Smart Agriculture Using Lora System.

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Abstract:

Given the world's population, it is critical to use water resources wisely and increase the quantity and quality of agricultural goods. Smart systems offer intriguing solutions to the mentioned problem. Wi-Fi modules and GSM-supplied smart irrigation systems have been published in literature. But while GSM-enabled smart irrigation systems struggle with power consumption, Wi-Fi enabled smart irrigation systems struggle with a constrained coverage area. In addition to having a great coverage range, Lora uses little power and can run for up to ten years on a single battery. To improve the quality of irrigation systems, a smart irrigation system with LoRa connectivity has been proposed in this study.

Keywords: LoRa, STM, IoT, Mobile App, ESP8266 Microcon- troller

1. INTRODUCTION

A. Overview

In recent years, agriculture has witnessed a transforma- tion driven by advancements in technology, particularly through the integration of Internet of Things (IoT) solu- tions. These technologies offer unprecedented opportu- nities to optimize agricultural practices, improve resource management, and enhance productivity. One such innova- tive approach is the implementation of a smart agriculture system utilizing LoRa (Long Range) technology. Traditional agricultural methods often rely on manual labor and periodic assessments, which can be inefficient and prone to inaccuracies. With the global population expected to reach 9 billion by 2050, the pressure on agriculture to increase yields sustainably is greater than ever. Smart agriculture addresses these challenges by harnessing the power of IoT to monitor, analysis, and control agricultural processes in real time. The main idea behind this project is to use LoRa technology, which is well-known for its low power consumption and long-range wireless connectivity, making it perfect for large-scale agricultural applications. Farmers may learn important characteristics like soil moisture levels, temperature fluctuations, humidity levels, and light intensity by installing a network of LoRaenabled sensors throughout the farm. A centralized LoRa gate- way receives wireless communication from these sensors, gathers data, and sends it to a cloud-based platform for analysis and storage. The data collected from these sensors empowers farmers to make informed decisions promptly. For instance, by adjusting irrigation schedules based on realtime soil moisture readings or deploying pest management strategies in response to environmental conditions. This proactive approach not only optimizes resource usage but also enhances crop health and yield

B. Motivation

“Smart agriculture using LoRa (Long Range) system” was inspired by the need for low-cost, scalable, and ef- fective ways to increase agricultural productivity. Problems with traditional farming include ineffective resource man- agement, insect control, and water constraint. Realtime monitoring of crop health, weather patterns, and soil conditions is made possible by LoRa technology, which provides a long-range, low-power wireless communica- tion platform. Farmers can maximize crop productivity, optimize resource use, and make data-driven decisions while reducing their environmental effect by gathering data from a variety of sensors. By increasing productivity and cutting expenses, this technique promotes sustain- able agriculture, especially in rural or expansive farming regions

C. Objective

The goal of “Smart Agriculture using LoRa System” is to use long-range, low-power wireless communi- cation technology to increase farming production, sustainability, and efficiency. Real-time monitoring and data collection from a variety of sensors placed in fields, measuring variables like crop health, tem- perature, humidity, and soil moisture, are made pos- sible by LoRa (Long Range). This method enables farmers to minimize labor expenses, optimize re- source utilization (fertilizers, water), and make data- driven decisions. It guarantees affordable and scalable solutions for big and remote agricultural areas by utilizing LoRa’s extensive coverage and low energy consumption, which eventually encourages precision farming and raises crop yields.

2. LITERATURE SURVEY

“LoRa Farm: A LoRa WAN-Based Smart Farming Mod- ular IoT Architecture” - This paper discusses a modular IoT platform based on LoRaWAN for smart farming. It focuses on collecting and analyzing environmental data (like soil and air temperature, and humidity) to improve farm management. The platform was tested in a real farm setting, demonstrating its potential to enhance agricul- tural processes.[1]

“Smart Irrigation System for Farm Application Using LoRa Technology” - This research reviews the imple- mentation of a smart irrigation system utilizing LoRa technology. It highlights how the system can optimize water usage by monitoring soil moisture and adjusting irrigation accordingly, promoting efficient and sustainable farming practices.[2]

"LoRa-based Novel System for Smart Agriculture” - This paper presents a system that uses LoRa technology to improve agricultural productivity and sustainability. It discusses the integration of sensors and IoT devices to monitor various parameters such as soil moisture, temperature, and crop health.[3]

