

PAPER • OPEN ACCESS

## Irrigation remote control system based on LoRa intelligence

To cite this article: Zhang Xue Yuan *et al* 2020 *J. Phys.: Conf. Ser.* **1635** 012067

View the [article online](#) for updates and enhancements.

### You may also like

- [The Synergistic Effect of Ferrocene and  \$\text{Cu}\_2\text{O}\$  to Construct a Sandwich-Type Multi-Signal Amplification Ultra-Sensitive Immunosensor for Carcinoembryonic Antigen Detection](#)  
Yiju Song, Wenjun Li, Chaoyun Ma et al.
- [Design of Intelligent Farmland Environment Monitoring System Based on Wireless Sensor Network](#)  
Xiaokang Lou, Lixin Zhang, Xueyuan Zhang et al.
- [Solar Powered Paddy Irrigation System Using Arduino UNO Microcontroller: Battery Performance](#)  
Baythanee Chan, Siti Amely Jumaat and Mohd Noor Abdullah

### ECS Toyota Young Investigator Fellowship

For young professionals and scholars pursuing research in batteries, fuel cells and hydrogen, and future sustainable technologies.

At least one \$50,000 fellowship is available annually.  
More than \$1.4 million awarded since 2015!



Application deadline: January 31, 2023



TOYOTA

**Learn more. Apply today!**

# Irrigation remote control system based on LoRa intelligence

Zhang XueYuan<sup>1,a</sup>, LouXiaoKang<sup>1,b</sup>, ZhangLiXin\*(Doctoral tutor)<sup>1,c</sup>,  
ShanYongChao<sup>2,d</sup>

<sup>1</sup>School of Mechanical and Electrical Engineering, Shihezi University, ShiHeZi, China

<sup>2</sup>School of Mechanical and Electrical Engineering, ShiHeZi, China

<sup>a</sup>821757842@qq.com

<sup>b</sup>1254624152@qq.com

<sup>c</sup>zhlx2001730@126.com.

<sup>d</sup>2465940927@qq.com.

**Abstract**—In order to realize automatic remote monitoring and intelligent management of intelligent irrigation system, aiming at the existing problems of water-saving irrigation system, an intelligent irrigation system based on wireless remote control was designed by using LoRa wireless communication technology to realize low power consumption and low loss monitoring technology. This paper introduces the way and system architecture of ad hoc network in detail, and the establishment of irrigation mathematical model and irrigation algorithm in different periods of cotton field, which not only improves the utilization rate of water resources, but also realizes the intelligence of irrigation system, and promotes the transformation from traditional agriculture to intelligent agriculture.

## 1. INTRODUCTION

China is seriously short of water resources <sup>[1]</sup>. According to the data of the National Bureau of Statistics, the total water consumption in China in 2019 was 599.09 billion cubic meters, of which agricultural water consumption was as high as 367.5 billion cubic meters, accounting for 61.34% of the total water consumption. A key part of agricultural water consumption is water saving <sup>[2]</sup>. From Figure 1, we can also see that the water-saving irrigation area in China was on the rise from 2010 to 2018, so the popularization of water-saving irrigation technology is urgent. In China, irrigation can be divided into the following types according to different technical methods: flood irrigation, sprinkler irrigation, micro irrigation, drip irrigation, etc. The significance of irrigation is not only to give plants the water they need when they grow <sup>[3-4]</sup>, but to establish a mathematical model according to the needs of different plants for water resources in different periods, so as to achieve effective irrigation. The significance of intelligent irrigation system lies in improving the efficiency of water transportation and improving the utilization rate of crop water on the basis of a deeper understanding of crop water demand and water consumption.

Intelligent irrigation system is based on wireless sensor network technology and intelligent control technology, which analyzes and stores data through embedded system and uploads it to cloud platform<sup>[5]</sup>. By analyzing the data monitored by sensors, the software in the cloud platform carries out the optimal irrigation strategy according to the established irrigation model.



