Sustainable and Collaborative Automated Farming Technology with LoRa

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Abstract

Due to the COVID 19 pandemic leading up to the complete shutdown has affected all sectors of the country, including the agriculture sector. With the population increasing at an exponential rate, the need for a low cost high productive, sustainable practice is increasing. With the main aim of monitoring the environmental factors, which are very influential for optimizing soil fertility levels to improve the yield of efficient crops, this model provides a method to maintain water requirement and monitor the temperature, humidity, soil moisture, etc., with the help of LoRa gateways. Data handling and tracking are accomplished using a graphical user interface.

Keywords: - *IoT, Irrigation, LoRa, Sensors.*

INTRODUCTION

Agriculture being the primary source of livelihood, India is among the top producers of several crops such as wheat, rice, pulses, sugarcane, and cotton. [11]

It has been widely acclaimed that improper methods of irrigation lead to waste of natural resources and stunted crop production. With a dire need to keep up with the rising population needs, a productive, competitive, diversified, and sustainable agricultural practice will need to emerge at an accelerated pace.

Due to the COVID 19 pandemic leading up to the complete shutdown, there seems to be a paradigm shift to the mode of sustainable farming practices by the local communities.

With the primary goal to minimize water consumption and increase crop production, the combination of sustainable methods with the latest technologies can lead to agricultural modernization.

Using IoT based smart equipment capturing the real-time values that play pivotal roles such as moisture, humidity, temperature, and by the effective application of accurate amounts of water, fertilizers, pesticides, enhanced productivity of crops can be achieved.

Our approach consists of an irrigation monitoring and controlling system with the main objective to control different parameters and enhance the water efficiency to obtain the optimal result that can work on both indoor and outdoor farming. To minimize localized errors, multiple sensors are installed throughout the farmland, and multi-node LoRa modules are used for communication. Collaborative farming practice can help local communities with an improved financial return and greater benefits with the combined effort and expertise by sharing their readings. The continuous monitoring of the real-time parameters can be done by the farmer via a UI interface.

In the event of the destruction of sensors due to pets or natural phenomena, our system will detect and alert the farmer to the particular site.

RELATED WORKS

Different approaches in this area consist of the methodology proposed by Nikita Bakhtar et al. [1] and IoT based hydroponic farm. A smart vertical farm module using hydroponics technology that monitors the temperature, humidity using sensors and liquid level using magnetic float switches and controls the liquid level, utilizing solenoid valves. Here a person who is in a remote location can keep track of the instantaneous estimation of the growth of a plant. Chris Jordan G. Aliac et al. [2] introduced the IoT hydroponics management system, which allows continuous monitoring of pH, water level, air temperature, and relative humidity andrefilling, sprinkling, draining, etc., are controlled by the users through the web application. Backend is a technology that is based on the cloud, and the sensor's input data is reserved, controlled, utilized, and made available to the users through the internet. A system that monitors and controls a smart irrigation system was proposed by Shweta B. Saraf et al. [3], and it's also IoT based where real-time data is inputted. Wireless communication systems that are based on clouds are evaluated by the system so that a set of sensors and actuators are controlled and monitored to assess the need for water for the plant. The supply of water in the irrigation system became more efficient without any human intervention when the proposed system was used. Muhammad Rusyadi Ramli et al. [4] presented an adaptive network mechanism that improves the network performance using LoRaWAN and IEEE 802.11ac as the network protocols. It maintains a log file to record every transmission to evaluate the performance.

