Smart irrigation system based on internet of things (IOT)

Nurulisma Ismail*, Sheegillshah Rajendran, Wong Chee Tak, Tham Ker Xin, Nur Shazatushima Shahril Anuar, Fadhil Aiman Zakaria, Yahya Mohammed Salleh Al Quhaif, Hussein Amer M. Hasan Karakhan, and Hasliza A. Rahim

School of Computer and Communication Engineering (SCCE), Universiti Malaysia Perlis, Perlis, Malaysia

*nurul@unimap.edu.my

Abstract. Nowadays, the Internet of Things (IoT) technology is very much used in agriculture. Therefore, this paper is about a project that focuses in the field of agriculture with the objective of controlling the water consumption in agriculture field which is based on IoT where all information is viewed and controlled in fingertips. As a part of the system development, few sensors applied such as: (i) a soil moisture sensor (YL-69) to detect the water level in soil; (ii) the humidity and temperature sensor (DHT-11) to trace early signs of temperature changes; and (iii) the pressure sensor (BMP 280) to measure the pressure of the surrounding. These sensors are connected to a Wi-Fi module (Node MCU) and they are interdependent to give extra sensitivity to the irrigation system. The data collected will be uploaded to the cloud (ThingSpeak.com and Firebase) and displayed in the form of graphs that could be seen through the app and website. The app functions to display the reading from the sensors and to control the water pump for emergencies purposes. In conclusion, the project managed to fulfil all its objectives in the aspects of water consumption, minimal project cost, less labour, power consumption, and reliability.

1. Background of Research
The irrigation system is very important in agriculture. For example, in Ancient Egypt since 1800, methods of the watering plant become popular. The population of Ancient Egypt started with residential sprinklers. The residential sprinkler is the oscillating sprinkler head which had a row of nozzles along with a bow like tubing that would shift back and forth. During the 50s, as the daily chores become less tedious and time consuming with the advent of more and more gadgets, has led to the implementation of the automatic irrigation system. In 1950, the sprinkler system was adopted by small lawns. This automated irrigation system makes monitoring of a particular land obsolete [1]. Next evolution is the smart irrigation system that is a way to help reducing water consumption by considering into agriculture field. Water is largely used for irrigation purposes. Smart Irrigation is an artificial application of watering the land to assist in the growing of agricultural crops [2]. Therefore, if the system is automated, the water flows to the crops could be controlled and monitored so as to reduce the amount of water being used for plantation purposes [2], [3]. The experts agree that smart irrigation systems and controllers versus traditional irrigation controllers conserve water across a
variety of scenarios. Several controlled research studies indicate substantial water savings anywhere from 40% to as high as 70% [4], [5], [6]. The tests conducted by the Irrigation Association (IA) and the International Centre for Water Technology at California State University in Fresno, have shown smart irrigation controllers can save up to 20% more water than traditional irrigation controllers [7]. Smart Irrigation system is based on the Internet of Things (IoT) [5], [6], [8]. The IoT simply means transferring data over a network without requiring human-to-human or human-to-computer interaction. Therefore, the irrigation system that is based on this concept would be interacting among the computing devices which are the sensors and sending real-time data to the cloud over the internet. Thus, there will no requirement for the user of this system to check the farming land and the places to be irrigated [9].

However, the irrigation of plants is usually a very time-consuming activity to be done in a reasonable amount of time and requires a large number of human resources. Traditionally, all the steps were executed by a human. Nowadays, some systems use technology to reduce the number of workers of the time required to water the plants. With such systems, the control is very limited and many resources still wasted. Water is one of these resources that are used excessively. Mass irrigation is one method used to water the plants. This method represents massive losses since the amount of water given excess of the plant’s needs. The contemporary perception of water is that of a free, renewable resource that can be used in abundance. However, this is not reality, in Malaysia water consumption needs to be paid. It is, therefore, reasonable to assume that it will soon become a very expensive resource everywhere. In addition to the excess cost of water, labour is becoming more and more expensive. As a result, if no effort is invested in optimising these resources, there will be more money involved in the same process. Technology is probably a solution to reduce costs and prevent loss of resources [2]. Another problem is when the farm field’s location is miles away from home. Sometimes several times were taken in a day to operate the water pumps, caused several trips a day to operate the pumps.

Due to this issue, the main aim of this project is to reduce the consumption of water in the agriculture field and to bring a system which is solely based on Internet of Things (IoT) where all information is viewed and controlled in fingertips. The following aspects have been count into consideration: (i) Water consumption, (ii) Minimal project cost, (iii) Less labour, (iv) Power consumption, and (v) Reliability [10]. Therefore, the project is oriented to these two (2) objectives such as (i) to develop an irrigation system that reduces water usage for better preservation, and (ii) to develop an application system that can assist the farmer to monitor the land’s condition and control the irrigation system via a mobile platform.

