Design of Weather Monitoring and Forecasting System Based on Computer Distributed Network

Jianye Cui(✉), Jian Huang, Youchun Li, and Yingwei Zhu

State Grid Zhejiang Electric Power Co., Ltd., Company Jinhua Power Supply Company, Jinhua 321000, Zhejiang, China
wenrrq911@163.com

Abstract. Meteorological monitoring and forecasting system is a new type of work equipment with real-time, high effectiveness, high degree of automation, convenient equipment maintenance, low economic cost, wide range of use, and long-term operation in harsh environments. Meteorological disaster monitoring and early warning systems have become an important part of modern meteorological services. Therefore, for the design of the weather monitoring and forecasting system, this article discusses from the distributed network. This article mainly uses experimental methods, data analysis methods and other methods to conduct an in-depth discussion on the research of system construction. Experimental results show that the system designed in this paper has a certain effect on weather monitoring and forecasting, and its accuracy can reach 98%.

Keywords: Computer · Distributed network · Weather monitoring · Forecasting system

1 Introduction

With the rapid development of China's economy, the government and the general public have put forward higher requirements for the accuracy and refinement of weather forecast, and also put forward new requirements for the pertinence, popularity and guidance of weather forecast. And meteorological disaster prevention and mitigation has put forward higher and higher requirements for the improvement of the detection and early warning capabilities of severe weather and meteorological disasters. Compared with modern hardware construction, software construction obviously lags behind. Although aiming at the actual business needs, some business systems have been developed and introduced by various meteorological administrations, but different business systems are independent from each other, and the sharing rate is poor, so there are many simple repetitive labor and transactional work in daily work. Meteorological service is also a basic public welfare undertaking for social development and people's life as well as economic and national defense construction. Its development is of great significance to the national economy and people's livelihood. Therefore, it is helpful to improve the quality of meteorological service to make full use of modern technology such as computer, network

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and satellite to carry out research on meteorological information and forecast information technology. As atmospheric science theory, numerical calculation method and the continuous development of high-performance computer technology, modern weather forecast method have been established from the traditional qualitative theory, mathematical statistics and forecasters in atmospheric semi-empirical method on the basis of experience, development on the basis of the theory of atmospheric science, through the high performance computing platform simulation prediction results of the numerical prediction method. Numerical weather forecast has effectively solved the problems in the past, such as insufficient forecast products, too short possible forecast time, and weak comprehensive processing ability of all kinds of meteorological observation data. It has become an important basis and fundamental way for meteorological departments to make weather forecast, and has irreplaceable status and function of other forecast methods. In management, with the rapid development of science and technology, the position of the computer has been gradually important.

Every year due to meteorological disasters, the modernization of meteorology has been greatly improved with the continuous development of technology. The weather detection business has also shifted from manual to automated. The development of automation can reduce unnecessary manual errors and achieve preventable and understandable effects. Therefore, based on the characteristics of the distributed network and the algorithm rules, this article is necessary for the design and research of the weather monitoring and forecasting system.

2 Related Work

For example, M. Doostmohammadian et al. consider a distributed support vector machine (SVM) binary classification problem. The idea is to train a network of agents with a limited amount of data to collectively learn an SVM classifier from a global database [1]. According to F. Rahimi and H. Rezaei, the error estimation controller design problem studies a class of nonlinear network systems with respect to communication topologies. In real systems, data may be delayed or lost due to unreliable communication channels in exchanges between agents and their neighbors [2]. In recent years, surveillance systems have played an important role in our lives. Therefore, Jamal Mabrouki et al. proposed an automatic weather monitoring system that can realize real-time dynamic climate data in a specific area [3]. Agnes Semwanga Rwashana argues that developing countries can benefit from ICT only if the framework conditions for the use of technology are adapted to their specific needs. The lack of timely, accurate and reliable meteorological data has caused serious loss of life and property in Uganda [4]. M. T. Falconi and F. S. Marzano proposed that backscattering properties allow retrieval of useful geophysical particle distribution parameters when electromagnetic radiation interacts with particle distributions, resulting in absorption and scattering. We describe ground-based weather radar as well as other platforms, such as airborne and space-based configurations [5]. Short-term load forecasting (STLF) plays a vital role in regulated power systems and electricity markets and is often used to predict the outcome of outages. Khalil et al.

Studied and evaluated the potential of combining satellite precipitation data set (MSPD) with rain gauge (RGS) and satellite precipitation data set (SPD) in monitoring meteorological drought in Pakistan from 2000 to 2015 [6]. Mikhail designed an automatic hydrometeorological station (ahms) to monitor high anthropogenic pressure areas along the coast of Lake Baikal [7].

