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Research on Meteorological Automatic Monitoring Intelligent System in Chemical Heavy Industrial Zones

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In order to improve the environmental quality of chemical heavy industrial zones and strengthen the meteorological monitoring in chemical heavy industrial zones, this paper studies the meteorological automatic monitoring intelligent system in chemical heavy industrial zones. This paper proposes the data acquisition performance index of monitoring system according to the production and environment conditions of chemical heavy industrial zones, and designs the functional requirements and performance of GPRS features, network scheme and system software. Then, the simulation experiment is carried out on the basis of the designed system. The study shows that the forecasting results of meteorological data are consistent with the measured ice thickness, which can meet the requirements of the power line ice forecasting. It can be seen that the system can meet the needs of meteorological automatic monitoring with good performance in industrial meteorological monitoring.

1. Introduction

Atmosphere is an essential element for human survival. With the rapid development of social economy, people pay more attention to their living environment, and put forward higher requirements for the meteorological conditions. In particular, the residents living near the chemical heavy industrial zones pay more attention to the green and healthy living environment. It is believed that the meteorological monitoring system should be used to monitor the emission and other phenomena in chemical heavy industrial zones and improve the atmospheric environment.
Based on this, this paper designs and analyzes a meteorological automatic monitoring intelligent system in chemical heavy industrial zones. This paper proposes the data acquisition performance index of monitoring system according to the production and environment conditions of chemical heavy industrial zones, and designs the functional requirements and performance of GPRS features, network scheme and system software. Then, the simulation experiment is carried out on the basis of the designed system.

2. Literature review

With the prosperous development of China’s social economy, the demand for chemical products is increasing rapidly. In order to develop local economy, more and more chemical industrial parks have been built and put into use in many regions. The emergence of chemical industrial parks has optimized the allocation of regional resources and boosted the regional economic growth. However, chemical industrial parks are special production places, especially in the production and processing zones of some hazardous chemicals, which often have a great impact on the environment, and are also an industry with frequent pollution incidents. In particular, for sudden pollution incidents, timely and accurate disaster assessment is crucial for effective relief and reduction of secondary pollution. Therefore, it is necessary to strengthen the pollution control and treatment of chemical industrial parks to prevent the potential environmental pollution and even the occurrence of accidents.
To reduce the loss of meteorological disasters, it is required to improve the ability to monitor and predict climate change. In recent years, China's meteorological administration has actively created conditions, and the state has also vigorously supported and promoted the process of China's automatic atmospheric

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monitoring, which has enabled China to make great progress in the construction of automatic meteorological stations, business management, technical training and guarantee and maintenance. There's also a lot of research on meteorological monitoring.

