Smart Irrigation: IOT-Based Irrigation Monitoring System

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Abstract The project aims at autonomous monitoring of irrigation system in both large- and small-scale plantation estates with a view to eradicating the manual system which involves personal liability concerns and the ignorance of the field workers. Even sometimes the experienced people cannot assure how much fertilizers or water must be used for the maximum yield. Hence, our system will monitor the temperature, humidity, moisture content of the soil and other physical factors like presence of major pollutants in air like PM2.5, PM10, CO, NOx. The factors and the crop yield are compared with dataset of past surveys and will try to predict whether irrigation is necessary or not. With the help of this information, the rate of releasing water from pumps is decided and fed to a microcontroller system which supervises and controls the whole irrigation system. Besides, there is also provision to monitor plant growth in both longitudinally and horizontally.

Keywords IOT · Irrigation · Smart irrigation

1 Introduction

Irrigation is the application of controlled amounts of water to plants at needed intervals. Irrigation aids in developing agricultural crops, upholding landscapes and revegetating disturbed soils in dry areas and during periods of less than average rainfall.

Irrigation has various other applications too, for example, safeguarding plants from frost, curbing the growth of weed in crop fields and preventing soil consol-

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idation. On the other hand, agriculture that counts only on unmediated rainfall is referred to as rain-fed or dryland farming.

Irrigation systems are also used for control of dust and sewage disposal and in mining. Study of irrigation is mostly accompanied by the study of drainage, which is the natural or artificial expulsion of surface and subsurface water from a given region.

Irrigation has been succoring agriculture for years and is the commodity of many cultures. Historically, it was the foundation for economy, from Asia to the Southwestern United States.

Smart irrigation is sustainably managed, accountable, responsible and trusted irrigation. Smart irrigation aims to diminish their environmental footprint through well-planned water applications and to guarantee a successful business. This enables them to reinvest in new and improved technologies which ensure sustainable irrigation over time.

New irrigation technologies and support tools are consistently being innovated in New Zealand and globally. Water use efficiency and energy use efficiency are the main focuses of these innovations. Over the last two decades, there has been a shift from manual flood irrigation to remotely controlled spray irrigation using techniques like center pivots, dripline and micro-sprinklers.

2 Need of the Device

India is an agro-based country, and now-a-days the small fields and farms are being merged with the large plantation farms. Due to the increase of 8% of foreign direct investment (FDI) in agricultural sphere, more and more farms are globalized. The multi-national companies cannot bear the loss due to the farmers (who are employed as field laborers) by means of excessive use of fertilizers and pesticides. The system will assist to implement optimal usage of man power and endeavor to reduce the burgeoning expenditure. Since the whole system will be integrated with a central server and will have mobile and web-app-based user interfaces, the corporate supervisors can control the system from their own work desk in offices. There will be just one-time investment for the purchase and installation of the system in the farm leading to a long-term benefit. The increase in yield will also benefit the consumers as the price of basic food materials will decelerate with the supply hike as a consequence of which the inflation in field of daily commodities may decrease.

3 Related Work

Technology is improving every minute. Even though irrigation ensures maximum overall crop yield, it might cause wastage of water resources. Let us introduce some of the systems proposed to improve irrigation processes and their advantages and disadvantages.

In [1], focus is on optimization of water usage and shows that this technique requires 10% of the water needed. The system turns on the water supply as soon as it detects the soil moisture values below a certain value or when the soil temperature exceeds the set threshold. This system provides irrigation for a fixed duration when switching on manually at a particular date and time exactly through an application running on another device as mobile or a laptop. Date and time details are then stored in the end nodes sensing unit, whereas data from other sensors and other irrigation results are uploaded to an application using the GPRS. Irrigation also depends on a lot of other parameters. That is one of the disadvantages of this system.

In [2], the focus is on the automated valve and a manual valve which is controlled by using sensors and wireless networks. All the end nodes send the soil moisture values to the base station after a fixed interval that is neither too long nor too small. Based on the moisture sensor value, commands are sent to the node containing valve actuator to either open or close the water supply valve. The node that contains the valve actuator is equipped with a boost regulator for relay operation. All these operations are executed via the application interface. Through the web interface, the user gets valve opened and closed. The advantage of this system is that by means of application interface the user can view the irrigation details and/or manually setup time-based irrigation and/or schedule-based irrigation irrespective of user's location. The major issues with this system are: not considering air humidity, sunshine brightness intensity and wind speed values which can have a great impact on the irrigation efficiency.

