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Iot-Based Tropical Plant Monitoring

Norfaradilla Wahid, Nur Liesa Mohammad Azemi
Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia,
faradila@uthm.edu.my

ABSTRACT
PixelPot Tropical is a plant monitoring web application which is based on Internet of Things (IoT) technology. It utilizes the YL60 soil moisture sensors where the computing devices have unique identifiers for transferring data over the network. While a few other similar applications do not focus on the special requirement needed for tropical planting, the developed application aimed to cater to a few selections of tropical plants typically for home gardens. Therefore, the web application is to monitor the soil moisture content of the plants and to conduct small-scale gardening activities at home. The methodology used to develop this web application is the Waterfall Model which emphasizes the development to be done in stages. The developed application allows user to register, login, add plants, remove plants, see plant growth, record soil moisture, update plant information, etc. Along with the soil sensor, microcontroller board type NodeMcu Lua WIFI WiFi Module V3 Internet Development Board CH-340 are used to read data from sensor. The functionality and acceptance test shows that the web application meets system requirements and user specifications. Gardening activities are becoming more attractive with the help of Pixelpot Tropical web application.

Key words : Internet of Things; Tropical Plant Monitoring; Soil Moisture Sensor; Web Application; Web Technology

1. INTRODUCTION

Internet of Things (IoT) technology has been applied in various fields specifically to improve urban life and boost up the attractiveness in lifestyle, i.e., to do many daily activities faster and convenient. Smart city systems like in [1] are among many well-known IoT systems.

In this article, an IoT-based application for gardening is presented. The proposed application is intended to help users who are interested in building their own garden with the help of IoT technology to monitor the growth and the needs of the plant. The application named PixelPot Tropical allows users to choose the desired crop type from the list provided in the app, i.e., specifically for tropical-adapted home gardening. Included with moisture meter measuring device, users can know if their plants are lacking in water and users will be given notification reminders from this app.

The focus of this study involves users in Malaysia who want to have a small garden in the yard and want to learn how to plant and monitor the growth of the plants. The target group for the development of this web application are consumers who love gardening and want to try to use technology in gardening activities ranging from adolescents as early as 12 years old to adults who are interested in gardening in their own home yard. Users only need to select a plant name from the list provided in the app. Plants listed are the short-term plants in Malaysia. Notifications will be issued if plants lacking water or plants are ready to harvest.

Since this system is a web-based mobile application, Pixelpot Tropical adopts Chrome and Firefox web browser platforms. In general, the objectives of the application development are: (i) to design a suitable IoT system for small-scale agricultural technology, (ii) to develop applications capable of monitoring tropical-adapted plants, and, (iii) to test the effectiveness of IoT on small-scale agricultural technology among users..

2. LITERATURE RIVIEW

This section explains the concepts related to the project including plant monitoring system, Internet of Things and short-term plants.

2.1. Plant Monitoring System

In order to be more bestow and adaptable in water and another resources reservation, people has becoming attracted to grow their own food source. However, they do not have enough knowledge and experience to ensure the plant receive enough water and nutrients. The existence of smart-gardening kit and system such as Edyn Smart Garden [3], FlowerCare [4] and Happy Plant Water Reminder [5] have helped the gardening activities becoming more enjoyable.

As mentioned by Kato et al [6], this system acts as a controller for the electronic equipment used. As an example, the sensor module for soil moisture, air and automatic watering will send the required data to the main controller board. The main controller board is programmed to determine the action to be taken based on the data obtained. For this system, for example, the guard board determines the plants to be watered within the specified time frame. This is different from the proposed system because Pixelpot Tropical prioritizes analytical display of plant moisture to ensure that plants get enough water.

2.2. Internet of Things

According to Mahya and Tahayori [7], Internet of Things are sub-categories of Systems for Systems (SoS). To illustrate the relationship between these two terms of technology, IoT is based on the ability of the surrounding object to interact with each other through smart sensors such as RFID and others. SoS is a sequence of systems comprising complex operating systems developed to achieve higher goals and IoT is one of the systems that take part in SoS. Quoting from interviews by the International Institute for Analytics with Mann, the most precise definition of IoT is that it is a group of physical objects that form a network linked to electronics, software, sensors and network connections that allow objects to collect and exchange data with each other [8].