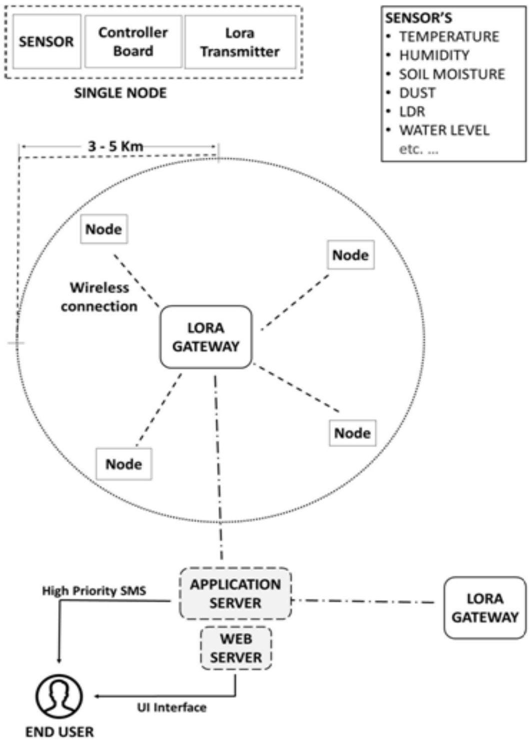

Figure 1: A general architecture of our system

There are many other works relating to smart agricultural systems, such as work by Prathibha SR et al. [5], a monitoring system based on IoT in smart agriculture is proposed. It uses a single CC3200 chip that contains a microcontroller, network processor, and WiFi unit to monitor temperature and humidity in the farm field. If these parameters fall out from the optimal range, it gives an MMS to the farmer. Kakkanallur Ethirajan Lakshmiprabha et al. [6] introduced a Hydroponic-based smart irrigation system capturing the real-time values of temperature, humidity, and water flow, monitored, controlled, and logged with the help of the ThingSpeak IoT platform. This system proved to be effective in monitoring and controlling the system, which resulted in obtaining a higher yield. Aris Munandar et al. [7] proposed the architecture and development of a smart hydroponic system using the IoT cloud platform. The serialized data obtained from an Open Garden is transferred to a WiFi module. This data can be shown on a network using a web app or android app by sending it to a Cloud Server.

Other exceptional works in this field include the system proposed by Danco Davcev et al. [8], where a smart IoT agricultural model that includes LoRaWAN modules was introduced for transmitting data from sensor nodes to cloud services. Using the LoRaWAN protocol helps in increasing the scalability and extensibility in addition to new services and integration with other IoT platforms that help in increased performance, Er. Faruk Bin Poyen et al. [9] proposed an automated irrigation system. This system controls and monitors various climatic parameters, temperature, humidity, automated watering methods, automated pest control approach, etc., by using suitable sensors, and in the laboratory end, algorithms are designed to fulfill required objectives. Also, the method proposed by Wenju Zhao et al. [10] designed and also implemented a smart irrigation system that uses LoRa. This method, where the system can be controlled remotely by mobile applications, proposes a setup that contains an irrigation node. This node consists of a LoRa communication module, hydroelectric generator, and solenoid valve. Wireless transmission is used to send data to the cloud along with LoRa gateways. Experimental results showed no fault in both the transmission distance as well as in the energy consumption of the proposed system.

Uferah Shafi [11] proposes an integrated approach for monitoring crops, combining machine learning, IoT, and drone technology, providing important insights into crop health by extracting relevant features. The obtained heterogeneous data is detected through strong indicators such as Normalized Difference Vegetation Index(NDVI) that helps to analyze crop health. Machine learning algorithms were applied to the collected data. Nurzaman Ahmed [12] introduced a fog computing and WiFi-based long-distance network in IoT that helps in improved connectivity in rural areas. The proposed system presents a scalable network architecture that includes cross-layered based channel access and routing that aids in monitoring activities.

ARCHITECTURE

LoRaWAN is a very cheap and cost-effective way of communication for IoT devices, especially in remote areas where internet connectivity is close to non-existent. Furthermore, LoRa has an impressive range of up to 7kms. This enables the farms(nodes) in a 3 to 5 km radius to connect to a single LoRa gateway, as seen in Fig. 1, which can collect data from each node and send it to the application server via the internet. This also implies that internet connection is needed only at the LoRa gateway, which means that the farmers in that area need only a single internet connection, thus further reducing personal cost.

