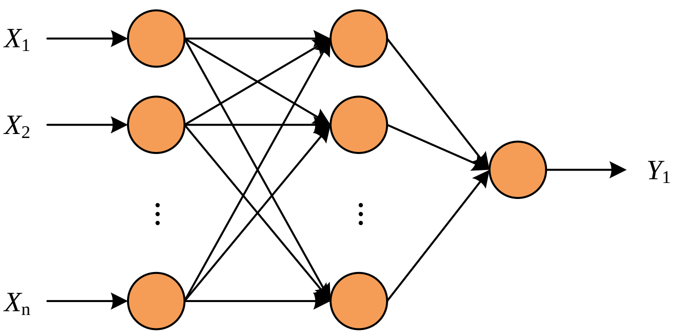

Figure 3. Common BP network structure diagram

Denote the BP neural network input sample as $x=\left(x_0,x_1,\cdots,x_{n-1}\right)^T$, where x_i is each sample value of the input, $i=0,1,2,\cdots,n-1$. The hidden layer in the network has n_1 neurons, and the hidden layer output is denoted as x', with $x'=\left(x'_0,x'_1,\cdots,x'_{n-1}\right)^T$, x'_i for each value of the hidden layer output, $i=0,1,2,\cdots,n-1$; the input layer has m neurons, with $y=\left(y_0,y_1,\cdots,y_{m-1}\right)^T$. In the BP neural network, the weight from the input layer to the hidden layer is w_{ij}, and the threshold is θ_j. The weight from the hidden layer to the output layer is w'_{jk} and the threshold value is θ'_k, then we have equation (1).

$$\begin{cases} x'_j = f\left(\sum_{i=0}^{n-1} w_{ij}x_i - \theta_j\right), j=0,1,\cdots,n_1-1 \\ y_k = f\left(\sum_{j=0}^{n_1-1} w'_{jk}x'_j - \theta'_k\right), k=0,1,\cdots,m-1 \end{cases} \tag{1}$$

Assuming that there is P vector sample in the learning sample, then the learning sample expects the output result $d^{(1)}, d^{(2)}, \cdots d^{(p)}$. When training the data, the network weights can be corrected using constant changes to the error so that $y^{(p)}$ approximates $d^{(p)}$. Let $\theta'_l = w'_{n_2 l}, \theta_k' = w_{n_1 k}', \theta_j = w_{nj}, x_{n_1}' = x_n = -1$, then the corresponding vectors w, w', x and x' in equation (1) increase in dimension by 1.

3.2 Particle swarm algorithm

Particle swarm algorithm, by random initialization of the particle swarm, and then according to the optimal solution information, particles constantly adjust their position and flight speed to search in the optimization space, that is, through an iterative process of global optimization.

Assuming that there are N particles forming a population in a D-dimensional search space, the position X_i of the i rd particle can be expressed as a D-dimensional vector, i.e.:

$$X_i = \left(x_{i1}, x_{i2}, \cdots, x_{ij}, \cdots, x_{iD}\right), \quad i = 1, 2, \cdots, N,\ j = 1, 2, \cdots, D \tag{2}$$

The velocity V_i of the particle is also abstracted as a D-dimensional vector, which is:

$$V_i = \left(v_{i1}, v_{i2}, \cdots, v_{ij}, \cdots, v_{iD}\right), \quad i = 1, 2, \cdots, N,\ j = 1, 2, \cdots, D \tag{3}$$

The optimal position p_{best} searched by this particle is the individual extreme value, i.e.:

$$P_{best} = \left(p_{i1}, p_{i2}, \cdots, p_{ij}, \cdots, p_{iD}\right), \quad i = 1, 2, \cdots, N,\ j = 1, 2, \cdots, D \tag{4}$$

