# RESEARCH ON SAVING IRRIGATION CONTROL SYSTEM BASED ON THINGS
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# 基于物联网的节水灌溉控制系统研究

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***Abstract:*** *Drought and water shortage is one of the main factors restricting the development of China's agricultural production, with the advance of modern agricultural policy, water resources become tighter. The emergence of the Internet of Things, will provide a good way for modern agriculture intelligent water-saving irrigation. In order to effectively solve the problem of waste water on irrigation and rationally use water resources to effective irrigate, a water-saving irrigation control system based on Internet of things is designed in this paper. Firstly, design the structure of the system. Then, according to the specific application environment, depending on the acquisition terminal of sensing layer, the gateway of the transport layer and the control end of the application layer are analyzed, the hardware is designed and the structure charts are given. According to the composition of the system, software structure of the system is designed. Finally, collecting data of the system is processed by data filtering and difference analysis, so as to obtain the control data effectively, and achieve the purpose of automatic control and water saving irrigation.*

***摘要：*** *干旱缺水是制约我国农业生产发展的主要因素之一，随着现代化大农业方针的推进、水资源日趋紧张。物联网的出现，将为现代农业智能节水灌溉提供了有效的方法。为了有效解决农田用水中的浪费问题，合理使用水资源进行有效灌溉，本文设计实现了基于物联网的节水灌溉控制系统。首先对系统的结构进行设计，根据具体的应用环境，分析了感知层的采集终端、传输层的网关以及应用层的控制端功能，对其采用的硬件进行设计并给出了结构图。根据本系统的组成，设计了系统的软件结构，最后对系统采集到的数据采用数据过滤和差值分析进行处理，从而得到有效的控制数据，进而达到自动控制节水灌溉的目的。*

***Keywords:*** *Internet of things, water-saving irrigation, software architecture, data filtering*

***关键词：*** *物联网, 节水灌溉, 软件结构, 数据过滤*

## INTRODUCTION

China is a large agricultural nation and agricultural water consumption occupy most of water in China, accounting for about 80%, while the agricultural irrigation efficiency is low at present, only 45% [11], [6]. Saving agricultural irrigation water can effectively alleviate the problem of shortage of water resources [13], [9]. In China, farmland is widely scattered and different crop have different water consumption, which lead to difficulties in agricultural water-saving irrigation [5], [4], [1]. Using trench irrigation, waste farmland utilization and water resources, while adopting the automatic control irrigation technology, not only can meet the different crops requirements of different water, rationally allocate of various water supply equipment but can also realize the statistical analysis of use of resources of farmland system, so that the staff can grasp the relevant information resources and reasonable dispatch water resources to achieve the purpose of saving water [14].

The Internet make people without space limitation come true, the Internet of things mainly make the human coherence together at any place at any time, the most important is to connect people and objects, make more intelligent and efficient management on things, to achieve the highest output at the lowest cost maximum efficiency. The Internet has changed the life, but the Internet of things is the essence of the change. The ultimate goal is to control the material, to realize the resource optimal allocation of control, material precise management, the most intelligent monitoring, with the minimum cost for the biggest value [15], [8], [12]. A lot of foreign agriculture has been implemented irrigation system based on the Internet of things, but it is rarely used in this aspect of the domestic. Therefore, this paper designed a

## 引言

我国是农业大国，农业用水量占据了我国大部分用水，约占 80%左右，而目前的农业灌溉效率较低，仅为45%[1][2]。节省农业灌溉用水能够有效缓解水资源的紧缺问题[3][4]。在我国，农田分布范围广泛，加上各种农作物用水量各不相同，导致农业节水灌溉困难[5][6][7]。采用沟渠灌溉技术，既浪费农田的利用率又浪费水资源，而采用自动化控制的灌溉技术，既能够满足不同农作物对水量的不同要求，又能够合理配置各个供水设备，还能够实现农田系统中的各种资源使用情况的统计分析，从而让工作人员能够及时掌握了相关资源信息，合理进行水资源的调度，达到节水的目的[8]。

互联网改变了人生，而物联网起来之后是本质的变。最终的目的是对物质的控制，人对物质的控制精准的管理实现资源最优的配置，最智能化的监测，以最小的代价换取最大的价值[9][10][11]。国外农业很多已经实现基于物联网的灌溉体系，但国内这方面的应用还很少。因此本文设计了一个基于物联网的节水灌溉控制系统，主要是通过传感器收集土壤的温湿度数据，设置打开关闭阀门的参数，

water-saving irrigation control system based on the Internet of things, which mainly collect soil data by temperature and humidity sensor, set parameter of the open or close the pumps, once reaches the valve of opening, irrigation system automatically open the pumps, if it reaches closing, irrigation system automatically close the pumps, which achieves the goal of automatic irrigation and water conservation.

