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Research on the Monitoring Method of Atmospheric Particle Pollutant Concentration Based on Genetic Neural Network

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Abstract:

Atmospheric environment is one of the important environments for human survival. With the continuous improvement of the degree of industrialization, while promoting the rise of economic prosperity, it has also caused serious environmental pollution problems to us. Therefore, environmental monitoring has become a hot spot, and the application of wireless sensor networks provides a great development space for the monitoring of polluting gas emission sources. Therefore, people have higher and higher requirements for real-time monitoring technology of polluting gas emissions. In order to more comprehensively understand and grasp the changing trend of air pollutants, and provide more comprehensive and timely information for air pollution prevention and control, it is imperative to carry out air pollutant forecast research. Atmospheric pollution forecast is the basis of atmospheric environmental planning, evaluation and management. It can provide basic data for urban environmental management, pollution control, environmental planning, urban construction and public health, so as to take necessary control and preventive measures. With the rapid development of wireless sensor networks, in order to monitor air pollution in real time and effectively, this paper builds an automatic air pollution monitoring system based on neural networks. Compared with the traditional multiple linear regression model, the neural network model can capture the nonlinear influence law between pollutant concentration and meteorological factors, and can better predict the mass concentration of particulate matter. Choosing meteorological parameters and pollution source intensity variables can describe the real-time change of atmospheric particulate matter mass concentration more accurately, and the prediction accuracy of particulate matter mass concentration is higher. The neural network prediction model is not only suitable for general pollution concentration, but also accurate for predicting the mass concentration of particulate matter in high pollution period.

Keywords: *Atmosphere, Neural Network, Concentration Monitoring, Contaminants.*

I. INTRODUCTION

With the continuous improvement of the degree of industrialization and the economic prosperity and development, our living environment has suffered unprecedented pollution, and environmental problems have increasingly attracted people's attention [1]. The emission of various air pollutants continues to

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increase, especially the haze weather in major cities in recent years, which poses a certain threat to the survival and development of human beings [2]. Since the 1970s, during the rapid development of industry and transportation, air pollution has seriously affected people's daily life. The atmospheric visibility of some polluted cities is only about 5 km, and the visibility is even lower when the pollution is serious, so the atmospheric visibility is low. It has become a major environmental problem in urban development [3]. Atmospheric particulate pollution, including monitoring indicators such as PM2.5 and PM10, are the contents of suspended particles with different maximum diameters per unit of atmospheric gas volume, and the unit is $\mu g/m^3$. Environmental monitoring refers to the activity of monitoring the quality of the environment that affects the survival and development of humans and other organisms. good or bad [4]. As far as the current situation is concerned, with the rapid increase of the population on the earth and the rapid development of the human economy, the quality of the air environment has also been seriously affected, and air pollution has become a very serious topic in contemporary times. The first step of atmospheric prevention and control is to take monitoring measures to grasp the emission of pollutants at any time, so as to take targeted and effective measures to prevent accidents [5].

Atmospheric pollutants are mainly divided into harmful gases such as carbon monoxide, nitrogen oxides, carbon ammoniated compounds, photochemical smog and sulfide, and particles such as dust, acid mist and aerosol. Their main sources are factory emissions, automobile exhaust and dust, etc. In practical work, with the increase of air pollution monitoring items, the expansion of monitoring scope and the dense spots, it is difficult for manual monitoring to meet the requirements [6]. The research shows that there is a strong nonlinear relationship between the change of particle concentration and meteorological conditions. Therefore, the traditional multiple linear regression model for predicting particle mass concentration has great limitations, and the relationship and influence law between particle mass concentration and meteorological parameters cannot be captured, which leads to inaccurate prediction results. With the rise of artificial neural network technology, artificial neural network technology has been widely used in the field of environmental monitoring. With the deepening of research, various monitoring models based on neural network technology have been realized, and the accuracy is constantly improving [7]. The artificial neural network can overcome the traditional limitations, it can establish a very complex nonlinear model, which can well reflect the nonlinear relationship between the concentration of particulate matter and meteorological parameters. BP neural network completes the mapping through the composition of simple nonlinear functions, and has been widely used in the fields of function approximation, process control and network traffic due to its strong nonlinear ability, but the structure design of neural network depends on experience, and its layer number And the number of neurons in each layer needs to be tried continuously, and too many or too few neurons will affect the final prediction effect [8]. So far, artificial neural network technology has achieved an irreplaceable position in the field of atmospheric pollutant prediction, and has always been a research hotspot in this field.

