Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 42 Issue: 02-2023
DOI 10.17605/OSF.IO/TJ3H7

LORA BASED SMART AGRICULTURE MONITORING AND AUTOMATED IRRIGATION SYSTEM

VANISHREE K*

Assistant Professor, Department of ISE, RV College of Engineering, Bengaluru, Karnataka, India. *Email: vanishreek@rvce.edu.in

Dr. G S NAGARAJA*

Professor and Associate Dean, Department of CSE, RV College of Engineering, Bengaluru, Karnataka, India. Email: *nagarajags@rvce.edu.in

KEDAR BHANDARKAR

RV College of Engineering, Bengaluru, Karnataka, India. Email: kedarbhandarkar195@gmail.com

SUDHANVA T MANUR

RV College of Engineering, Bengaluru, Karnataka, India. Email: sudhanvamanur@gmail.com

SYED FARHAN

RV College of Engineering, Bengaluru, Karnataka, India. Email: fsyed3824@gmail.com

LEELA GANESH

RV College of Engineering, Bengaluru, Karnataka, India. Email: 19454leelaganesh@gmail.com

Abstract

Agriculture contributes significantly to India's economic growth. To reach its full potential and address its problems, it is essential to replace conventional farming methods using IoT and sensor technologies. The main goal is to integrate a monitoring and irrigation system for agriculture with the processing of collected data in the cloud. Different sensors used in this project measure the humidity, temperature, and moisture content of the soil. The system can deliver optimal water to the crops using these data. It also has additional sensors for fire and intruder detection. All the operations will be monitored through an internet-connected mobile application integrated with cloud storage. A LoRa module is used to overcome low internet connectivity. The system is powered using a renewable source of energy, and a transceiver is used to access the field conditions without the internet. A website has also been developed which contains various information for farmers. It will assist them in determining whether the environment is compatible with their farming system.

Keywords - Smart agriculture; IoT; Agricultural field monitoring; Irrigation system; Cloud processing; LoRa.

1. INTRODUCTION

Agriculture is a primary source of income for the majority of the population in India. As a result of the growing population, food is in great demand and there is an urgent need to improve crop productivity using limited natural resources. An IoT-based approach is more in demand to address these issues. The proposed system is an application of IoT that uses wireless sensors to monitor agricultural fields and automates irrigation systems to ensure the proper use of water resources. It allows controlling the system from a remote place through the internet [2] [9]. Field data from the sensors are stored automatically on the cloud server. The farmer can use a smartphone app to control the irrigation and monitor the field.

2. LITERATURE REVIEW

In the paper [1] a wireless sensor network is used to control irrigation via Dual Tone Multiple Frequency communication (DTMF). The system operates on two guiding principles: circuit switching and WSN. It explains the installation procedure along with the circuit, which has been created and tested in a prototype setting.

The system in the paper [2] employs an intelligent, remote-controlled robot to carry out field activities such as moisture detection, weeding, frightening away birds and other animals, etc. It is equipped with an automated watering system that makes use of field data for irrigation. All of these processes can be monitored by a remote device linked to the internet. A microcontroller and raspberry pi are used to integrate the sensors and ZigBee modules.

The paper [3] explores IoT's applications in agriculture and coconut tree farming. A hardware setup is proposed that uses wireless sensor motes to gather a variety of environmental data, including pH value, soil moisture level, and macronutrients (NPK). A classifier is used to process the data and make an accurate diagnosis of the coconut tree deficiency. As a result, it reduces the time and cost needed for soil testing.

A Raspberry Pi-based system is proposed in the paper [4] for improving crop yield. The developed system feeds the data from the sensors to the ground station and using this data the system calculates the quantity of water required. Precision Agriculture with cloud computing is used to optimize water usage while maximizing the yield of the crops.

Paper [5] proposes a new IoT technology that uses Li-Fi. Li-Fi uses infrared light instead of radio waves for sending information. It has better efficiency and bandwidth than Wi-Fi. The setup is remote-controlled to carry out various agricultural activities. All these operations will be controlled through Li-Fi, and ZigBee modules.