“Design, Implementation, and Empirical Validation of an IoT Smart Irrigation System for Fog Computing Appli- cations Based on LoRa and LoRaWAN Sensor Nodes”- The system is designed to optimize water usage in agriculture, ensuring efficient and sustainable irrigation practices. The study covers the architecture,implementation, and empirical testing,demonstrating the system’s capability to provide reliable communication over long distances with minimal energy consumption. By integrating varioussen- sors and leveraging fog computing, the system can process and analysis data locally, reducing latency and improving decisionmaking in irrigation management. The results in- dicate significant potential for agricultural applications.[4] “An Intelligent LoRa-Based Wireless Sensor Network Mesh Architecture to Improve Precision Agriculture” The study aims to demonstrate how the convergence of mul- tiple parts of agricultural demands works together to syn- chronize computational capabilities offered by ML models and data created through the use of IoT sensors, which are exchanged across LoRa-based WSN networks. This re- search presents a three-tier architecture-based integrated system that uses ML and IoT systems to process data for yield prediction and then generates a visual representation of the outcome.[5]

“An IoT-Based Smart Irrigation System” Created a proto- type system using Arduino microcontrollers and a Rasp- berry Pi. When compared to a timer-based system, the smart system used less water and made it easier to maintain a target soil moisture level.[6]

“LoRa Based IoT Platform for Remote Monitoring of Large-Scale Agriculture Farms in Chile” Using LoRa WAN technology, the suggested methods for remote plant, soil, and environmental condition monitoring have been devel- oped, put into practice, and assessed. The platform may be used to collect useful real- time monitoring analytics that facilitate decisions and actions like controlling the irrigation system or setting off alarms, according to results from simulation and experimental validation. This work’s contribution is the proposal of a modular hardware and software platform based on LoRa WAN technology that is intended for agricultural farm monitoring at various scales.[7]

"LoRa Network Based Multi-Wireless Sensor Nodes and LoRa Gateway for Agriculture Application": This paper included three wireless sensor nodes and a single LoRa gateway According to the experimental results, the sensor node can detect environmental changes and send data to the gateway. The environmental data of soil moisture under the ground surface at 20 cm ,40cm, and 60cm were more than 90accurate when compared to the standard instrument. Furthermore, the LoRa transmitter range is roughly 600 meters (NLOS), and the LoRa gateway auto- matically transmits environmental data to cloud storage every 15 seconds.[8]

"LoRa based intelligent soil and weather condition monitoring with internet of things for precision agricul- ture in smart cities": The function, potential, and dif- ferentaspects of smart cities, urban farming, communi- cation technologies, IoT, andmachine learning in agricul- ture are all thoroughly examined. The construction of an intelligent irrigation system based on weather and soil characteristics is explainedin the article. The selection of the soil and climatic parameters is based on research articles in ML and Agriculture 4.0. For local weather monitoring, the method suggested in this article offers an innovative and reasonably priced option.[9]

3. METHODOLOGY

A. Theory

1) **Transmitter side:** The transmitter side collects real-time data from soil moisture, DHT11, and raindrop sensors using an STM32 microcontroller. The processed data is sent via a LoRa SX1278 module to a LoRa gateway, which forwards it to the ThingSpeak cloud for monitoring. they need to germinate.

2) **Receiver side:** On the receiver side, an ESP8266 with a LoRa receiver module processes the data and uploads it to ThingSpeak. It also integrates with Blynk, allowing farmers to remotely monitor conditions and control the water pump, either automatically based on soil moisture or manually via the app.

B. Block Diagram

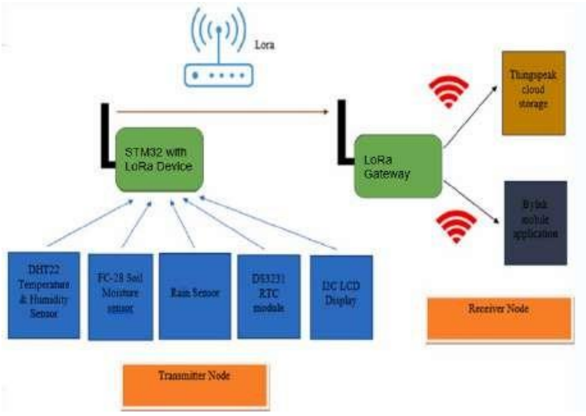

Fig. 1. Block Diagram

C. Circuit Diagram

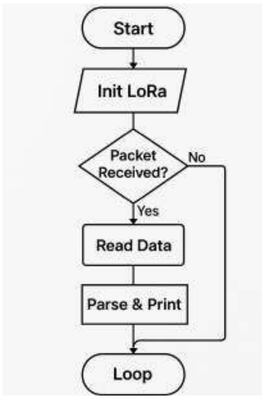

Fig. 4. Receiver Flowchart

Using initialization, sensor readings (DHT11, rain, soil), data validation, and LoRa transmission in a loop, the flowchart represents the STM32 LoRa transmitter exe- cution. For clarity, actions make use of rectangles and decision points use diamonds.

