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Smart Plant Monitoring System Using LoRa Antenna

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Abstract

Effective, long-range, low-power monitoring devices are required in smart agriculture to continuously monitor environmental conditions. This project works on designing a smart plant monitoring system using LoRa antenna technology for long-range communication. In this project, an ESP32 microcontroller is combined with temperature, humidity, and soil moisture sensors to acquire environmental data. To make it work in an independent outdoor setting, a solar-powered power supply system has been established. LoRa transceivers help in transmitting data from sensors to a receiver node for online monitoring. The results of this experiment confirm effective data transmission from sensors and reliable long-range communication. In the field of smart agriculture for plant monitoring, this proposed system offers an economical, power-efficient alternative.

1. Introduction

Food security at the international level is heavily dependent on the agricultural sector, yet farming practices are dominated by conventional methods that rely on manual observation, which are inefficient, time-consuming, and prone to human error. With the advent of the Internet of Things (IoT), smart farming, or precision agriculture, has emerged as a viable approach to improving crop yields and resource management by continuously monitoring environmental conditions such as temperature, humidity, and soil moisture [1][2].

Agricultural monitoring systems often use wireless communication technologies, such as Bluetooth and Wi-Fi. Despite their advantages, these wireless communication technologies are not suitable for large-scale, remote farmlands because they operate over short ranges and consume high power [3]. Hence, to facilitate smart farming applications, it is necessary to use power-efficient, long-range wireless communication technology.

Being capable of supporting long-range transmission with low power consumption and guaranteed functionality in outdoor environments, LoRa communication technology has gained significant popularity [4][5]. LoRa is suited to low-data-rate applications such as agricultural and environmental monitoring, where LoRa communication technology operates in an unlicensed sub-GHz frequency band. LoRa-based monitoring systems can support smart agriculture with low power consumption, as found by previous studies [6][7].

In particular, energy availability is another major challenge for rural agricultural monitoring networks. To ensure the system continues to function reliably outdoors and reduce maintenance needs, solar-powered options have become increasingly attractive [8][9]. The viability and value of sustainable agricultural IoT networks are further enhanced by the use of low-power wireless communications and renewable energy sources.

The proposed thesis work describes the development of a smart plant monitoring system based on a LoRa antenna for long-range communication. A solar power energy supply system is also integrated to enable an outdoor, autonomous setup. The purpose of the proposed work is to develop a low-cost, energy-efficient, and long-range plant monitoring system for smart agriculture applications.

2. Methodology

In Fig. 1, the transmitter and receiver nodes are the two major components of the proposed system. While one node receives and displays the data, the other node collects environmental information. Based on LoRa technology, this system enables wireless communication over longer distances. A temperature and humidity sensor, a soil moisture sensor, and an ESP32 microprocessor are integrated into the transmitter node. Processing this value, the ESP32 microprocessor uses a LoRa module to transmit it wirelessly. Receiving these packets and decoding them for monitoring is handled by the receiver node, which consists of an ESP32 microcontroller and a LoRa module.

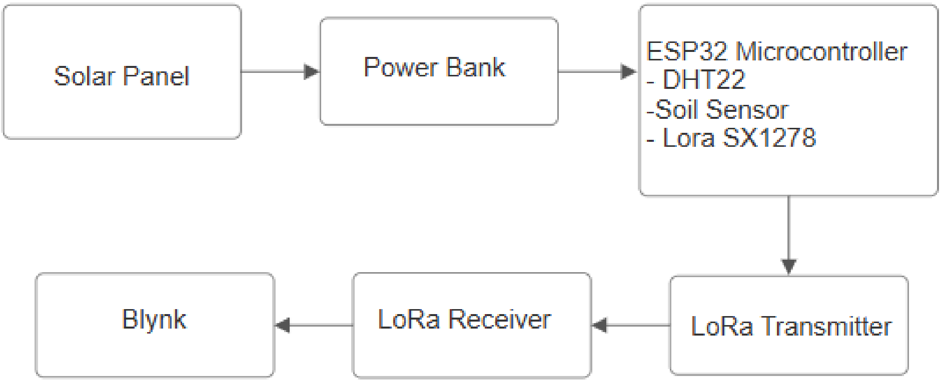


Fig. 1 *Block diagram of the system*

The sensor's initialisation process starts the system shown in Fig. 2. The transmitter node uses an ESP32 board to interpret soil moisture, temperature, and humidity measurements. These values are then communicated wirelessly. Received packets are received, decoded, and displayed at the receiver node to interpret the signals. To ensure constant monitoring of plants, this process is continuous.