The optimal position searched by the other particles in the population is the global extremum g_{best}, which is:

$$g_{best} = \left(p_{g1}, p_{g2}, \cdots, p_{gD}\right) \tag{5}$$

Using Eqs. (2) and (3), each particle in the population can continuously change its position and velocity to find the optimal solution, i.e.:

$$v_{id} = w * v_{id} + c_1 r_1 \left(p_{id} - x_{id}\right) + c_2 r_2 \left(p_{gd} - x_{id}\right) \tag{6}$$

$$x_{id} = x_{id} + v_{id} \tag{7}$$

3.3 BP neural network algorithm based on particle swarm algorithm optimization

To address the problems of the BP neural network algorithm, such as low convergence accuracy and weak generalization ability, this paper optimizes the network parameters of this network by using the PSO algorithm with strong global search ability. At the same time, a new optimization model is proposed for the disadvantage that the PSO algorithm does not deal well with discrete optimization problems and easily falls into local optimum.

According to the literature, it is known that the linear decay function can be used in the PSO algorithm to reduce the inertia weight to improve the global search ability in the optimization search process, i.e.:

$$w(t) = 0.9 - \frac{t}{MaxEpoch} \times 0.5 \tag{8}$$

Where $MaxEpoch$ denotes the maximum number of iterations, w is the inertia weight and determines the convergence rate of the PSO algorithm depending on the value. When the value of w is 1, the algorithm is a basic PSO algorithm. When w is greater than 1.2, the PSO algorithm has a high probability of falling into local minima. When w takes a value less than 1.2, different values can make the particles have different convergence abilities. Specifically, the larger the value of w in this range, the stronger the global convergence of the particle. On the contrary, the smaller the value of w, the stronger the local convergence of the particle. Therefore, the algorithm can be designed so that the inertia weight decreases slowly to increase the global search capability in the optimization process. At the same time, it is also possible to design the algorithm to obtain strong local convergence in the later stages of the algorithm operation according to different requirements. According to equation (8), the value of $w(t)$ can be linearly decreased in the interval of $[0.9, 0.4]$.

In this paper, the linear decay function used to reduce the inertia weights is abandoned, and the higher order function method is used to reduce the inertia weights. Although this method improves the global search capability of the algorithm at a slower rate in the early stage of operation, it improves faster in the later stage of operation. The linear decay function for improving the inertia weight of equation (8) is improved as:

$$w(t) = 0.9 - \left(\frac{t}{MaxEpoch} \right)^4 \times 0.5 \tag{9}$$

where $MaxEpoch$ is the maximum number of iterations.

In this paper, the number of units in the hidden layer is set to 4 in the performance analysis of BP neural network algorithm, and then the value of learning efficiency is changed, and then the relationship between learning efficiency and minimum convergence accuracy is derived. The improved BP algorithm uses a single-layer neural network with a tansig function for the neuron transfer function. The initial value of each particle range is set to $[-1,1]$, the number of individuals in the particle population is $m = 40$. The maximum number of iterations is set to $T = 400$, the minimum training stop error is $\lambda = 10^{-5}$, and the learning factor is $c_1 = 2.05, c_2 = 2.05$. The search space dimension is calculated according to equation (10).

$$D = (indim + 1) * hiddennum + (hiddennum + 1) * outdim \tag{10}$$

where parameters $indim$, $hiddennum$ and $outdim$ denote the number of neurons in the input, hidden and output layers, respectively, and can be derived $D = 25$.

The flow of the improved BP neural network algorithm is shown in Figure 4.