This process [3] is focused on automatic irrigation based in the greenhouses using actuator networks and wireless sensors. On the basis of knowledge of the environmental parameters and plant growth, a decision will be made on the regulation of water supply. The system uses machine learning process to enhance the diagnosis process for plants. Machine learning totally depends on logging data, and it is used to set rules and parameters for irrigation threshold. To derive these parameters and rules, the system uses a rule editor tool. This rule editor tool provides the visualization of evaluated states and measured constraints too. Quality indicators are used for handling the uncertainty of data. The advantages of this system are the integration of plant-based method with soil moisture sensor method and the fast configuration of sensor nodes with OS (Tiny OS) used which improves the accuracy of irrigation. The less coverage area of about 120 m because of XBee devices is the major contention with this system.

In [4], the focus is on closed loop distant observing of precise irrigation by means of Citect configuration software. All the end nodes transmit the data of soil temperature, humidity from DHT11 and soil moisture values to the sink node. As the sink node receives the data, the values received re-compared with the set threshold values as per the process mentioned above. Based on that, sink node sends a command to open as well as to close the valve. Information obtained from sensors like soil temperature, moisture and humidity and valve status at various time intervals is transmitted to the web server using the GPRS module. The end user has the freedom to monitor the process remotely via web interfaces. The advantages of the developed system include the conservation of water up to 25% when compared to normal irrigation systems and also real-time collection and transmission of data. The major disadvantage is tapered irrigation efficiency by reason of not considering the wind speed values and sunshine intensity and duration as parameters for reference evapotranspiration.

Process [5] is based on the use of wireless sensor networks for dynamic automatic irrigation and to avoid the use of pesticides. The on stream camera compares the measured value with reference values as soon as the wireless sensor nodes measure the soil moisture and soil fertility. When the soil is wet and there are no pesticides found, the valve remains closed. It gets open when the soil is dry and pesticides are found. The microcontroller is put in sleep mode when there is no need of irrigation, and when needed, the microcontroller will go into active mode for power consumption. The advantages of this system are improved energy efficiency using power saving modes, dynamic irrigation and pesticide avoidance. Reduced irrigation efficiency because of not considering bright sunshine duration, air temperature and wind speed values for reference evapotranspiration are considered as the main issues with this system.

In [6], focus is on irrigation system using wireless sensor network and fuzzy logic to preserve the water resource and to improve the soil fertility. Soil humidity sensors are equipped to all the end node areas. The coordinator receives the measured soil moisture value and different crop growth information during different periods by the end node. All the data from the coordinator node are then transmitted to the monitoring station using RS232. The inputs to the fuzzy logic controller are deviation of soil moisture value and the time at which the deviation occurs. From that, opening and closing of the irrigation valve will be computed. The main problem with this system includes inconsistency of fuzzy logic and lesser bandwidth coverage for as much as Xbee is confined to 120 m.

In [7], focus is on the automated irrigation system to ensure low-cost and high power efficiency. The wireless sensing unit (WSU) is built with soil temperature sensor and humidity sensor. Once the soil temperature and humidity are read by the WSU, it forwards those values to wireless interface unit (WIU). Then, WIU actuates the solenoid valve for the irrigation process on the basis of threshold-based algorithm. All the irrigation details will be intimated via short message service (SMS) and also forwarded as an email to the farmer using general packet radio service (GPRS) module. The main issues with this system are the signal quality of the wireless sensing unit that differs time to time due to soil moisture dynamics and other environmental parameters like sunshine duration, wind speed which might have not been used for the irrigation decision which significantly affects the irrigation efficiency.