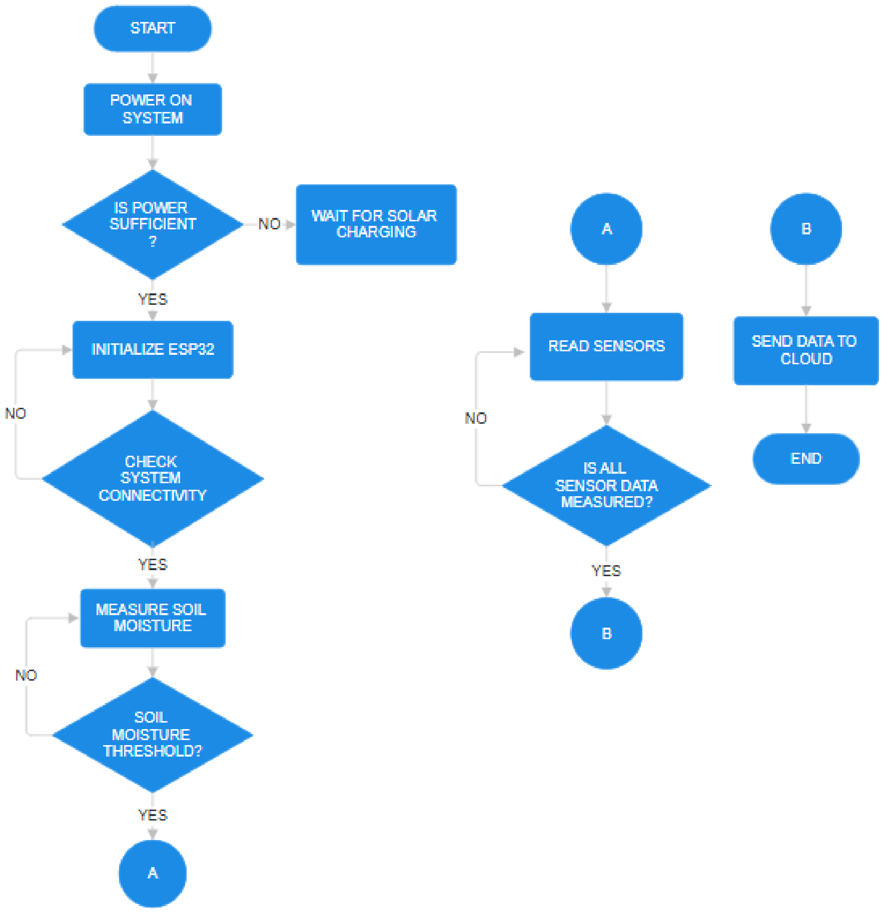


Fig. 2 *Flowchart of the system*

In figures 3 and 4, the ESP32 microcontroller, soil moisture sensor, temperature and humidity sensor, and LoRa communication module form the transmitter node. The main controlling unit of wireless communication and data acquisition is the ESP32. The LoRa module is configured for receive mode, and the ESP32 microcontroller serves as the receiver node. The design considered power consumption requirements, ease of implementation, and suitability for outdoor agricultural use when choosing components.