In the paper [6] a low-cost soil monitoring system is developed by using sensors in a wireless Zigbee network. It transmits information to a server, that gathers the data, and makes it available for analysis. An algorithm is used so that the network can transmit data with high reliability.

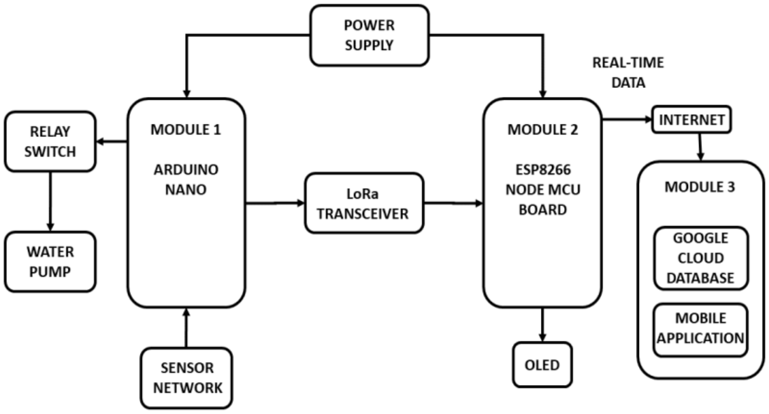
Research Gaps

A major hindrance to the smart farming system is low internet connectivity in remote areas. The IoT device will be useless as a result. To solve this problem a LoRa transceiver is used which provides long-range spectrum communication. It works on low power and has high efficiency in data transmission.

3. PROPOSED SYSTEM DESIGN

The system comprises both software and hardware units. An ESP8266 Node MCU board, LoRa transceiver module, Nano Arduino, 3W solar panel, relay, water pump, and several sensors are all part of the hardware. The software comprises Fritzing simulator, MIT app inventor, Firebase database, and Arduino IDE.

Figure 1. System Design



Hardware used

A. ESP8266 Node MCU

The ESP8266 Node MCU board has an internal protocol that the microcontroller may use to connect to any Wi-Fi network. It is affordable and simple to program using the Arduino IDE. It requires a 3.3V operating voltage and has a fast clock speed. The GPIO pins allow for the integration of various sensors with a short runtime. Furthermore, it features a large flash memory that can save data for a longer time.

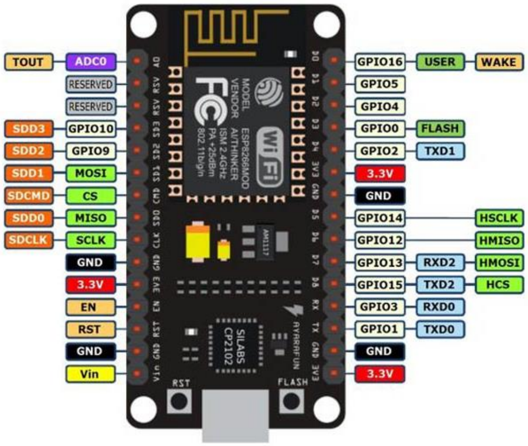


Figure 2. ESP8266 Node MCU Board

B. LoRa transceiver

LoRa is a popular wireless technology used for long- distance communications for IoT. It comprises a radio layer, GPIOs, interface buses, protocol stack, UART, etc. UART is used to interface the microcontroller unit to the LoRa transmitter for monitoring and controlling applications. In urban and rural areas, it offers a transmission distance of more than 5 km and more than 15 km, respectively, while using less power.

C. Nano Arduino

The Nano Arduino is a microcontroller board based on A Tmega 328p used widely in robotics, IoT, embedded systems, and electronics projects. It is designed to produce a clock of precise frequency at a constant voltage.

Figure 3. LoRa Transceiver

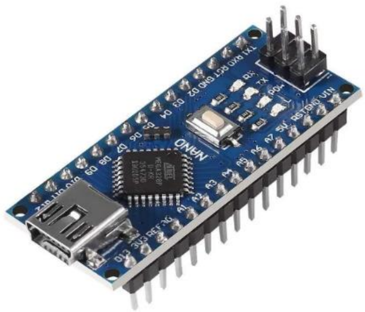


Figure 4. Arduino Nano

D. Sensors

1) Soil Moisture Sensor

A soil moisture sensor is used to gauge the amount of water in the soil. To calculate the water content, various soil properties are used, such as resistance value and dielectric constant. The sensing range is high and it is platinum coated to increase efficiency. The sensor can be used by the farmer at a cost as it resists corrosion and has a long lifespan.

