Smart Irrigation System for Urban Gardening using Logistic Regression algorithm and Raspberry Pi

R Aminuddin¹, A S Sahrom¹ and M H A Halim²

¹Faculty of Computer and Mathematical Sciences, MARA University of Technology Malacca Branch (Jasin Campus), 77300 Merlimau, Malacca, Malaysia.
²JHill Agro Dagang (JIHAD), Jalan Teman Indah Utama, 77000, Jasin, Malacca, Malaysia.

Email: raihah1@uitm.edu.my

Abstract. People have shown an increasing interest in urban gardening. Irrigation is one of the common methods used to take care of the plant growth. However, the proper irrigation timing of plant is much unclear for most people. Moreover, the manual irrigation is impossible when people do not have physical access to the plant in a long period of time. Hence, a smart irrigation system using Raspberry Pi has been proposed to ease the irrigation. In this system, three different sensors, including moisture, humidity and temperature sensors are installed in the soil of the plant. The collected data from the sensors will be used to predict whether the plant need to be watered or not. This system implements a machine-learning algorithm called Binary Logistic Regression using Python library to test the accuracy of the system. The accuracy of the algorithm to predict the irrigation is 82%. The finding from this study is believed to be helpful as it may contribute to the development of better irrigation system.

1. Introduction

Internet of Things (IoT) is a global structure in connecting society through information and communication technologies. It enables services to connect both physical and virtual things. The connection allows both things to communicate through real-time data [1]. According to [2], the IoT solutions are increasingly extending to virtually all areas of everyday life. For an example, users can easily switch on and off the fan at home by using smartphone anywhere and anytime. Application of IoT is not just an in-home automation, but also has been implemented in agriculture. The IoT can monitor the crop or make irrigation a lot easier.

Irrigation is the method or process of watering plants artificially in a controlled manner at regular and intervals time required [3]. There are many types of automatic irrigation systems such as Automatic Irrigation System on Sensing Soil Moisture Content, Solar Powered Auto Irrigation System, and Global System for Mobile Communications (GSM) Based Automatic Irrigation System [4]. Each type of irrigation systems has its own benefits and limitations. For an example, the Automatic Irrigation System on Sensing Soil Moisture Content system used the moisture content of the soil to monitor and control the irrigation status. However, users unable to view the online status of the plant as the component does not connect to any network. While Solar Powered Auto Irrigation System is good to reduce the consumption of electrical energy, the system might not work well during rainy season or in absence of sunlight, particularly in artic countries. Lastly, GSM Based Automatic Irrigation System can send
message or information about the irrigation status of the plant to end-users. However, people nowadays are moving from messaging to mobile apps, hence GSM technology may be less preferable.

1.1. Problem statement
From time to time, people such as city dwellers are growing interest in urban gardening. These people are interested in producing their own inexpensive and organic fresh food for healthy lifestyle. Furthermore, in some countries, the COVID-19 pandemic may have also interrupted the food supply chain. Therefore, the urban gardening may provide easy day-to-day access to fresh vegetables and fruits, thus contributing to improved food security and enriched and balanced meals [5].

Most people are currently using a manual irrigation to water their plants. However, there are several limitations on doing manual irrigation. Firstly, people cannot oblige to water their plant if they have a hectic day or week. The plant needs a consistent amount of water to sustain its life and growth. If the plant is lacking with water, the growth and photosynthesis processes will be affected. After some time, the plant will wilt and die.

Furthermore, a plant does not require to be watered all the time. The water requirement for a plant is depending on the moisture of the plant’s soil. Since people do not know the condition of their plant’s soil, hence it is hard to predict whether their plant needs to be watered or not at the current time. A manual irrigation is not an effective way as it does not consider the current condition of the plant such as the soil moisture and humidity. People mostly depend on the weather of the day and specific timing to irrigate their plant.

Besides, it could become a problem for people who need to go for outstation or be outside from the plant area for a long period of time to do a manual irrigation.

Therefore, this project developed a smart irrigation system by using a low-cost Raspberry Pi device. The system automated the process of irrigation by using the data collected from soil moisture, temperature and humidity prediction sensors. A mobile application was developed for users to monitor the plant growth in real-time. This allowed the users to monitor and maintain their plant.