There are so many people researching weather monitoring systems from different aspects, but the research on the monitoring system of the computer distributed network is still a research hotspot, so this article is also based on this for the forecast system design.

3 Weather Monitoring and Forecasting System Based on Computer Distributed Network

3.1 The Necessity of System Construction

Most weather early warning equipment does not have remote monitoring and automatic alarm functions. A connection failure during operation can only be found through telephone consultation, manual troubleshooting, and recording. Key data and technical indicators of the equipment in operation cannot be obtained. If the device has hidden vulnerabilities, serious errors can easily occur. Therefore, to maintain the normal operation of the equipment, in addition to doing routine maintenance, it is necessary to have a substantial and complete system that can monitor the operating status of the equipment in real time to further improve the operation of the equipment. It can grasp the operating status of system equipment in time, and realize remote diagnosis and maintenance of system faults [8].

At present, the monitoring and management capabilities of the weather detection network are obviously insufficient. Traditional maintenance support methods show the following defects: monitoring information is single, monitoring information management is difficult, monitoring status data is not uploaded in real time, and monitoring methods are conservative.

3.2 System Construction Goals, Principles and Requirements

(1) Goal

The overall design goal of the platform is to create a unified sharing system of weather forecast and early warning information centered on the data center, including conventional weather observation data, unconventional weather observation data, monitoring information, forecast analysis data, weather forecast warning information, etc.

(2) Principle

1) Normative. The established system is mainly provided to the meteorological department. Therefore, it must comply with the meteorological business specifications and meet the needs of the meteorological business system. The data collection time, data organization and data storage can all meet the business system specifications.

2) Scalability. Meteorological undertakings are also undergoing continuous development, and new requirements will also be put forward for ground observation systems, such as increasing observation density, adjusting observation time, and new communication methods. We must fully consider the future development direction of ground meteorological observations in system design. It is to give full consideration [9].
3) Practicality. The forecast and early warning information release system needs to have an in-depth understanding of user needs and has a scientific design concept and technical structure. Therefore, it can have sufficient predictability when solving business and technical problems to meet the long-term business development needs in the future.
4) Manageability. The management of the entire system can be realized by the sub-station administrator.

(3) Demand

With the automation of the ground weather observation system, the number of observation sites has increased significantly, and the observation time density has also increased significantly. The remote monitoring and alarm system of the comprehensive meteorological observation system is an industry-specific monitoring business application software designed around the business of monitoring the operation of the ground observation system for the needs of ground observation automation [10].

3.3 The Key Technology Used by the System

(1) MESIS system

MESIS is a new generation of weather service product analysis and production system. It is produced under the background of information technology such as geographic information, database, visualization, multimedia and Web.

(2) UML modeling technology.

UML eliminates unnecessary differences between modeling languages.

(3) Web Service technology.

Web service technology is a technical framework that calls each other in the Internet environment, which can add other functions to WEB applications.

(4) XML document object model.

XML is a universal and adaptable format, it can be used anywhere.

(5) Visual InterDev

Visual InterDev is a Web development tool provided by Microsoft for programmers and developers. It has a powerful integrated database tool. It provides an integrated and visual development environment and is also a complete and detailed website development system. It can be used to achieve Fast and visual development. It has the characteristics of dynamics, powerful database tools, integration with existing business systems, and reusability of components.

(6) Neural network prediction method

The neuron model of the artificial neural network is designed by simulating the information input and output characteristics of biological neurons.

Σ represents the accumulation of all input signals. G(I) represents the response function of the neuron. The expression of the neuron model is:

$$I = \sum_{s=1}^{m} A_s W_s - \chi \tag{1}$$

$$R = G(I) \tag{2}$$

For the response function F(S), different functions can be selected according to actual needs, which mainly include three types of response functions, namely linear function, Sigmoid function, and step function. The expressions are as follows:

Linear function

$$G(I) = S * I \tag{3}$$

Sigmoid function

$$G(I) = \frac{1}{1 + f^{-SI}} \tag{4}$$

Step function

$$G(I) = \begin{cases} 1, & I \geq 0 \\ 0, & I \prec 0 \end{cases} \tag{5}$$

3.4 Design of the Monitoring Center of the Early Warning System

(1) Design of data acquisition and preprocessing module

1) Data collection. In the early warning system, data collection must be carried out first, and the performance of the module that intercepts network data is the basis for realizing the high efficiency of the early warning system.
2) Data preprocessing. After the network data packet is captured by the data acquisition device, the data is stored in a table. For the captured data packet, extract the connection record in it. The function of the data preprocessing module is to organize the data in the data packet into a format that can be directly processed by the data mining algorithm for analysis [11, 12].