For the application mentioned in this article, the sensors used are type YL-69 soil moisture sensors (refer Figure 1), Arduino ESP8266 NodeMcu Lua WIFI Controller Board V3 (refer Figure 2). In keeping with the user scope, installing IoT hardware in gardening and smart integration with smartphones will make this app more appealing to use.

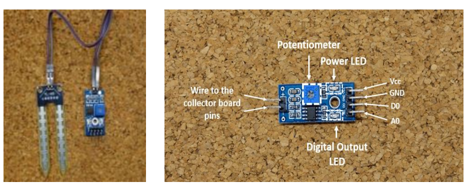

Figure 1: Type YL-69 sensors to measure the soil moisture of the crop.

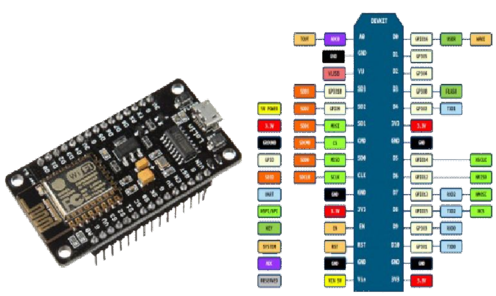

Figure 2: Arduino ESP8266 NodeMcu Lua WIFI Controller Board Version 3 with the label for each components.

2.3. Short-term Plants

Malaysia is a climate of equator in which this country experiences hot and humid weather throughout the year. Several types of tropical-adapted plants that can be selected due to the climate's suitability in Malaysia and can be harvested in less than a year. Furthermore, these plants require only small spaces to be planted.

Table 1: Type and Specifications of Plants

Plants		Specifications		
Name	**Scientific Name**	**Harvest Duration**	**Moisture Rate (%)**	**Breed Type**
Toma to	*Solanum lycopersicum*	3 - 4 months	300 - 400	Seed
Bird's Eye Chilli	*Capsicum annuum 'Bird's Eye'*	2 - 3 months	500 - 550	Seed
Tume ric	*Curcuma longa*	9 - 10 months	500 - 600	Rhizo me
Garlic	*Allium sativum*	3 - 4 months	400 - 450	Bulb
Potato	*Solanum tuberosum*	10 - 14 days	450 - 580	Bud
Pinea pple	*Ananas comosus*	4 - 5 months	350 - 450	Roots
Water melon	*Citrullus lanatus*	4 - 5 months	300 - 400	Seed
Ginge r	*Zingiber officinale*	5 - 6 months	500 - 600	Rhizo me
Eggpl ant	*Solanum melongena*	3 - 4 months	450 - 500	Seed
Bean Sprouts	*Vigna radiata*	4 - 5 months	250 - 350	Green Bean

Table 1 shows ten species of plants that can be planted in less than a year along with additional information for each plant type. Plant-related information is divided into four parts: the scientific name for each plant, the harvest period, the plant's requirements on moisture and the type of breed. All the types of plants displayed are included in the MySQL database

3. METHODOLOGY

The Waterfall Model is the most appropriate methodology to use in this project throughout the life cycle of the project system development. The development of this system involves phases such as planning, analysis, design and implementation. The main factor of this model was chosen because the system was on a small scale and was able to identify project requirements before programming began. Figure 3 shows the waterfall method used.

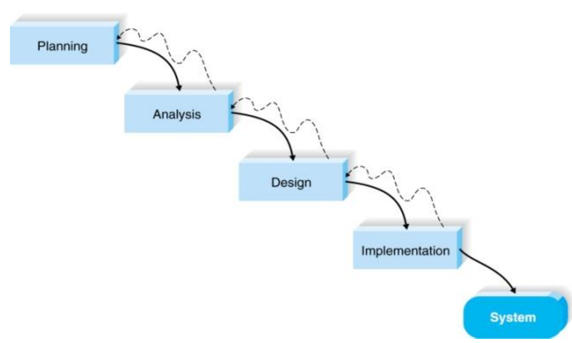

Figure 3: Waterfall model methodology.[9]

Applying the concept of waterfalls, the phases involved need to be solved one by one in order to follow the next phase to begin to ensure the smoothness of the project. In every software development phase, there is implementation for the purpose of project documentation so that the final result can be expected and improved. The activities conducted in every single phases included in this methodology are listed as shown in Table 2.

