Design of Atmospheric Environmental Health Monitoring System Based on Spatial Bayesian Network

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Abstract. With the rapid development of our country's economy and industry, atmospheric environmental issues have gradually attracted more and more people's attention. In recent years, the vigorous development of the Internet of Things technology has made it possible to "Internet of Everything". At present, the common traditional atmospheric environment monitoring systems on the market generally have shortcomings such as single function, large system measurement error, inability to collect data for a long time, large system power consumption, and inability to view data after being far away from the device. As Bayesian network theory is more and more applied to the modeling of monitoring events, more and more learning optimization methods about Bayesian network have been proposed and become a research hotspot. The purpose of this paper is to study the design of atmospheric environmental health monitoring system based on spatial Bayesian network. This paper studies the intelligent anomaly detection technology based on Bayesian network, the purpose is to use the intelligent anomaly detection technology to predict unknown behaviors that affect the health of the atmospheric environment, improve the learning ability of the detection system, and strengthen the active defense capability of the atmospheric environmental health monitoring system; Secondly, this article proposes an improved spatial Bayesian network model based on the shortcomings of the spatial Bayesian network. Finally, in view of some of the shortcomings of the detection system, this paper proposes a system model that combines anomaly detection with other detection mechanisms, which can significantly improve the accuracy of detection and reduce the false alarm rate of the atmospheric environmental health monitoring system. This paper aims at the above shortcomings and at the same time integrates the current situation of the atmospheric environment monitoring system, analyzes the possible trends of the atmospheric environment monitoring system, and combines the advantages of the spatial Bayesian network to address temperature, humidity, carbon monoxide concentration, and suspended particle concentration. For the main atmospheric environment indicators, a multi-functional,
low measurement error, low power consumption, and low-cost atmospheric environment monitoring system is designed. Experimental research results show that: in terms of concentration, nitric oxide and nitrogen dioxide are the highest, at 58% and 68%, respectively, and they are also the largest in the air, accounting for a total of 70%. All in all, the monitoring system needs to monitor even more types of gases listed above, so that the feedback of the atmospheric environment health status is more accurate.

Keywords: Space Bayesian Network, Atmospheric Environment, Health Status, Monitoring System Design

1. Introduction

With the rapid development of my country's economy and industry, atmospheric environmental issues have gradually attracted more and more people's attention [1-2]. In recent years, the vigorous development of the Internet of Things technology has made "Internet of Everything" possible [3-4]. At present, the common traditional atmospheric environment monitoring systems on the market generally have shortcomings such as single function, large system measurement error, inability to collect data for a long time, large system power consumption, and inability to view data after being far away from the device [5-6]. As Bayesian network theory is more and more applied to the modeling of monitoring events, more and more learning optimization methods for Bayesian network have been proposed and become a research hotspot [7-8].

In the research on the influence of big data technology on new media communication, many domestic and foreign scholars have studied it and achieved good results. Vala proposed to use genetic algorithm to search for Bayesian network structure [9]. Genetic algorithm has many advantages. Among them, effective utilization of global information and implicit parallelism are two of the more important characteristics of the algorithm. At the same time, genetic algorithms have fewer restrictions on the problem itself, so it has a strong general optimization ability [10]. However, genetic algorithms tend to converge prematurely, which will prevent effective genes in other individuals from being effectively replicated and eventually lost; moreover, the difference between chromosomes in the later stages of evolution is very small, which easily causes population evolution to stagnate and search efficiency is low, resulting in the search result is not the global optimal solution [11]. Lyon-Caen proposed the use of Structure EM algorithm (SEM algorithm) to learn missing data and hidden variables, and proved the convergence of the algorithm [12].

