Implementation of LoRa-based Water-saving Irrigation System

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***Abstract*— Water is an important agricultural resource. Traditional irrigation has excessive utilization of water resources. The larger the farm, the worse the waste of water. This paper proposes a water-saving irrigation system using LoRa wireless communications and the Management Allowable Depletion (MAD) value to reduce water waste. In this system, the sensing-node transmits data through the LoRa gateway via a wireless connection. The main server then determines the necessary irrigation procedures. The results of the experiment show that 10% of water saved with the proposed system compared to the manually operated irrigation.**

***Keywords*— IoT, LoRa, Smart farm, Irrigation system**

I. Introduction

IoT technology provides the interconnection of objects with built-in computing, communication, and sensing [1]. The development of the Internet of Things has greatly promoted its implementation in various industries, including agriculture, cities, factories, and healthcare. LoRa, designed for long-range and low-power communication, is one of the important communication technologies of IoT applications [2]. Systems that use ZigBee or Wi-Fi have low coverage. However, in general, LoRa Wide Area Network (LoRaWAN) can communicate 20Km in rural areas and 8Km in urban areas with guaranteed high system coverage [3].

Management Allowable Depletion (MAD) is the value of how dry the soil is compared to the maximum amount of water it can hold. This information can be used to identify insufficient moisture content in soil conditions and to irrigate efficiently [4]. In the long run, this saves water, which is environmentally friendly and economically beneficial. This paper proposes a water-saving irrigation system that utilizes LoRa and MAD. The system identifies the status of the farm through a sensor, send sensor data to the gateway, and store the data in the database using the API.

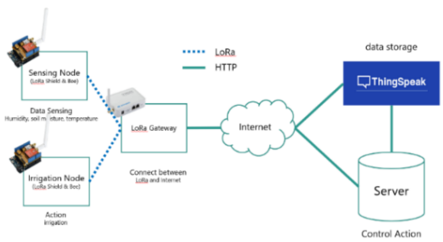

Fig. 1. Structure of irrigation system

II. Material and Methods

The proposed irrigation system consists of four parts: sensing node, irrigation node, server, and LoRa gateway as shown in Fig. 1. The server sends control commands to irrigation nodes and determines how long to irrigate using the irrigation nodes. Then users can check the current status of the farm on the website.

A. Sensing Node

Arduino UNO is a microcontroller with ATmega328P that allows a simple digital circuit. As shown in Fig. 2, we connected each sensor to the port with the ADC module and use a library to read sensor values. Then, sensor values are transmitted through SPI communication with LoRa. The connection with the sensor is configured as follows.

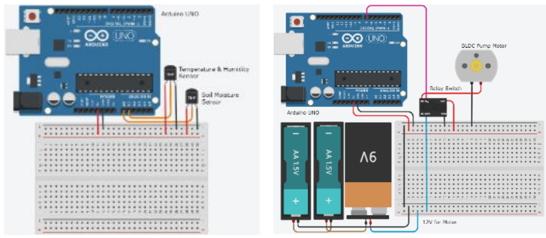

Fig. 2. Sensing (left) and Irrigation (right) node circuits

The VH400 provides soil moisture data using voltage in response to moisture[5]. The sensor calculates a value of 0V to 3V and converts it into Volumetric Water Content(VWC, % moisture) units using the 'readVH400' library. The VWC units are the same as Water Fraction by Volume (WFV) in relative units, and the graph in Fig. 3 can be used to match the MAD and the Soil Moisture values for the Available Water Capacity (AWC)[6]. The DHT22 can get data by a serial interface which is single-wire, two-way. This temperature and humidity sensor sends current farm status to LoRa through an Arduino.

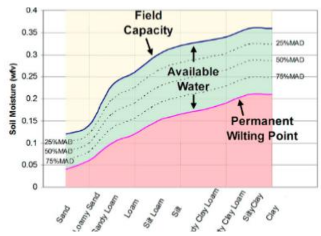

Fig. 3 Soil textures and available water [6]

B. *Gateway*

The LG01-P can support limited LoRaWAN protocol in single frequency and customized LoRa transmit protocol [7]. Sensing node and irrigation node are wirelessly connected to LoRa on the ATMga328P inside the gateway. The MCU on the gateway and Linux are connected by the SPI Library.

C. *Server*

The server uses the HTTP API to observe soil moisture on the farm. The server can determine the required quantity by considering soil moisture and sending a control packet using HTTP API in the irrigation node. The system uses ThingSpeak to store data. If soil moisture of the current field is lower than MAD value, which depends on plant species, it sends an irrigation control packet to gateway using HTTP API. The MAD algorithm regulates the maximum depletion that the plant can stand water stress. The relation between MAD value and soil moisture (in wfv) depend on AWC in soil.

D. *Irrigation Node*

Using LoRa, an irrigation control packet comes to an irrigation node from LoRa Gateway. The data can determine how much to irrigate from the packet. When the conditions are met, the Arduino and relay switch send 5V to the connected signal.

E. *Testing in small box farm*

As shown in Fig. 4, a 60(L) x 40(W) x 12(H) inch-sized box was used. Due to the limited system design and experiment time, green onions with short growth time were applied. They were placed at 1-inch depth and 2 inches apart. The MAD value applicable to green onions set 50%. Total AWC for our system was used as 0.18 (wfv/in) x 4(in) = 0.72(wfv), since the soil used in the experiment consists of 4-inch loam. Micro-sprayers were also used to simulate the actual environment of growing green onions.

Fig. 4. Testing box

Using the amount of water running for 30 seconds, the flow rate of the sprinkler was calculated. The circuit consists of Arduino UNO, VH400 as soil moisture sensor, DHT22 as temperature and humidity sensor, AD20p-1230C as a brushless DC pump motor, and relay switch. When conditions for irrigation are met, Arduino gives 5V signal to relay switch and it makes the motor and 12V power connected.

III. Results

To determine the amount of water that should be given as current soil moisture, the soil moisture change was measured by watering the soil with sprinklers of the set time. Fig. 5 shows the relationship between watering time and the soil moisture in wfv. Then, we got increased soil moisture due to the time given by the linear regression. It increases by 1.3 wfv per 10 seconds.

In the testing box, we planted the seeds of green onions in the experimental and comparison groups at an area of 100 square inches, respectively, and exposed it to the same amount of light over the same period. The temperature, humidity, and type of soil are all the same. The manually operated group was watered one inch per week, resulting in a total of 8256 ml for four weeks. The experimental group using our proposed system was irrigated to 0% when 50% MAD was reached, and a total of 7420 ml of water was used. The grown lengths of green onions in both groups were similar. As shown in Table 1, with this proposed system, we achieved about 10% of water-saving.

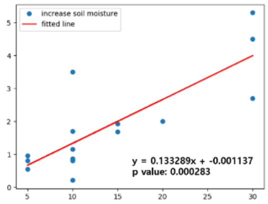

Fig. 5 Relationship between watering time and soil moisture

TABLE I. DIFFERENCE IN WATER USAGE

Method	**Amount of Water Used** (ml)
Manual	8256
Proposed system	7420

IV. Conclusion

The experiment was conducted indoors, and precipitation could not be considered. The experimental group used 10% less water compared to the comparison group. It means it can save a considerable amount of water if it is applied to large-scale farms. In this paper, the automatic irrigation system was implemented by applying irrigation methods that could maximize efficiency while saving economic resources. Due to the limited experiment time, the results of corn were not applied to this study. Further studies are being considered to compare the amount of water used according to various crops in the future.

Acknowledgment

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