2) DHT11 Sensor

DHT11 is used to measure the temperature and humidity of the surrounding air in the crop field and can be easily interfaced with the Node MCU board to provide appropriate readings.

3) Rain Sensor

A rain sensor is used to detect rainfall and it works on the principle of resistance. The board includes nickel-coated lines and has both digital and analog output pins.

4) PIR (Passive Infrared) Sensor

PIR sensors are used for motion detection. It can sense both human and animal movement. It does not radiate energy to space. To enhance its sensing ability a silicon covering or a lens is used. It receives infrared radiation from the human/animal body to make an alarm.

5) Smoke Sensor

A smoke sensor is a low-cost, reliable semiconductor sensor module that works with any microcontroller. The sensor is sensitive to smoke and can be used for fire detection.

Figure 5. Soil Moisture Sensor

Figure 6. DHT11 sensor

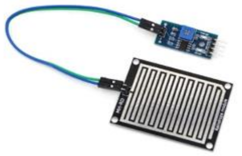


Figure 7. Rain Sensor

Figure 8. Smoke Sensor

Figure 9. PIR sensor

Figure 10. Relay Switch

E. Relay and Water Pump

The water pump and the Nano Arduino board are connected through a relay switch. It regulates the water supply to the crops through the water pump. Depending on the condition of the plant relay can switch the water supply.

F. Solar Panel and Battery

A 3W solar panel and a battery are used to power the system. As farms are located in remote areas supplying energy to the device can be exceedingly difficult. The advantage of using solar power is it provides power to the sensors and other devices without the need for any electrical sources.

Software Used

A. Arduino IDE

Arduino IDE is a platform used to program a variety of microcontrollers and can be used in different operating systems. The microcontroller can be programmed in C and C++ languages. When the program is ready, it is compiled and then uploaded to the board.

B. Fritzing simulator

Fritzing is an open-source tool used to create and prototype electronic projects. it has many electronic components already installed in the software. One may even design their PCB designs and have the files manufactured. The software can also be used as Arduino IDE to write and upload code.

C. MIT app inventor

The MIT app inventor is a free web application IDE used to build mobile apps. It allows users to program a mobile application interface that can be used in both Android and iOS operating systems.

D. Firebase database

Firebase Database is a database that enables a user to sync, store, and access the app data anywhere. With one app all the users can access a database instance and receive instant updates with the most recent data.

4. METHODOLOGY

The project comprises the following modules:

A. Transmitter and wireless sensors module

The transmitter and wireless sensors module are shown in Fig. 11. It includes a Nano Arduino, LoRa transceiver, relay switch, water pump, and a variety of sensors (DHT11 sensor, Rain sensor, Soil moisture sensor, and Fire and Motion detection sensor). The Nano Arduino collects the data from these sensors and sends it via LoRa for transmission.

B. Receiver module

The receiver module shown in Fig 12 consists of an ESP8266 board, an OLED, and a LoRa transceiver. The ESP8266 microcontroller receives data from all the sensors through the LoRa receiver. Automatic irrigation is based on the comparison between sensor values and threshold values. The predefined values for soil moisture can be varied for different crops and the system determines whether to irrigate the field depending on these values. The Nano Arduino receives a control command to switch on the water pump to irrigate the field when the sensor output falls below the defined threshold. Thus, the system automates irrigation based on real-time values.