(2) Improvement of association analysis algorithm and establishment of association rules

The data mining algorithm based on association rules is divided into two steps: find out the set of all elements, and generate strong association rules from the set of elements.

For credibility, the following formula can be used.

$$confidence(Q \Rightarrow S) = P(Q|S) = \sup\_count(Q \cup S)/\sup\_count(Q) \quad (6)$$

Among them, $sup\_count(Q \cup S)$ is the number of transactions that include $Q \cup S$ itemset, and $sup\_count(Q)$ is the number of transactions that include itemsets Q. According to this formula, the association rules can be generated as follows:

For each frequent itemset s, all non-empty subsets of s are generated;

For each non-empty subset k of s, if

$$\sup\_count(Q \cup S)/\sup\_count(Q) \geq \min\_conf \quad (7)$$

Then output rule "$k \Rightarrow (s - k)$". Among them, $\min\_conf$ is the minimum confidence threshold.

(3) Establishment of classification rule set

In a period of time, there are many connections in the network, and there will be confusion. Therefore, it is necessary to collect and restore all the data packets of the same connection.

1) The selection method of characteristic attributes. It is arranged according to the chronological order of the appearance of the data, and statistics are made for multiple connection records.
2) Mining design of classification rules. The classification attribute of the record is extracted, and the classification model obtained is used to map it to a specific class.

(4) Use mining rules for detection

First, take the detection rules in the detection rule set as the standard, judge the records to be detected, and compare the records to be detected with the rules in the rule set one by one to see if the rules are met:

1) If the detected network connection record conforms to a rule in the rule set, its record conforms to the type of a certain rule, and the classification result can be output.
2) If there is no rule in the detection rule set that matches the detected record, it proves that the record has never appeared before, and it is a new connection.

3.5 Design of Meteorological Data Analysis System

(1) The weather history data analysis system is a comprehensive system that integrates data collection, data filtering, data analysis and structure display. The structure can be divided into 4 modules, as shown in Fig. 1:

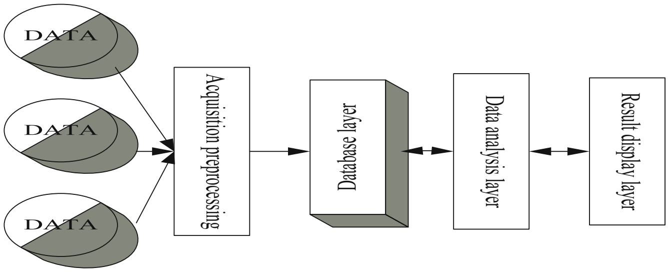

Fig. 1. The overall structure of the meteorological data analysis system

(2) System function

From the user's point of view, the system functions include 6 modules including single-site live display, regional live display, single-site data statistics, regional data statistics, time-dependent data statistics and report statistics.

1) Single station live display: display the forecast data value of each mode to a single meteorological station based on the time distribution curve graph comparison, histogram comparison and data table as needed.
2) Regional live display: According to the needs, display the forecast data value of each mode to the individual weather station based on the curve graph comparison, histogram comparison and data table of the regional distribution.
3) Single-site data statistics: Taking timeliness as the main element, statistically analyze the weather forecast quality distribution of each site under different elements, and its display methods include graphs, histograms and data tables.
4) Regional data statistics: Statistics of the weather forecast quality distribution of all stations in each area under different elements by region. In addition to the three comparison methods of graphs, histograms and data tables, a map comparison mode is also introduced.
5) Time-effectiveness data statistics: With time-effectiveness as the main element, statistically analyze the distribution of weather forecast quality under different elements in each area as a whole, and its display methods include graphs, histograms and data tables.
6) Report statistics: According to the needs of users, generate data reports needed by them to assist them in completing their work.

3.6 Overall System Design

(1) Hardware design

In order to design a suitable monitoring unit, it is necessary to select a suitable microprocessor and design corresponding sensors and communication interfaces. Figure 2 shows the overall structure of the data acquisition sensor hardware system.