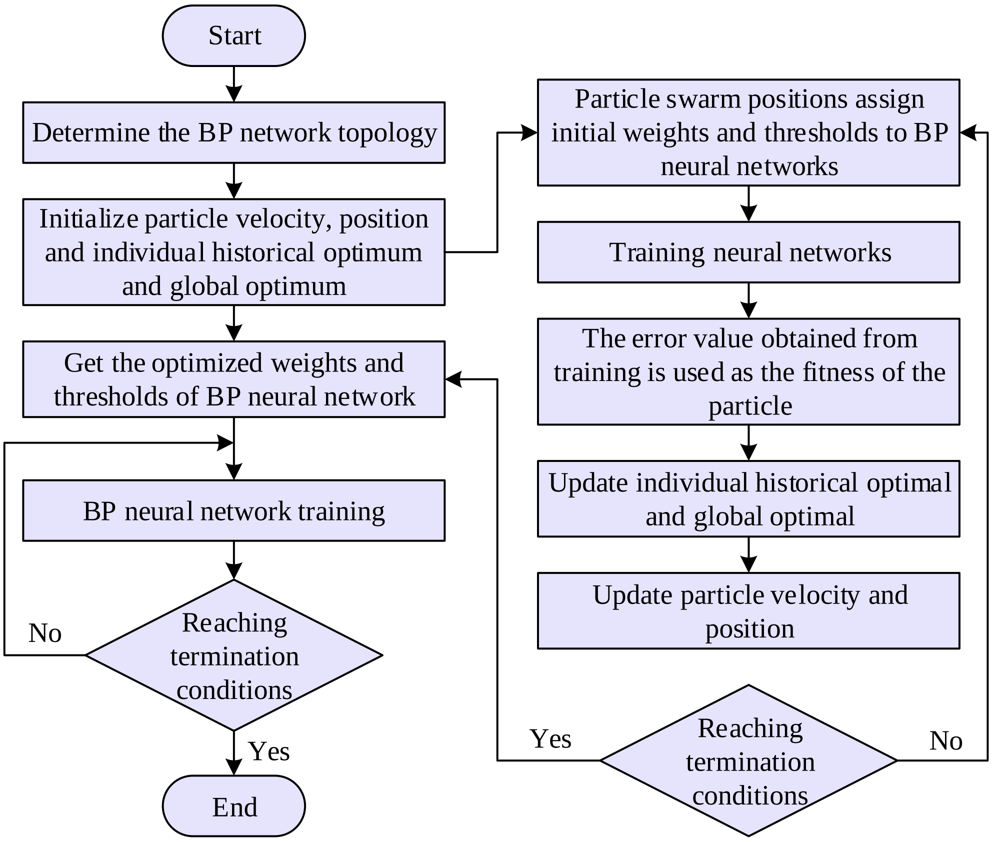

Figure 4. The improved BP neural network algorithm flow is shown

4 Analysis of water supply and drainage engineering design of urban construction supported by AI

In order to make the design of urban building water supply and drainage, this paper constructs a quantitative analysis of residents' evaluation data related to water supply and drainage projects on the web using the constructed optimal BP neural algorithm.

4.1 Testing and analysis of the improved BP neural network algorithm

4.1.1 Test content

The BP neural network is constructed as a double implicit layer with 13 nodes, the output layer function is set to PURELIN, the implicit layer function is set to LOGSIG, the target 1.0e-005, the learning rate is 0.1, the particle swarm size of the genetic algorithm is set to 40, the weight factor is 0.6, C1 and C2 are 2, the particle dimension is set to 287, and the maximum speed is set to 0.5. The total mining 404 cases of quality pass rate of relevant data information as the sample of this experiment, 20 cases are taken as prediction samples, the rest are training samples, the evaluation indexes of experimental error are error, total error, total error percentage, mean square error, ten experiments are conducted, the specific process is shown in Figure 5.