The flowchart explains how to set up the LoRa module, continuously monitor for incoming packets, and, in the event that a valid packet is received, read and display sensor data. Actions are shown in rectangles, and decision points such as "Packet Received?" control the flow.

I. HARDWARE REQUIREMENTS

D. Flowchart

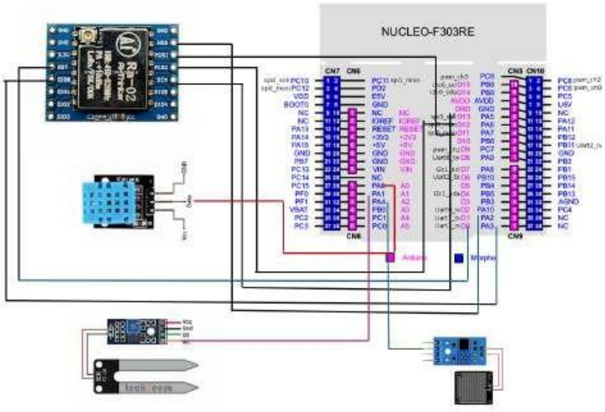

Fig. 2. Circuit Diagram

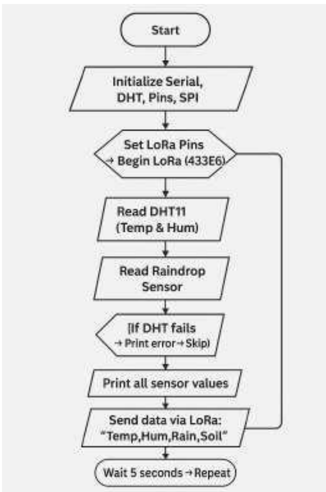

Fig. 3. Transmitter Flowchart

STM32 Microcontroller:

The STM32L4 series MCU, which has an ARM Cortex-M4 processor and ex- tremely low power consumption, is included in the STM32 Nucleo-L42RG kit. It supports a number of IDEs, including Keil, IAR, and STM32 CubeIDE, and offers Arduino Uno and ST morpho connectors for flexible prototyping. It is perfect for low-power and Internet of Things applications since it has an on- board ST-LINK/V2-1 debugger/programmer and has improved peripherals including timers, DACs, and ADCs for quick development and integration.

Fig. 5. STM32 Nucleo 64 L476RG

- **LoRa SX1278** :LoRa (Long Range) transceiver mod- ules like the RFM95W work in the 868/915 MHz ISM frequency ranges. It provides low-power, long- range wireless communication through the use of LoRa modulation. The module can support data rates

Fig. 6. LoRa SX1278

ranging from 0.3 kbps to 37.5 kbps and a range of up to 15 km in open spaces. It is appropriate for Internet of Things applications such as industrial automation, smart metering, and agricultural monitoring due to its high sensitivity and low power consumption.

- **ESP8266** : The ESP8266 is a low-cost, Wi-Fi-enabled microcontroller widely used in IoT applications. It supports wireless communication, making it ideal for cloud-based data transmission and remote control. With built-in GPIOs, it can interface with sensors, actuators, and platforms like ThingSpeak and Blynk.

Fig. 7. ESP8266

- **Soil Moisture Sensor** : Soil moisture sensors measure the water content in the soil. They are crucial for agriculture as they help farmers optimize irrigation practices. These sensors often use capacitance or electrical resistance to gauge moisture levels. By mon- itoring soil moisture, farmers can avoid over watering or under watering, conserving water and improving crop yields. These sensors are typically placed at various depths in the soil to provide a comprehensive understanding of moisture distribution.

Fig. 8. Soil moisture sensor

Raindrop Sensor : By sensing the water droplets on its surface, a raindrop sensor can identify rain. A control unit and a water detecting module are usually its two primary parts. The sensor completes a circuit when raindrops land on it, alerting the control unit to initiate actions like wiping the wipers or closing the windows. For intelligent reactions to weather conditions, these sensors are extensively utilized in home automation, weather monitoring, and automo- tive systems.

