Intelligent Environment System Based on CIM

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Abstract. The construction of smart city has added a lot of charm to our country, and has been paid attention to by everyone, but there are still environmental pollution problems. The emergence of urban information model technology (CIM) makes the construction of three-dimensional composition combined with environmental perception to solve this problem. In this paper, the intelligent environment system based on CIM is studied, which is based on the requirements of intelligent environment system. Starting from the basic content of CIM, the smart city construction and CIM technology are combined, and the architecture of CIM intelligent environment system is established through data collection, wireless communication, micro processing and other aspects. Aiming at the non-uniformity of the system itself and the inaccuracy of the temperature measurement distance, the error caused by the temperature perception of the furnace wall is corrected. The Kalman filter algorithm is used to eliminate the noise and redundancy, and the accuracy of the collected data is improved. The experimental results show that the system can monitor the environmental problems intelligently in real time, and the accuracy rate is as high as 89.38%. It can effectively monitor environmental changes and prevent large-scale environmental pollution.

Keywords: CIM; Intelligent Environment; Intelligent Monitoring; Kalman Filtering Algorithm

1. Introduction

With the development of industrial industry, global warming has become a world-famous problem. At present, the haze weather caused by automobile exhaust, air conditioning exhaust and factory exhaust is serious, which is harmful to human body. Therefore, it is urgent to solve the haze problem. In China, the haze and other environmental pollution caused by the exhaust gas from factories is far and very serious, especially for large enterprises, such as power plants, steel plants, chemical plants, etc. Among them, the coking plant waste gas related to steel is the most serious. On the one hand, toxic gases such as nitrogen oxides, $CO$, $SO_2$, and polycyclic aromatic hydrocarbons produced by coke oven chimneys can cause acid rain and photochemical smog, which is harmful to human health. On the other hand, the leakage of coke oven gas leads to poisoning or explosion death accidents, so how to reduce the emission of coke oven gas has become the primary problem to be solved.

Around the world, we are improving our living conditions and conditions through various meaningful smart city [1-3] construction activities. As one of the key technologies supporting the
implementation of smart city construction, CIM technology [4-5] can be used in urban planning, design, and multi domain analysis and operation management. The main purpose of CIM is to provide an effective way to organize the information used to describe the city. CIM is closely related to BIM [6], GIS [7], Internet of things [8-9], etc., which inevitably needs to be applied to cloud computing, big data and other new information technologies. Among them, the premise of realizing intelligent environment is environment perception [10-11]. How to carry out environmental awareness has been the main goal of research in recent years. Environmental perception is mainly composed of two parts: one is perception, that is, the use of sensors to detect environmental parameters; the other is commonly known as "know yourself and know the other", that is, using intelligent fusion technology to analyze and use the detection data. The process of environmental perception includes information acquisition, information processing and behavior guidance. Ecological environment parameters, working environment parameters, equipment control parameters and state parameters are all objects of perception.

In this paper, on the basis of a lot of literature research, fully absorb some research results of existing scholars, and use inductive analysis method to study the current technology development needs. Another important reason for the emission of pollutants from coke oven is gas leakage. Due to the aging of coke oven, the furnace wall damage produces cracks, but at present, the intelligent and effective diagnosis and repair of coke oven wall damage cannot be realized in China. The innovation of this paper lies in the environmental perception of coke oven emissions and composition, monitoring and reminding emissions, so as to achieve the role of environmental protection; secondly, the pressure and temperature of the coke oven can be detected, and the internal damage of the coke oven can be obtained through CIM technology; the system can be used in industrial enterprises, real-time monitoring and warning of large areas of harmful gas emissions beyond the normal range. Finally, the experimental results show that the accuracy of the intelligent system is 89.38%. Many experts strongly suggest that the application of this system in industry, power plant and chemical plant can achieve better maintenance environment, and it also has the function of three-dimensional composition, which can play an important role in many aspects.

2. General Situation of Intelligent Environment System Based on CIM

2.1. Overview of Intelligent System Architecture
According to the environment perception, network data, support and application architecture, the core of intelligent city system is data collection operation, mainly for construction sites, gardens, roads, environment, pumping stations, etc. The data collected by the data center is transmitted to the demonstration area through the Internet of things. According to the characteristics of intelligent environment application, data can be fused, cleaned, converted and stored, providing data source for subsequent tasks. Combined with the construction of three-dimensional geographical composition, environmental perception, video images, etc., it provides a comprehensive display of environmental conditions and practical application of enterprise sewage management for the city.