Adnan et al. made comprehensive use of the Internet of things technology, modern sensing technology, geographic information technology and network technology to monitor pollution sources, realized the data collection of monitoring points, and most of them were single point monitoring for a specific pollutant. However, for chemical industrial parks with various types of enterprises, there were various types of characteristic pollutants in the air, most of which were toxic and harmful gases, which were often distributed in large areas. Single-point monitoring didn't accurately understand the distribution of pollutants throughout the region, nor did it provide sufficient data support for the study of meteorological changes in the park (Adnan et al., 2015). Bogushevich et al. studied the remote monitoring of inhalable particles, sulfide and other specific pollutants in the environment with the U-SKY101 integrated environmental monitoring station system (Bogushevich et al., 2015). Chapman et al. studied the automatic weather station, but limited to the development level of the basic technology and the level of meteorological sensors, the meteorological elements monitored by the weather station were still small, the accuracy and accuracy of the detection were still low, and the speed and quality of data communication were not high (Chapman et al., 2015). De Vos et al. analyzed the operation monitoring platform of the integrated meteorological observation system. It served technical support personnel and operational management personnel of the detection network. The system can monitor the new generation of weather radar, national automatic weather station, sounding system and other equipment, but does not include regional automatic weather station and rainstorm monitoring station (De Vos et al., 2017). Li et al. studied the automatic weather station system based on GPRS. The system realized the automatic management of meteorological monitoring in northeast China by relying on advanced computer technology such as GIS technology and satellite positioning system technology (Li et al., 2016). Peng et al. studied the automatic weather station system based on Zig Bee technology to realize automatic summarization and analysis of meteorological information. Relying on wireless technology, the system overcame the environmental and geographical limitations brought by the wired network (Peng et al., 2015). Sherriff et al. studied the national operation monitoring system with GIS, expanded the scope of equipment monitoring (adding sounding system and automatic weather station), and preliminarily tried data quality monitoring (Sherriff et al., 2015). Skupin et al. analyzed the ground automatic observatory network that was in parallel with the traditional manual station. It set up a special operation monitoring and technical support center and had a special national maintenance and repair team. However, the system only aimed at the operation monitoring and assurance of the automatic observation station on the ground and didn't involve the production and distribution function of the monitoring product (Skupin et al., 2016). Tan et al. studied the weather radar center, which was responsible for operation observation, data analysis and processing, application development and analysis, and overall planning and design (Tan et al., 2015). Zuev et al. studied the automatic meteorological data collection system, which can obtain a large amount of ground meteorological data and play an important role in improving the forecast quality of weather forecasting and developing and utilizing climate resources (Zuev et al., 2016).

To sum up, the above research mainly makes in-depth research on the related progress of meteorological monitoring system at home and abroad, but the specific research on the intelligent system of automatic meteorological monitoring in the chemical heavy industry zones is rare. Therefore, based on the above research status, according to the production and environmental conditions of chemical heavy industrial zones, the data collection performance index of the monitoring system is proposed, and the networking scheme with GPRS characteristics and the functional requirements and performance of the system software are designed.

3. Principle and Methods

Generally, the terminal equipment transmits information wirelessly through GPRS modules in the GPRS network application. The basic networking scheme of GPRS can be divided into many kinds, but most of them take the Internet as the external group network of GPRS. Among the four networking schemes of GPRS described above, the private line networking performs the best, followed by the public networking, and the dial-up networking and the Intranet networking are poor in terms of the real-time and security. The better the real-time and security, the higher the cost. In the actual application, the mode selection should consider the actual situation of the subject. As this system is developed for the public, it does not have high requirements on the meteorological data security. There will not be many funds during the initial research stage, and this subject needs to accurately transmit images with a large amount of data. Taking all factors into consideration, the subject adopts the GPRS public networking scheme to give full play to its features of fast communication speed, stable communication quality, small investment in system construction, better real-time and security. The GPRS networking scheme presented in this paper is shown in Figure 1.

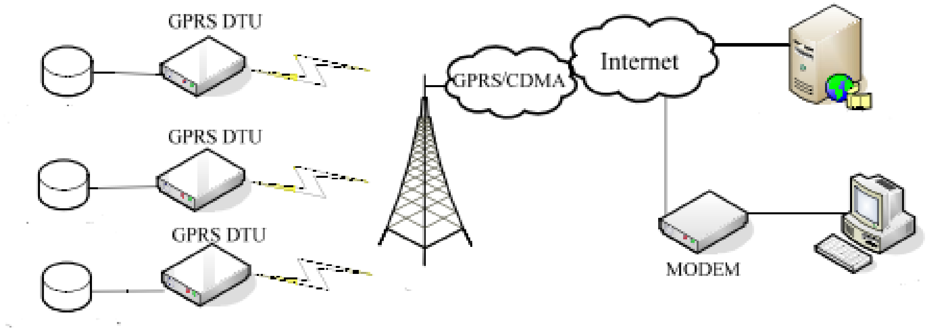

Figure 1: GPRS networking solution

The converter of wind direction sensor adopts the precision conductive plastic potentiometer. When the wind direction changes, the tail fin rotates through the shaft driving the axle core of potentiometer, generating the changing resistance signal output at the free end of potentiometer. The air pressure sensor is used to measure the absolute pressure of gas. The scale of all barometers used in meteorology is hPa. Under standard conditions, the pressure of 760 mmHg is equal to 1032.25 hpa. The technical indicators of air pressure sensor are shown in Table 1.

