Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 5, 2021, Pages. 4417 - 4426
Received 25 April 2021; Accepted 08 May 2021.

Implementation of Smart Automatic Farm Irrigation of Fields Using Internet of Things

Ilanchezhian P[1], Shanmugaraja P[2], Thangaraj K[3], Aldo Stalin JL[4]
[1, 2]Associate Professor, Sona College of Technology, Salem, India
[3, 4]Assistant Professor, Sona College of Technology, Salem, India
ilanchezhianp@sonatech.ac.in

ABSTRACT

Agriculture is the practice of farming followed from our ancestors. Over the decades farming technique has changed with the development of technology. Current farming techniques make work more simple and reduces man power. Though there are developments in farming techniques still farmers face more problems in producing 100% yield. The IoT technology has lend a hand to agriculture in the name of Internet Of Things. Internet of Things, a widely known branch of computer science has introduced sensible farming to every farmer's neighborhood and also providing constructive inexperienced agriculture. These IoT can be helpful to farmers in many agricultural disasters like climate changes, improper cropping pattern, pandemics, over irrigation and inadequate knowledge on farming techniques. Our paper presents a way to one of the major issue faced by farmers the over irrigation by introducing automatic irrigation of fields regularly with the help of IoT. The IoT makes use of moisture sensor and humidity sensor along with solenoid valve for providing automatic irrigation of fields whenever the moisture level in the soil goes under the fixed value. The whole process of automatic irrigation is carried out by photon (the microcontroller) and the moisture sensor. The photon which makes use of the in-built Wireless Fidelity (wifi) send the moisture level and humidity level frequently to any online platform or web services. These web services acts as user interface or controller for the farmers which allows them to control the devices remotely over the air.These platforms also stores the recorded data daily and provides as a database which can be used for future prediction. When the moisture level falls below the threshold level the photon sends signal to the solenoid valve through relay. Current moisture level and valve state are monitored through web services.

Keywords
Over Irrigation, IOT, Photon, Moisture sensor, Automatic irrigation.

Introduction

Agriculture the science or act of farming is the backbone of our world. Agriculture developed the farmers and the farmers developed the human civilization. Agriculture helped the humans to learn to cultivate and paved them a way to live without hunting. Agriculture has decreased hunting and helped to achieve a balanced food chain. Agriculture has also led farmers to achieve various types of domestic animal farming and various crops. Humans directly depend upon agriculture for sustainable living. Agriculture acts a fuel to earth. It is unimaginable the world without agriculture. World economy and Indian economy depends mostly on agriculture. Around 60-70% of Indian economy depends on agriculture. About one hundred and fifty million people in India is directly involved in agriculture. 18% of India's GDP is contributed by farmers. Since 60% of the Indian population works in the agriculture industry. As it is clear that agriculture is main source for humans it is necessary to develop the farming techniques with the current technology so that the crop cultivation can be maximized and modernize the conventional agricultural practices for the better productivity. Due to lack of knowledge in water management and over usage of water by farmers led them to deplete water reservoirs and in over irrigating of crops. Scarcity of water for farming is a big issue in India faced by farmers. Farmers require water in abundance for cultivation of crops. In providing water resources a nation must primarily focus on providing farmers. The farm lands require pure water for cultivation so there should be no usage of any chemically processed, factory waste or sea waters. Some farmer's in the thought of getting more yield they would over irrigate or under irrigate the fields which may also lead to the death of the crops. Facing the difficulties in farming most of the people are choosing different path to make their living. Even the children of farmers and even some farmers tempt to move out of farming. This would seriously affect the agriculture industry. Farmers spend about 75% of crops life time in irrigating them. Irrigation is highly time consuming and requires man power to monitor the fields regularly. The time required to irrigate increases proportionally to the area of land and so the man

Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 5, 2021, Pages. 4417 - 4426
Received 25 April 2021; Accepted 08 May 2021.

power. Development of sensors and other technologies can make irrigation process easy with the help of automation. In particular IOT helps more in automation of agriculture.
Need of Automatic Irrigation:

- Automated irrigation system encourages the youngsters to do farming and also enables even the bedridden to cultivate farms.
- Helps farmers to focus more on personal life since nearly 50% of their work load would be reduced with automatic irrigation since there is no need for them to be onsite to irrigate fields.
- The development web services helps farmers to monitor the water content of their fields from anywhere around the world.
- Electrically controlled valve eliminates the needs of hoe and man power.
- Prevents over irrigation and under irrigation.