2.2. System Model of CIM
CIM is a kind of architecture which adopts network communication equipment and is designed by computer. System management is based on the integration of information technology, which runs through the whole activities of related systems to realize the effective management of a large number of data ensure automation and improve productivity. CIM built in intelligent automation system is a part of public information model. It needs to apply EMS-API semantics to build CIM model. This is an abstract modeling technology. The software package is designed by generator and the object relationship is defined.

CIM model is a collection of computer system classes. It defines the relationship between systems, constructs an abstract framework that is easy for designers to understand, and forms tiny information. There are three types of CIM models: (1) the core model is the basic vocabulary management system
which is analyzed and described. Each system platform manages some basic classes of field definition and function Association. The starting point of common models is based on extended and extended basic vocabulary system. (2) The general model is defined by the specific management domain of the general model, to achieve system independent technology, is conducive to the development of management applications. The core model and general model build CIM model. The general model is helpful to the application of technology system, Internet application and equipment. (3) Extension model is the technical extension of general model, which is mostly used in specific environment.

2.3. Kalman Filter Algorithm

Kalman filter algorithm has two significant characteristics: first, it can improve the accuracy of data acquisition; second, it can speed up the data transmission efficiency and reduce the power consumption of nodes. The intelligent environment system obtains the data of multi-sensor nodes at the same time. The data transmission problem in the channel is easy to cause congestion and low-speed transmission problems, which is not conducive to control. The input of Kalman filter algorithm reduces the pressure of channel transmission between nodes. The data is transmitted in a structured way. The collected data are integrated to eliminate noise interference and avoid duplicate data.

The surrounding environment is equivalent to an independent system. The time domain discrete method is used to collect the environmental data, and the Kalman filter equation is used for the sensor:

\[ X(k) = AX(k-1) + BU(k) + W(k) \]  

The detection results are as follows:

\[ Z(k) = HX(k) + V(k) \]  

Among them, \( X(k) \) is the state variable, \( U(k) \) is the control variable, \( Z(k) \) is the measured value variable, \( W(k) \) is the system noise, \( V(k) \) is the measurement noise, \( A \) and \( B \) are the system defined parameter values, \( H \) is the observation matrix of the measurement system, \( Q \) is the Gaussian white noise, and \( R \) is the covariance of the optimal estimation value.

According to the principle of Kalman filter algorithm, in order to get the optimal estimation value at \( k \), the predictive value \( k-1 \) and covariance \( X(\frac{k}{k-1}) \) of the system at \( P(\frac{k}{k-1}) \) time are needed. Assuming that the current time is \( k \), the predicted value of \( k \) time at \( k-1 \) is as follows:

\[ X((\frac{k}{k-1}) = X(\frac{k}{k-1}) + BU(k)) \]  

Covariance formula:

\[ P(\frac{k}{k-1}) = AP(\frac{k}{k-1})A + Q \]  

Among them, \( X(k) \) is the pre-test of time \( k \), \( X(\frac{k}{k-1}) \) is the optimal estimation of \( k-1 \).

3. Experimental Ideas and Design

3.1. Experimental Ideas

In this experiment, we collect a lot of data from the environment near the coke oven. The data is recorded on February 2, 2020 and August 2, 2020. The data mainly include flue pressure, flue temperature, discharge flow, \( O_2 \) concentration, \( CO \) concentration, \( NO_x \) concentration, etc. each data is detected once every 12 hours. The concentrations of \( CO \) and \( NO_x \) were screened and the accurate data values were selected. In order to avoid the error as much as possible, this paper collected enough detection data. During the removal period, 500 pieces of experimental data were obtained and divided into experimental group and control group with 250 groups in each group. On the basis of the
previous detection, the experimental group carried out field survey, detected the pressure and temperature values of the environment near the coke oven and inside the coke oven, supervised the gas emission, protected the environmental safety, and let the intelligent environment system play its due role.