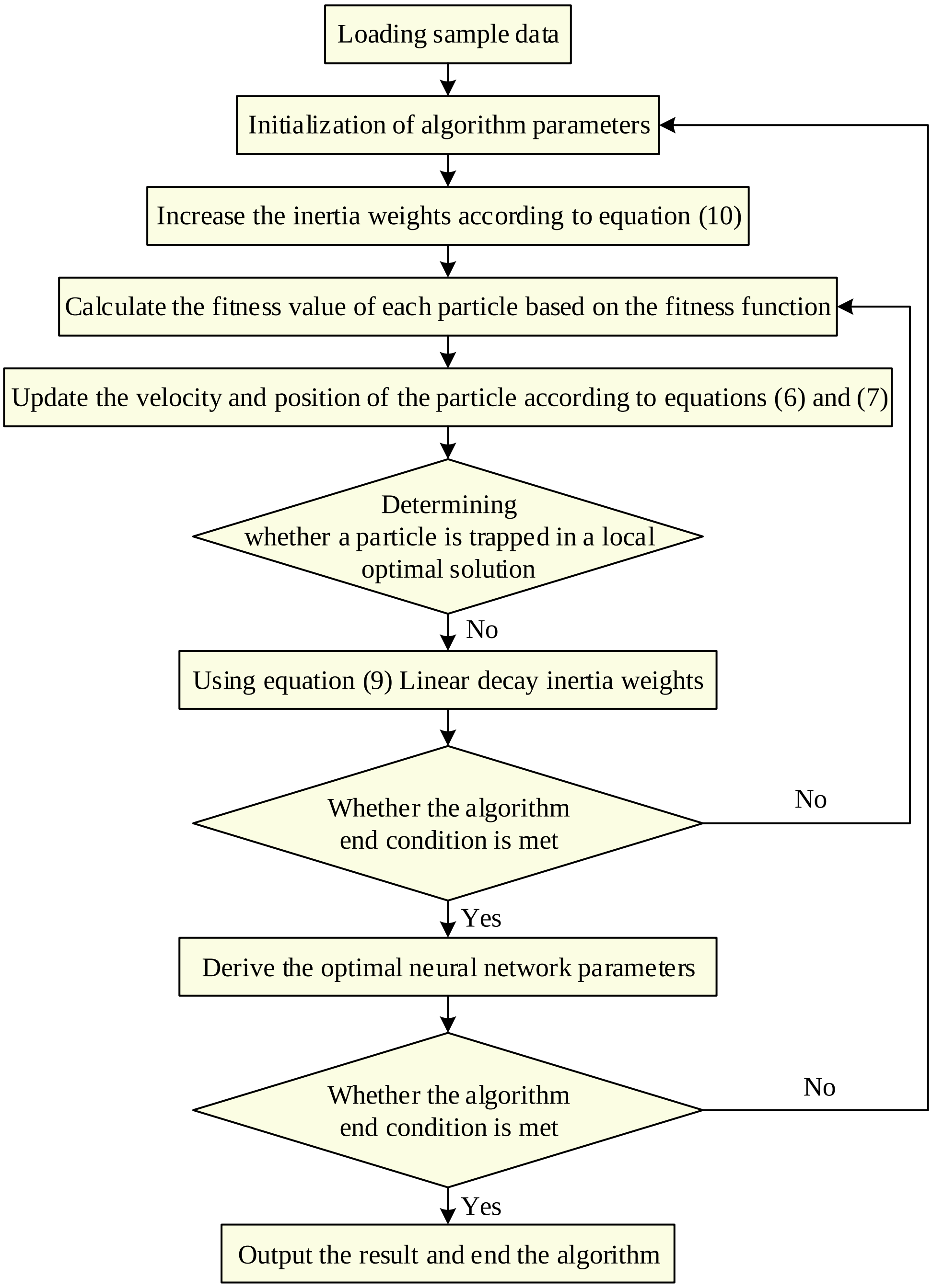

Figure 5. Flow chart of prediction

Ten experimental data were collected to compare the algorithms before and after optimization, respectively, to the different algorithms for error comparison Table 1.

Table 1. Algorithm error comparison

Algorithm	Errorsum	pere	mse
BP neural network algorithm	0.2933	0.3%	2.8E-4
Optimized BP neural network algorithm	0.0185	0.02%	1.9E-6

4.1.2 Test results and analysis

The expected output obtained by comparing the obtained experimental results with the expected output of the BP algorithm is shown in Figure 6.