Literature Review

Joaquin, Gutierrez et al (2014) describes the wireless sensor network using General packet radio service based irrigation system. Pravina B et al (2015) presents the overall system monitored by Zigbee protocol technology. Stefanos A. Nikolidakis et al (2015) describes the effective approach on energy efficient automated Control system of irrigation in Agriculture with the help of Wireless Sensor Networks. Venkata Naga RohitGunturi (2013), explain the irrigation system concepts with the help of latest micro controllers like PICMicro Controller. D. K. Fisher and H. A. Kebede (2010) was described the low-cost microcontroller-based system to monitor the temperature of crop status of the water level of the system. A detailed precise agriculture monitoring system using WSN was explained by S.Li et al by (2011). K. Honda, A. Shrestha, A. Witayangkurn, (2009) was explain the real time monitoring for Ubiquitous based sensor networks in the fields. I. Mampentzidou, E. Karapistoli, A.A. Economide, (2012) have described the basic Strategies for arranging Wireless Sensor Networks in the area of agriculture domain. G. Yuan, Y. Luo, X. Sun, and D. Tang, (2004) provide the detailed evaluation of a region north china for crop water stress index for detecting water stress in winter wheat. KshitijShinghal, Arti Noor, NeelamSrivastava, Raghuvir Singh, (2011) was explained the intellectual humidity sensor for wireless sensor network in the domain of agricultural application . For Malaysia country, MuhmadAzmanMiskam, Azwan bin Nasirudin, InzarulfaishamAbd. Rahim, (2009) has discussed the preliminary design on the Development of Wireless Sensor Network for Paddy Rice Cropping Monitoring Application.

Device and Description

Arduino and Raspberry is the most commonly used microcontroller and microprocessor which requires GSM for internet connection and to send message whereas the photon has an inbuilt wifi module which connects to the internet. Detailed description of devices used is given below.

Photon

Photon is a microcontroller developed by particle as shown in figure 1. The photon act as the brain of the system. Particle provides an web ide for developers to code the program for photon over the air and also has an inbuilt OS .The particle provides a good service for their products by providing continuous updates. The photon also helps the developers to make use of cloud platforms by using cloud functions of particle. The OS of photon gets updated automatically once connected to the internet. The in-built device OS helps to run the application firmware successfully. It alsoexposes the behavior of the device. Following points shows the responsibilities of the device OS.

- Secure communication: Data transfer between the device and Particle cloud takes place only after the authorisatioin and encryption. Which enables the secured communication.
- Hardware abstraction: Interface provided by the particle is single and unified and supports any hardware architecture.
- Application enablement: The API provided has many features enabling the developers to write applications for the device.

Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 5, 2021, Pages. 4417 - 4426
Received 25 April 2021; Accepted 08 May 2021.

- Over-the-air updates: Since the photon is wifi enabled the updates are done over air without human interaction even in poor connectivity environments.