一旦达到打开阀门的条件，灌溉系统阀门自动打开，如果达到关闭阀门的条件，则自动关闭灌溉系统阀门，从而实现了自动灌溉和节水的要求。

## MATERIALS AND METHOD

### The Design Of The System Structure

Irrigated data situation of farmland can be collected, analyzed and processed by the system designed in the paper. The system can develop an appropriate scheme and timely irrigate. First, are set parametric conditions of irrigation on monitoring computer, in advance of irrigation operations depending on weather conditions provided by the Internet. The system consists of three layers: the perception layer, which is responsible for collecting air temperature, light, soil moisture and other data related to irrigate farmland, is also responsible for neighbouring node routing; transmission network layer is responsible for data transmission; l; terminal control layer, which used for monitoring terminal data and control transmission network layer, deploy related services on the server for network members to connect, and provides data service, the user can view the data on the server by different ways. The structure of the system is shown in fig.1.

## 材料和方法

### 系统结构设计

本文设计的系统能够采集农田的灌溉数据情况、对采集到的数据信息进行分析处理、制定相应的灌溉方案和及时进行灌溉。首先在监控计算机一端设置灌溉的参数条件，根据互联网提供的天气情况，提前进行灌溉操作。系统主要分为三层：感知层，负责农田中空气温度、光照、土壤湿度的等相关灌溉数据的采集，同时负责相邻节点的路由；传输网络层，负责数据的传输；终端控制层，监测数据及控制传输网络层，用户可通过不同方式查看服务器上的数据。系统结构如图 1 所示。

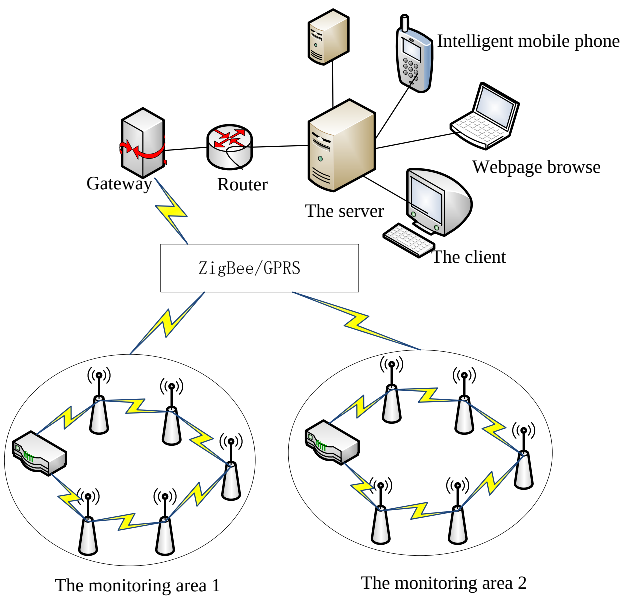


**Fig. 1 –** System structure diagram

Wireless sensors of temperature and humidity embedded in the soil are the Internet of things acquisition unit, which collect soil moisture information and the other using GPRS network model to transfer soil moisture information to the monitoring computer installed in the control center. Since the ZigBee wireless communication technology with the advantages of low power consumption, low cost, short time delay, large network capacity and safety and reliability [7], so use ZigBee wireless communication technology as a technology center. Each ZigBee monitoring network has a plurality of soil temperature and humidity data acquisition node. The monitoring center computers recycling receive soil moisture information sent by every acquisition terminal, analyze and compare the received data and the crop water requirement to them in historical database. Then

物联网终端采集单元为埋入土壤中的无线温湿度传感器，它们负责感应和采集土壤的水分情况，然后通过 GPRS 网络将收集到得这些数据信息传送到监控中心的计算机上。由于 ZigBee 无线通信技术具有低功耗，成本低，时延短，网络容量大，安全可靠等优点[12]，因此采用 ZigBee 无线通信技作为中心技术。每个 ZigBee 监测网络有若干土壤温湿度数据采集节点。监控中心计算机循环接收各个采集终端发送的土壤墒情信息，监控计算机将接收到的数据与历史数据库中的对应作物需要的水

analyzed the data meet or do not meet the need, the most suitable for crop irrigation scheme is maken according to the analysis results. Watering orders are transmitted from computer monitors to the sprinkler control terminal, which is responsible for controlling the implementation of tasks sprinkler irrigation and other irrigation equipment.

资源量作比较，然后分析是满足还是不满足，根据分析结果制定好最适合作物的灌溉方案。浇水命令由负责监控的计算机传送给喷灌机控制终端，由其负责控制执行灌溉任务的喷灌机等喷灌设备。

**System Hardware Design**

***A. Acquisition Terminal Design***

Sensing layer is responsible for rapidly, accurately collect and transmit related data information, provide an effective basis for the development of irrigation schemes to adapt to the environment.Terminals are composed of sensing nodes which represent the basic functional unit. Given that the farmland under irrigation for the use of detection covers a wide range as well as plenty of senser nodes scatters in the farmland etc, the acquisition terminals shall be designed to be flexibly move and easily installed. Analysis of functional characteristics of sensor nodes, the design of sensing node structure are shown in Fig.2, mainly make up of components such as the general information collection board, power supply, communication unit, GPS positioning unit etc.

