IOT BASED SOIL WATER POTENTIAL MONITORING SYSTEM USING IRROMETER SENSORS

[1]A.Susmitha, [2]A.Subramanyam, [3]M.Rudra Kumar

[1]UG Student, [2]Professor, [3]Professor,

[1,2,3]Department of Computer Science and Engineering, AITS, Rajampet, India.

Abstract : Now a days monitoring soil moisture is one of the methods used by farmers for irrigation purpose. Due to that point developing numerous sensor types and data logging systems but their widespread adoption in years for this purpose due to a number of factors, the practical schedule for irrigation is still limited. Significant Factors that limit farmers ' use of soil moisture sensing technology Include high costs and challenges in collecting and interpreting timely data. Recent developments in microcontrollers in open source (such as Arduino) Internet - of - Things (IoT) and wireless communication provide farmers with opportunities to reduce costs and facilitate timely data collection, visualization and interpretation. The aim of this study was therefore to develop and test a low cost IoT system for the monitoring of soil moisture using Watermark 200SS sensors. The system uses Arduino-based microcontrollers and field sensor data (End Nodes) is transmitted wirelessly via LoRa radios to a receiver (coordinator) that connects to the Internet via WiFi and sends data to an open source website (ThingSpeak.com). Under field conditions, the system was successfully tested by installing watermark sensors at wheat field. The system described here could contribute to the widespread adoption of easy-to - use and affordable moisture sensing technologies among farmers.

IndexTerms – -Internet of Things, Automation, soil moisture, sensors, Arduino, Watermark Sensors.

1. Introduction

The efficient and efficient use of irrigation water in agriculture is essential for the long - term economic and environmental sustainability of irrigation. Agricultural operations. Therefore, it is important to develop and promote cheaper and efficient precision irrigation for farmers allowing irrigation water to be applied where, where and in the amount needed to maximize profits while protecting the environment. Over the years, a number of sensing technologies have been developed to help farmers schedule irrigation appropriately.

Weather - based irrigation schedules use weather information and other auxiliary inputs to model the development of crops and the state of soil water [1]. Despite a great deal of effort to make this method available to growers Its practical application among commercial farmers remains limited through the development of local weather station networks and the creation of software and apps to automatically download and analyze the weather data collected [2][3].

The use of plant sensors for irrigation planning, in particular in arid regions, has The focus was on using infrared thermometers to detect the temperature of the canopy [4][5] 6]. This approach was based on the inclination of water - stressed crops have a higher temperature of canopy than unstressed crops; that has long been proposed as an irrigation schedule [7][8][9][10][11]. Despite some success, the use of canopy temperature for irrigation scheduling can have significant limitations [12][13], especially for crop canopies that are incomplete and humid. Its application among commercial farmers is therefore still very limited. Sensing the soil with soil moisture sensors is another important technology for farmers to decide when to irrigate their crops and how much water to use. A recent large - scale commercial study Nebraska corn farmers [14] showed that sensor - based irrigation schedules saved 33 percent of water and reduced pumping costs of $ 28.5 per acre per year without significant yield reduction Compared to the irrigation scheduling strategy of the farmer. But, even if a large one Different sensors and data logging systems. There are currently commercially available soil moisture monitoring logging systems, and the use of soil moisture sensors to make decisions on the scheduling of irrigation among commercial farmers remains limited. Factors that affect farmers ' limited adoption of this technology include a lack of Information, high costs, difficulty in installing and maintaining equipment and difficulties in transmitting data in real time from field sensors to the farmer.

Development and integration of low - cost and open - source microcontroller devices and software Communication technologies such as radio, cell phone and WiFi [15] offer opportunities for more cost - effective and efficient soil moisture monitoring systems [16] and their integration into irrigation schedules [17] and automation systems [18]. Furthermore, recent developments in Internet - of - Things (IoT) technologies are used in a wide range of applications, including smart wearable’s, smart homes, smart cities, smart environments and smart businesses [19]. The Implementation of These technologies are still very limited in commercial agriculture, but could offer opportunities to improve irrigation schedules based on soil moisture monitoring by making data more accessible in real time to farmers. The objective of this study was therefore to develop and test a low cost IoT system for monitoring soil moisture with the Watermark 200SS sensor. The overall objective of this project was to make the monitoring of soil moisture more affordable and efficient to promote the adoption of irrigation planning technologies among commercial farmers.