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II. AIR POLLUTION

2.1 Current Status of Air Pollution

When the concentration of pollutants in the air reaches or exceeds the harmful level, it will destroy the normal survival and development of ecosystem and human beings, and cause varying degrees of harm to humans and organisms. Although the total emission of air pollutants in China is decreasing year by year, the emission level of some pollutants is still higher than the national standard. The air pollution in many cities and regions is still serious, and people's daily life has been greatly affected. Sulfur dioxide and other pollutants in the atmosphere are oxidized to form sulfuric acid, and acid rain is formed with the natural rain falling. Acid rain not only harms forests and crops, but also corrodes buildings, metals and other products. The concentration of total suspended particulate matter in urban atmospheric environment generally exceeds the standard, especially the concentration of PM2.5 is too high. There are three main air pollution sources in China: industrial pollution sources, traffic pollution sources and domestic pollution sources [9]. The unorganized emission of waste gas seriously pollutes the atmosphere. The common unorganized emissions in our daily life include automobile exhaust and domestic waste gas emissions and so on. Unorganized emission forms are scattered, and the emissions are small, which is not easy to attract people's attention. However, its pollution and destruction to the atmosphere can not be ignored, and it is also difficult to monitor and control. Nitrogen oxide pollution is on the rise, and some cities are experiencing photochemical smog. Nitrogen oxides are also the most important factor in the formation of photochemical smog, which damages the health of humans and animals, mainly irritating the eyes and respiratory tract, causing pink eye and chronic respiratory diseases. It can be seen that it is imperative to do a good job in the monitoring and control of polluted gases.

2.2 The Importance of Air Pollution Monitoring

Atmospheric environment is one of the important environments for the survival and development of human beings and even all organisms on the earth. The quality of atmospheric environment will directly affect the health of biological life. Therefore, it is very important for us to pay close attention to the state of atmospheric environment. Since the first industrial revolution, the global economy has developed rapidly and the degree of industrialization has increased day by day. At the same time, the number of urban population has expanded rapidly. Human activities such as industrial production and automobile transportation have made the problem of urban air pollution increasingly serious. The development history of human industry is a history of environmental pollution. People monitor the atmospheric environment through various methods in order to know the advantages and disadvantages of air quality, so as to provide reliable security for people's normal life. The vigorous development of computer technology and communication technology has brought technological innovation to the field of environmental monitoring. The field of environmental monitoring has moved towards informatization and intelligence. Because the distribution and concentration of air pollutants change with time and space, it is necessary to collect a large number of effective monitoring data to obtain the situation and development trend of air pollution timely and accurately, which requires us to establish a perfect air pollution monitoring system. Therefore,

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artificial neural network technology has achieved an irreplaceable position in the field of air pollutant prediction, and has been a research hotspot in this field. Monitoring the atmospheric environment can accurately predict and forecast the air quality, provide the basis for citizens to understand the state of the atmospheric environment and then make reasonable travel plans, and also provide the basis for government departments to make appropriate environmental management decisions and regulations, which is of great significance for promoting social harmony and sustainable development [10].

2.3 Air Pollution Monitoring System

According to the specific environment and actual situation, the air pollution monitoring system needs to have a wide monitoring range, monitoring items, high monitoring frequency, multiple data collection and analysis functions, data transmission, storage, and monitoring information processing functions. The whole system software includes resource layer software, middle layer software and application layer software. The resource layer software is responsible for data acquisition, processing and data transmission, the middle layer software is responsible for data storage and analysis, and the application layer software is responsible for data display. The system software flow is shown in Fig 1.