4 Proposed System

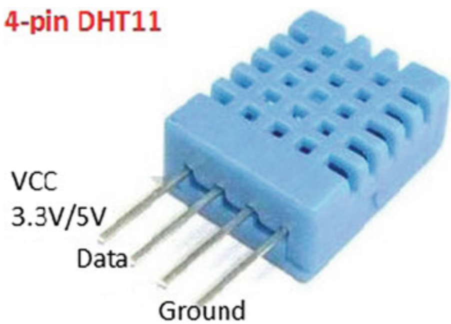
The system can be operated in two modes—(i) manual and (ii) autonomous. The rate of irrigation, physical factors, etc. are continuously uploaded in the server. The manual mode gives option to select the rate of releasing water by pumps, duration of irrigation, etc. In the first phase, the autonomous mode decides the rate of irrigation according to the present physical parameters by the analysis of previous standard surveys uploaded initially in server. The next phase of automation will recognize the ideal rate of irrigation by using machine learning where the physical factors, rate of irrigation and the rate of growth in the first phase are used as training data. The pumps can also be controlled from a distant place via web-based apps or mobile apps. The product will be like a thin slab having all the sensors embedded on it. The product possesses a vertical track along which an ultrasonic sensor traverses to and fro to measure the longitudinal plant growth. Another sonar moves in a horizontal track to map the distance between the crops (in a particular plot or area) and the product itself to monitor the secondary growth.

When the implementation of fertilizers and pesticides is executed, the system administrator will have the option to switch on to a special mode where the whole system becomes dedicated in supervising the change in moisture content, acidity of the soil and the rate of photosynthesis and transpiration in a more precise way for studying how the plants react immediately to the fertilizers. It also observes how the Air Quality Index (AQI) is changing for the application of fertilizers.

The project has four fields in technical sphere:

Sensors:

A. Temperature and humidity sensor DHT11 will measure the ambient atmospheric temperature and humidity. There is a control unit in DHT11. The output of the control unit is used to control the irrigation system by switching it on and off depending on the soil moisture contents. If the moisture value obtained is less than the preset value, then the motor will be automatically turned ON. The change in moisture is proportional to the amount of current flowing through the soil.



1. DHT11 temperature humidity sensor

B. Hygrometer sensor measures the soil moisture content

2. Hygrometer sensor
C. PH meter sensor calculates the acidity of the soil
D. MQ135, MQ131, MQ2, MQ 9 sensors are used to measure the pollutants in air to evaluate AQI.
E. Ultrasonic sensors are used for pest control and also to monitor the plant growth.
F. Water level indicators are used to fill the field with water up to the required level.

MCUs and wireless communication modules:

A. MCU plays the vital role in making judgments and taking vital decision and is the main apparatus for interfacing the sensors and connecting to network.
B. Wi-Fi module is used to upload the sensor data to web-cloud.
C. GSM module is used to control the pump.
3. Apps and dedicated web server and APIs: These will be required to analyze the data and develop various GUIs.
4. Miscellaneous: DC geared motors will be used to control the movement of ultrasonic sensors. Stepper motors are used to move the water level indicator sensor to the required height.

DC Geared Motor

The device is divided into two parts: one is the transmitter and other is the receiver. The transmitter part attached with sensors is placed in the field to detect various parameters like temperature, humidity. The transmitter portion senses the parameters from the field through its sensors and sends it to the other part that is the receiver. The receiver portion in turn sends it to the server through the GSM module that is attached with it. The server is where centrally all the data related to the various parameters that is sensed from the field is saved. Water pumps are placed at various portions of the field that supply water in a concerned area if required so as a result of analysis on the various data of various parameters that is saved in the central server at various time from the field conditions. Water pumps operate through the transmitter portion that sends commands for its operation. The data that are saved in the server are taken into consideration to analyze the field condition and predict whether irrigation is necessary or not (Figs. 1 and 2).