This paper studies the intelligent anomaly detection technology based on Bayesian network, the purpose is to use the intelligent anomaly detection technology to predict unknown behaviors that affect the health of the atmospheric environment, improve the learning ability of the detection system, and strengthen the active defense capability of the atmospheric environmental health monitoring system; secondly, this article proposes an improved spatial Bayesian network model based on the shortcomings of the spatial Bayesian network. Finally, in view of some of the shortcomings of the detection system, this paper proposes a system model that combines anomaly detection with other detection mechanisms, which can significantly improve the accuracy of detection and reduce the false alarm rate of the atmospheric environmental health monitoring system. This paper aims at the above shortcomings and at the same time integrates the current situation of the atmospheric environment monitoring system, analyzes the possible trends of the atmospheric environment monitoring system,
and combines the advantages of the spatial Bayesian network to address temperature, humidity, carbon monoxide concentration, and suspended particle concentration. For the main atmospheric environment indicators, a multi-functional, low measurement error, low power consumption, and low-cost atmospheric environment monitoring system is designed.

2. Research on the design of atmospheric environmental health monitoring system based on spatial bayesian network

2.1. Spatial bayesian network construction method

2.1.1. Expert learning. This method completely relies on the experience accumulation of domain experts to construct the network structure model. With the help of experts’ experience accumulation, certain characteristics of the system are determined through the analysis and evaluation of the domain experts to determine the node meaning of the Bayesian network, construct the network model, and then Use expert scoring method to determine the parameters of the network. Because expert experience often does not fully cover all the information of the system, it has certain subjectivity and knowledge limitations. The model and the actual situation may have certain deviations. It is necessary to continuously learn or solicit the opinions of experts in multiple fields to combine with the historical data of the system.

2.1.2. Data learning. After artificially researching the system, define the node variables in the network system, and then use learning methods to train them to obtain network knowledge such as the relationship between nodes and the degree of influence. This is a data-based model algorithm that can Learn the comprehensive information of the system well. With the development of data mining and artificial intelligence, this method has also been developed rapidly.

2.1.3. Data and experience combination method. In the process of Bayesian network construction, according to the actual knowledge base situation and learning level of the system, expert knowledge and data learning are used flexibly to train the data, obtain the structure of the network, and determine and modify the parameters.

2.2. Atmospheric environmental health status monitoring module

2.2.1. Suspended particle concentration monitoring module. The main part of the suspended particle concentration monitoring module refers to the suspended particle concentration sensor PMS3003. The sensor has the advantages of digitization and versatility. This sensor is designed with the current more popular laser scattering principle. Since the sensor has a laser source, when air enters the sensor, the laser light generated by the laser source is mapped on the suspended particles in the air, and scattering will occur at this time. At the same time, the suspended particle concentration sensor PMS3003 will collect scattered light at a specified angle. After obtaining the relationship between the scattered light intensity and time, the microprocessor in the sensor will use this classic algorithm to obtain the suspended particles. The equivalent particle diameter and the number of suspended particles (in unit volume) are two aspects of data.

2.2.2. Carbon monoxide monitoring module. The core component of the carbon monoxide sensor module is the gas sensor MQ-9. When designing the gas sensor MQ-9, it is necessary to use gas-
sensitive materials that are more sensitive to carbon monoxide and combustible gas in the air. Generally, two points should be considered when selecting gas-sensitive materials: relatively low conductivity and low cost in pure air. Therefore, tin dioxide (SnO2) naturally becomes a very ideal gas-sensitive material. The gas sensor MQ-9 has the following two working modes: Low temperature mode: This mode uses 1.5V voltage to heat it. If carbon monoxide gas is present in the current environment, the conductivity of the gas sensor MQ-9 will vary with the concentration of carbon monoxide gas. Change and change, the two show a positive linear relationship. High temperature mode: This mode uses 5V voltage to heat it. The high temperature mode can detect methane (CH4), propane (C3H8) and other combustible gases in the air. Different from the low temperature mode, the high temperature mode will automatically clean during operation. Stray gas attached to the gas-sensitive material in the low-temperature mode.