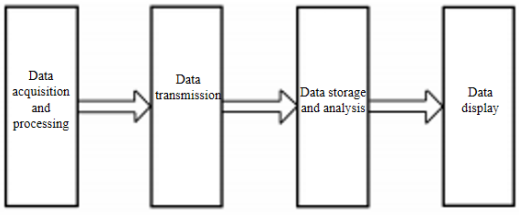

Fig 1: system software flow

Resource layer: it is the lowest layer in the system design, and it is the most basic guarantee for the realization of the functions of the whole system. This layer includes all hardware management in the system, including sensor networking technology, data acquisition, storage and transmission. Data acquisition and processing mainly includes A/D conversion controlled by single chip microcomputer, data processing, data storage and so on.

Middle layer: This is the core layer to manage the sensor network architecture. This layer mainly includes the functions of execution management, distributed data mining activities, sensor registry and control. Data storage and analysis is mainly based on database storage and analysis, which extracts useful information by managing, analyzing and data mining a large number of data collected by sensors.

Service layer: through the middle layer, the service layer can obtain the information of the resource layer, that is, it allows applications to access the data about monitoring information stored in the database and call these data into their own programs for their own needs.

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III. NEURAL NETWORK

3.1 Overview of Neural Networks

Artificial neural network, also known as neural network, is a mathematical model established by imitating the information processing mechanism of brain synapses. The mathematical model of artificial neural network is a mathematical expression of the information transmission process of biological neurons by using mathematical language. Neuron (node) is the basic processing unit of artificial neural network (ANN), usually a multi-input and single-output information processing unit, in which the information processing process is nonlinear as shown in Fig 2. Neural network consists of one input layer, one or more hidden layers and one output layer. There are two similarities between neural network and brain: one is to obtain information from external environment through learning; Second, neurons are used to store the acquired information. Research shows that a single-hidden-layer neural network with enough neurons can approximate any smooth and measurable function between input and output by choosing appropriate connection weights and transfer functions. The neural network system obtains a nonlinear mapping describing the relationship between input variables and output variables by "learning" the input and output data pairs under study. At present, the widely used ones are: Error Back Propagation Neural Network (BP), Genetic Algorithm (GA) Neural Network, Radial Basis Function (RBF) Neural Network. The characteristics of neural network include: information storage and processing are carried out in neurons; strong robustness and fault tolerance, local errors will not affect the overall operation; strong self-learning ability, and can be in the learning process SS. Neural networks are mainly used in the fields of modeling, pattern recognition and control.

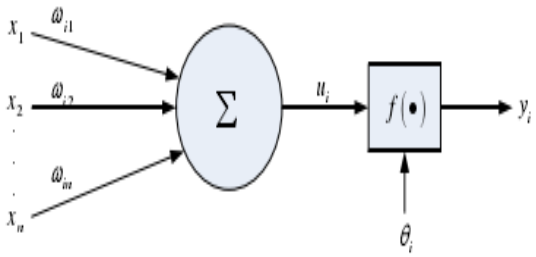

Fig 2: typical model of neurons

In the Fig, x_i is the input signal of the neuron i, ω_{ij} is the connection weight; u_i is the output value of the input signal after linear operation, which is also the net input value of the neuron; θ_i is the threshold (deviation value) of the neuron, b_i is used for Representation; $f(\bullet)$ is the transfer function, the output of the y_i neuron.

$$u_i = \sum_{j=1}^{n} \omega_{ij} x_j$$

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$$y_i = f\left(\sum \omega_{ij} x_j + b_i\right)$$

There are three commonly used transfer functions:

(1) Threshold function

$$f(x) = \begin{cases} 1, x \geq 0 \\ 0, x \leq 0 \end{cases}$$

(2) Linear function

$$f(x) = x$$

(3) S-type function

$$f(x) = \frac{1}{1 + \exp(-\alpha x)}$$

In the formula, α is the slope parameter of the sigmoid function, which can be changed to obtain the S-function with different slopes.