**系统硬件设计**

***A. 采集终端设计***

感知层负责迅速、精确地采集和传输相关数据信息，为制定适应环境的灌溉方案提供有效依据。感知节点构成采集终端，是最基本的功能单元。因为具有灌溉需要检测的农田范围广，大量的感知节点随机分布在农田中等特点，因此设计采集终端时应该采用灵活移动，容易安装的策略。分析感知节点的功能特点,设计感知节点结构如图 2 所示，主要由通用信息采集主板、电源、通信单元、GPS 定位单元等部分组成。

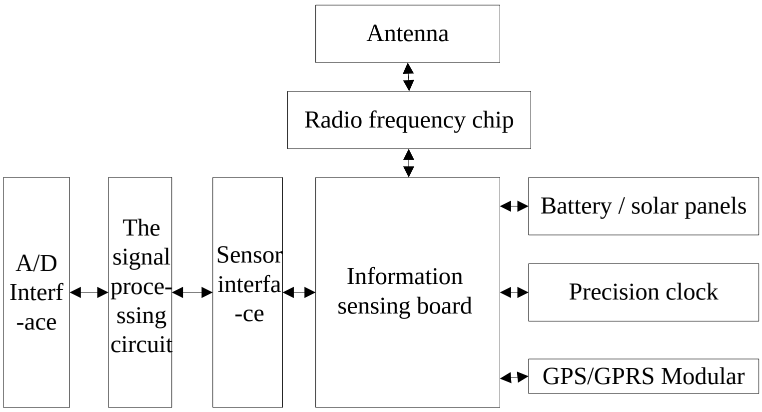


**Fig. 2 –** Sensor nodes structure diagram

General information acquisition board is mainly composed of MCU (Micro-Controller Unit) unit, acquisition unit, memory and so on. Acquisition unit uses soil humidity and temperature sensor to collect soil moisture data; after processing by MCU, the data is sent to the monitoring center computer through the GPRS network, center computer collects the temperature and humidity data and automatically displays the relevant information. The core control of acquisition terminal MCU is the core of acquisition system, this system chooses ATmega128L, which is a 8 bit single chip microcomputer with high performance and low power consumption[2]. Wireless transmission module selects the high price of the RF chip CC2420. The data acquisition unit uses "solar panel and battery" to power for collection unit. The output signal of sensor nodes is transferred to digital converter A/D of internal subsystem after processing by signal conditioning circuit. MCU starts A/D timely, converts analog to digital and takes data. Then sends the processed data to wireless transmission module through the serial port, and starts the module to send the data to the GPRS wireless network. After receiving by the network, the data is transferred to Internet via a gateway, eventually received by central station computer which is connected to the Internet.

通用信息采集主板主要由 MCU(MicroControUer Unit) 单元、采集单元、存储器等构成。通过土壤湿温度传感器，采集单元采集到农田中的土壤墒情信息，然后由 MCU 进行处理，将处理好的数据经由经 GPRS 网络传到监控中心，位于监控中心的计算机收集与灌溉相关温湿度和光照信息，并将其显示到屏幕。采集终端的核心控制 MCU 是整个采集系统的核心，本系统选用的是 ATmega128L，是一款高性能、低功耗的 8 位单片机[13]。无线传输模块选用了性价比较高的射频芯片 CC2420。数据采集单元采用“太阳能电池板 +电池”的形式为采集单元供电。信号调理电路负责处理传感器节点输出的信号，处理好的数据信号传至模数转换器 A/D，由 MCU 按特定时间启动，将该模拟信号数据转换成数字信号数据，转换后的数据被取走并经由串行口发送至无线传输模块，无线传输模块被启动，GPRS 网络接收来自该模块的数据信息，通过网关发到 Internet 中，最终监控中心计算机接收该数据。

### *B. The Transport Layer Design*

The communication system of water saving irrigation control system based on the Internet of things is set in the fundamental of ZigBee wireless communication technology and GPRS. ZigBee network connects control nodes, wireless routing nodes and wireless gateways whereas GPRS network transmits the collected data to remote monitoring computers. Wireless gateways plays a central role in the system because it is used for protocol conversion between ZigBee network and GPRS network, just as a bridge between them. The structure diagram is shown in Fig. 3.