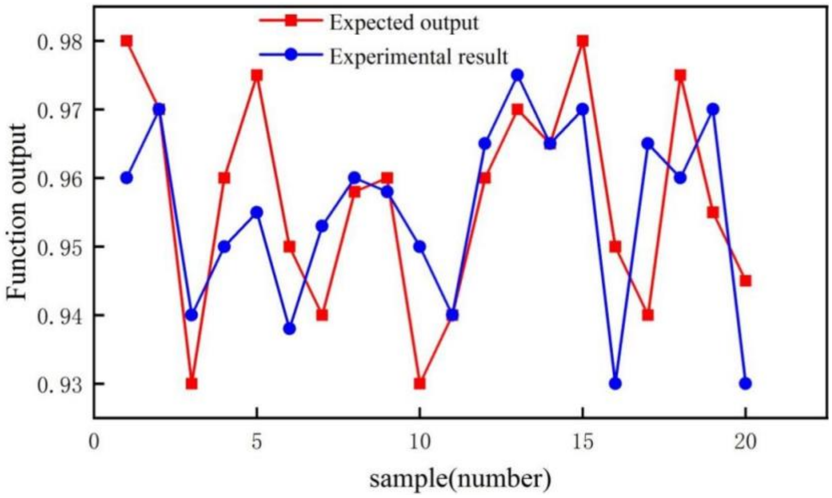

Figure 6. Output comparison of BP network algorithm

The experimental results obtained were compared with the expected output obtained from the BP algorithm based on the optimization of the particle swarm algorithm Figure 7.

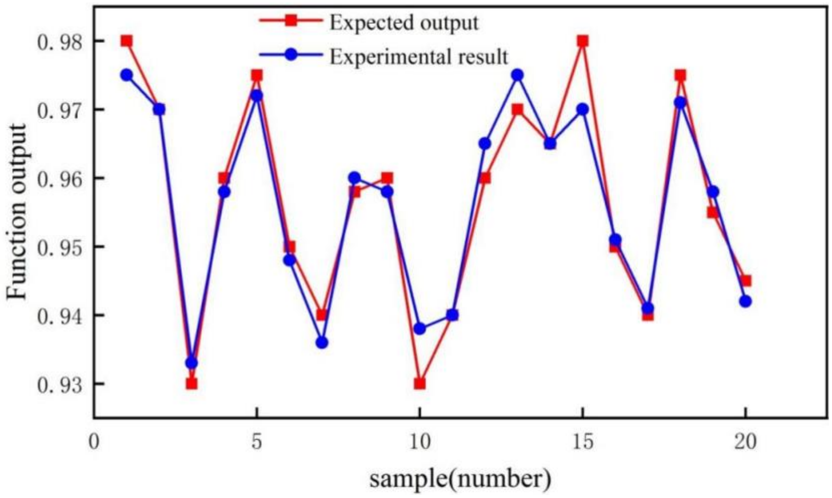

Figure 7. Output comparison of optimized BP network algorithm

As can be seen by Figure 6 and Figure 7, the prediction results obtained by the optimized the BP neural network algorithm based on the particle swarm algorithm and the expected results are basically the same with an error of no more than 0.02%, while the prediction results obtained by BP neural network algorithm alone differ too much from the expected results by about 0.3%. It can be seen that the improved BP neural network algorithm based on particle swarm algorithm has higher prediction accuracy and can predict the product quality more accurately compared with the conventional BP network as shown in Table 2.

Table 2. Compares the results of different methods

Monitoring point	Quality parameter	Expected output	BP algorithm output	Optimized BP algorithm output
001	75-92	75	68	74
002	75-92	76	70	76.5
003	75-92	79	69	79
004	75-92	81	88	83
005	75-92	83	63	83
006	75-92	85	80	81
007	75-92	87	80	87
008	75-92	88	80	88.5
009	75-92	89	81	88.8
010	75-92	92	76	90

So the artificial intelligence model of BP neural network improvement algorithm based on particle swarm algorithm can design a targeted and highly accurate product quality prediction model for the survival and development of enterprises with significant practical significance. This shows through experiments that the improved algorithm of BP network based on particle algorithm has higher prediction accuracy and can predict product quality more accurately compared with conventional BP neural network, which is worth promoting.