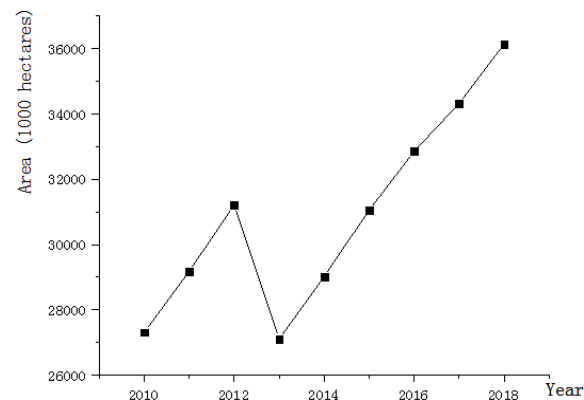


Figure 1. Water-saving irrigation area from 2010 to 2018

The research on water-saving irrigation in foreign countries is much earlier than that in China, and the results are also very remarkable. Marti et al., Spain, used the neural network method to mathematically fit the reference transpiration of plants in Valencia, and the input quantities of air temperature and humidity and the highest and lowest temperature crop models were constructed, and the experimental results were very good [6]. The research on irrigation management informationization in America can remotely control the corresponding irrigation process through large monitoring centers, and even use simulation technology to simulate according to different crops and different climatic conditions in different regions, so as to determine whether irrigation is needed [7]. Israel is the country with the best effect of intelligent water-saving irrigation in the world. At present, the whole country has implemented the intelligent water-saving irrigation strategy for agriculture, which has realized the intelligence, automation and integration of water and fertilizer in the national agricultural irrigation, and delivered water and fertilizer directly to the roots of plants at regular and quantitative times, and the utilization rate of water resources has reached about 80% [8]. However, most of the researches on intelligent irrigation systems in China only stay in the laboratory stage, and most of the wireless communication methods used in the system are GPRS and ZigBee ad hoc networks. Therefore, the development of intelligent irrigation system technology is urgent for our country, and how to effectively improve the utilization rate of water resources and reduce agricultural water consumption is one of the urgent problems to be solved.

## 2. WIRELESS SENSOR NETWORKS

With the rapid development of Internet of Things and RFID radio frequency technology, wireless sensor networks (WSN) have attracted more and more attention. Wireless sensor networks have the characteristics of low cost, low power consumption, high reliability and self-organization, and are widely used in agricultural detection systems. At present, the wireless communication technologies involved in the field of intelligent irrigation mainly include ZigBee [9], 3G, NB-IOT and LoRa. The advantages and disadvantages of the main communication technologies are shown in Table 1:

For intelligent irrigation system, low cost, low power consumption and low loss are urgent problems to be solved. ZigBee communication technology is widely used in irrigation system, and its communication frequency is high, but it is not suitable for the actual situation in Xinjiang because of its short transmission distance, complex network structure and easy interference; GPRS network does not cover the network because many agricultural planting areas are remote; Both NB-IOT and LoRa communication technology are suitable for intelligent irrigation system, but compared with NB-IOT communication technology, LoRa technology is more perfect and has longer transmission distance, so it is more suitable for places like Xinjiang [10].

Table 1. Advantages and Disadvantages of Different Wireless Communication Technologies

Name	Distance	Rate	Energy consumption	Cost	Communication cost	Adapt to the occasion
ZigBee	Shorter	Slow	Low	Lower	Free	Indoor
GPRS	medium	Faster	medium	Extremely high	traffic fee	Talking and surfing the internet
NB-IOT	Long	Slow	Very low	Higher	traffic fee	Outdoor sensor
LoRa	Extra Long	Very slow	Very low	medium	Free	Outdoor sensor