2. Approaches

2.1. Description about sensors

The system described in this paper was created to monitor soil water status from four depths using Watermark 200SS soil moisture sensors (Irrometer Company, Inc., Riverside, CA) (Figure 1(a)). This type of sensor was selected for its relatively low cost, which makes the sensors affordable for most growers. In addition, this type of sensor has been used for several decades in many field applications and has proved to be durable and reliable when used properly. The Watermark 200SS sensor is an electrical solid state device that senses electrical resistance and is commonly used for measuring soil water Potential (SWP), not soil humidity. The sensor has two concentrated rings in the form of a pair of corrosion resistant electrodes. The gypsum material fills the space between the two rings (to provide a buffer against salinity changes). The electrodes are inside a granular matrix (similar to very fine sand) that creates the instrument's bulk. The grain matrix is in two layers. The inner layer is a filter-like material allowing the exchange of water between the grain.

Figure 1. (a) Watermark 200SS sensor **b) Watermark 200SS manual readout.**

Matrix and the ground. The outer layer is a perforated steel frame that provides stiffness and preserves the sensor's shape and physical integrity. At each end of the sensor there are two ABS plastic green caps installed. The electrodes are connected to two cables connecting to the AWG 20 System of data acquisition.

When water is installed in the ground, it is exchanged between the ground and the granular matrix until balance is achieved. As water is an electrical conductor, the resistance between the electrodes is inversely linked to the moisture of the ground. Sampling the sensor involves powering the sensor with an electric current (AC instead of DC) and reading the output of the electric resistance. The electrical resistance corresponds to SWP (negative pressure), usually expressed in centibar units (cb) or kilopascal units (kPa) (cb= kPa). According to the sensor specifications of the manufacturer, the measurement range of the Watermark 200SS sensors is from 0 to −239 kPa, although the normal usable range is from 0 to −200 kPa, where a reading of approximately 0 kPa indicates that the soil is near or at saturation and a reading or reading. There are several types of commercial loggers that can automatically read and store the collected data at specified time intervals on the Watermark 200SS sensors, and a device is also available for manually reading these sensors (Figure 1(b)).

2.2. Sensor Design

The data sampling and data communication system design for four 200SS sensors consisted of a coordinator and a number of end nodes in a star topology [20]. Basically, start topology has one or more end nodes that send data to a central node that acts as a coordinator. The end nodes are hardwired to the humidity sensors and periodically sample the sensors and transmit the data wirelessly to the coordinator via radio communication. The coordinator receives the data from the terminal nodes (each terminal node has a unique address) and sends the data to a website.

The End Nodes were created using the Adafruit Feather 32u4 RFM95 LoRa Radio (RFM9x) device (Adafruit Industries, New York, NY, adafruit.com) that combines an Arduino-based microcontroller with a packet radio transceiver (LoRa). The microcontroller is based on the 8MHz ATmega32u4 chip with a 3.3V logic. The radio transceiver can transmit or receive radio signals at a specified frequency of 868 or 915 MHz in the software. The Adafruit website (adafruit.com) claims that these radios can have a line - of - sight range of more than 2 km (1.2 mi) using a wire quarter-wave antenna and that a range of about 20 km can be achieved by adjusting the settings and using a direction antenna. Feather 0.1" Pitch Terminal Blocks (Adafruit Industries, New York, NY, and adafruit.com) were soldered to the End Nodes so that sensor and power supply wires could be attached.

Since the Watermark sensor output is an electrical resistance that cannot be measured directly by the microcontroller and a sensor as Fisher and Gould [16] and Fisher [20] described. A circuit board (PCB) for four Watermark 200SS sensors has been designed and manufactured using the online Pad2Pad (Pad2Pad.com) system for this project. The electronic diagram for the circuit of the voltage divider is shown in Figure 2(a), in which A1 to A4 are analog input pins, D1 and D2 are digital output pins, and WM1 to WM4 represent the four sensors. Figure 2(b) shows a sample End Node for the Watermark 200SS sensors that shows the microcontroller and the PCB voltage divider circuit. On the other hand, the Coordinator was created by combining a Feather 32u4 RFM95 LoRa Radio (RFM9x) with a Feather M0 WiFi w / ATWINC1500 (Adafruit Industries, New York, NY, adafruit.com) (Fig. 3). The Feather M0 Wi-Fi w / ATWINC1500 has a 3.3V logic clocked ATSAMD21G18 ARM Cortex M0 Processor. This device also has an Atmel Wi-Fi module that allows you to connect to the Internet using 802.11bgn networks that support encryption of WEP, WPA and WPA2. The Feather 32u4 RFM95 LoRa acts as a server in this arrangement, receiving data from LoRa clients (End Nodes) and transmitting the data received to the WINC1500 Feather MO. The Feather MO WINC1500 connects via Wi-Fi to the Internet and sends the data to the ThingSpeak open source website.