3.2. Experimental Design

First of all, we use the system module to detect the indicators around the coke oven detection, remove the abnormal values and leave qualified data samples. The experimental group continued to use $O_2$ concentration, flue pressure and temperature as fixed values to detect $CO$ concentration. Then, by comparing with the predicted output of the control group, the real output value of $CO$ concentration was obtained, and the error between the two was compared. Secondly, visit the local experts in this field, and let them evaluate the satisfaction of the intelligent environment system.

4. Discussion

4.1. Analysis of Internet plus Double Innovation Education Combining Artisan Spirit

| Sample sequence | Time    | CO concentration (mg/m³) | Oxygen concentration (%) | Flue pressure (PA) | Flue temperature (ºC) |
|-----------------|---------|--------------------------|--------------------------|--------------------|------------------------|
| 1               | 2020/3/2| 84.29                    | 6.382                    | 248.38             | 176.36                 |
| 2               | 2020/4/2| 91.03                    | 6.413                    | 251.63             | 175.38                 |
| 3               | 2020/5/2| 89.37                    | 6.220                    | 226.95             | 174.32                 |
| 4               | 2020/6/2| 87.05                    | 6.482                    | 234.19             | 172.47                 |
| 5               | 2020/7/2| 88.46                    | 6.981                    | 242.98             | 177.67                 |
| 6               | 2020/8/2| 92.31                    | 6.306                    | 253.47             | 172.34                 |

Shown as Table 1, in order to facilitate calculation, we take the monthly average value of the results detected from February 2, 2020 to August 2, 2020. We can see that there is no significant change in the average value of the monthly test data sample, then we can get the $CO$ emission standard, the normal flue temperature value, the normal flue pressure value, the oxygen concentration, etc., which can be used as the enterprise exhaust emission standard.

4.2. Comparison of $CO$ Concentration between Experimental Group and Control Group
Figure 1. CO concentration of experimental group and control group

Shown as Figure 1, CIM platform stands out for its excellent characteristics of coordination, simulation and multi-level, which will effectively avoid the authenticity in the process of intelligent environment system detection. The Kalman filter algorithm is introduced to eliminate noise and redundancy and improve the accuracy of data acquisition. In order to verify the accuracy of the intelligent system to detect the concentration of CO gas emitted around the coke oven, we conduct field survey and use the most traditional way to complete the CO detection. It is found that from the average data detected from February 2, 2020 to August 2, 2028, the error between them is very small, the experimental value and the real value are very close, and the error between them can be ignored. In the intelligent system detection, the environmental temperature changes may affect the measurement data. There are some unpredictable external factors, which make it difficult to get accurate to zero error. In this way, a large amount of carbon dioxide emission can be predicted in real time by this way.

4.3. Survey on Expert Satisfaction

Figure 2. Expert satisfaction results
Shown as Figure 2, we visited 35 experts with outstanding works in the fields of sensors, intelligent technology, Internet, and environmental awareness. Talking and recording each writer's satisfaction evaluation of the environmental system, 83% of the experts concluded that the Department has a good development prospect, only a few experts believe that the system test data cannot be used as a reference standard, even if the error between the experimental test and the real value is not always small, the change of environmental temperature is difficult to control. The temperature difference between winter and summer is large, which will affect the data extraction of the system. For similar problems, I have made the corresponding countermeasures in this paper, the introduction of Kalman filter algorithm to eliminate uncertain factors, improve the detection accuracy. Most experts still praise the system and expect that the system can be used in enterprises with serious pollution discharge to avoid harmful gas emissions to human beings and monitor their behaviors in real time.

5. Conclusions
Through the research of intelligent environment system based on CIM, the object of perception environment is coke oven. Coke oven has a great impact on the environment in the current production process in China. In this paper, through the establishment of intelligent environment system, which is applied to the perception of the internal and external environment of coke oven, it is analyzed that the emission of coke oven production process has great impact on the environment. The error between the sample data detected by the intelligent environment system and the field survey data is very small, which can effectively monitor the gas emission of coke oven. In addition, the Kalman filter algorithm is introduced to obtain more accurate temperature measurement effect. In order to prolong the service life of coke oven and reduce the environmental pollution, three-dimensional composition can be used to check the internal damage of coke oven. Finally, the satisfaction of experts to the system is as high as 83%, which has a good role in promoting the future industrial development and achieving sustainable economic development.

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