2. Objective
The goal of this project is to automate the irrigation by applying Logistic Regression algorithm for predicting the irrigation. At the same time, users can monitor the status of the plant without having physical access to the plant through an Android application. This solution will be benefitted to users who always have a limited access to their crops or users who have lack of experience and knowledge on how to take care of their plants.

3. Methodology
Figure 1 shows the architecture of the irrigation system. Firstly, soil moisture, temperature and humidity sensors are connected to a Maker Uno. The Maker Uno converts an analog signal to a digital signal by using an Analog to Digital Converter (ADC). Next, the Maker Uno sends the data to the Raspberry Pi. To build an IoT Android mobile application, the data need to be uploaded to a cloud database. In this project, Firebase Database has been chosen as the database platform because it can integrate easily with Android application. Then, users can monitor the status of the sensors through the Android application. This system also comprises an ultrasonic sensor that able to measure the distance of an object. In this system, the sensor is used to detect water level inside the water tank.
3.1. Final product
The built system constitutes of the following subsystems: i) Irrigation System, ii) Android Application and (iii) Short message service (SMS) Notification System.

3.1.1. Irrigation System. As shown in Figure 2(a), the main hardware used in this project is Raspberry Pi 3 B. There are two programming languages used to develop this system, as described in detail in the next subheadings: (1) Java programming language is used to develop an Android application for end users. (2) Python programming language is used to implement Logistic Regression algorithm to predict the irrigation status and to gather the output from the sensors.
3.1.2. Android Application. The mobile application is built on Android platform using Android Studio software. Firstly, user needs to create their own account by filling up their full name, email address, account’s password, and phone number. After completed, the user can login to the system using their registered email and password. After a successfully login, the user can view sensors and irrigation status pages. The sensor page shows the real-time sensor data: the soil moisture (%), humidity (%), temperature (Celsius) and water level in the tank (centimetre) (Figure 2(b)). Meanwhile, the irrigation status page shows the time and date of last irrigation (Figure 2(c)). The data will be updated every 1 hour.

3.1.3. SMS Notification System. This system uses Nexmo SMS Application Programming Interface (API) to notify the user that the water level inside the tank is low and the tank need to be refilled. Python programming language is used to configure the messages and the output is shown in Figure 3.

4. Results and Analysis
Briefly, this study tested the built system on a drip-type irrigation system for chili plant. To allow the system to water the plant successfully and correctly, a logistic regression algorithm was used to predict the irrigation based on existing data: soil moisture, humidity and temperature values.

Then, the dataset was divided into two parts, whereby 75% and 25% of the data were used for training and testing respectively. The logistic regression was used to predict binary values. In this case, after given values are accepted as input, the algorithm will determine whether to irrigate the plant (1) or not (0). If the output value is 1, then the water pump will pump the water to the plant for two seconds. Two seconds is set as the duration of irrigation to provide a suitable amount of water to the plant. The system will take the value of sensors at one-hour intervals. The accuracy score was obtained based on the data collected. As shown in Table 1, the accuracy score of the model to predict the irrigation is 0.82 or 82%.

| Table 1. Accuracy score of the machine learning model |
|-----------------------------------------------------|
| Classification | Precision | Recall | f1-score | Support |
|----------------|-----------|--------|----------|---------|
| 0              | 0.84      | 0.88   | 0.86     | 104     |
| 1              | 0.79      | 0.72   | 0.75     | 61      |
| Accuracy       | 0.82      |        |          | 165     |
| Macro average  | 0.81      | 0.80   | 0.81     | 165     |
| Weighted average | 0.82 | 0.82 | 0.82 | 165    |

Accuracy score is: 0.82
5. Conclusions and Future Work

In conclusion, a smart irrigation system for urban gardening was developed to monitor the water of a plant. The system was designed and developed in Python and using Raspberry Pi. This study proposed the implementation of Binary Logistic Regression algorithm for real-time irrigation. The finding shows that the system could predict the irrigation status using the data collected from soil moisture, temperature, and humidity sensors. The overall percentage of accuracy is 82%. In the future, instead of displaying the data values, the sensors data can further be graphically visualized over time. For an example, a presentation of the values of soil moisture sensor versus time plot allows for better monitoring on how well the system controls the moisture of the plant. Other than that, the implementation of this system on IOS platform remains to be explored in the future.

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