### *B. 传输层设计*

基于物联网的节水灌溉控制系统的通讯系统是树立在 ZigBee 无线通讯技术和 GPRS 的根本上。ZigBee 网络负责控制节点、无线路由节点、无线网关之间的通信。GPRS 网络负责将采集到的数据传送至远程的监控计算机中。无线网关是本系统的中心局部，负责这两种网络之间协议的转换，是 ZigBee 网和 GPRS 网络连接的桥梁，其构造图如图 3 所示。

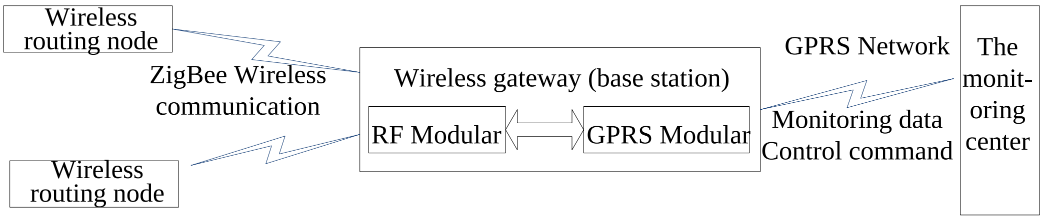


**Fig. 3 –** Schematic diagram of the gateway structure

Gateway with ZigBee RF module, GPRS module, RS232 interface, Ethernet interface, in order to realize the conversion of two arbitrary communication buses.In interface, mismatch of the industrial control field can facilitate to interconnect various interface equipment. In the application of engineering control, if interfaces do not match, the devices with different interfaces can be connected through a wireless gateway. More than that, ZigBee can transmit data in the environment, in which the arrangement of wire is hard to realize, to the monitoring and control center by means of wireless communication while GPRS can also transmit data to the public network in the same way. Thus, remote control is achieved.

无线网关主要由 RF、GPRS 两种模块以及 RS232 、以太网两种接口构成，因而达到对任意两种通信总线之间的相互转换的目的。一方面，在工程控制应用中，若接口无法匹配，经无线网关即可实现不同接口设备之间的互连；另一方面，在布线困难的环境中，通过 ZigBee 可以将困难环境中的数据以无线通信方式传送至监控控制中心，公网也能够接收来自 GPRS 网络传送过来的数据，从而实现远距离的控制。

### *C. Control Layer Design*

Based on analyzing the overall perception of information, control layer realizes the automatic control of water saving irrigation. Control terminal realizes the direct controlling of irrigation equipment. Terminal is connected with the scene equipment through standard interface, after receiving the scene perception information, control terminal firstly treats, and sends the control command according to predetermined rules. Besides having the function of automatic control, it also can realize the control of field devices through the controller and PC machine etc. Control terminal structure is shown in fig.4.

### *C. 控制层设计*

经过全面分析感知信息，控制层实现节水灌溉的自动控制。由控制终端控制，灌溉设备经由标准接口连接到现场设备,处理采集到的信息，依据设定的条件发出灌溉控制命令，现场设备根据命令进行灌溉作业。除此之外，控制终端还能够利用 PC 及等控制现场设备，具体的结构如图 4 所示。

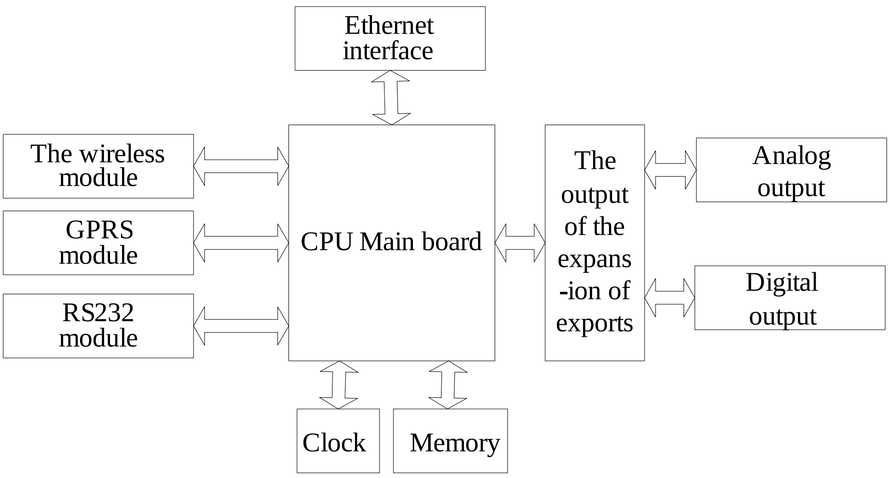


**Fig. 4 –**Control terminal structure diagram

**Software Structure Design**

The system uses the Internet environment, using B/S mode to develop. The system server uses Linux operating system which is the most popular operating system. Java language is used to develop the front interface and background database system uses SQL Server 2005 which is a medium-sized database which is easy to develop and maintain. The structure of the software is shown in fig. 5. The field data can be timely processed by real-time database and the processing results are displayed on the screen, which can be used by staff to form operators and quickly reach the field end.