Table 1: Specifications of air pressure sensor

Parameter	Technical indicators
Measuring range	500～1060hPa
Resolution	0.1hPa
Accuracy	±0.3hPa
Power supply	24VDC
Output form	4～20mA
Nonlinear	≤±0.2%F.S
Hysteresis and repeatability	≤±0.2%F.S
Long-term stability	≤±0.2%F.S/year
Thermal zero drift	≤±0.2%F.S/℃

The calibrations of temperature sensor are without acceleration, vibration and shock, at the temperature of 20℃±5℃, the relative humidity of 85% or less, and the atmospheric pressure of (101±7) kPa. The steps are as follows: firstly, segmenting measuring range. Thermocouple signals are input into the collecting module. When the thermocouple is in the ice-water mixture, the temperature is defined as 0℃. When the thermocouple is in the boiling water, the temperature is defined as 100℃. A hundred parts are divided evenly between 0℃ and 100℃. Secondly, increasing point by point. The thermocouple is put in the ice-water mixture, and a temperature that is defined as 0 ℃ is read by the acquisition module. The ice-water mixture is heated gradually until it boils. The temperature is increasing to reach 100 ℃ eventually. Thirdly, diminishing point by point. The thermocouple in the boiling water is defined as 100 ℃. Then, it is put in the ice-water mixture directly. The temperature showed on the intelligent acquisition module should be 0 ℃. Fourthly, repeating steps 2 and 3 for many times to observe whether the temperature change of thermocouple is even. Fifthly, processing data. The linearity, sensitivity and repeatability of thermocouple can be analyzed according to the experimental data and actual needs.
ADAM-4019+ is a multi-channel general analog quantity intelligent acquisition module with Modbus, which is a new generation of Advantech. This module has built-in watchdog timer and supports Modbus/RTU

communication protocol. Its power consumption is only 1.0 W, which can well satisfy the characteristics of portability and low power consumption of the system. Signal types of each channel of the acquisition module are as shown in Table 2.

Table 2: Signal types of each channel of the acquisition module

Channel number	Signal input type
0	T/C TypeE -50～100℃
1	4～20mA
2	±100mV
3	±500mV
4	±2.5V
5	±2.5V
6	±1V
7	±1V

The output signal of wind speed and direction sensor is 0 to 5V, which is easily interfered with the thermocouple and mA signal at the input end of acquisition module. Moreover, processing this signal by the intelligent acquisition module easily occurs some errors, hindering the wireless transmission of subsequent signals. Therefore, this paper designs a circuit to convert 0 to 5V signals into 4 to 20mA ones. The input signals are unified and the interference is reduced, so as to facilitate the subsequent signals process and effectively improve the accuracy and economy of monitoring system. The U/I conversion circuit converts the input 0 to 5V voltage signals into 4 to 20mA current signals that satisfy certain relations. The converted current is equivalent to an output adjustable constant current source. Its output current should be stable without changing with loads. The U/I conversion circuit diagram is shown in Figure 2.