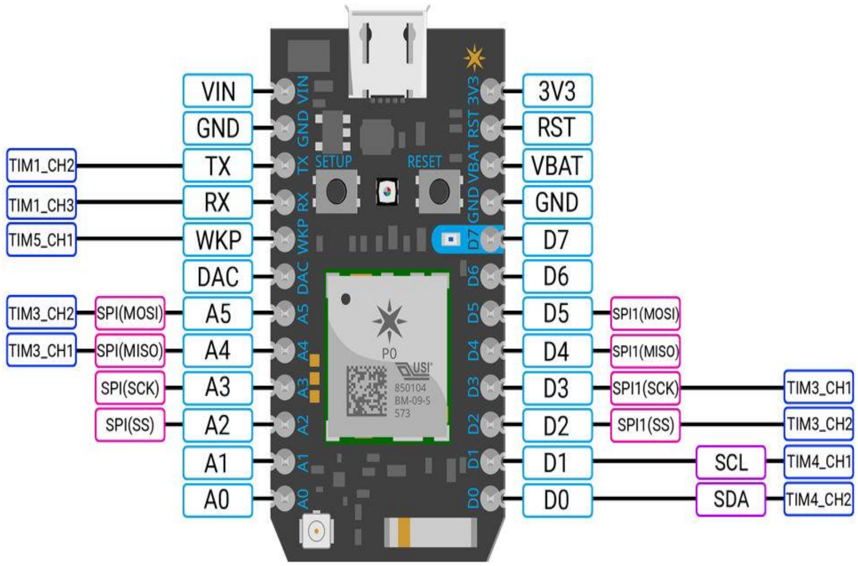


Figure 1: Photon

Moisture sensor

The Soil Moisture Sensor uses capacitance which collects and stores the energy in the form of an electrical charge. The moisture sensor makes use of this capacitance to measure the water content of soil (by measuring the dielectric permittivity of the soil, which is a function of the water content). When the sensor is implemented in the soil it measures the volume of liquid water per volume of soil as volumetric water content of the soil and returns the value in percentage.Soil moisture sensors shown in figure 2 measure the volumetric water content in soil. Properties of the soil such as, electrical resistance, dielectric constant, or interaction with neutrons are used to indirectly measure the volumetric content in soil. The formula to calculate the volumetric water content in soil is shown below.

Gravimetric water content formula,

$$\theta g = \frac{m(water)}{m(soil)} = \frac{m(wet) - m(dry)}{m(dry)}$$

Volumetric water content formula,

$$\theta v = \frac{\text{volume of water}}{\text{volume of soil}} = \frac{\frac{m(water)}{\rho(water)}}{\frac{m(soil)}{\rho(soil)}} = \frac{\theta g * \rho(soil)}{\rho(water)}$$

where,

θg = Gravimetric water content
θv = Volumetric water content
m = mass
ρ = density

The Volumetric content in the soil is preferred by sensors to return the moisture content rather than using gravimetric measurement . Since the direct gravimetric measurement of free soil moisture requires huge process to return the value which is difficult.Specifications of moisture sensor is listed below.

- Range: 0 to 45% volumetric water content in soil (capable of 0 to 100% VWC with alternate calibration)
- Accuracy: ±4% typical

Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 5, 2021, Pages. 4417 - 4426
Received 25 April 2021; Accepted 08 May 2021.

- Typical Resolution: 0.1%
- Power: 3 mA @ 5VDC
- Operating temperature: –40°C to +60°C
- Dimensions: 8.9 cm × 1.8 cm × 0.7 cm (active sensor length 5 cm)

Figure 2: Moisture sensor

Humidity sensor

As like the other sensors humidity sensor shown in figure 3 is also an electrically operated sensor which converts its findings into electric signal. Humidity sensor is of two types.

- Relative Humidity sensor
- Absolute Humidity sensor

Relative humidity sensor calculates the value from live humidity of air at the given temperature to the maximum humidity of air at the same temperature. Whereas Absolute humidity sensor measures only the humidity of air. In this project we have made use of Absolute humidity sensor.The typical accuracy of an absolute humidity sensor is +3 g/m^3.The humidity sensors are used widely in areas like printer and fax machines, weather stations, automobiles, food processing, refrigerators etc.Irrigation techniques like drip irrigation need accurate moisture content for plants. Humidity sensor plays an important role in indoor vegetation.

