

# **Design of Temperature and Humidity Monitoring System for Finished Grain Warehouse Environment Based on Wireless Sensor Network**

**Abstract:** As the core link of logistics and supply chain, warehousing plays a crucial role in food safety control. Temperature and humidity are the main factors affecting grain storage quality. In this paper, wireless sensor network is used for data collection, software system is designed through Qt platform, and data storage and analysis with the help of database, to achieve online monitoring of grain warehouse environment. The system realizes the functions of data acquisition and storage, real-time monitoring of temperature and humidity, over-limit alarm, historical inquiry and temperature and humidity field fitting, and realizes the modern monitoring and analysis of warehouse environment.

**Key words:** finished grain, warehouse, temperature and humidity monitoring, wireless sensor network, Qt

## **0 Introduction**

With the continuous development of society and the surge of population, food has become an important product related to the national economy and people's livelihood. Finished grain warehouse is an important part of grain logistics. In order to ensure the safety of grain products, it is necessary to periodically detect the temperature and humidity data of multiple locations in the warehouse. In recent years, due to the sensor technology, computer technology and the development of integrated circuit technology and network communication technology, domestic also emerged gradually rich products, digital sensor technology is mature, also make the monitoring system is widely used in logistics, warehousing, etc., the past warehouse monitoring technology research in the hardware and software has made great progress in such aspects as.

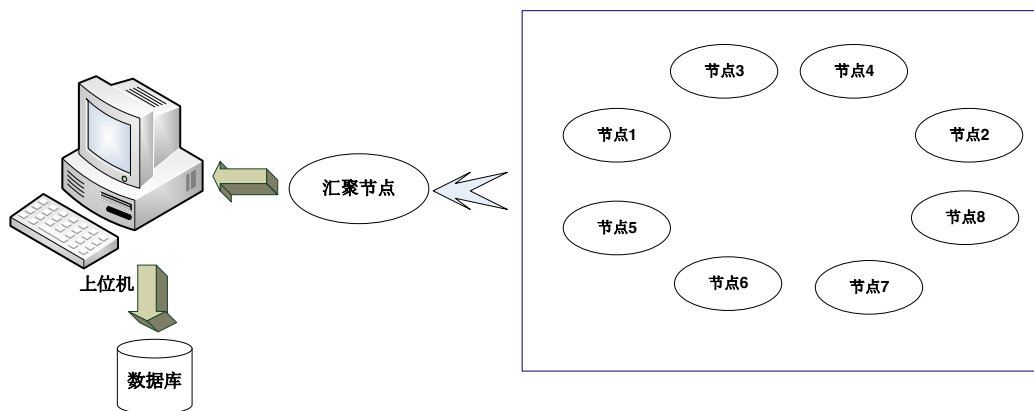
The traditional on-line monitoring system of stored grain temperature and humidity mainly includes wired and wireless. For large finished grain depot, the application of wired way is limited by wiring, installation and other conditions. It is impossible to monitor the distribution points of existing warehouse system by wired way. Zigbee-based wireless sensor network has become an important trend in the development of warehouse system monitoring system.

This paper provides a temperature and humidity monitoring system for grain warehouse environment based on wireless sensor network, and calculates the average value of the monitored existing data with interpolation algorithm to obtain the missing value of variables, draw the temperature and humidity curve, and realize the wireless automatic monitoring of temperature and humidity in the warehouse environment to ensure the real-time and reliability of data.

# 1 Structure of monitoring system

## 1.1 Overall structure of monitoring system

The structure of temperature and humidity monitoring system for grain warehouse consists of two parts: upper computer and lower computer. Based on the upper computer using Qt platform software system development, and database connection, data storage. The lower computer is composed of temperature and humidity wireless sensor nodes. The temperature and humidity data are collected and transmitted to the upper computer through the wireless sensor network. The system architecture is shown in Figure 1.



(数据库-Database, 汇聚节点-Gathering node, 节点 1~节点 8-Node1~Node8)

Figure 1 System architecture diagram

## 1.2 Functional structure of monitoring system

The software system is composed of five subsystems: data acquisition and storage, real-time temperature and humidity monitoring, over-limit alarm, historical inquiry and temperature and humidity field fitting. The realization of the function of the system is beneficial to the modern management of warehouse, and improves the efficiency, real-time and accuracy of warehouse environment monitoring. The functional structure of the system is shown in Figure 2.