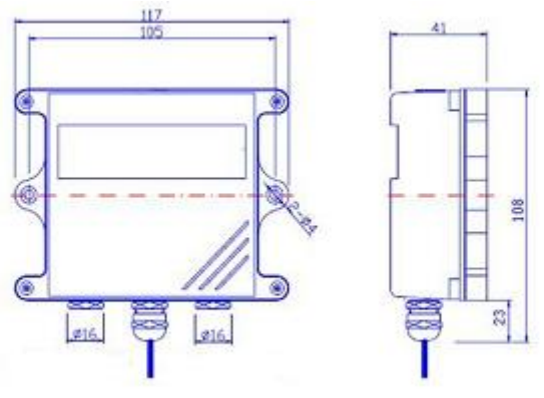

Figure 2: Circuit diagram of wind speed and direction transmitter

The meteorological monitoring system studied in this paper is usually deployed in the field and powered by solar energy, which has a high cost and poor power supply capacity. Therefore, the camera power consumption of image acquisition system needs to be low. CAMV33 camera adopts a 300,000 pixel CMOS color image sensor, with the weak light effect close to CCD, which has a price advantage. It supports three image formats: VGA (640 x 480), QVGA (320 x 240) and QQVGA (160 x 120). Each image format has four compression rates, which correspond to the image quality D (very good), C (good), B (fairly good) and A (general). When the light is insufficient, this camera can automatically fill infrared light. It has functions of power-on and serial command sleep/wake. There is no inrush current impact. It can be in the sleep state with only dozen mA.

4. Results and Analysis

The implementation process of ice forecasting based on BP neural network is divided into two parts. The first part is the training of neural network, and the second part is the simulation of generated neural network to complete the ice forecasting. The formation of neural network requires a large amount of input data for training to achieve a training accuracy. The BP neural network training error curve is shown in Figure 3.

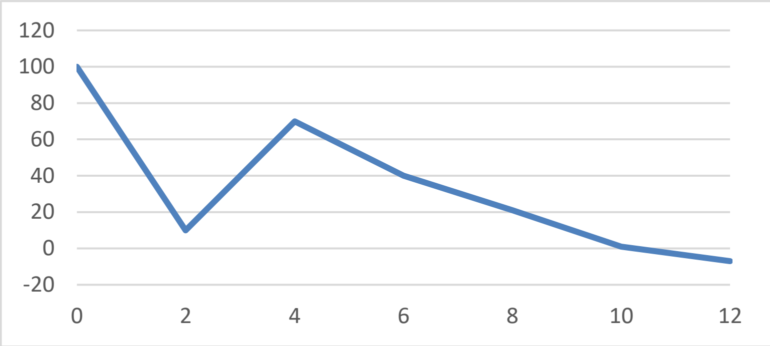

Figure 3: BP neural network training error curve

In order to verify the ice forecasting algorithm accuracy of meteorological monitoring system based on the BP neural network, another five sets of meteorological data are used. The verification data of algorithm are shown in Table 3. Through the experiment, it can be found that the forecasting results of five sets of meteorological data are all consistent with the measured ice thickness, which can meet the requirements of the power line ice forecasting. The forecasting accuracy will be improved with the combination of image information. The system can be operated in the field for a long time with the low cost, high reliability, and simple construction. It can reflect the ice condition comprehensively, which is consistent with the field conditions. It shows that the information reflected is true and reliable, that can give the ice forecasting information in time and accurately, and realize its monitoring function well.

Table 3: Verification data of ice forecasting algorithm

	Temperature / °C	Humidity/%	Wind speed / m/s	Forecast evaluation
1	-0.33	86.7	0.00	Successful
2	-0.79	90.3	0.00	Successful
3	-2.89	94.4	4.84	Successful
4	-2.91	93.5	5.29	Successful
5	-3.63	91.9	3.93	Successful

5. Conclusion

The automatic meteorological monitoring system can timely reflect the field ice status. The information such as temperature, humidity and wind speed transmitted from the field can be analyzed through the ice forecasting algorithm based on BP neural network. Combined with field images, the actual ice information of the measured tower can be accurately achieved. According to the actual meteorological conditions, ice warning information can be issued to guide the normal operation of power lines. In addition, the training accuracy of neural network can be improved by further complementing training data, so as to effectively enhance the ice forecasting accuracy of the system.