2.3. Reading parameters of Watermark 200SS Sensors

The Watermark 200SS sensors were read with the microcontroller using a process similar to that described by Fisher and Gould (2012), except that the Feather microcontroller uses an excitation voltage of 3.2 VDC instead of 5 VDC. In short, each sensor was read by alternating the polarity of the DC voltage used to power the sensor between the two wires of the sensor.

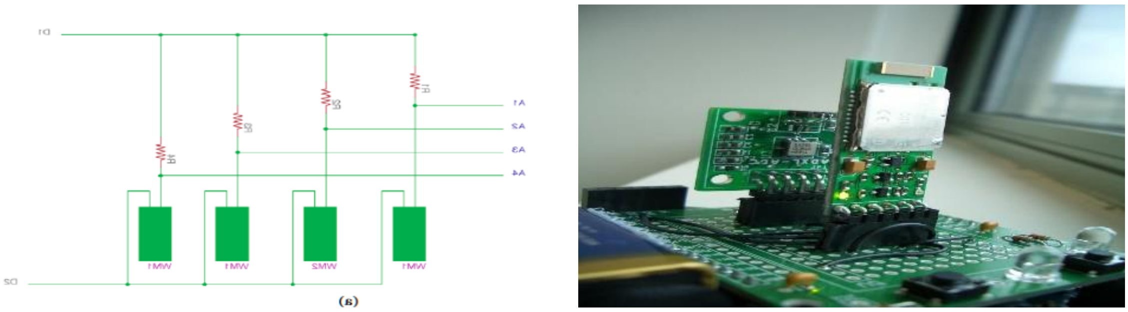

Figure 2. (a) Voltage divider circuit (b) End Node

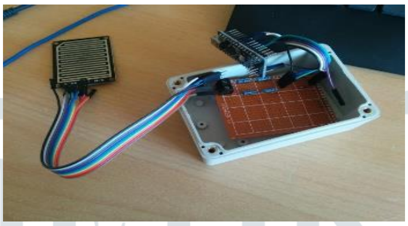

Figure 3. Coordinator

Powered (excited) by setting one of the two connected digital channels HIGH The voltage divider was set LOW while the other was set. A delay of 1000 ms was then allowed Before taking a reading to stabilize capacitance effects. Analog reading was then taken on the connected sensor analog channel, To produce an integer output, use the analog to digital converter (ADC). The entire output range depends on the ADC resolution (number of bits). As the Feather device has a 10-bit ADC, the output ranges from 0 to 1023 (= 2bit= 210= 1024). Another reading was taken through the reversal of the excitation polarity and the two readings were averaged. This procedure has been repeated ten times, leading to an average reading. The mean reading was converted to voltage output (Vout) based on voltage input or excitation (Vin=3.2 V) as follows:

$$Vout=((reading*Vin)/1023.0) \quad (1)$$

Then, the resistance of the Watermark sensor (Rwm, KOhm) was calculated as:

$$Rwm= ([res*(Vin-Vout)]/Vout) \quad (2)$$

where, res = resistance used in the voltage divider (15 KOhm).
Fisher et al, respectively. 16] used the Shock et al equation. 21] conversion of the Rwm Potential values for soil water (SWP) (in Kpa) that can be written as:

$$SWP=-(4.093+3.213*Rwm)/1-0.009733*Rwm-0.01205*Tsoil \quad (3)$$

Where, soil= temperature of soil (EUC). This equation was originally developed, however with data ranging from only 0 to −80 kPa, less than half of that Watermark 200SS sensors normal range. A calibration was therefore developed converting Rwm to SWP which would be applicable in this study (see below) to the entire Watermark 200SS sensor response range.