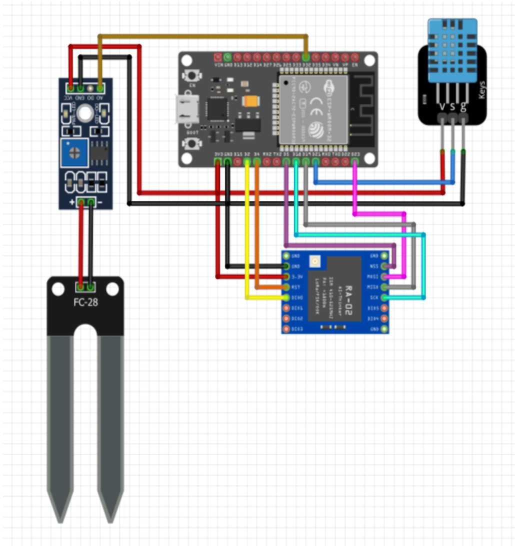


Fig. 3 *Transmitter connection*

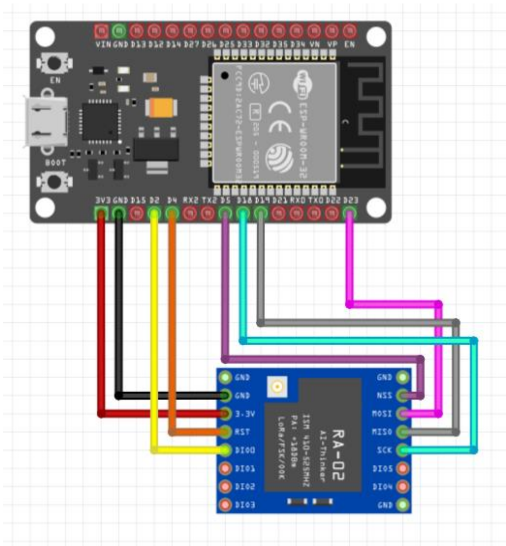


Fig. 4 *Receiver connection*

3. Result and Discussion

This section presents the results and discussion of the Smart Plant Monitoring using LoRa Antenna developed in this work. The performance of the proposed system was verified through an experiment. The soil moisture, temperature, and humidity parameters were duly monitored by the system, which used LoRa to wirelessly transmit the data. Throughout the experiment, the received sensor data remained steady and consistent.

Connectivity between the transmitter and receiver nodes was demonstrated in long-range transmission experiments. The feasibility of use in rural agricultural settings was demonstrated by the LoRa modules' ability to provide smooth, long-distance data transmission. Continuous, long-term, and remote system operation was possible due to the inclusion of a solar power system.

3.1 Prototype of the system

To obtain environmental data, the transmitter prototype shown in Fig. 5 was designed and built on a hardware platform positioned in the vicinity of the plant. Although the temperature humidity sensor was strategically positioned to monitor the ambient environment, the soil moisture sensor had to be placed in the soil. Data acquisition from the sensor was handled by the ESP32, which transmitted the data.

Fig. 5 *Transmitter prototype*

In Fig. 6, the ESP32, combined with a LoRa module, forms the receiver prototype in the receiver setup. Data from the broadcasting system was received by the receiver system, which simultaneously displayed the conditions in the ambient environment. The development of this prototype confirms the feasibility of the proposed smart plant monitoring system.

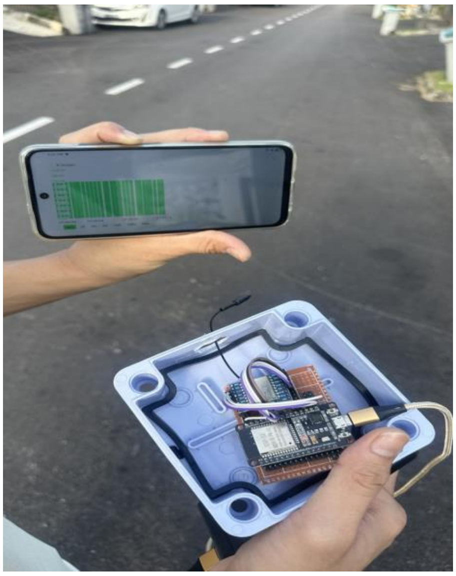
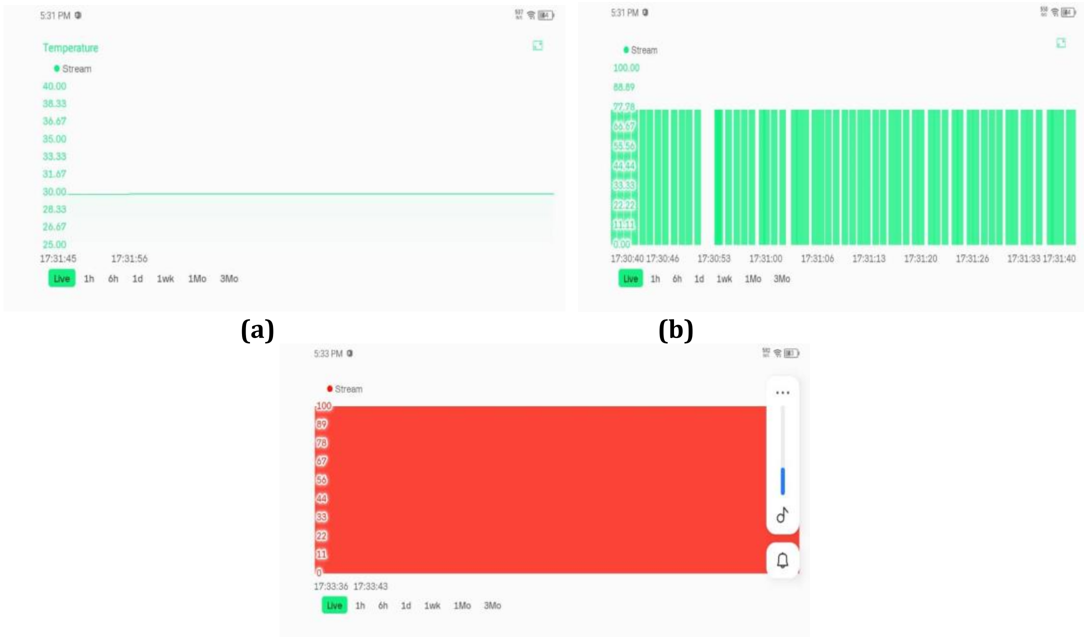