Table 2: Activities conducted in each phases of the selected methodology

Phase	Activity
Planning	• Review the background of the title • Identify problems • Determine the objectives and scope of the project • Undergo literature review • Create a project work schedule
Analysis	• Conduct research on project areas • Get suggestions from target groups • Analyze possible requirements
Design	• Design prototypes of web applications • Designing databases according to system requirements • Designing interfaces as needed
Implementation and Testing	• Translate design in code form • Identify the advantages and disadvantages of web applications • Conduct testing phase

4. SYSTEM AND HARDWARE DESIGN

4.1. Use Case Diagram

Use Case is a set of activities in the form of a diagram showing the interaction between the user and the system. This figure describes the relationship between users involved with different activities. In this proposed application system, there are two actors involved, which is Arduino sensor and the user. There are eight main functions in Pixelpot Tropical and the function has been described as in Figure 4. The potentiometer will detect soil moisture and then send soil moisture input to the application after receiving instruction from the user, while users can create visual plants and monitor plant developments through the application.

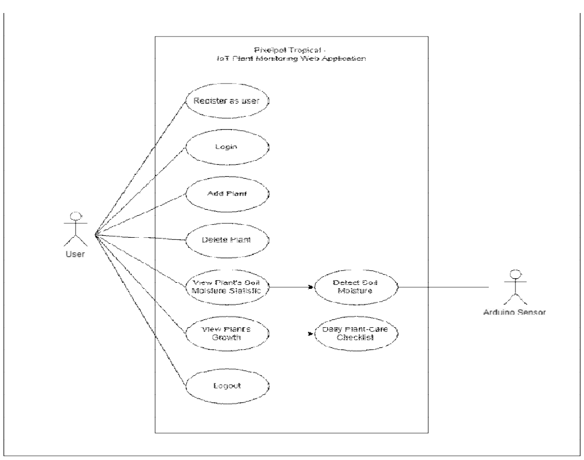

Figure 4: Use Case of Pixelpot Tropical Web Application

4.2. Hardware Configuration

This hardware consists of Arduino ESP8266 NodeMcu Lua WIFI Controller Board V3 and YL-69 type Arduino ground moisture sensor module. IoT board arrangement scheme to be installed according to the suitability of components as listed in the IoT requirements section [10]. Figure 5 describes the layout for the Arduino ESP8266 NodeMcu Lua WIFI Controller Board V3 as a WiFi connectivity function to transmit sensor data. Figure 6 describes the layout for installation between Arduino ESP8266 NodeMcu Lua WIFI Controller Board V3 and YL-69 sensor module with LM393 [11].

For installation and configuration of WiFi on NodeMCU (refer Figure 5), users should only follow the predefined schema guide. The LED foot should be connected to the GPIO (D4) above the breadboard. For installation between NodeMCU and sensor modules, the guide is as shown in Figure 6 and the settings are as follows:

1. Pin A0 sensor module connected to pin A0 on ESP8266
2. The GND pin on the sensor module is connected to the GND pin on ESP8266
3. The VCC PIN on the sensor module is connected to the 3v3 pin on ESP8266

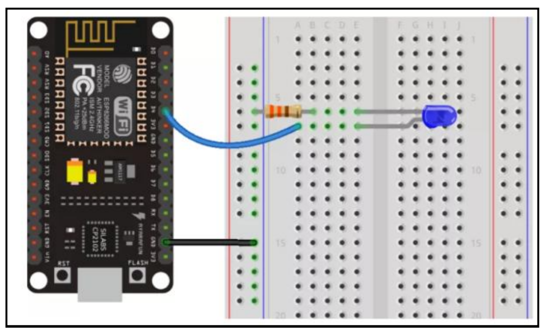

Figure 5: Wi-Fi configuration on NodeMCU .

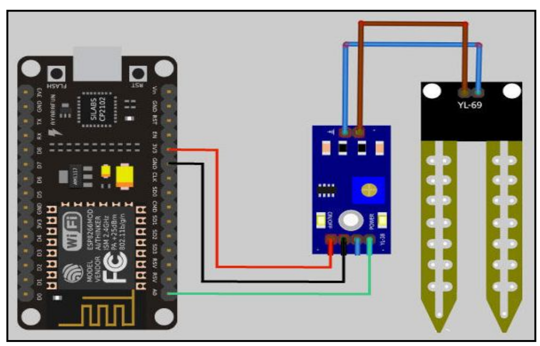

Figure 6: Installation of NodeMCU with the soil moisture sensor.