Figure 3: Humidity sensor

Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 5, 2021, Pages. 4417 - 4426
Received 25 April 2021; Accepted 08 May 2021.

Relay

Generally a relay is an important device and acts like an electrically operated switch. A relay normally contains five pins ,out of which three pins on one side and other two pins at the opposite. The two pins at the opposite of three pins acts as normally act as closed and the other one as normally act as open. At three pin side the two end pins are connected to the coil terminals irrespective of poles and the single middle pin acts as the input. Routinely open and closed pins act according to the coil pin and input pin. If no power supply is given to the coils then the normally closed pin is connected to the input pin and the normally closed pin acts as the output and vice versa. The open and closed pins are controlled by the coils which makes use of electromagnetic field and relay shown in figure 4.

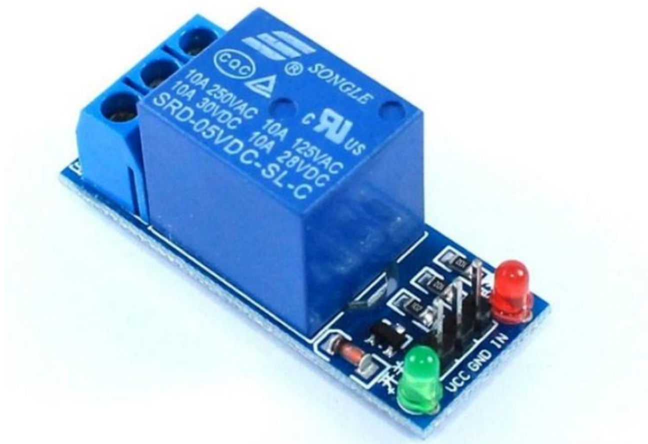


Figure 4: Relay

Solenoid valve

Solenoid valve shown in figure 5 is an electrically controlled valve which makes use of the feature solenoid. The solenoid valve works on the principle of magnetic field. Solenoid is an electric coil which makes use of the movable ferromagnetic core present at the centre. Solenoid valve makes use of plunger to control the small orifice with magnetic field. When no power supply is provided the plunger in rest state closes of the small orifice. When an electric supply is provided the coil gets energized and creates magnetic field . The magnetic field produced exerts an upward force on the plunger opening the orifice. This is the basic principle that is used to open and close solenoid valves.

Figure 5: Solenoid valve

Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 5, 2021, Pages. 4417 - 4426
Received 25 April 2021; Accepted 08 May 2021.