4.2 Analysis of water supply and drainage engineering design of urban construction under artificial intelligence

Based on the national engineering evaluation criteria table, 50 sets of data were collected for each interval segment, 40 sets for training and 10 sets for testing, when the selected four categories of quality evaluation indexes were trained for sample collection. The evaluation criteria for one type of quality are met only when the quality of the project exceeds 85. The same method can be used to generate 300 sets of quality evaluation data. Similarly, 300 sets of data are generated for the remaining three quality evaluation indexes, and the generated sample data are shown in Table 3.

Table 3. Sample generation

Sample number	Sample range	Expected output	Recognition result	Sample group number
1	[90-100]	1	S	50
2	[78-90]	2	A	50
3	[69-78]	3	B	50
4	[60-69]	4	C	50
5	[20-60]	5	D	50
6	[0-20]	6	E	50

The experimental data, the predicted output and the desired output of the quality of urban building water supply and drainage engineering design, and the actual output were compared to obtain Figure 8.

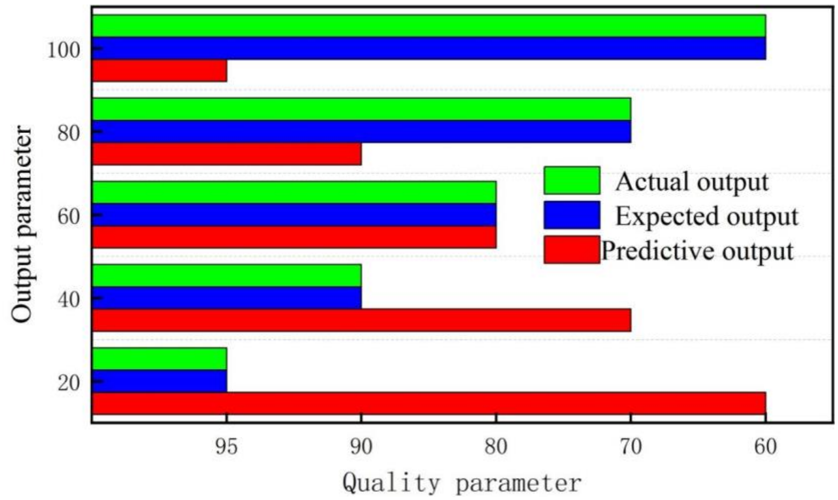

Figure 8. Comparison of output results

It can be derived from Figure 6 that the quality of the project using BP neural network algorithm is more in the range of 85-100, the difference between the expected output and the actual output is larger by about 10, and the difference with the predicted output is about 12, which cannot get the quality of urban building water supply and drainage project well. The quality of the project obtained by using the improved algorithm of BP neural network based on particle swarm algorithm is around 78-92, where the difference between the expected output and the predicted output is around 2, and the difference between the actual output and the expected output is only 1, which is very small. So the use of artificial intelligence can accurately solve the problems of remote cities and high-rise buildings in water supply systems and the design of urban drainage pipes, and the monitoring of industrial production effluents in drainage systems.

5 Conclusion

In order to reform and improve the water supply and drainage engineering design in a targeted way to ensure the smooth implementation of urban water supply and drainage engineering, and then to promote the scientific, harmonious, and stable development of the overall urban planning work. In this paper, the optimized BP neural network algorithm is applied to the design of urban building water supply and drainage engineering, and the following two conclusions are obtained:

1) The artificial intelligence model based on the improved BP neural network algorithm of particle swarm algorithm can design a targeted and highly accurate prediction model of product quality parameters that has significant practical significance for engineering design and development.

2) The use of artificial intelligence can accurately solve the problems of remote cities and high-rise buildings in water supply systems and the design of urban drainage pipes and monitoring of industrial production effluents in drainage systems, promoting the sustainable development of water supply and drainage engineering.

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