A laboratory test was also carried out to assess the circuit of the voltage divider and the Software used during the entire soil to sample the Watermark 200SS sensor Cycle drying. The test was carried out using Arduino UNO and a logging of data Shield that allowed (Adafruit Industries, New York, NY, adafruit.com) Collecting data in an SD card. The software has been developed for this test Use equation 3 for SWP calculation. A 200SS Watermark sensor has been submerged 24 hours in water and then installed in a 600 mL glass beaker Filled with soil saturated. At room temperature for 21, the soil was allowed to dry Dec. Days. 16, Jan 2016. 6, 2017) and every minute the SWP was recorded.

2.4. Analysis of sensors

Functions should be developed to convert the resistance output Watermark 200SS sensors into the soil water requirement Laboratory sensor calibration experiments. The calibration of the sensor was developed comparing the sensor outputs with the microcontroller using manual readings with their readings (shown in Figure 1(b)), within a range of soil moisture content from saturated soil to air Soil dried. Four watermarks were used for the calibration experiments Sensors 200SS. Watermark 200SS Sensor calibration requires starting with a saturated sensor and balance between the soil must be established and the sensor to obtain an accurate reading from a representative Represent the soil's moisture condition. Because of the need to create Balance, there would be a time delay between soil moisture changes and a Corresponding change in reading Watermark 200SS.

In order to calibrate the watermark sensors, the first four sensors were entirely submerged in water for 24 hours to allow for their granular matrix to saturate. The sensors were then vertically installed in a 600 ml glass beaker. saturated soil, ensuring good contact between the ground and the Captors (Figure 4). Then the soil container could dry for some time and Sensors attached to the microcontroller and with measurements have been taken Manual readout of the manufacturer. The container was intermittent in order to dry the soil faster. In the ISOTEMP Fisher oven (200 Series Model 230F).

Figure 4. Watermark sensors in soil container.

60 ETC temperature. Normally the ground container was placed in the oven for It was allowed to cool at room temperature approximately 30 minutes before Taken readings. A ventilator was used to blow air into the soil sample and speed up The process of cooling. Since the process of calibration took several days, readings were also taken at the end of the working day (approximately 5:00 pm) and at the beginning of the working day the next day of work (around 8:30 am) after the soil sample was allowed to sit overnight at temperature in the room.

2.5. Sensor Data Storage in cloud

The idea behind the Internet-of-Things (IoT) is to have objects from our daily Internet - connected lives that allow these objects to send periodically Web data, where it can be accessed from remote locations in real time [22]. This normally requires a web server to receive and Data host. This web server can be constructed or customized for a particular application. Or a general IoT platform may be used. In the last few years, a Number of IoT platforms for this general purpose have become available as Open - source or free for-profit organizations. Examples of such IoT platforms the subway (http:/www.wunderground.com), the Carriots ThingSpeak (http:/www.carriots.com), meshify (http:/www.thingspeak.com) Meshify.com), Adafruit IO, EasyIOT (http:/iot-playground.com/), Https:/io.adafruit.com), Xively and Thinger.io (https:/www.xively.com/) Among others (https:/thinger.io).

The ThingSpeak for the application of soil moisture monitoring IoT platform (http:/www.thingspeak.com) has been used mainly because it was free of charge and to receive data from microcontrollers based in Arduino and Raspberry Pi and Beagle Bone Black from other microcontrollers. The platform ThingSpeak allows users to create a number of channels. Each one Channel includes data, location and status fields. After creating a ThingSpeak channel, the data can be written to the channel, MATLAB ® code processing and viewing data and reacting with tweets to data and other warnings. Each channel receives a unique code (key). That's the This key is used by the Arduino microcontroller to direct the data to the specific Channel ThingSpeak. The system is able to receive data every 20 years. seconds, but to update our soil moisture monitoring system Every 20 minutes, every channel.

3. Conclusion

In this study, watermarks were developed using 200SS moisture soil sensors installed on a farm and send automatically the data to a website using wireless radio and WiFi communication. The system in question Open - source electronics and software (Arduino based devices) have been developed and using the Things platform open - source Internet (ThingSpeak.com) Hosting the data. The system in question was installed in a wheat production field and data was successfully collected under Real conditions in the field. However, possible future system improvements could include the integration of the coordinator in a printed circuit board and the creation of the End Node more battery efficient so that a solar panel is not required for installing field. Our next step is to display the relevant data collected from the different sensors and show their data in graphical representation using MATLAB software and see how effectively these sensors are gathered the information from sensors in multiple conditions placed at farm field.

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