### 3. OVERALL DESIGN OF THE SYSTEM

According to the soil types and irrigation methods in Xinjiang, as well as the demand of Xinjiang cotton for water resources in different periods, the system uses computer network, Internet of Things wireless network, solar charging technology, wireless LoRa communication technology, sensors and automatic control technology, and combines information such as soil moisture and weather to achieve the purpose of intelligent and water-saving irrigation by remotely controlling on/off valves. The intelligent irrigation system (Figure 2) includes three platforms: intelligent monitoring platform, wireless transmission platform, operation and maintenance management platform and application platform. The intelligent monitoring platform includes: soil temperature and humidity sensors and meteorological information monitoring; Wireless transmission platform includes: wireless LoRa communication technology to realize remote monitoring and data transmission; The operation and maintenance management platform includes: soil moisture, remote control valve, gateway information management; The application platform includes: farmers can receive soil temperature and humidity information and weather notification through mobile APP, computer management platform and cloud platform, and realize remote control of wireless electric valves through this platform.

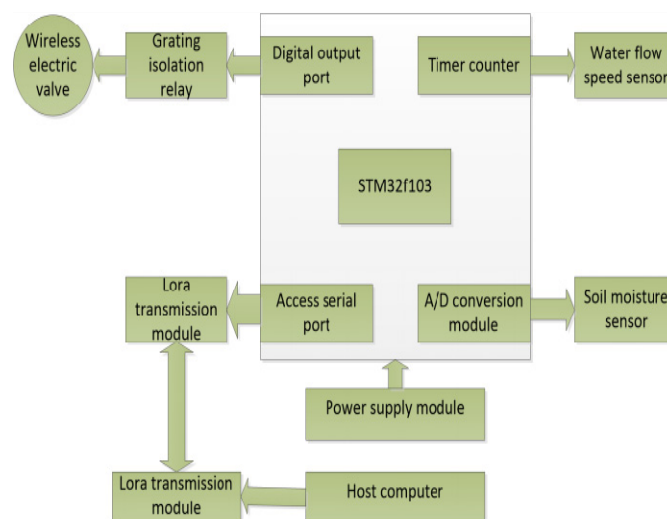


Figure 2. Intelligent irrigation system

#### 3.1 Hardware design

In the water-saving irrigation system, the number of intelligent gateways (Figure3) should be configured according to the number of acres of cotton fields, and one gateway can control multiple valves<sup>[11]</sup>. Intelligent official website needs the following modules: ARM controller, GPRS module, LoRa module, spread spectrum module, solar controller, lithium battery and antenna. Intelligent gateway is used to control the switch of wireless electric valve and collect soil moisture, and upload

the collected data to computer and store it. The valve control unit is also an important link in water-saving irrigation system, and whether it can effectively receive the signal sent by the host computer to open the valve is one of the important factors that determine how much water is saved. The control part of the valve includes wireless communication module, solar module, relay and valve driving module, valve positioning module and MCU module.

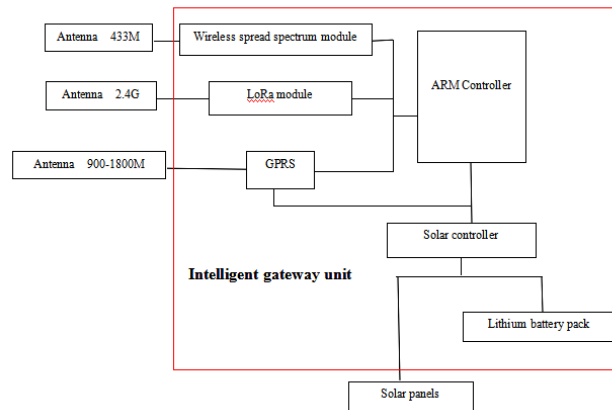


Figure3. Block diagram of intelligent gateway system

### 3.2 Software design

When the system terminal node equipment does not work, the MCU sends an instruction to adjust the equipment to sleep state. When the host computer interface sends an instruction to the gateway terminal node controller, the wireless communication module changes from sleep state to working state, sending information to the MCU module and controlling the valve and sensor module according to the instruction requirements. In order to improve the reliability and real-time performance of water-saving irrigation system and reduce the power consumption of equipment, the control system implements the protocol in intelligent gateway. The gateway node automatically uploads the node information once every 10-20min.