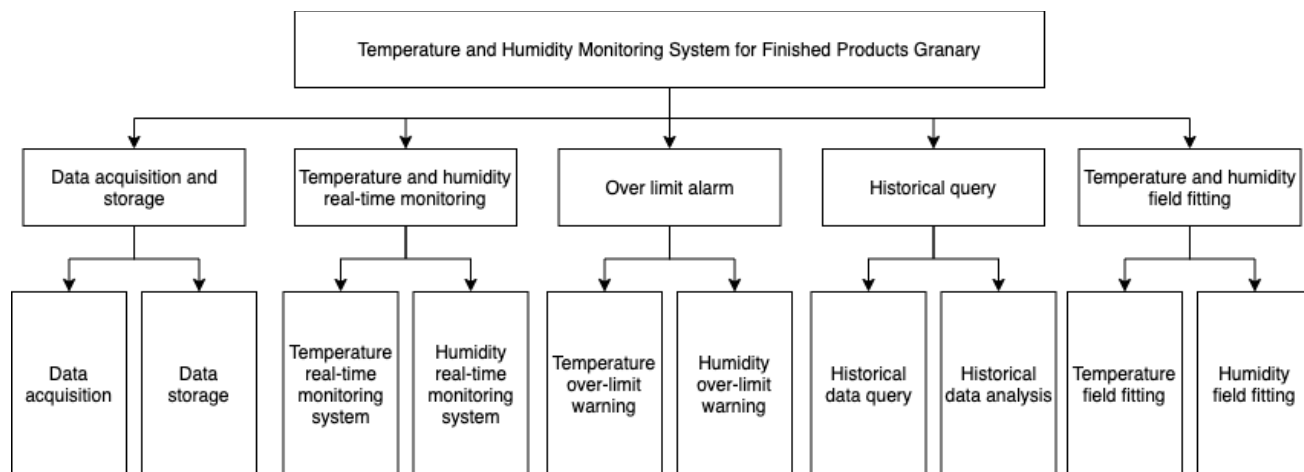


Figure 2 System functional structure diagram

## 2 monitoring system design

### 2.1 Monitoring system hardware

Wireless sensor network nodes are based on ZigBee protocol, using ATmega1281V microprocessor and AT86RF rf transmission chip of ATmel Company, with 128KB Flash memory and wireless transmission rate up to 2Mbps. The monitoring system adopts eight temperature and humidity sensor nodes and one sink node. The T/H sensor uses SHT10.

### 2.2 Software design of monitoring system

The wireless sensor sink node is connected to the upper computer through a serial port. Part of the software of the upper computer needs to verify the collected data. After the verification is correct, the effective fields will be extracted. The extracted information includes temperature, humidity and node information, which will be displayed on the real-time monitoring interface and stored in the database. If the temperature exceeds the limit, an alarm will be given. The real-time monitoring interface is shown in Figure 3, and the interface running process is shown in Figure 4. The monitoring system can also realize the query and curve analysis of historical data, as shown in Figure 5 and 6 respectively.



(成品粮温湿度实时监控-Real-time monitoring of temperature and humidity of refined grain)

(节点 1~节点 8-Node1~Node8, 温度-Temperature, 湿度-Humidity)

Figure 3 Real-time monitoring interface

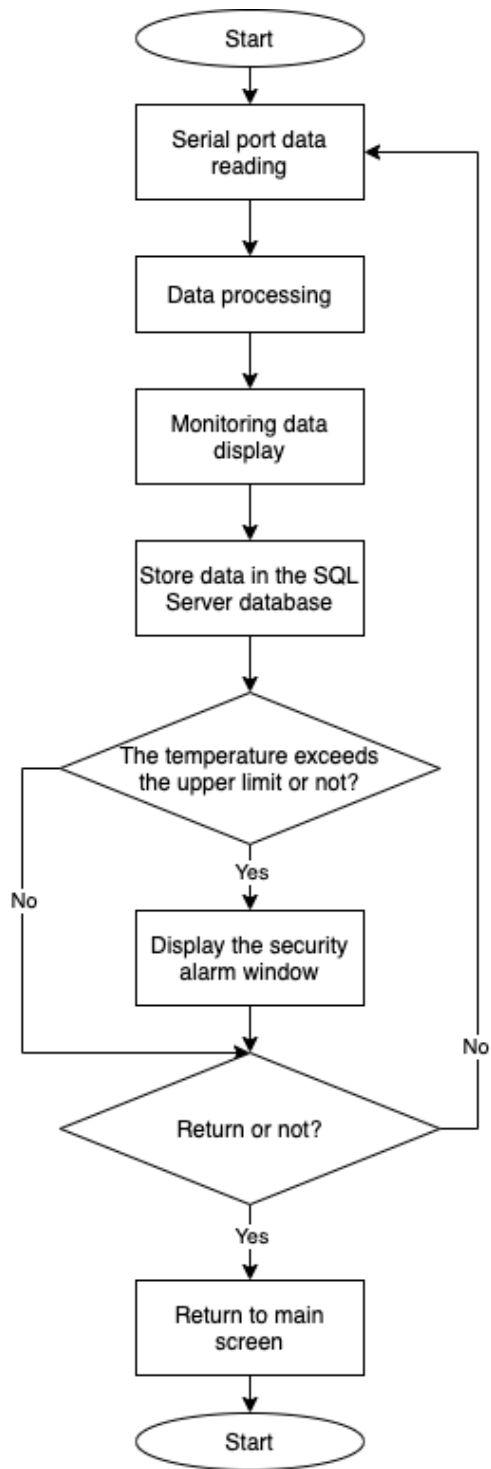


Figure 4 Flow chart of real-time monitoring interface



(历史数据查询-Historical Data Query, 节点 1~节点 8-Node1~Node8)