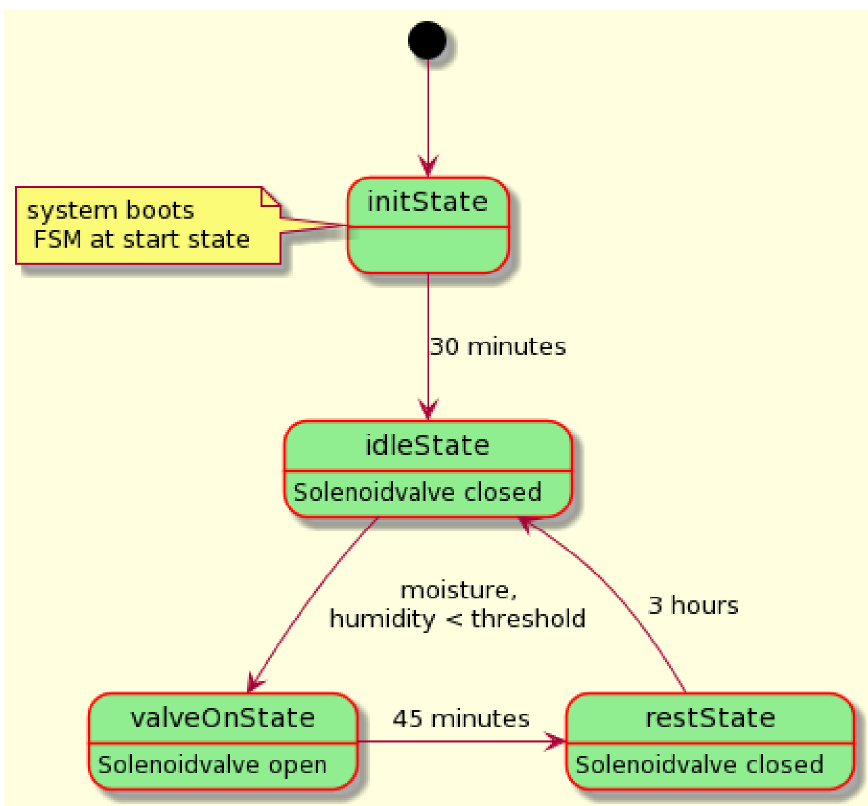
Methods

Wiring

The soil moisture sensor and humidity sensor power are wired to the battery and the output wire is connected to pin A0 and A1 respectively. Normally connected and normally closed pins of relay 1&2 are connected to positive and negative terminal of battery respectively. An terminal of the solenoid valve is wired to the commons of relay 1 &2 and the other wire of solenoid valve is connected directly to one terminal of battery. Two momentary PCB switches are mounted on the relay board connecting the +5V to the relay 1&2 activation pads for manual control and troubleshooting.

Software

Particle provides an Integrated Development Environment for developers to code for photon. The code for the system is executed using particle build platforms like particle web ide, visual studio code or through command line interface (CLI). The Finite State Machine (FSM) shown in figure 6 is used to write a clean code and in implementing sequential work. The Finite State Machine is coded to be at the initial state at the begining. The Finite State Machine which is at the initial state transitions to the idle state after a fixed time when the code is executed. At the idle state of the Finite State Machine the moisture level and the humidity level around the field is monitored. The data recorded at the idle state of the Finite State Machine is continuously transferred to the Thingspeak. The thingspeak process the provided data give as a chart value in dashboard. At the idle state of the Finite State Machine the solenoid valve remains closed. When the moisture level or the humidity level falls below the threshold the FSM transitions to the valve on state and the field is irrigated for the fixed time. The valve remains open for the fixed time. After the fixed time the valve gets closed and the FSM returns to the rest state. The FSM remains at the rest state for the fixed time and then again returns to the idle state. The process is runs like a loop.



Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 5, 2021, Pages. 4417 - 4426
Received 25 April 2021; Accepted 08 May 2021.

Figure 6: Finite State Machine of one of the valves

Data publish to web services

Data can be published to any web services for easy monitoring.Data publishing to Thingspeakshown in figure 7.There are many web services available currently over the internet. Thingspeak and ubidots are one of the most used web services for particle projects. Photon transfers data to Thingspeak using webhooks, ethernet using HTTP, UDP , TCP, MQTT, SNMP LoRaWAN etc. Webhook or web callback or HTTP push API is an inbuilt data transfer technique supported by both thingspeak and photon. The webhook helps in transferring data from photon to thingspeak dashboard in a very simple and easy way. The main feature of using webhook is that the data can be securely shared and extracted over the air from anywhere around the world which helps in continuous monitoring of datas. The easiest way of transferring data particularly from photon to Thingspeak is webhook. Webhooks also helps us to store data securely in Thingspeak using Thingspeak HTTPS API. Thingspeak store and publish data from and to any IOT devices. The data are stored in a separate databse enabling users to visualize every datas they have stored or read by the sensors. Particle makes use of Particle.publish() statement to transfer data to Thingspeak using webhooks.