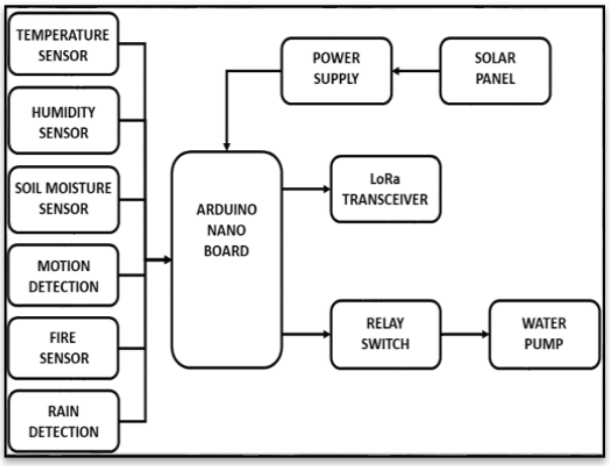


Figure 11. Transmitter and Wireless

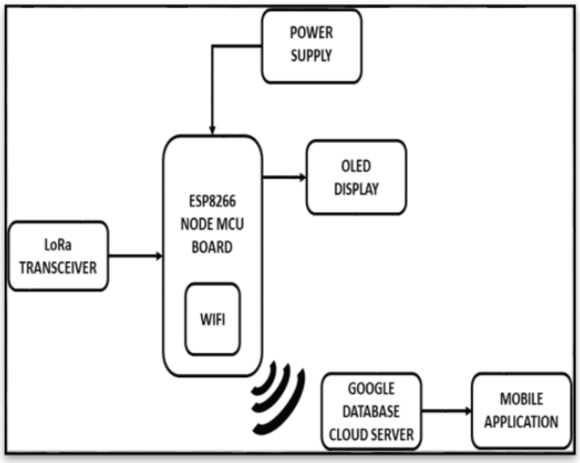


Figure 12. Receiver Module

C. Communication module

The data is transferred to the farmer's mobile frequently via the internet. The sensor values are transferred to Google Cloud Storage for further analysis. The farmer may analyze the previously saved data (temperature, humidity, soil moisture, and water pump status) from the cloud storage.

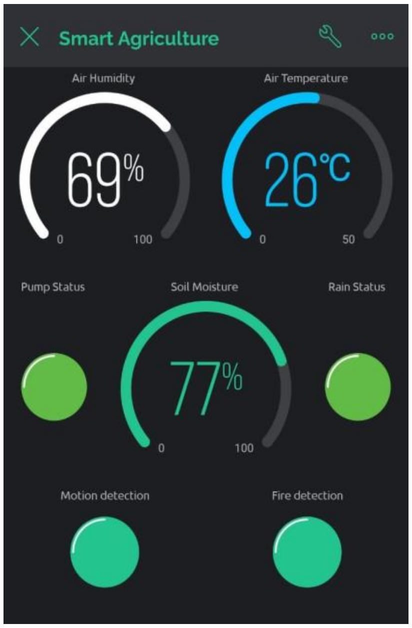
5. ANALYSIS

The Arduino Nano is interfaced with all the sensors (for live monitoring), the relay switch, the water pump, and the LoRa transmitter. LoRa is used for low-power and long-range spread spectrum communications. This module is used to send the information frequently to the Node MCU board. The ESP8266 microcontroller is connected to the LoRa receiver and an OLED at the receiver module.

The system is powered by a battery and a 3W solar panel. During the daytime, the solar panel drives the system and charges the battery, while the battery powers it at night. A 7805 regulator is used to step down the voltage from 10 to 5V for the battery. The farmer can monitor the field through the mobile app and also see the previous data using Google cloud services.

Fig 13 shows the app interface of the mobile application. It has a LED template to indicate motion, fire, rain, and pump status. A gauge template is used to display the measurements of humidity, temperature, and soil moisture.