The meteorological data measured by the automatic meteorological monitoring system is actually the refinement of macro meteorological information. For local points, the data are more detailed. If the data of these observation points are integrated, the real-time meteorological distribution map of grid system will be formed, which will provide a new idea for the application of meteorological monitoring system. The automatic meteorological monitoring system is usually in the field. Therefore, lightning protection measures should be adopted. There are two methods: the first one is to prevent the destruction of direct lightning strike by setting up lightning rods or lightning belts. The second one is to prevent the inductive lightning strike, a lightning induced overvoltage and overcurrent damage, by adding an SPD or metal shield to the circuit.

Reference

Adnan S., Ullah K., Khan A H., Gao S., 2017, Meteorological impacts on evapotranspiration in different climatic zones of Pakistan, Journal of Arid Land, 9(6), 938-952, DOI: 10.1016/j.egypro.2017.10.163

Bogushevich A.Y., Korol'Kov V.A., Tikhomirov A.A., 2015, Some results of operation of the spatially distributed measuring meteorological system based on the network of ultrasonic automatic weather stations, Russian Meteorology & Hydrology, 40(10), 699-706, DOI: 10.1016/j.phpro.2015.08.004

Chapman L., Muller C.L., Young D.T., Warren E.L., Grimmond C.S.B., Cai X.M., 2015, The birmingham urban climate laboratory: an open meteorological test bed and challenges of the smart city, Bulletin of the American Meteorological Society, 96(9), 197-210, DOI: 10.1016/j.uclim.2015.04.002

De Vos L., Leijnse H., Overeem A., Uijlenhoet R., 2017, The potential of urban rainfall monitoring with crowdsourced automatic weather stations in Amsterdam, Hydrology & Earth System Sciences, 21(2), 1-22, DOI: 10.1016/j.uclim.2017.01.006

Li M., Jia L., Zhang F., Hu M., Shi Y., Chen X., 2016, Characteristics of haze weather in chongqing, china and its determinants analysis based on automatic monitoring stations, Atmospheric Pollution Research, 7(4), 638-646, DOI: 10.1016/j.apr.2016.02.012

Lin Y.X., Wang H.T., 2018, Chemical Production Process Monitoring System Based on Embedded Trusted Computing Platform, Chemical Engineering Transactions, 66, 907-912, DOI: 10.3303/CET1866152

Peng Y., Mi K., Qing F., Liu X., Liu L., Chen Q., 2015, Ecological risk assessment for key industrial development zones in the areas surrounding the bo sea in china, Human & Ecological Risk Assessment an International Journal, 22(2), 475-488, DOI: 10.1080/10807039.2015.1080592

Sherriff S.C., Rowan J.S., Melland A.R., Jordan P., Fenton O., Ó'hUallacháin D., 2015, Identifying the controls of soil loss in agricultural catchments using ex situ turbidity-based suspended sediment monitoring, Hydrology & Earth System Sciences Discussions, 12(3), 2707-2740, DOI: 10.5194/hessd-12-2707-2015

Skupin A., Ansmann A., Engelmann R., Seifert P., Müller T, 2016, Four-year long-path monitoring of ambient aerosol extinction at a central european urban site: dependence on relative humidity, Atmospheric Chemistry & Physics, 15(8), 12583-12616, DOI: 10.1016/j.jaerosci.2016.07.004

Tan J., Yang L., Grimmond C.S.B., Shi J., Gu W., Chang Y., 2015, Urban integrated meteorological observations: practice and experience in shanghai, china, Bulletin of the American Meteorological Society, 96(1), 197-210, DOI: 10.1016/j.ufug.2015.02.005

Zuev V.V., Nakhtigalova D.P., Shelekhov A.P., Shelekhova E.A., Pavlinskii A.V., Baranov N.A., 2016, Application of mtp-5pe meteorological temperature profiler in an airport for determining spatial zones of possible aircraft icing, Atmospheric & Oceanic Optics, 29(2), 186-190, DOI: 10.1016/j.sste.2016.03.004