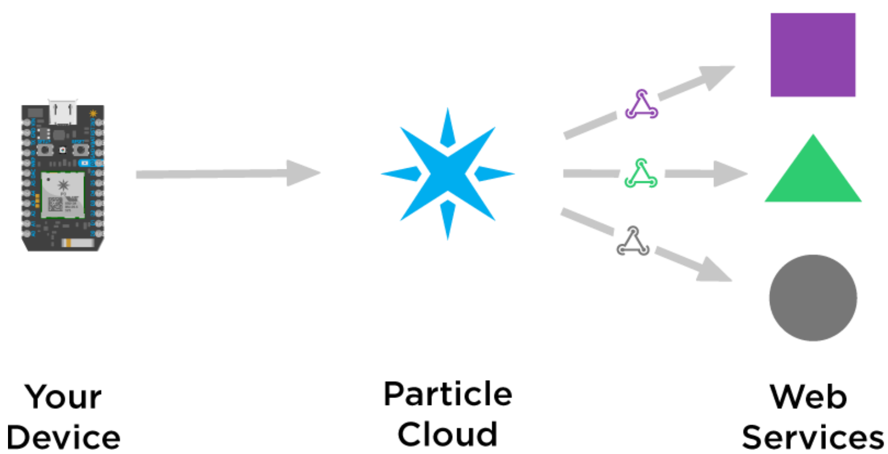
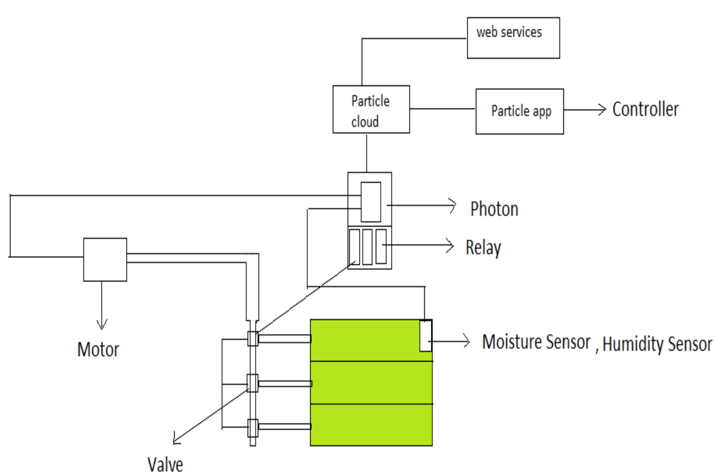


Figure 7: Data publishing to Thingspeak

Architecture



Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 5, 2021, Pages. 4417 - 4426
Received 25 April 2021; Accepted 08 May 2021.

Figure 8: Architecture

The architecture block diagram of the automatic Smart Irrigation using IoT is shown in Figure 8. When waste is dumped, then infra-red sensor detects the entry of the waste. Thus, its sensing space is maximum at this point. The transmitter uninterruptedly transmits the signal to detect the occurrence of obstacle. When the waste is dumped into the bin the receiver collects the reproduced signal from the waste and starts the entire process by the activation of microcontroller. The microcontroller in turn activates Direct current motor by completing program to rotate the motor in the forward track.

Two Direct current motors are used for the charming rotation of the conveyor belt. Both DC motors rotates in forward direction allowing the waste to be detected by the sensors connected in series near the conveyor belt. Sensors are normally used to detect different types of waste. Principal sensor connected is the Inductive type proximity sensor which is generally to detect solid waste and which is having highest priority among the two sensors connected. This sensor gives truthful results even for smaller objects. If sensor is detecting metal then program is written to choice that particular dustbin using DC motor. If the waste is not metallic then it passes through another sensor connected near belt itself called the moisture sensor. The ultrasonic sensor is used to detect the level of waste bin once it's fills it inform to concern authority by using Android Studio application.Microcontroller uninterruptedly checks the status of moisture sensor and if it is getting stimulated then bin for wet waste is selected using Dirrect current motor otherwise by default it is dry waste. The system is driven up by using solar panels.