Figure 5 Historical data query

In grain warehouse, the distribution of temperature and humidity field has great influence on the safe storage. However, in this case, the sensor layout cannot be infinite, and the distribution of temperature and humidity will not jump in space. Therefore, the interpolation method can be adopted to fit the distribution of temperature and humidity through finite points. In the mean interpolation algorithm, the mean value of the population is used as the substitute value of all the missing values of the variable. After calculation, the mean value of the population is used to replace all the missing values. The missing values of the variable can be obtained by calculating the mean value of the existing data. Therefore, mean interpolation is used to obtain the distribution of temperature and humidity in the monitoring system. Longitudinal distribution fitting of temperature and humidity in the warehouse is shown in Figure 7.

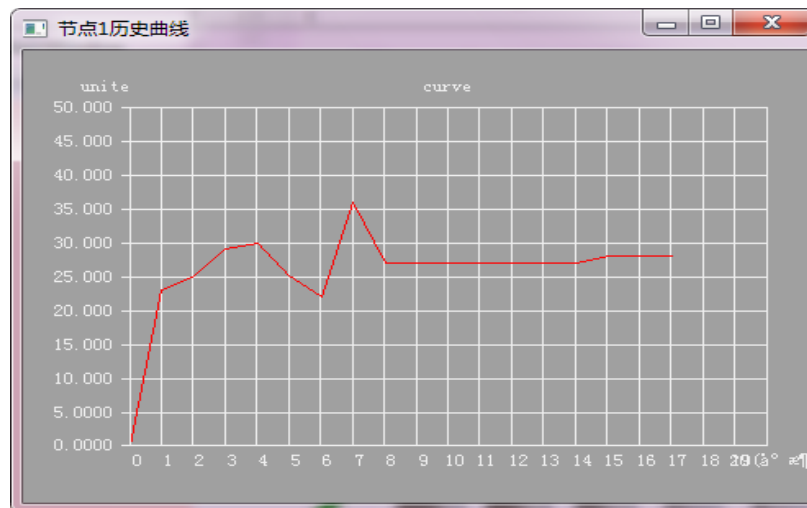
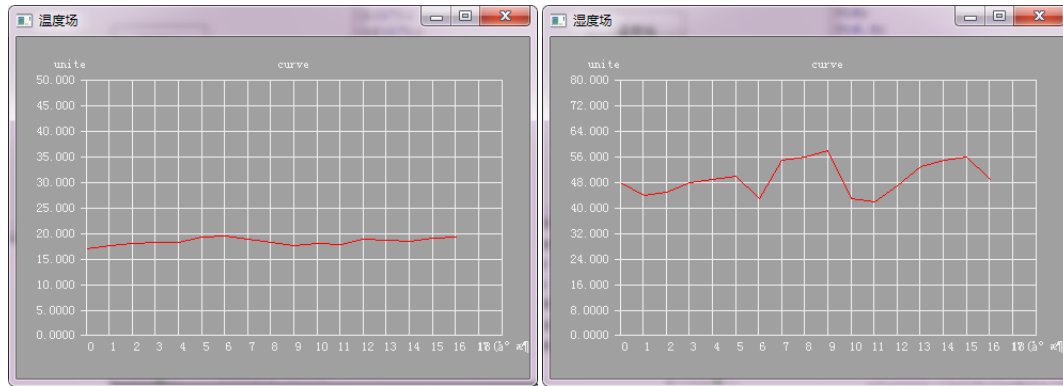


Figure 6 Curve analysis of historical data



(a) Temperature distribution

(b) humidity distribution

Figure 7 Fitting of temperature and humidity distribution

The temperature and humidity monitoring system of grain warehouse environment based on wireless sensor network has been tested and run successfully.

### 3 Conclusion

This paper design the past based on wireless sensor network warehouse environment temperature and humidity monitoring system, completed the finished product grain depot temperature and humidity real-time data acquisition, storage and display, and be able to curve of transfinite alarm, historical data query and analysis, at the same time interpolation method was adopted to get the distribution of temperature and humidity on temperature and humidity data fitting, the system run successfully, It provides effective monitoring means for the safe storage of refined grain.