5. SYSTEM IMPLEMENTATION

Pixelpot Tropical is developed with Preprocessor Hypertext (PHP) programming language written in Visual Code Studio software to produce interface design. This section focuses on the implementation process of the proposed web. Figures 7 until 13 display an illustration of interface designs including check-ins, logins, dashboard, analytics, diaries, crop lists and the web for Pixelpot Tropical. The user must register a new account first before being allowed to login to the system. After login, users will be taken to a dashboard page where users can add new plants (for new users) or monitor existing crops. The crop removal function can also be done in this page.

Next, Figure 10 shows a calendar of gardening activity for the user. Users are allowed to add or delete notes in the activity calendar. Figure 11 shows the crop list interface that allows users to see info about plants such as plant scientific name, harvest duration and nutrition info. Figure 12 shows an analytical interface that shows the soil moisture graph on a weekly and monthly basis. Finally, Figure 13 shows the display of the hardware information used in the system and a brief analysis of the system.

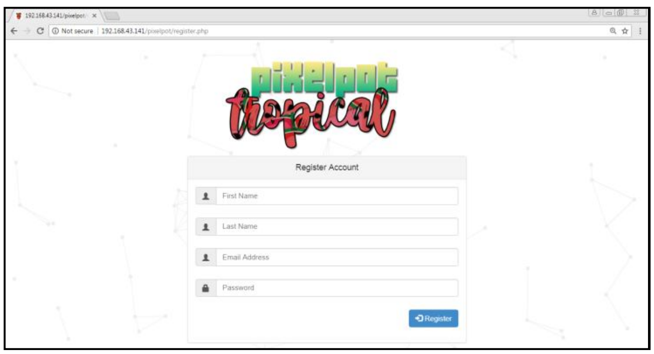

Figure 7: Register Account Interface

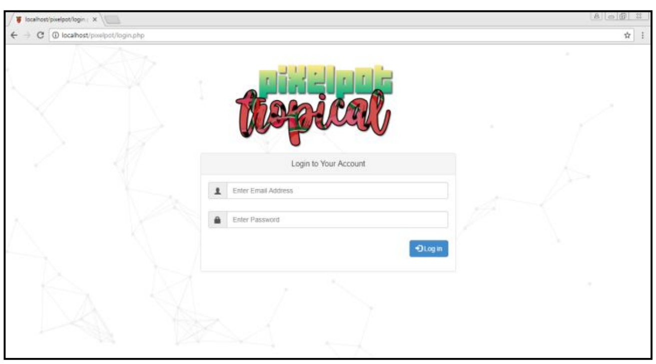

Figure 8: Login Interface

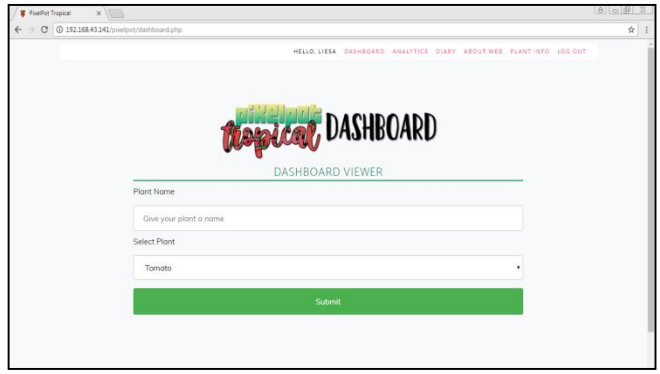

Figure 9: Dashboard page

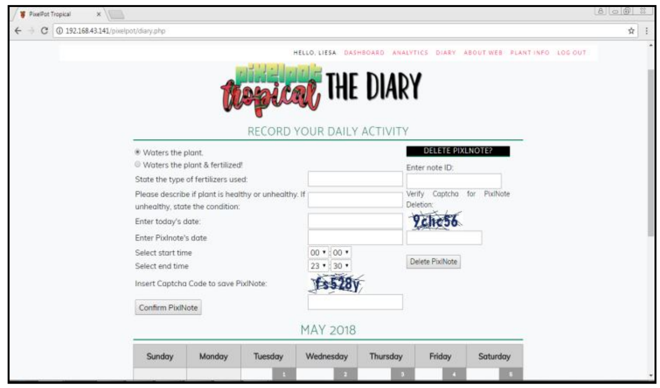

Figure 10: Diary for daily activity page

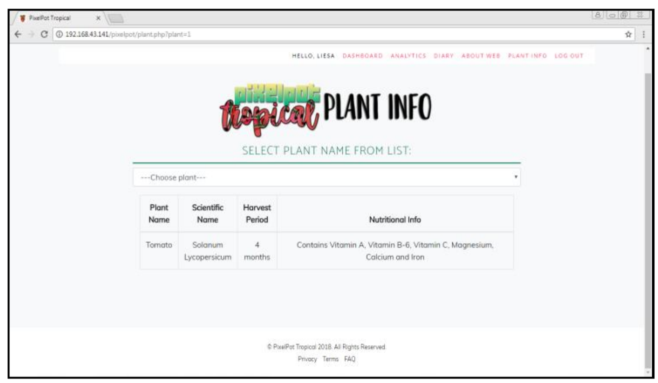

Figure 11: Page of plant information based on user selection

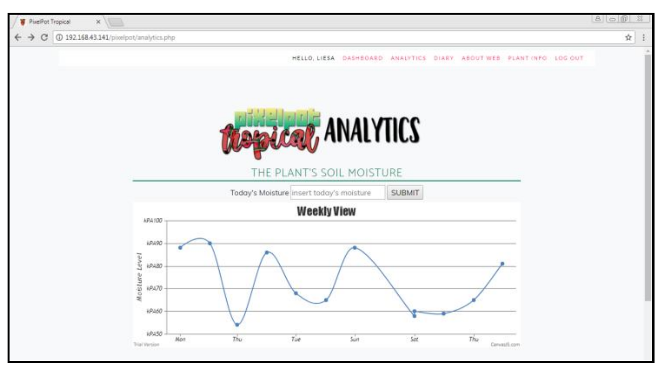

Figure 12: Plant's soil moisture analytics page

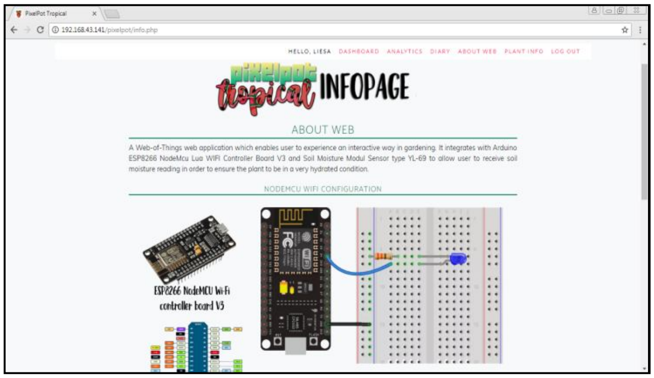

Figure 13: Hardware configuration tutorial page

6. RESULTS AND DISCUSSION

System testing is a test conducted to ensure the design and smoothness of the IoT system and hardware in full functionality. There are several types of system testing, i.e., user testing, load testing and service testing. For this project, user testing and user acceptance tests have been conducted to identify the strengths and weaknesses of the developed web. Target users have the opportunity to use this web for the purpose of ensuring that this web application can be used with full functionality. This test becomes a benchmark for developer to make the final changes before being displayed for users.