2.2.3. Temperature monitoring module. The temperature monitoring module in this design uses the temperature sensor LM35DZ as its core device. The temperature sensor LM35DZ is produced by National Semiconductor (currently acquired by Texas Instruments) and adopts a TO-92 package. The temperature sensor LM35DZ has the characteristics of wide application range, low price and high accuracy. According to different design needs, the typical working circuit of the temperature sensor LM35DZ is mainly divided into a basic temperature monitoring circuit and a full range temperature monitoring circuit. The basic temperature monitoring circuit is shown in Figure 3-18. The output voltage of the basic temperature monitoring circuit has a linear relationship with the current atmospheric environment temperature. For example, when the atmospheric environment temperature is, the output voltage of the temperature sensor LM35DZ is 0mV. The temperature rises, correspondingly, the output voltage of the temperature sensor LM35DZ rises by 10mV.

2.2.4. Humidity monitoring module. In terms of humidity monitoring, the design chose to use the humidity sensor HIH-5030. The manufacturer of the humidity sensor HIH-5030 is the world-renowned Honeywell International Company, and its packaging form is SMD packaging. By consulting the manual, we can see that the operating voltage of the humidity sensor HIH-5030 needs to be set between 2.7V and 5.5V DC. At the same time, the sensor HIH-5030 has the following advantages: low power consumption, low cost, high accuracy, fast response and low drift. Humidity sensor HIH-5030 converts the humidity of the environment into electrical signal output. Unlike the temperature sensor LM35DZ, the voltage value output by the humidity sensor HIH-5030 and the atmospheric humidity value are not completely linear, and need to be used in the application Convert the formula to get the atmospheric humidity level.

2.3. Software design of the monitoring system for atmospheric environmental health

2.3.1. Server window design. Monitoring nodes distributed outdoors use GPRS communication to upload atmospheric environment information to the server. In order to facilitate the debugging of the system and the daily use of the operators, a data receiving window is designed on the server side. The receiving window creates a ServerSocket for the server port and monitors the request from the monitoring node. When there is a Socket connection request from the monitoring node, it will perform a Socket connection with it, thereby receiving the information uploaded by the monitoring node.
2.3.2. The design of the database. The server-side database of the environmental monitoring system designed this time uses the Bmob cloud. Bmob cloud database solves the problem of repeated development and maintenance of back-end logic, supports 10 data types (including String, Number, Boolean, Data, File, Array, Object, etc.), provides a large number of standard API interfaces, and establishes a security mechanism. Increased data security isolation, distributed storage architecture, multi-tenant virtualization technology, and its key matching and access control functions, which further ensure the security of data, can meet the support of various back-end capabilities, and greatly reduce the development time of the application product.

2.3.3. Server monitoring design. The server-side monitoring center only serves the managers of the atmospheric environment monitoring system, and has the functions of viewing the real-time and historical information of the monitoring nodes, and managing the information of the monitoring nodes and managers. The entire monitoring center software can be divided into: first-level window: login window, main window; second-level window: add node, delete node, modify node information, view node list, add employee, delete employee, modify employee Information, view employee list, view historical information of monitoring nodes. The monitoring center software is not open to the public, so there is no new user registration function. When you need to add managers, you can only log in to the main page to add employee information with an existing account. The first manager account information has been stored when the database is created.

2.4. Algorithm

The calculation formula of atmospheric humidity (take an external temperature of 25 degrees Celsius as an example) is as follows:

\[ V_{\text{OUT}} = (V_{\text{SUPPLY}})(0.00636(\text{sensor RH}) + 0.01515) \]  \hspace{1cm} (1)

Among them, sensor RH represents the relative humidity at room temperature of 25 degrees Celsius, and further derivation can be obtained:

\[ \text{sensir RH} = \frac{V_{\text{OUT}}}{V_{\text{SUPPLY}}} - 0.1515 \times \frac{0.00636}{0.00636} \]  \hspace{1cm} (2)

In addition, since the relative humidity is also affected by the external temperature, it is necessary to use the temperature compensation formula to obtain the final relative humidity True RH. The calculation formula is as follows:

\[ \text{True RH} = \frac{\text{sensir RH}}{1.0546 - 0.00216t} \]  \hspace{1cm} (3)

The final calculated relative humidity unit is %RH.