#### 3.2.1 Software design of upper computer

According to our functional requirements, the intelligent water-saving irrigation platform (Figure 4) is divided into several parts, including: information collection and valve control module, irrigation parameter setting module, data management module and login management module<sup>[12]</sup>. The platform not only collects the temperature and humidity information of cotton field data, but also controls the switch of wireless electric valve, and sets different parameters according to the establishment of cotton irrigation model in different growth cycles; Data management is mainly to query historical data; The login management interface is that users register their login accounts through mobile phone numbers or mailboxes, thus ensuring the security of the system platform.

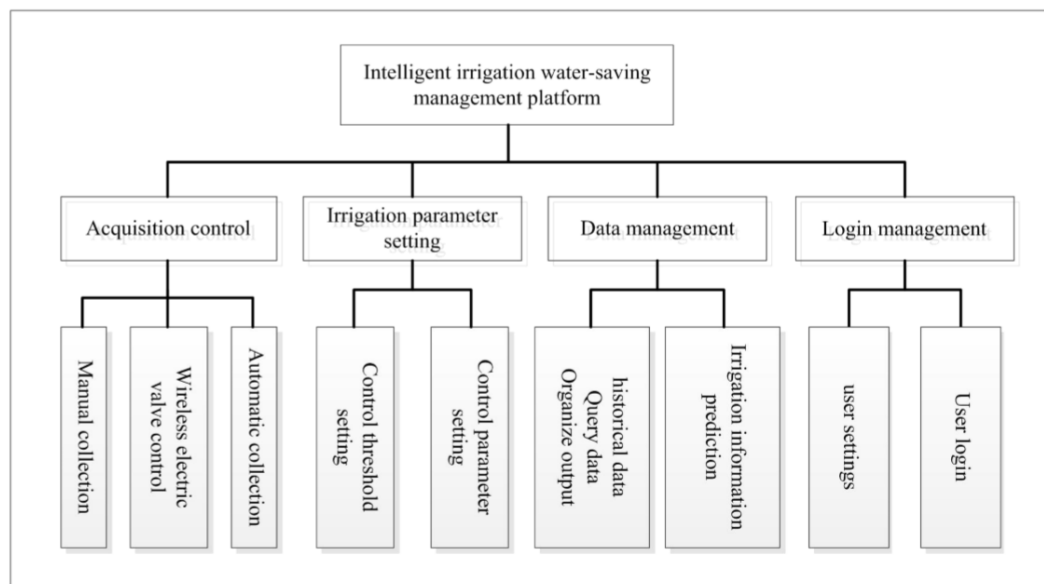


Figure 4. intelligent water-saving irrigation platform

### 3.2.2 Software design of lower computer

The lower computer control software design mainly includes the following parts: subprograms of cotton field irrigation control, subprograms of cotton field growth environment and soil temperature and humidity parameter acquisition module, subprograms needed by numerical filtering, subprograms used to interrupt display and subprograms of software serial communication. The cotton field irrigation control program is the core technology of the whole software design, which directly affects the irrigation amount and irrigation time of cotton field.