The tests are carried out among 30 respondents. As for the acceptance test, 87% agreed that the content layout are suitable and very practical towards the target users. The interface design for Pixelpot Tropical are majorly rated as a user-friendly user interface.

For the functionality test, the IoT hardware are tested to ensure the soil moisture rate are precise for every different plant. A percentage of 92% can be achieved as the IoT hardware are able to produce accurate reading and displayed on the LCD screen. The analytics of the daily soil moisture records are also displayed as graph and obtained 63% as it is easily viewable.

7. CONCLUSION

Pixelpot Tropical is developed to provide a platform for users to monitor the growth of tropical plants in their own home yard. This web application provides short-term tropical plant info, which is harvested for less than a year. The information provided includes scientific names, harvest periods and nutrition info so users can know about the advantages of each crop that you want to choose. The integrated system of electronic hardware has also made the system an "Internet Of Things" web application capable of transmitting data from the ESP8266 NodeMCu Lua Wi-Fi controller board to the Pixelpot Tropical web. Additionally, the web uses an email notification function which will send a warning to registered users about their crop's moisture rate.

With this web application, users can see the moisture content of the soil for their crops and receive reminders to water the plants to keep the plants in good health. Some suggestions have been considered in order to improve the features. One of it is to continue the development of the Android app for Pixelpot Tropical so that crop monitoring is easier to do as it is portable and accessible anywhere.

ACKNOWLEDGEMENT

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