**软件结构设计**

本系统采用 B/S 结构，在网络环境下开发。服务器端采用目前最流行的 Linux 操作系统，系统前台界面的开发语言采用 Java 进行，后台数据库选用易于开发和维护的中型数据库 SQL Server 2005，软件结构如图 5 所示。通过实时数据库，农田数据得到及时的处理，将处理的结果反映到各种终端设备屏幕上，管理人员根据屏幕显示的数据发出相应的指令并及时传至农田终端。

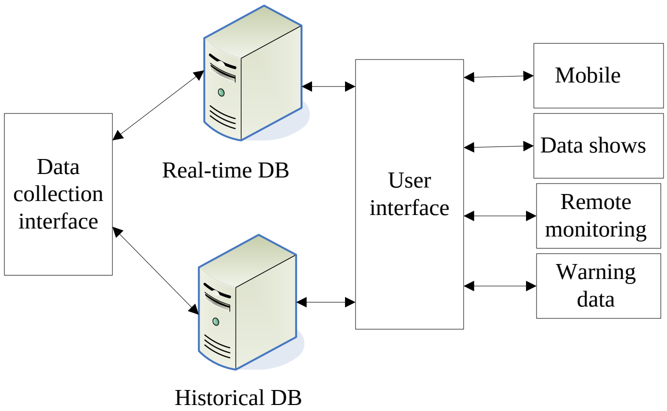


**Fig. 5** – The structure of the software

First the sensors collect data and feedback to the central computer. Then the system database based on a pre-set alarm conditions call control algorithms, open or close irrigation equipment based on the data values which are output by control algorithm, until the soil moisture reaches the optimum preset value of crop growth. The user can view the data, also can realize remote monitoring irrigation. The flow chart of control program of runtime system is shown in fig. 6.

首先中心计算机接收来自传感器节点采集到的农田数据信息，然后系统数据库依据预设定的报警条件调用控制算法，根据算法输出的数据值控制打开或关闭灌溉设备，直到土壤湿度达到预先设定的最适宜作物生长的值，用户可以查看数据，也可以远程监控灌溉。系统运行时的控制程序的流程图如图 6 所示。

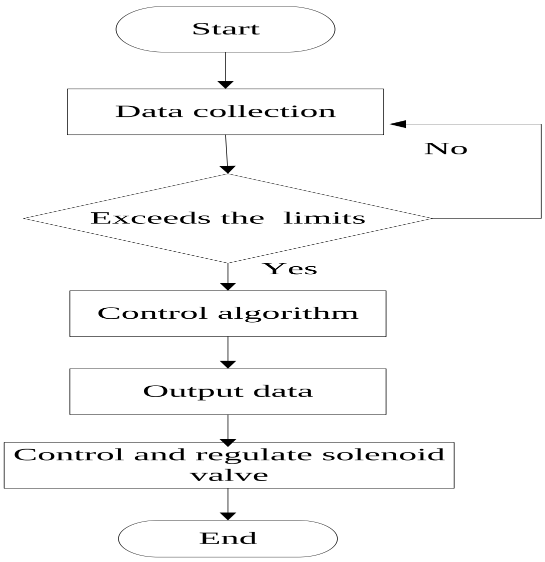


**Fig. 6 –** Flow chart of control processing system

**Data Processing**

In this system, not only manual intervention can be achieved, but also automatic irrigation can be achieved. Monitoring centre of the system processes the data which are collected by sensing terminal, the user

**数据处理**

在本系统中，即可实现人工干预，也可实现自动灌溉。感知终端收集到的数据由监控中心进行分析处理，

determine whether need for irrigation according to the obtained data. If the automatic irrigation is enabled, the real-time database processes the received data, analyzes and compares them with the historical database. The system automatically sends command when the soil is dry, opens the solenoid valve for irrigation. Because the Internet of things emphasizes the connectivity between each connected things, and the controllability of the system, sensor network in the Internet of things is the channel of connecting the observer and the observed object. Therefore, it needs to process the data collected by sensor networks, release out as observers need form to achieve better control of irrigation purposes. This system uses the filtering and interpolation for data processing.

工作人员根据处理得到的最终数据，结合农田的实际情况，决定灌溉作业。如果启用自动灌溉功能，则由实时数据库根据接收到的数据进行处理，与历史数据库进行分析比对，自动发出灌溉指令控制终端灌溉设备进行灌溉。物联网注重事物之间的关联性和系统的可控性，而观测者与被观测对量之间连接的桥梁是传感器节点构成的传感器网络，因此，对该网络采集到的数据信息作相应的处理，然后根据观测者的需要发布出去，以达到更好控制灌溉的目的。本系统采用滤波和插值对数据进行处理。

### *Data Filtering*

In the physical experiment, data obtained whether by artificial observation or by acquisition system, is inevitably superimposed noise signal. In order to improve the quality of the data, the noise must be removed. Because sensor networks is no filtering at the sensor end, there some singular data may have been collected back, in general use, it needs to be filtered, only observe reasonably reliable data. To ensure that only reliable data will be observed, it's necessary to subject the collected data to filtering procession. Therefore, the system employs smoothing filtering [3] easy to calculate, in which high-frequency components and minor disruption in the observation value are decreased or removed on the premise that low-frequency components are not affected, as shown in formula (1).