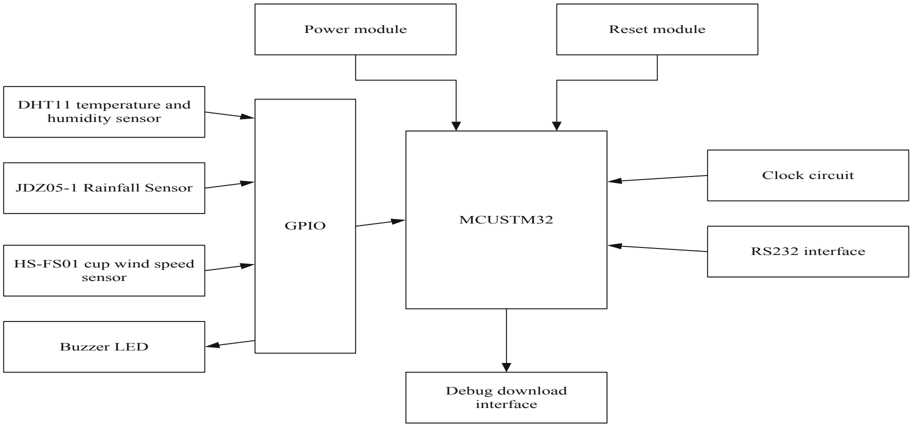

Fig. 2. System hardware overall design

Among them, the MCU uses an interconnected series of microcontrollers. The power module ensures the normal operation of the entire system. Through the RS232 interface, the wireless module can be used to communicate with the host computer.

(2) Program design

The normal operation of the data acquisition sensor terminal requires the support of the program, and a good program design can make the hardware work stably and ensure the normal operation of the entire acquisition system. The entire program is designed around the STM32f103RET6 microcontroller. After the system is powered on, first initialize each module. Then upload the data according to the design requirements of each module, which can be active transmission. According to the design requirements, the data is transmitted every certain time.

(3) Host computer design

Taking into account the requirements of the weather data monitoring system for data storage, a SQL Server database is designed here to build user information tables, temperature data tables, rainfall data tables, wind speed data tables, and humidity data tables.

4 System Function Test

After the development of the meteorological disaster monitoring and early warning and emergency service auxiliary decision-making system is completed, in order to ensure the safe and stable operation of the system, system testing is required.

4.1 Hardware Environment

(1) Server-side configuration
CPU: Intel(R) Core(TM) i5 2.6 GHz
Memory: 8G
Hard Disk: (SCSI) 50G*3
Network card: 100/1000M
(2) Data collection and processing terminal configuration
CPU: Intel(R) Core(TM) i5 2.6 GHz
Memory: 4G
Hard Disk: (SATA) 100G
Network card: 10/1000M

4.2 Operating System and Development Environment

The server operating system is Windows Server 2018+SQL Server 2018, the data processing operating system is Windows XP, and the development and debugging tools are Microsoft Visual Basic.

4.3 System Test

After the development of the system is completed, the meteorological information is measured. The main collected data include temperature, rainfall, wind speed, humidity, etc.

5 Analysis of Test Results

Use the host computer serial port for data collection, and get the following data. The host computer has well realized the monitoring of temperature, rainfall, wind speed and humidity data. The details are shown in Table 1.

According to Table 1, we can know that the specific monitoring conditions of temperature, rainfall, wind speed and humidity collected in this article are more in line with the actual weather conditions of the monitored area. From the perspective of temperature changes, the temperature in this area remains cool. From the point of view of rainfall, there is a certain amount of precipitation, so its humidity is maintained at a relatively high level.

Table 1. Test data

	Temperature value (°C)	Rainfall value (mm)	Wind speed value (m/s)	Humidity value (%)
1	23	12	10	65
2	26	17	15	70
3	21	11	17	68
4	20	13	12	73
5	25	16	15	80
6	22	17	16	81
7	20	13	11	69
8	24	15	13	74

6 Conclusion

From ancient times to the present, weather monitoring has been an important indicator task in agriculture and daily life. In ancient times, there were night observation celestial phenomena, seismographs, and weather forecasts based on common sense of life, but today's weather forecasts rely on science and technology, satellites and the movement of the earth. The weather forecast can give people hints, such as whether it is suitable to go out, whether it is suitable to grow crops, and whether it is suitable for production. Therefore, the monitoring and early warning of meteorology is a very basic and important research activity. Especially for the study of meteorological disasters, it is necessary to predict in advance to reduce losses. For the real-time monitoring design of the weather system, the idea proposed in this paper is to highlight the following aspects of the overall design of the system: one is data processing and analysis, and the other is early warning monitoring. The system of this article needs to have excellent data statistics and analysis capabilities, and its early warning capabilities cannot be ignored. In addition, the overall design of the system needs to be supported by sensitive sensors and controller devices. Although the system designed in this paper can basically achieve the functions of monitoring and forecasting, it still has certain shortcomings. The monitoring of extreme weather can also be displayed in a dynamic way to make it more specific and vivid.

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