Results and Discussion

The developed working system is implemented in the respective fields and the moisture and humidity values are continuously monitored using particle app or through thingspeak. When implemented the photon is set to the idle State and the moisture and humidity value is read by the photon. If the moisture value with correspondence to humidity value is below the threshold then photon sends signal through relay to turn on the valve that is at valveon State. Picture of the monitored thingspeak dashboard is shown below in figure 9.

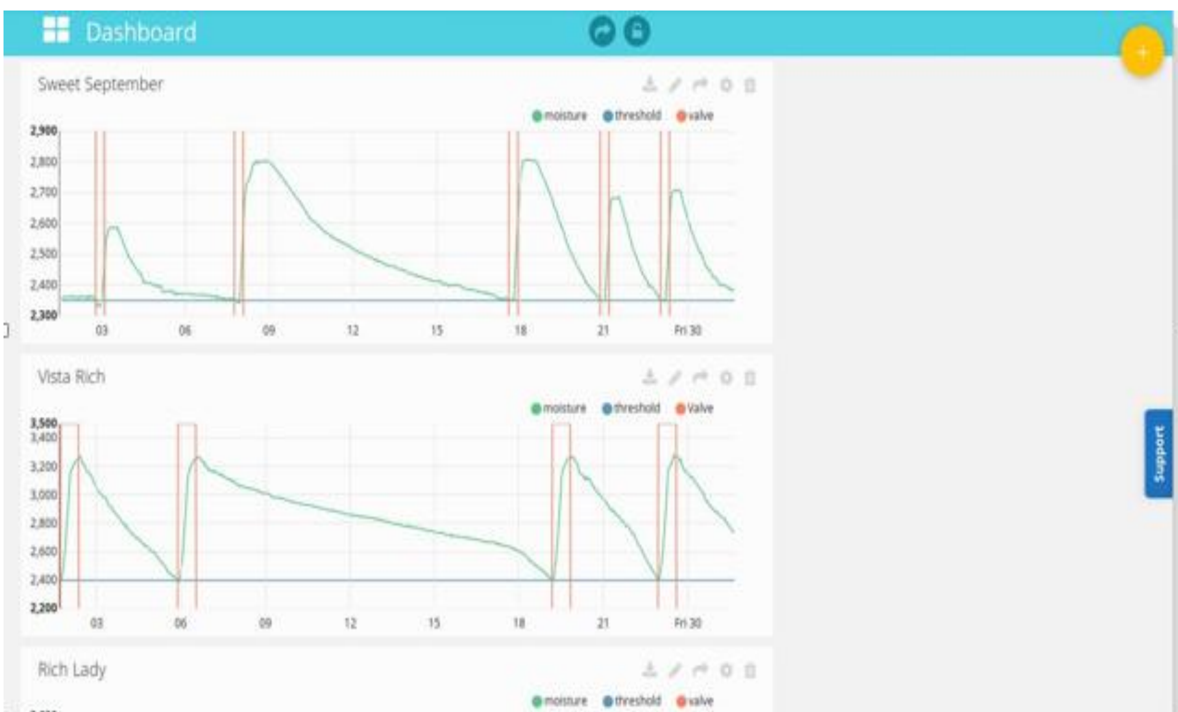


Figure 9: Moisture level graph with historic data

Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 5, 2021, Pages. 4417 - 4426
Received 25 April 2021; Accepted 08 May 2021.

Photon over arduino and raspberry

Table 1: Photon vsarduinovs raspberry pi

Features	Photon	Arduino	Raspberry pi 3
Processing chip	STM32 ARM Cortex M3 microcontroller.	Atmel 8-bit AVR microcontroller	quad-core Arm Cortex-A53 CPU microcomputer
Inbuilt memory size	1MB flash, 128KB RAM	32K bytes of Flash memory and 2K bytes of SRAM	2GB RAM and expandable ROM
Supports cloud functions	Yes	Yes	Yes
Setup	Moderate	Easy	Difficult
Clock speed	24 to 72 MHz	20 MHz	1.4GHz
wifi	Inbuilt(Cypress Wi-Fi chip)	External module need to be used	Inbuilt(WLAN)
OTA updates	Yes	No	No
Cost	Moderate	Low	High