### 数据滤波

在物理实验中，不论是人工观测的数据还是由数据采集系统获取的数据，都不可避免叠加上噪声信号。为了保证采集到的数据质量，需要将噪声过滤掉。而传感器网络终端未对数据进行过滤，因而会采集回部分奇异数据。为了保证只观测合理可靠的数据，需要对采集到的数据进行滤波处理。基于此，本系统采用易于计算的平滑滤波[14]，保证图像在低频率分量不受影响的前提下，减少或去掉高频率的分量以及连接观测值中的微小中断，如式（1）所示。

$$y_k = \sum_{i=k-N}^{i=k+N} a_i x_i \qquad (1)$$

Any of the output value $y_k$ after processing is the result of observed value $x_i$ compute with the adjacent elements. The filter window width is $2N$, $k$ is the median filter window, $a_i$ is the weighted coefficient. In order to easily calculate, must be used the matrix expression, available formula (2).

其中，$y_k$ 为被平滑滤波处理后得到的任一输出值，$x_i$ 为与邻元素运算后的值。$2N$ 为滤波窗宽度，$k$ 为滤波窗中值，$a_i$ 为加权系数。采用矩阵表达可以便于计算，如式（2）所示。

$$Y = [A]X / n \qquad (2)$$

Where $[A]$ is the filter matrix, $X$ is the input vector, $n$ is average parameters and $Y$ is output vector. The filter matrix is 7 ranks with matrix elements 1, $n$ is 7.

The corresponding service is *record [] Data Process. Smooth (Datetime start, Datetime end, bool linear),* of which, the return value is the value of the output filtering, *start* is the starting time, *end* is the termination of time, *linear* is linear filtering.

其中滤波矩阵是 $[A]$，输入向量是 $X$，平均值参数是 $n$，输出向量是 $Y$。滤波矩阵为行列元素皆为 1 的 7 阶矩阵，$n$ 为 7。

record [] DataProcess.Smooth (Datetime，start, Datetime end, bool linear) 为对应服务。其中，滤波后的输出值就是返回值，起始时间是 start，终止时间是 end，线性滤波标志是 linear。

### *Linear Interpolation*

If observers only get the sensor location data, it cannot reflect the relationship between observed farmland and the observer. Thus, it is necessary to interpolate the acquisition of sensor data; data after space interpolating will be provided to the user, so that the observer only has to input the location information to obtain the required data. Because the temperature, humidity and light are continuously changing in the same farmland, the obtained data by using the interpolation analysis is credible. The system uses two simple interpolations [10].

### *线性插值*

观测者与被观测对象即农田之间的关系无法通过观测者收到的传感器节点的位置信息体现出来，所以需要对传感器节点采集到的数据信息做插值处理。数据经过空间插值处理后再传给观测者，使他仅输入位置数据就能获得需要的信息。而温湿度以及光照在相同农田里是连续变化的，因而通过插值处理后得到的数据信息可信度很高。本

Two interpolations take observations of 2 point *A* and *B* as the reference value, calculating the value of any point, as shown in formula (3).

文利用易于运算的两点插值方法进行插值处理[15]。

在两点插值法中，参考值选用相近的两节点A， B的观测值，利用式（3）计算任意点的距离值。

$$y = (x_2 y_1 - x_1 y_2) / L \tag{3}$$

Where $y_1$ is the observation value of node A and $y_2$ is observation value of node B. Distance between interpolation points and node A, B are $x_1$ and $x_2$. Recent distance between two points is L. Two interpolation method has the advantage of being simple, free from interference of other points, which is often used in the deployment of a network of observation points.

The corresponding service is *double [] DataProcess, getValue (double longitude, double latitude, bool simple)*, of which, *longitude* is longitude of the in the interpolation points and *latitude* is longitude of interpolation points, *simple* is interpolation sign for the two nodes. The return values are point humidity, temperature and light observation of interpolation point.

其中A、B点观测值分别是 $y_1$ 和 $y_2$，插值点距A、B点距离分别是 $x_1$ 和 $x_2$， 最近两点距离是 $L$。两点插值法具有简单易行、不受其他点干扰等优点，因而在部署网络时常用来校验观测点传感器的工作情况。

double[]DataProcess, getValue (double longitude, double latitude, bool simple) 是对应服务。其中插值点经度和纬度分别是 longitude 和 latitude，simple 为两点插值标志，插值点湿度、温度和光照观测值就是返回值。

## RESULTS AND ANALYSIS

The overall design of control system of water saving irrigation is shown in Fig.7. Light, temperature and humidity of crop in field are viewed and monitored by monitoring station through sensor network and the results are displayed in the main control computer. According to data displayed, the staff decided whether is needed to irrigate.