Fig. 6 *Receiver prototype*

3.2 Sensor Data

The system developed collected and wirelessly transmitted data from environmental sensors in real time. Throughout the experimental procedure, the aforementioned parameters played an important role and were recorded at regular intervals. The soil moisture sensor effectively detected changes in soil parameters. Changes in moisture levels directly influenced the sensor data, demonstrating the system's effectiveness in accurately detecting soil moisture levels. The temperature and humidity sensor maintained consistent results throughout the system's efficiency. Consistency in efficiency was observed in the sensor data, which varied with the natural surroundings. The data is shown in Fig. 7.



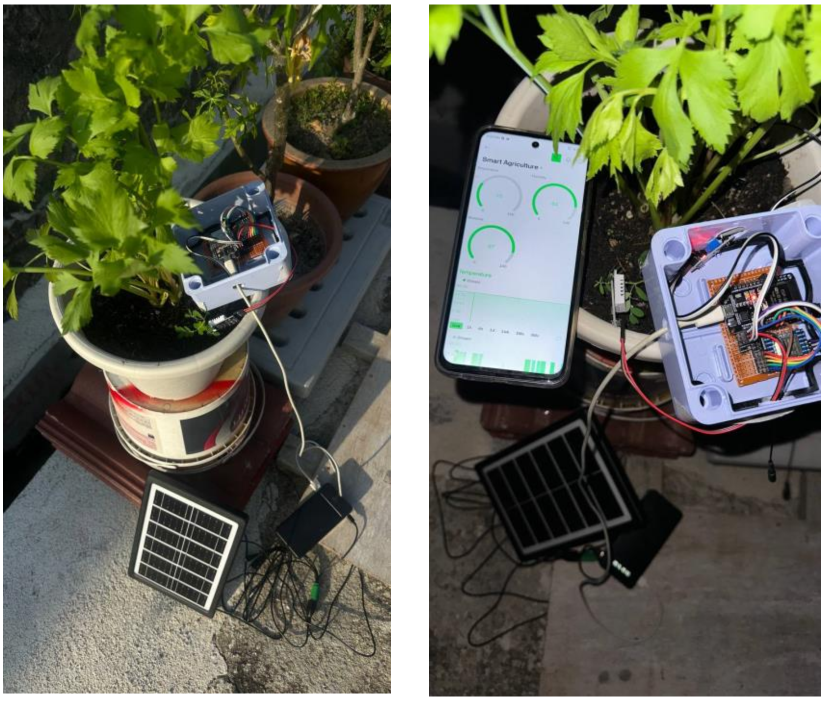
(a) (b)

(c)

Fig 7 *(a) temperature data, (b) humidity data, (c) soil moisture data*

3.3 Solar Power System Performance

Throughout the experimental testing period, the transmitter node's continuous operation was effectively supported by the solar-powered energy system. In a bid to properly charge the rechargeable battery, the photovoltaic panel utilised solar energy effectively to generate electric power, which could be regulated by the charge controller. Fig. 8 shows that the energy storage system was effective, operating normally during the night and in periods of low sunlight. By using renewable energy, dependence on external power supplies was significantly reduced. In general, the use of solar energy and low-power LoRa communication technologies improved the system's sustainability and reliability. The results of this research demonstrate that the proposed system is suitable for implementation in rural areas and outdoor agricultural settings.



(a) (b)

Fig 8 *(a) solar performance in low sunlight (b) solar performance at night*

4. Conclusion

This paper focused on the design of a smart plant monitor that employed LoRa antennas in long-range transmission. The technology reliably transmitted data over a wide area and effectively monitored environmental factors. The battery's ability to operate autonomously outdoors was enabled by a solar-powered energy source. The proposed smart agriculture system presented an efficient, low-cost solution. In addition, due to ongoing system development, current efforts will focus on automated irrigation control and cloud integration.

Acknowledgement

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors were responsible for system design, hardware and software development, experimental testing and data analysis.

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