Conclusion

The fully developed and real time setup of automatic irrigation system is found to be more helpful for the farmers by saving time, money and water. The system has saved so much of water by reducing over irrigation and extending the use of water. The photon enabled the farmers to control and monitor the fields remotely from any where around the world. It has also developed curiosity among children and teenagers to learn new technologies.
Farmers also felt satisfied irrigating their crops from their comfort zone eliminating the need to go to the lands for irrigation during the sunny or winter times. The time reduced by automatic irrigation helped the farmers to do multi task at the same time and improve their earning capacity. It has also encouraged the farmers and even the youths to increase and consider agriculture as their main source. Since the there is no failing in irrigation it has increased the crop productivity. Since the over irrigation is reduced it has led to the reduction of power of consumption.

Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 5, 2021, Pages. 4417 - 4426
Received 25 April 2021; Accepted 08 May 2021.

References

[1] Joaquin, Gutierrez, Juan Francisco Villa-Medina, Alejandra Nieto Garibay, and Miguel ÁngelPorta-Gandara", (January 2014), "Automated Irrigation System Using a Wireless Sensor Network and GPRS module" ,*IEEE Transactions On Instrumentation And Measurement*, 63(1).

[2] Pravina B. Chikankar, Deepak Mehetre , Soumitra Das (2015), "An Automatic Irrigation System using ZigBee in Wireless Sensor Network", *2015 International Conference on Pervasive Computing* (ICPC)-IEEE, 1(1).

[3] Stefanos A. Nikolidakis , DionisisKandris,Dimitrios D. VergadoschristosDouligeris A, (2015) "Energy Efficient Automated Control Of Irrigation In Agriculture By Using Wireless Sensor Networks", *Computers And Electronics In Agriculture*, Vol.

[4] Venkata Naga RohitGunturi, (2013) "Micro Controller Based Automatic Plant Irrigation System" *International Journal of Advancements in Research & Technology*, 2(4).

[5] D. K. Fisher and H. A. Kebede, (2010) "A low-cost microcontroller-based system to monitor crop temperature and water status," *Comput. Electron. Agricult*., 74(1),168–173.

[6] S. Li, J. Cui, Z. Li, (2011) "Wireless Sensor Network for Precise Agriculture Monitoring", *Fourth International Conference on Intelligent Computation Technology and Automation, Shenzhen,China*, March 28-29, 1(1).

[7] K. Honda, A. Shrestha, A. Witayangkurn, (2009).,"Fieldservers and Sensor Service Grid as Real-time Monitoring Infrastructure for Ubiquitous Sensor Networks", *Journal of Sensors*, 9(1),2363-2370.

[8] I. Mampentzidou, E. Karapistoli, A.A. Economide, (2012) "Basic Guidelines for Deploying Wireless Sensor Networks in Agriculture", *Fourth International Workshop on Mobile Computing and Networking Technologies*, 864-869.

[9] G. Yuan, Y. Luo, X. Sun, and D. Tang, (2004) "Evaluation of a crop water stress index for detecting water stress in winter wheat in the North China Plain," *Agricult. Water Manag*., 64(1),29–40.

[10] KshitijShinghal, Arti Noor, NeelamSrivastava, Raghuvir Singh, (2011) "intelligent humidity sensor for wireless sensor network agricultural application", *International Journal of Wireless & Mobile Networks* (IJWMN), 3(1).

[11] MuhmadAzmanMiskam, Azwan bin Nasirudin, InzarulfaishamAbd. Rahim, (2009) "Preliminary Design on the Development of Wireless Sensor Network for Paddy Rice Cropping Monitoring Application in Malaysia", *European Journal of Scientific Research*,1450- 216X , 37(4).