Figure 12. Application Interface



6. RESULTS AND DISCUSSION

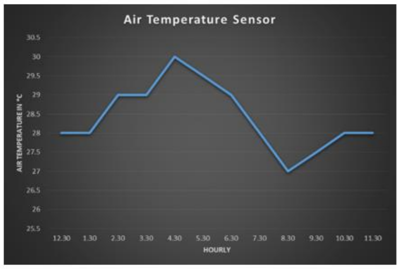


Figure 14. Air temperature graph

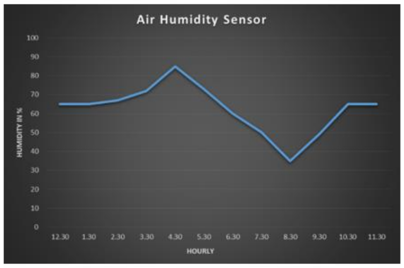


Figure 15. Air humidity graph

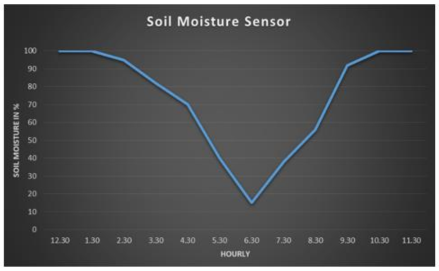


Figure 16. Soil moisture graph

The ESP8266 microcontroller transmits the sensed data, like soil moisture, temperature, humidity, fire, and intruder detection to the Blynk app. Fig 14, 15, and 16 show temperature, humidity, and soil moisture for different conditions. When the moisture content of the soil decreases, the water pump turns on. When it rains, the rain status led is turned on, and the water pump is turned off automatically. Based on the observation of the traditional methods employed for irrigating the field, it is noticed that water must be properly utilized. Thus, by regulating the water pumping to the field and continuously monitoring the status of the crops, smart irrigation systems work together to decrease water wastage during irrigation. It also serves as a feedback mechanism for farmers.

A website has been developed to provide useful information for farmers. There are different sections that offer information on a variety of subjects including dairy, fertilizers, pesticides, irrigation, seeds, weather, soil pH, water conservation, organic farming, etc. There is also a news section that provides details on current government initiatives, insurance, schemes, and policies. The user interface of the website is shown in Fig 17, 18, and 19.

The Future of Agriculture through Technology

Efficiency in Production

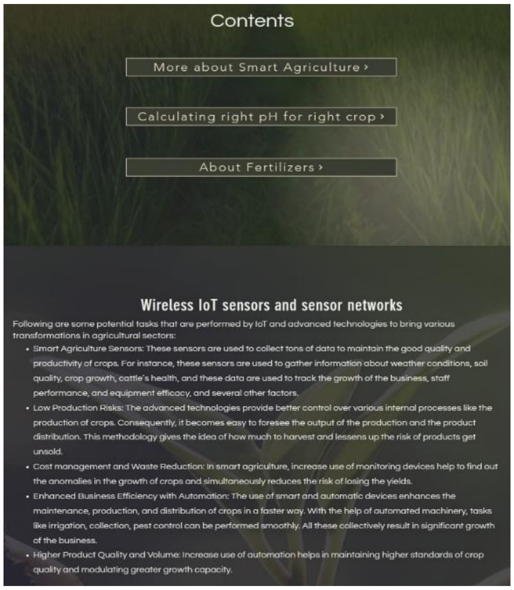
Agriculture

Agriculture, with its allied sectors, is unquestionably the largest livelihood provider in India, more so in the vast rural areas. It also contributes a significant figure to the Gross Domestic Product (GDP). Sustainable agriculture, in terms of food security, rural employment, and environmentally sustainable technologies such as soil conservation, sustainable natural resource management and biodiversity protection, are essential for holistic rural development. Indian agriculture and allied activities have witnessed a green revolution, a white revolution, a yellow revolution and a blue revolution.
This section provides the information on agriculture produces; machineries, research etc. Detailed information on the government policies, schemes, agriculture loans, loans & credit etc. is also available.

Smart Agriculture
Agriculture with a New Perspective

Smart agriculture is experiencing rapid transformation with reference to products and services. The adaptation of new business models, technological disruptions, and organizational changes are projected to bring massive growth in the agricultural sector but result in some challenges too. The advancement in hardware and software technology is resulting in new and different ways of agriculture. The introduction of robotic automation, smart sensors, modern biologics, and increasing use of digital data, is driving the global smart agriculture market to a great extent in terms of sales.