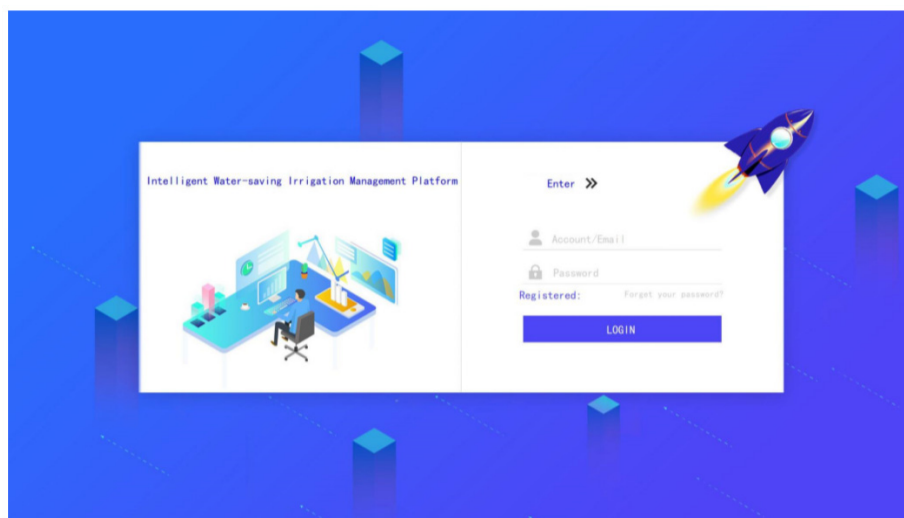


Figure 5. Login interface of intelligent irrigation system

## 4. ESTABLISHMENT OF WATER-SAVING IRRIGATION MODEL FOR COTTO

The whole growth cycle of cotton is divided into four parts: seedling stage, budding stage, flowering and bolling stage, and the demand for water resources is different in each period. We should establish a water demand model of cotton according to the characteristics of water demand in each growth cycle, and water is an important factor affecting cotton yield.

Table 2. Division of each growth period of cotton and crop coefficient of different growth periods of cotton

Growth stage	Crop coefficient	Start and end time
seeding stage	0.25	May 1st-June 19th
Bud stage	0.47	June 20th-July 15th
Blossoming and boll-forming stage	1.76	July 16th-August 11th
Boll opening stage	0.14	August 12th-September 30th

Table 3 Irrigation cycle and lower limit of suitable water content in cotton growth period

Growth stage	Soil wetting depth (cm)	Suitable water content of soil (%)	Lower limit value of water content (%)	Maximum irrigation quota (mm)	Irrigation cycle (d)
seeding stage	30-40	55-70	0.165	21.312	4.3
Bud stage	40-60	60-75	0.180	31.968	6.4
Blossoming and boll-forming stage	50-70	70-80	0.210	24.864	5.0
Boll opening stage	50-70	50-70	0.150	49.728	9.9

The most important step in establishing irrigation model is to determine the water demand of cotton in different periods. There are many factors that affect the water demand of crops, such as temperature, humidity, precipitation and soil fertility, and the key factor that affects the water demand of crops is the transpiration and evaporation of crops. We set up an irrigation model based on Penman-Monteith public announcement, combining related growth parameters and cotton growth indicators. The public announcement not only considered the physiological characteristics of crops themselves, but also considered the influence of meteorological factors. The formula is calculated according to cotton water demand and irrigation demand index<sup>[13]</sup>, thus making irrigation strategy. Classification of cotton in different periods and crop coefficients of cotton in different periods are shown in Table 2:

Penman-Monteith Formula:

$$ET_c = K_c * ET_0 \quad (\text{Formula 1})$$

$ET_c$  — Characteristics of crop water demand, mm

$K_c$  — Crop coefficient

$ET_0$  — Reference crop evapotranspiration, mm/d

The reference crop evapotranspiration is calculated by formula 2<sup>[14]</sup>:

$$ET_0 = \frac{0.408\Delta R_n + \gamma \frac{900}{T + 273} U_2 (e_n - e_d)}{\Delta + \gamma (1 + 0.34U_2)} \quad (\text{Formula 2})$$

## 5. CONCLUSION

Intelligent irrigation system should start from the present and be based on the future. The construction of smart irrigation area should form the top-level framework design standard, and integrate the existing AI intelligence, "3S" technology, cloud computing, big data, model calculation and other technical means and scientific research achievements in agriculture, water conservancy and computer into agricultural irrigation. It is the only way for smart irrigation system to realize the perfect combination of hardware, software and data through information technology and automation technology. This system adopts LoRa wireless communication technology combined with cloud data platform to change the problems of short transmission distance and high power consumption of traditional ZigBee system, which not only improves the utilization rate of water resources, but also realizes the automation of agricultural irrigation.