Each of the farms or nodes themselves consist of several sensors that can detect the environmental conditions of the crops, like temperature, humidity, the moisture content in the soil, and other conditions like water level and sunlight if the implementation is an indoor hydroponic farm. The sensors are managed by a controller board that can process these values for transmitting them through LoRa. These readings are crucial for maintaining the health of the plants. Many areas throughout the country are flood ridden, especially during the monsoon season. The sensor can detect floods and alert both the farmers as well as the whole community so that they can take measures to prevent damage or loss.

An application server can be used to communicate with multiple LoRa gateways to collect and process data from multiple nodes and store them in a database. Each farmer under the network can register with his contact information like a mobile number. When the data from the node of a particular farmer shows devious readings, say a sharp increase in temperature or a lack of moisture content in the soil, then a text message as shown in Fig. 1 can be sent to alert that farmer of the deviations. These kinds of variations can also imply a fault in the setup of that node. The application server also has an attached web server that provides a comprehensive UI(see Fig. 4) of both individual nodes and the data of the whole region in general, which is useful for research purposes and can help in improving yield.

Furthermore, the application server can be set up locally if the area is small enough to be covered by a single LoRa gateway, and if the area is too remote to have internet accessibility, then an application server can be set up locally and can connect to the gateway via LAN. The server can then be accessed via LAN by those who have access to mobile devices. Some community volunteers can then access the UI locally and help farmers who may not have such access. They can also recommend to them the right steps to take if an alert occurs.

EXPERIMENT AND RESULTS

We have implemented this architecture in the hydroponics farming system to monitor the temperature, humidity, water level. The setup consisted of 8 plants of different kinds. The setup also had an automatic pump system to circulate the nutrient-rich water, which was triggered by the readings of the sensors.

An LDR system was also integrated with the setup, which can detect lack of sunlight and hence direct an array of UV LEDs to supply the required amount. A humidity control system was also implemented that can manage the humidity of the greenhouse where the setup was housed.

Figure 2: Experimental Hydroponics Setup

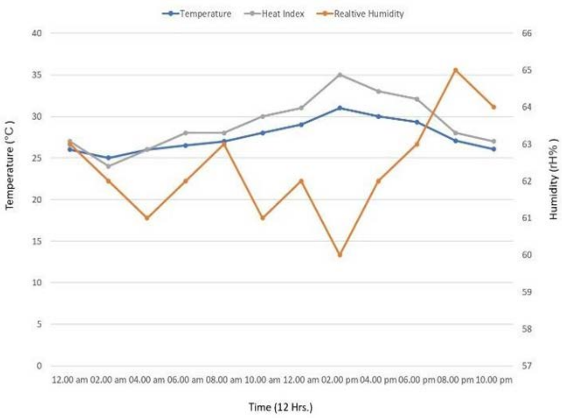

Figure 3: Graphical Representation of Sensor Data

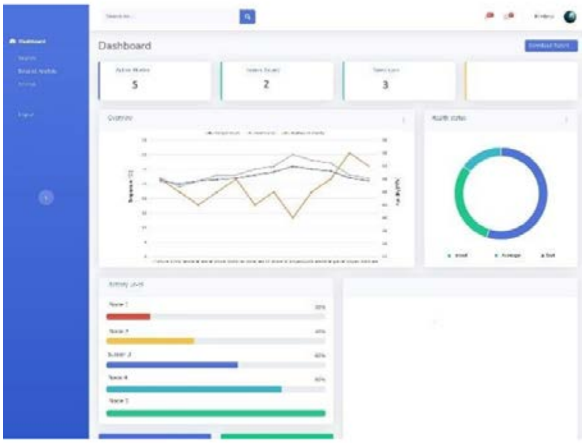

Figure 4: A Sample Screenshot of UI

Figure 5: Sensor Module

Figure 6: A LoRa Node Interface

CONCLUSION

We have constructed architecture and system that can automate the agricultural process with the help of LoRa technology. We also were able to collect data on different plant species as part of this project. Implementing this will not only improve productivity but also reduce the time spent on tending the needs of the plant. As the data of a person can be shared, this helps even non-farmers to get good yield even on their first try.

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