Figure 17. Website Interface

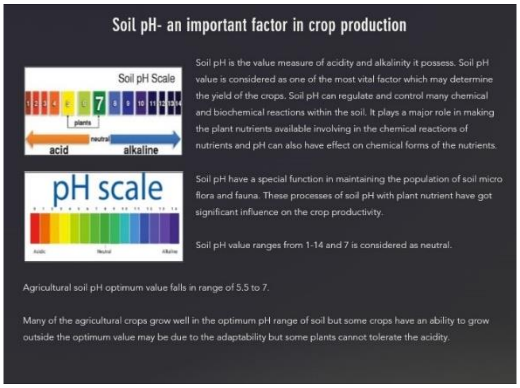


Wireless IoT sensors and sensor networks

Following are some potential tasks that are performed by IoT and advanced technologies to bring various transformations in agricultural sectors:

- Smart Agriculture Sensors: These sensors are used to collect tons of data to maintain the good quality and productivity of crops. For instance, these sensors are used to gather information about weather conditions, soil quality, crop growth, cattle's health, and these data are used to track the growth of the business, staff performance, and equipment efficacy, and several other factors.
- Low Production Risks: The advanced technologies provide better control over various internal processes like the production of crops. Consequently, it becomes easy to foresee the output of the production and the product distribution. This methodology gives the idea of how much to harvest and lessens up the risk of products get unsold.
- Cost management and Waste Reduction: In smart agriculture, increase use of monitoring devices help to find out the anomalies in the growth of crops and simultaneously reduces the risk of losing the yields.
- Enhanced Business Efficiency with Automation: The use of smart and automatic devices enhances the maintenance, production, and distribution of crops in a faster way. With the help of automated machinery, tasks like irrigation, collection, pest control can be performed smoothly. All these collectively result in significant growth of the business.
- Higher Product Quality and Volume: Increase use of automation helps in maintaining higher standards of crop quality and modulating greater growth capacity.

Figure 18. Website Contents



Soil pH- an important factor in crop production

Soil pH is the value measure of acidity and alkalinity it possess. Soil pH value is considered as one of the most vital factor which may determine the yield of the crops. Soil pH can regulate and control many chemical and biochemical reactions within the soil. It plays a major role in making the plant nutrients available involving in the chemical reactions of nutrients and pH can also have effect on chemical forms of the nutrients.

Soil pH have a special function in maintaining the population of soil micro flora and fauna. These processes of soil pH with plant nutrient have got significant influence on the crop productivity.

Soil pH value ranges from 1-14 and 7 is considered as neutral.

Agricultural soil pH optimum value falls in range of 5.5 to 7.

Many of the agricultural crops grow well in the optimum pH range of soil but some crops have an ability to grow outside the optimum value may be due to the adaptability but some plants cannot tolerate the acidity.

Figure 19. Website Information

7. CONCLUSION

The Lora-based monitoring system is a safe and effective agricultural field monitoring system. The smart system helps to reduce water wastage by automating the irrigation system and the farmer can monitor the field conditions using a mobile application. Additionally, the data is maintained in Google Cloud so that the farmer may view the previous field conditions whenever needed. This reduces manual work and allows farmers to monitor their fields at any time. The important thing is the device is cost-effective and needs a very minimal amount of power for its sensors. The transceiver used eliminates the Wi-Fi problems and makes it easy for field installation. Modifications can be easily made at any time anywhere. Implementing such a system can help improve overall crop yield.

8. LIMITATIONS AND FUTURE STUDIES

Farmers must comprehend and learn the use of technology in order to employ smart farming equipment. This is a significant barrier to the widespread adoption of smart agricultural farming in rural areas. Another drawback is that farms in remote locations have limited internet access owing to poor communication infrastructure. As a result, connectivity problems would render the monitoring system ineffective. These issues can be resolved by educating farmers about smart farming techniques and making mobile apps simpler to use.

The system can be enhanced in the future by adding more sensors to fetch data such as the pH and NPK content of the soil. This will help farmers to identify nutrient deficiencies in the ground and take the necessary action. The website provides useful information for farmers on the amount of lime or sulfur required to change the pH following crop requirements.

Acknowledgment

We are grateful to our project guide Vanishree K for her excellent guidance in our project. We appreciate for providing all the necessary facilities required for the project.