## 结果和分析

节水灌溉控制系统整体设计如图 7 所示，监控站通过传感器网络查看和监控田间作物的温湿度及光照情况，查看结果在主控电脑上显示，工作人员根据显示的数据决定是否进行灌溉。

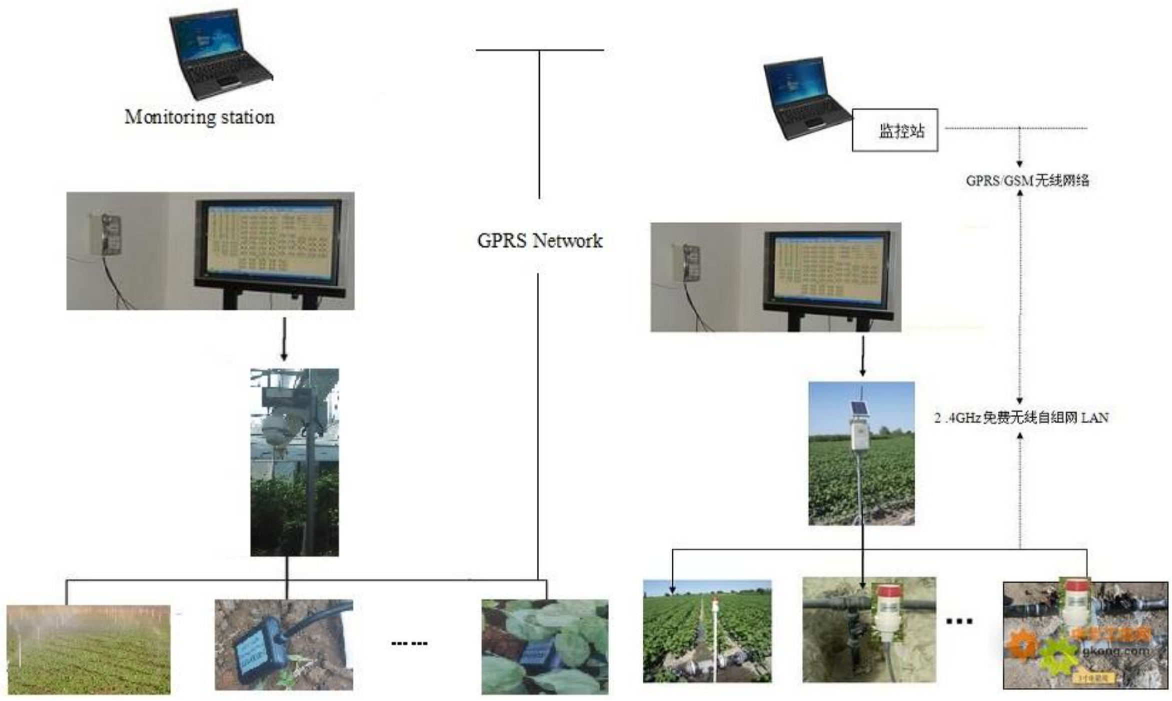


**Fig. 7 -** System design

The sensor network collected a large amount of data. Through the corresponding service, data curve at any point within the region can be collected. The object observed by user has been transformed into the observation object by sensor nodes. The observation can be directly obtained by selecting location. Fig.8 shows the latitude and longitude of the soil moisture in acres and light curve of fertile farmland. From October 1, 2014 to October 2nd, Suzhou has experienced a period of

传感器网络采集到大量的数据，区域内任意节点的数据曲线可以通过对应的服务采集到。传感器网络节点由用户观测的对象转换成被观测对象，观测值由选择位置得到。图 8 展示了宿州千亩良田中经纬度的土壤湿度和光照曲线，在 2014 年 10 月 1 日至 10 月 2 日宿州经历

rainfall, the light intensity decreased sharply during rainfall, while the soil humidity is rising rapidly until the rain stopped and began to fall at night.

了一场降雨，因而光照强度急剧下降，土壤湿度则随着降雨过程一直升高，当降雨结束时，湿度开始下降。

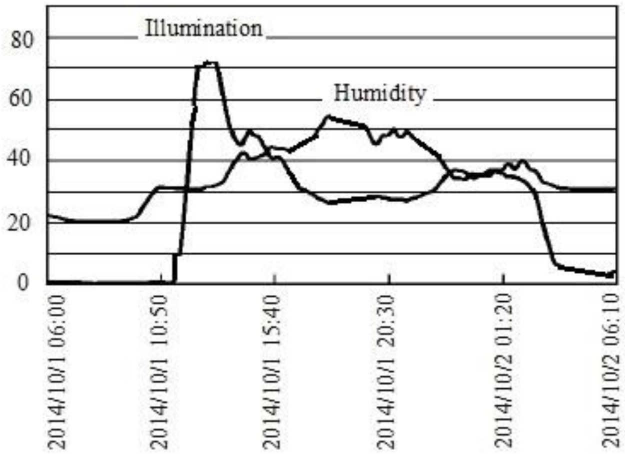


**Fig. 8** - Light, soil moisture curve

The limited energy of sensor nodes will reduce the life of the network. In this paper, because the use of filtering methods for data corresponding treatment, it reduces the spread of unwanted data in the network, so it can reduce the burden on the network. It is possible to reduce the energy consumption of the network. The energy consumption of the network is shown in Figure 9, the abscissa represents rounds of the network work and the vertical axis represents the current round of total energy consumption of network operation, unit Joule. It can be seen from the figure, energy consumption of the whole network of this system during the operation is small, so it can ensure that the network has a long life period.