3.2 Genetic Algorithm

Genetic algorithm (GA) is an optimization algorithm based on the principles of natural selection and genetic genetics, which has attracted much attention in recent years. GA algorithm refers to the elimination mechanism in the process of biological evolution, encodes the mathematical parameters to be optimized according to certain rules to form population individuals, evaluates the individuals in the population by using the fitness function constructed by mathematical method, selects the individuals with higher fitness from the population, enters the next operation process, and eliminates the individuals with lower fitness value, so on, The population fitness value is increasing. The basic idea of genetic algorithm (GA): firstly, a fitness function should be designed according to the objective function of the problem to be optimized, and then the parameters of the optimization problem should be coded according to certain rules to obtain the initial population, and then the population should be evaluated and genetic operated. In this way, after multiple generations of evolution, the individual with the best fitness is obtained as the optimal solution of the problem. The flow of genetic algorithm is shown in Fig 3. The implementation process of basic GA algorithm is described as follows:

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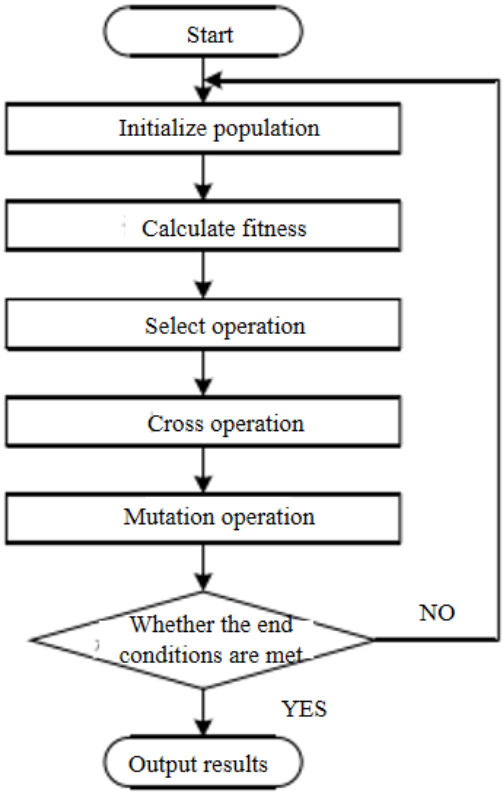

Fig 3: flow of genetic algorithm

Genetic algorithm is a general algorithm to solve search problems, which can be used for all kinds of general problems. The common features of the algorithms are as follows: firstly, a group of candidate solutions are formed; secondly, the fitness of these candidate solutions is measured according to some fitness conditions; then, some candidate solutions are retained according to the fitness, and others are abandoned; finally, some operations are performed on the retained candidate solutions to generate new candidate solutions.

Genetic algorithm has excellent global searching ability, and it is not easy to fall into local extremum. In genetic algorithm, fitness function is used to evaluate the advantages and disadvantages of individuals in the population. The operation process of genetic algorithm takes the population as the operation object, and can be carried out on multiple individuals simultaneously, with parallelism and simple process. The parallel operation process of genetic algorithm can realize distributed computing, which effectively improves the computing speed. In addition, genetic algorithm has good scalability. The actual problems to be solved or optimized are different, and the fitness function is also different. The fitness function is usually transformed from the objective function of the problems to be solved. Therefore, it is easy to realize the mixed use with other algorithms, but the genetic algorithm still has some defects: for example, the local search ability of the genetic algorithm is not ideal, so the efficiency of the simple genetic algorithm is not high, and it needs to be evolved later to meet the needs. Genetic algorithm mainly relies on experience to select the parameter design of genetic operator, such as crossover rate and mutation rate, and the choice of these parameters directly affects the performance of the algorithm and makes the results

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unreliable. In addition, the potential capacity of the parallel mechanism of the genetic algorithm is not fully utilized.

IV. CONCLUSIONS

Today, with the rapid development of economy, the serious air pollution brought by industrial modernization has affected human production and life. The emission of various air pollutants has increased, resulting in the concentration exceeding the standard, which poses a certain threat to human survival and development. Carrying out environmental monitoring and prediction has very important theoretical and practical significance for environmental protection, and can provide effective decision-making basis for environmental protection. The artificial neural network model can well monitor the concentration of atmospheric particulate matter, and its prediction results can better capture the nonlinear influence law between pollutant concentration and meteorological factors than the traditional multiple linear regression model. The data processing scheme based on neural network can obtain higher data processing accuracy. With the continuous strengthening of people's awareness of environmental protection and the continuous improvement and expansion of environmental monitoring system, the prediction research of environmental pollutants will continue to deepen. Neural network technology will also be more widely used in the field of environmental prediction, and achieve more ideal results, so as to provide a strong decision-making basis for environmental prevention and control.

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