2. Design of Smart Irrigation System

The Smart Irrigation System is based on Internet of Things (IoT) technology that capable to control the water pump to irrigate water to the farm field and monitor the condition of soil moisture, temperature and pressure of the farm field [5], [9]. The flow of the system algorithm is illustrated in Figure 1. The first step, the user starts with run the application system via the Android platform which is through the smartphone to monitor the irrigation system of the farm field. The user needs to obtain the login account detail on the username and password of the apps from the developer. Then, the user can refer to the displayed menu on the app’s screen that based on three (3) modules: (i) Control, (ii) ThingSpeak Webpage, and (iii) Sensor Reading. The smart irrigation system enables the user to monitor the status of the farm field’s irrigation on the five (5) parameters that are the status of (i) humidity, (ii) soil moisture, (iii) temperature, (iv) pressure, and (v) water pump. The control module enables the user to control the water pump via three (3) forms of control method: (i) on, (ii) off, and (iii) auto which is either to turn on the water pump, turn off the water pump, or set the water pump to be in automatic mode. Next, the user can view the readings of the sensors via graphs that can be accessed through the module of ThingSpeak website. This app also facilitates the user with a manual on the guidelines of how to use the irrigation system. The smart irrigation system is controlled via the
Wi-Fi module with a controller. It is also integrated with sensors to receive and send data to and from the cloud.

![Flow chart of the smart irrigation system](image)

**Figure 1.** Flow chart of the smart irrigation system

### 2.1 Block Diagram of the Smart Irrigation System

The Block Diagram of the Smart Irrigation System is illustrated in Figure 2. It represents the process flow of the components integrated into the system [3]. According to Figure 2, the main board is Node MCU (ESP 8266) a Wi-Fi module. There are three (3) sensors connected to the Node MCU. The three (3) sensors are a barometric sensor (BMP 280) that is used to detect the pressure of the surrounding, humidity sensor (DHT 11) which is used to detect the humidity and temperature of the surrounding, and soil moisture sensor (YL 69) which detects the water level in the soil. There are two (2) clouds that are being used which are ThingSpeak that monitors the data of sensors and represent them in the form of graphs and Firebase which reads the real-time database. A water pump is also connected to the Node MCU and will receive a control signal from the Firebase to perform any action.
2.2. Component Description
The components of the Smart Irrigation System are described as follows [8], [11]:

2.2.1. Soil Moisture Sensor (YL 69)
A soil moisture sensor (Figure 3) can read the amount of moisture present in the soil surrounding it. The new soil moisture sensor uses Immersion Gold which protects the nickel from oxidation. Electroless nickel immersion gold (ENIG) has several advantages over more conventional (and cheaper) surface platings such as HASL (solder), including excellent surface planarity (particularly helpful for PCB’s with large BGA packages), good oxidation resistance, and usability for untreated contact surfaces such as membrane switches and contact points. This soil moisture Arduino sensor uses the two probes to pass current through the soil, and then it reads that resistance to get the moisture level. More water makes the soil conduct electricity more easily (less resistance), while dry soil conducts electricity poorly (more resistance) [12].

![Figure 3. Soil moisture sensor](image)

2.3. Humidity and Temperature Sensor (DHT11)
The DHT11 (Figure 4) is a basic, digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin (no analogue input pins needed). It is simple to use but requires careful timing to grab data. The only real downside of this sensor is you can only get new data from it once every 2 seconds, so when using the library, sensor readings can be up to 2 seconds delay [12].

![Figure 4. Humidity and temperature sensor](image)
2.4. **Pressure Sensor (BMP 280)**

Figure 5 shows the pressure sensor that can measure barometric pressure and temperature with very good accuracy. Because pressure changes with altitude we can also use it as an altimeter with ±1 meter accuracy. Accuracy for barometric pressure is ±1 hPa and ±1.0°C for temperature [13].

![Figure 5. Pressure sensor](image)

2.5. **Wi-Fi Module Node MCU (ESP 8266)**

Node MCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "Node MCU" by default refers to the firmware rather than the dev kits.

2.6. **Water Pump**

This is a compact size submersible water pump (none self-prime). It is built by a brushless motor providing smooth and quiet operation than a non-brushless water pump.

2.7. **Transistor (BC 548)**

The BC548 is a general-purpose NPN bipolar junction transistor. It is used for amplification and switching purposes. The current gain may vary between 110 and 800. The maximum DC current gain is 800.

2.8. **Relay**

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts.

2.9. **Resistor (1K Ω)**

Resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses.