**ACKNOWLEDGEMENT**

Thanks to the following two fund projects:

- 1、Autonomous Region Science and Technology Supporting Xinjiang Project (2017E0227)
- 2、International Cooperation Project of Shihezi University (KX01210104)

**REFERENCES**

- [1] Wang Jiulin, Zhao Chengping, Yan Hua. Design and research of water-saving irrigation system based on LoRa [J]. Water-saving Irrigation, 2017 (12): 104-106+111.
- [2] Chen Ziwei, Yao Junguang, Sun Daozong, Li Si. Water-saving Irrigation System of Farmland Based on LoRa Wireless Sensor Network [J]. Modern Computer, 2020(02):98-102.
- [3] Yu Guoxiong, Wang Weixing, Jiaxing Xie, Lu Huazhong, Lin Jinbin, Mo Haofan. Design and implementation of intelligent irrigation remote monitoring system for litchi orchard based on ASP.NET technology [J]. Journal of Fujian Agriculture, 2016,31(07):770-776.
- [4] Zhao Tiantu, Ma Rong, Liu Nanjiang, Zheng Yuling. Design method and research of intelligent irrigation wireless valve controller [J]. Water-saving Irrigation, 2016 (12): 131-135.
- [5] Ma Xuefen, Sun Min. Design of intelligent irrigation system based on Internet of Things [J]. Southern Agricultural Machinery, 2019,50(01):9+25.
- [6] P.Marti,A.Royuela,J.Manzano,G.Palau.Improvement of temperature Based ANN Models for ETo Prediction in Coastal Locations by Means of Preliminary ,Models and Exogenous Data[C].2008 Eighth International Conference on Hybrid Intelligent Systems , IEEE.2008:344-349.
- [7] Q.Zhang.X.L.Yang,Y.M.Zhou,L.R.Wang,X.S.Guo.A wireless solution for greenhouse monitoring and control system based on ZigBee technology[J].Journal of Zhejiang university(Science A),2007,8 (10) : 1584-1587
- [8] Du Zhongping. Investigation Report on Water-saving Irrigation and Integration of Water and Fertilizer in Israel [J]. Qinghai Agriculture and Forestry Science and Technology, 2012, (4): 17-20.
- [9] Wen Zongzhou, Dou Pengda, et al. Design of Stirrup Irrigation System Based on ZigBee [J]. Application of Single Chip Microcomputer and Embedded System, 2016 (11): 38-42.
- [10] Feng Xun. Remote intelligent water quality detection system based on CDMA2000 [D]. Xi 'an; Xi 'an University of Posts and Telecommunications, 2015
- [11] Li Xuechun, Meng Liqing, wang zheng. Implementation of intelligent agricultural irrigation monitoring system [J]. Wireless Internet Technology, 2020,17(02):54-56.
- [12] Li Ai-chuan, Sang Yi-ning, Liu Xuan-ji. Design of automatic control platform for water-saving irrigation of rice in cold region based on wireless transmission[J]. Journal of Heilongjiang Bayi AgriculturalUniversity, 2019,31(06):85-90.
- [13] Wang ruifen. determination of basic parameters of cotton optimal irrigation system [J]. science and technology information development and economy, 2007(30):172-173.
- [14] Wan Wei, Li Jianyi, Wu Jianming. Study on Decision Model of Water-saving Irrigation of Rice [J]. Innovation and Application of Science and Technology, 2018(04):153-154.