3. Experimental research on the design of atmospheric environmental health monitoring system based on space bayesian network

3.1. Experimental subjects and methods

This paper takes various atmospheric environment monitoring system functions and various gases in the atmosphere as the research object, and improves the system design of this study through actual investigation and analysis, so that the feedback of the atmospheric environment health status is more accurate.
3.2. Data collection

The data is obtained through field tests, and calculations are in progress. Assign test tasks to investigators or investigation teams, and the tasks are equally distributed by default within the investigation team. The survey task is divided into specific task assignments, such as how many pieces of data each field tester or test team needs to collect, the scope of data collection, and the location of the actual test.

4. Experimental research and analysis on the design of atmospheric environmental health monitoring system based on space bayesian network

4.1. Analysis of the concentration of each gas in the atmospheric environment

This experiment takes the gases in the atmosphere as the research object, mainly including four gases such as nitrogen dioxide, sulfur dioxide, ozone, and nitric oxide. The concentration of these four gases and their proportion in the atmosphere are investigated, and the investigation is carried out. The experimental structure is shown in Table 1:

| Gas type         | Concentration | Percentage |
|------------------|---------------|------------|
| Nitrogen dioxide | 58%           | 30%        |
| Sulfur dioxide   | 43%           | 20%        |
| Ozone            | 21%           | 10%        |
| Carbon monoxide  | 68%           | 40%        |

![Table 1. The concentration and proportion of each gas in the atmosphere](image)

Figure 1. The concentration and proportion of each gas in the atmosphere
As shown in Figure 1, in terms of concentration, nitric oxide and nitrogen dioxide are the highest at 58% and 68%, respectively. They are also the largest in the air, accounting for 70% in total. All in all, the monitoring system needs to monitor even more types of gases listed above, so that the feedback of the atmospheric environment health status is more accurate.

4.2. Comparative analysis of related monitoring systems

This experiment compares the functionality of this system with other monitoring systems, analyzes the advantages of other monitoring platforms, and learns from them. For the bad places, we should learn from them and even optimize them. This experiment compares the alarm configuration, data collection, and real-time monitoring. The experimental results are shown in Table 2.

| Monitoring platform A | Monitoring platform B | Monitoring platform C |
|-----------------------|-----------------------|-----------------------|
| Alarm configuration   | Data collection       | Real-time monitoring  |
| 35%                   | 37%                   | 38%                   |
| 26%                   | 35%                   | 22%                   |
| 39%                   | 28%                   | 40%                   |

Table 2. Comparison of monitoring system functions

As shown in Figure 2, compared with other monitoring platforms, the functionality of monitoring system A is 37% on average, and monitoring platform C does better in terms of alarm configuration and real-time monitoring, accounting for the largest proportion of 39% and 40%. The monitoring system designed in this article should learn from it.

5. Conclusion

This paper uses spatial Bayesian networks to design an atmospheric environmental health monitoring system under the background that the current atmospheric pollution is becoming more serious and the
monitoring methods of atmospheric pollutants have limitations. From real-time monitoring of the health status of the atmosphere, and continuous improvement of its design ideas, a rapid judgment of the health status of the atmosphere in the monitoring system is realized, and diagnosis is performed to understand the reasons and solve the problem of unhealthy atmosphere. It can even make predictive judgments, collect various required data from the existing atmospheric environment, analyze the future atmospheric health status, and be prepared to solve it in advance. Aiming at various known and unknown air pollution and the impact of the space environment, based on the Bayesian network, the model is established by studying the needs of the monitoring system and some construction elements, which can solve various atmospheric environmental health at multiple levels problem.

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