3. **Results of the Smart Irrigation System**

The Smart Irrigation System is integrated into the mobile application system to enable the user to easily monitor and control the irrigation of the farm field. On the mobile application system, there is an interface to view data collected directly from the sensors via the help of the Firebase, which is the cloud that creates a bridge between hardware and the cloud database. The main interface of the mobile application is the main menu that displays the login page of the system. This is to create a secured login for each user and to prevent others from knowing data owned by another client. Once the user successfully login to the app, there is another menu display the options control the irrigation system. The user has to select any of the options to go about the system. The control option leads the user to control the water pump to either force “ON” or “OFF”, or just set it to the AUTO mode where it navigates the pump's control based on the sensor's value that set in the system. Then, the control system leads the user to access the ThingSpeak.com. This process is to display graphs of all the sensors which display the report of the status of the farm field's soil. Figure 6 illustrates the flow of the Smart Irrigation System that integrated into the mobile application system.
4. CONCLUSION

In conclusion, the Smart Irrigation System meets the objective to monitor and control the irrigation system of the farm field. It is based on the technology of Internet of Things which is integrated with few sensors: (i) humidity sensor, (ii) soil moisture sensor, and (iii) pressure sensor to control the status of the farm field's soil. In the meantime, these sensors are connected to the Internet via the Wi-Fi module. This interconnected activity is to give additional sensitivity to the irrigation system. The data collected on the cloud (ThingSpeak and Firebase) will be downloaded and displayed in graphical form. The user can monitor the irrigation system via the report displayed from the application system on the mobile platform. The application works to display readings from sensors and control the water pump in case of an emergency. This is to alert the user and make the system easy to use.

REFERENCES

[1] Pro Green Irrigation, “Pro Green Irrigation: Your Lawn Sprinkler Professionals,” 2017. [Online]. Available: https://progreenirrigation.com/.

[2] V. C. Gungor and G. P. Hancke, “Industrial wireless sensor networks: Challenges, design principles, and technical approaches,” IEEE Trans. Ind. Electron., vol. 56, no. 10, pp. 4258–4265, Oct. 2009.

[3] J. Gutierrez, J. F. Villa-Medina, A. Nieto-Garibay, and M. A. Porta-Gandara, “Automated irrigation system using a wireless sensor network and GPRS module,” IEEE Trans. Instrum. Meas., vol. 63, no. 1, pp. 166–176, Jan. 2014.

[4] K. Taneja and S. Bhatia, “Automatic irrigation system using Arduino UNO,” in Proceedings of the 2017 International Conference on Intelligent Computing and Control Systems, ICICCS 2017, 2018, vol. 2018-Janua, pp. 132–135.

[5] V. Krishna Nare, K. R V Siva Naga Durg, R. Krishna Muddineni, and S. Gowtham Peri, “Smart irrigation using WSN based on IOT,” Int. J. Eng. Technol., vol. 7, no. 2.8, p. 331, Mar. 2018.

[6] K. C., K. H. U, P. H. S, K. S. P, A. G. B, and D. J. Nayaka, “Water usage approximation of Automated Irrigation System using IOT and ANN’s,” in 2018 2nd International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC)-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), 2018 2nd International Conference on, 2019, pp. 76–80.

[7] I. HydroPoint Data Systems, “What is Smart Irrigation?,” 2019. [Online]. Available: https://www.hydropoint.com/what-is-smart-irrigation/.

[8] T. Robles et al., “An internet of things-based model for smart water management,” in 2014 28th International Conference on Advanced Information Networking and Applications Workshops, 2014, pp. 821–826.

[9] Meeradevi, M. A. Supreetha, M. R. Mundada, and J. N. Pooja, “Design of a smart water-saving irrigation system for agriculture based on a wireless sensor network for better crop yield,” in Lecture Notes in Electrical Engineering, 2019, vol. 500, pp. 93–104.

[10] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, “A survey on sensor networks,” IEEE Commun. Mag., vol. 40, no. 8, pp. 102–105, Aug. 2002.

[11] J. Yick, B. Mukherjee, and D. Ghosal, “Wireless sensor network survey,” Comput. Networks,
vol. 52, no. 12, pp. 2292–2330, Aug. 2008.

[12] Digi-Key Electronics, “Analog Soil Moisture Sensor for Arduino,” 2019. [Online]. Available: https://www.digikey.com/catalog/en/partgroup/gravity-analog-soil-moisture-sensorfor-arduino/70784.

[13] Autodesk Inc., “How to Use the Adafruit Bmp280 Sensor - Arduino Tutorial,” 2018. [Online]. Available: https://www.instructables.com/id/How-to-Use-the-Adafruit-BMP280Sensor-Arduino-Tuto/.