Fig. 10. Raindrop sensor

A. Hardware Interface

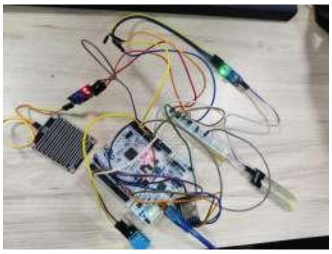

Fig. 11. Transmitter setup

Temperature & Humidity Sensor(DHT11):

The DHT11 is a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistore to measure the surrounding air. It has a single-wire serial interface, making it easy to connect to microcontroller like Arduino or Raspberry Pi. The DHT11 is ideal for simple projects and has a wide range of applications, including home automa- tion, weather stations, and environmental monitor- ing. and humidity, allowing for more informed decisions and automated irrigation. The low-power, long-range capabilities of LoRa proved effective for remote farm monitoring, offering a scalable and cost-efficient so- lution. This prototype paves the way for smarter agriculture by reducing water usage, improving crop management, and increasing efficiency in farming operations.

B. Results

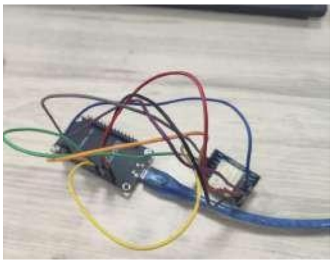

Fig. 12. Receiver setup

```
Sensor data + 'hello' sent via LoRa.
Temp: 37.60 °C | Humidity: 19.00 % | Rain: 278 | Soil: 275
Sensor data + 'hello' sent via LoRa.
Temp: 38.00 °C | Humidity: 58.00 % | Rain: 273 | Soil: 270
Sensor data + 'hello' sent via LoRa.
Temp: 38.10 °C | Humidity: 73.00 % | Rain: 280 | Soil: 277
Sensor data + 'hello' sent via LoRa.
```

Fig. 13. Transmitted data

```
Received packet:
Data: hello Sir37.40,16.00,277,273
RSSI: -81
ThingSpeak updated. Code: 400
Waiting for packet...

Received packet:
Data: hello Sir37.40,16.00,276,273
RSSI: -78
ThingSpeak updated. Code: 400
Waiting for packet...

Received packet:
Data: hello Sir37.40,16.00,276,273
RSSI: -79
ThingSpeak updated. Code: 400
Waiting for packet...

Received packet:
Data: hello Sir37.40,16.00,275,272
RSSI: -79
ThingSpeak updated. Code: 400
Waiting for packet...
```

Fig. 14. Received data

Future Scope

- Add pH sensors, CO2 sensors, and nutrient sen- sors for enhanced soil and crop health monitor- ing.
- Collaborate with agriculture departments and agritech startups for smart farming policies and innovations.

B. Applications

1) Real-time monitoring of soil moisture, tempera- ture, and humidity for efficient resource utiliza- tion.
2) Automatically controls water pumps based on soil moisture levels, reducing water wastage.
3) Maintains optimal temperature and humidity for better crop growth inside greenhouses.
4) Collects real-time weather data to help farmers prepare for changing climate conditions.
5) Enables farmers to monitor and control farm activities remotely via IoT platforms like Blynk & ThingSpeak.

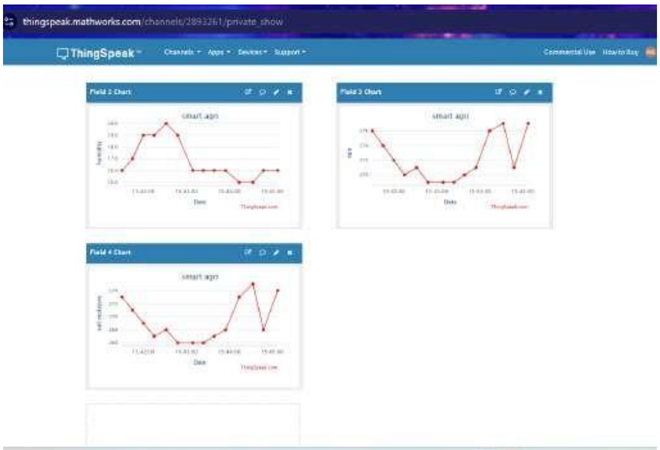

Fig. 15. Thinspeak inertface

ACKNOWLEDGMENT

I would like to express my sincere gratitude to ev- eryone who contributed to the successful comple- tion of the project "Smart Agriculture Using LoRa System." I am deeply thankful to my guide Mr. S.
D. Biradar. for their continuous support, guidance, and valuable insights. I also extend my appreciation to Vidya Pratishthan's Kamalnayan Bajaj Institute of Engineering & Technology for providing the necessary resources and environment.

CONCLUSIONS

The ”Smart Agriculture Using LoRa System” project successfully demonstrated the use of IoT and LoRa technology for real-time monitoring and manage- ment of agricultural conditions. By integrating sen- sors with STM32, Blynk, and ThingSpeak, the system provided valuable data on soil moisture, temperature,

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