Dataset Collected from the Central Server

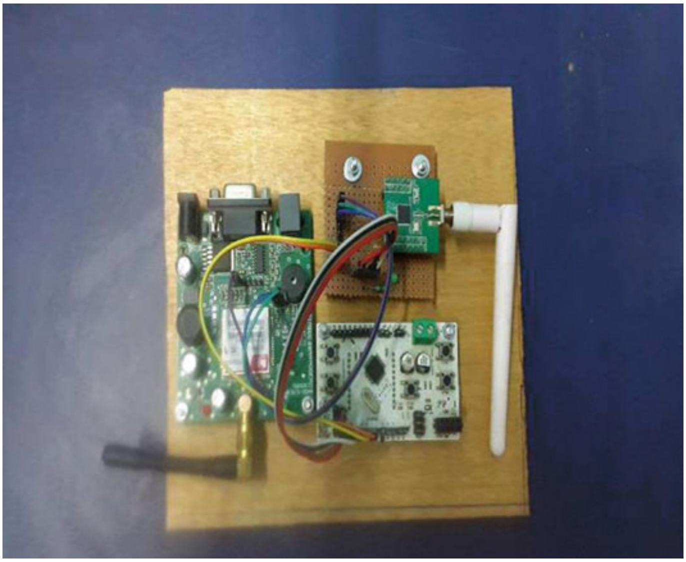


Fig. 1 Picture of the receiver module of the smart device

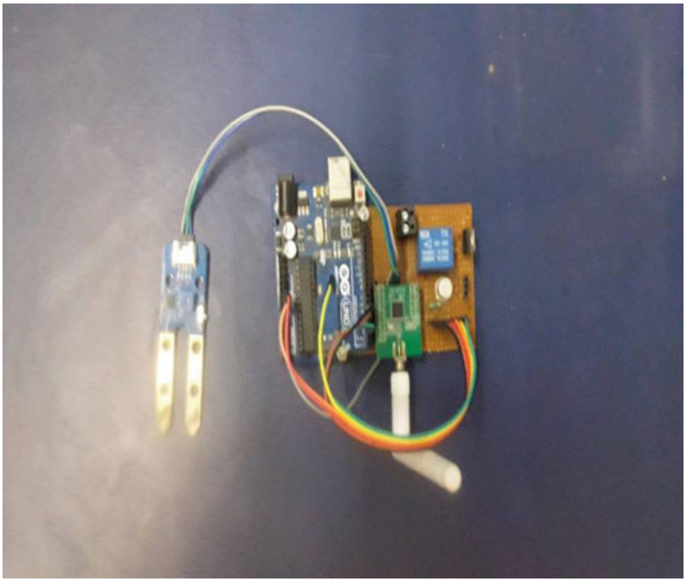
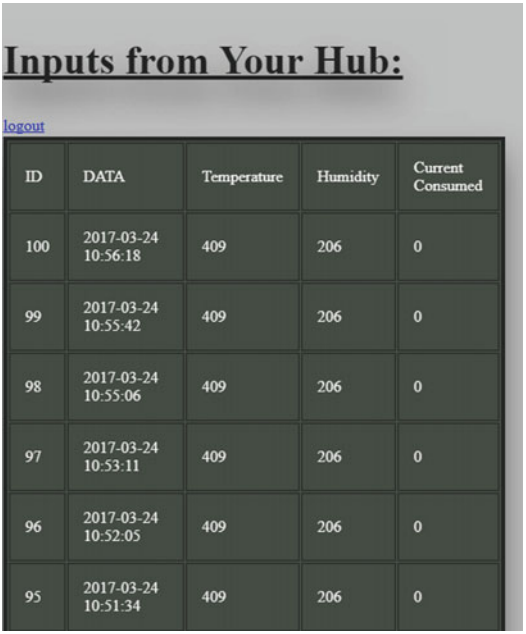


Fig. 2 Picture of the transmitter module of the smart device



Inputs from Your Hub:

logout

ID	DATA	Temperature	Humidity	Current Consumed
100	2017-03-24 10:56:18	409	206	0
99	2017-03-24 10:55:42	409	206	0
98	2017-03-24 10:55:06	409	206	0
97	2017-03-24 10:53:11	409	206	0
96	2017-03-24 10:52:05	409	206	0
95	2017-03-24 10:51:34	409	206	0

5 Conclusion

Agriculture is a field that still lacks the mass innovation and applications based on modern techniques. Our proposal of smart irrigation will make optimized use of resources and solve the problem of water shortage. The data are stored in the server. Based on the conditions, data would be retrieved, so that the system can adjust itself according to that.

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