传感器节点能量的有限性会减少该网络的寿命。本文因为采用滤波方法对数据进行了相应的处理，减少了不需要数据在网络中的传播，减少了网络的负担。因而能够降低网络的能量消耗。具体能量的消耗如图 9 所示，纵坐标为当前轮网络运行消耗的总能量，横坐标为网络工作的轮数。从图中可以看出，本文设计的系统在运行期间整个网络能量消耗不大，保证了网络具有较长的生命期。

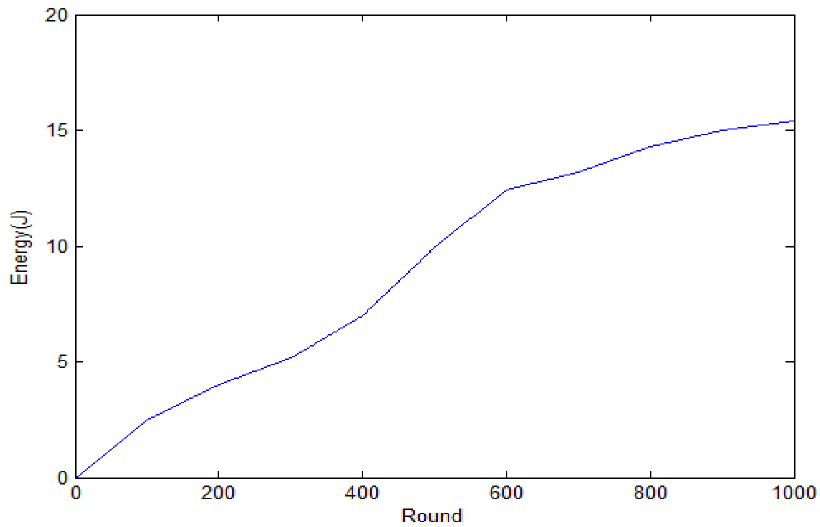


**Fig. 9 -** Energy consumption of the whole network

## CONCLUSION

The system is designed to ease the problem of domestic agricultural irrigation water waste. According to soil temperature and humidity conditions and the demand for agricultural crops in water, the system uses a database system to automatically develop optimal irrigation strategy, both to meet the demand for agricultural crops in water to be more conducive to the growth of the agricultural environment, but also to avoid

## 结论

本文设计的系统是为了缓解国内农业灌溉用水浪费问题。根据土壤温湿度情况和农田中作物对水量的需求情况，系统利用数据库系统自动制订最优的灌溉策略，既能满足农田中作物对水量的需求，使其得到更利于生长的农田环境，又能避免了多余水量的浪费，达到节

the waste of excess water, to achieve the purpose of saving and improve the efficiency of agricultural water use. A test on the system was first conducted in a large area of farmland in Suzhou. As the test showed, the system succeeded in collecting and detecting information about soil temperature, soil moisture, light etc, analysing and comparing historical database with the collected data, updating and processing the database in real time, figuring out the optimal water demand for crop growth in the farmland, working out the irrigation sheme that is most suitable for crop growth, and so on. Test experiments in Suzhou acres of fertile land show that in water-saving irrigation system designed in this paper, the sensor nodes collect accurate data-aware layer, transport layer control data transmission in a reliable and less energy consumption. So the system can better complete automatic irrigation tasks and achieve the purpose of saving water.

水的目的，提高了农田用水的效率。系统研制成功后，首先在宿州千亩良田进行了实验,系统可完成土壤温湿度、光照等信息的收集和检测,利用采集到的数据与历史数据库进行分析比对，实时数据库实时地进行处理，得出农田中作物生长的最佳需水量，制订最适合农田作物生长的灌溉方案。通过在宿州千亩良田实验园的试验表明,本文设计实现的节水灌溉系统中，感知层的感知节点采集数据准确、在控制传输层中数据的传输可靠、而且能耗较小，能较好地完成自动灌溉任务，实现了节水了目的。

**Acknowledgement**

The work has been funded by the Young Talents Fund Project in Anhui Province of China (No.2013SQRL083ZD), Anhui University Provincial Natural Science Research Project (No.KJ2014A247) and the Young Talents Fund Project in Anhui Province of China (No.2012SQRL199ZD).

**基金支持：**

安徽省青年人才基金重点项目(2013SQRL083ZD);安徽省自然科学研究项目(No.KJ2014A247) ，大学生创新训练项目（201310379019).

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