The Automation of Mobile Application to Manage the Rice Fields

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***Abstract* – The Internet of Things becomes increasingly prevalent. It is the inter-networking of physical devices and connected devices together. Soil and water management play an important role in the Agricultural smart farming. In this paper, the prototype of automation system for measuring and monitoring soil and water was developed to control the pH of the water, the level of water in the rice field by using the Internet of Things (IoT), and mobile computing technologies. The results found show that the system can solve the flood problem in the rice fields during the rainy season, and control the pH of water and soil for growing rice. They also suggest the farmers how to prepare the field to cultivate rice.**

***Keywords* –Automation system, Internet of Things (IoT), Soil and Water Management, Cloud, Mobile Application.**

1. Introduction

Thailand has grown rice as a food crop and a major economic crop for many years, Thai society has long been associated with rice. Also, it is one of the main foods of Thai people, and it still brings the income to the country.

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However, cultures and technologies from many countries have come and changed the rice trade targets, and now most of farmers use more modern technology such as irrigation systems, transport systems etc. All this is to provide and support rice production. In the 21st century, Agricultural Version 4.0 becomes the agricultural era of a paradigm shift to be innovatory for the farmers who should have knowledge, technology, processing, and marketing strategy altogether. Thailand 4.0 is the newest development model which develops Thailand in all dimension, and the agricultural sector is the main driver of this policy by using Smart Farming in order to increase the value of agricultural products. Nowadays, technology has evolved to help the farmers use less labor, and it can reduce production and time costs. With recent advances in Mobile Technology, it is possible to take advantage of these devices to design an application that educates, the application provides farming or cultivation with high precision, in a friendly environment in order to increase agricultural production and protect the environment.

According to Bouman et al [1], rice is planted in flooded fields by maintaining a depth of water about 5–10 cm. Rice can be grown in from sandy soil to clay, but rice is growing better in the clay because it can keep water longer. The pH is, in the range of 5.5-6.5, adequates better for rice cultivation. Water requirements regarding rice cultivation in Thailand are different due to the soil's ability, temperature and the type of rice. Therefore, water management in paddy fields is correlated with the growth of rice and the Internet of Things (IoT). It is a new technology linked with computers, cell phones, mechanical and digital machines, objects, animals or people to enable connection and communication with others through the internet [2]. AEROFARMS [3] is one of the commercial leaders in indoor farming businesses that focus on adopting the Internet of Things (IoT) comprising machine learning in order to cultivate closed indoor farming. The smart IOT system was developed on the measurement of physical parameters such as soil moisture content, nutrient content, and pH of the soil that plays a vital role in farming activities [4]. Therefore, this research aims at developing IoT solutions for automation system to control the soil and water management for rice fields.

The remainder of this paper is organized as follows. Section 2 presents the related works on the mobile application with IoT and section 3 present the system overview of this project. Section 4 describes the experimental setup based on the purposed model and section 5 shows the results of this research. Finally, the conclusion and future research are presented in section 6.

2. Related Works

IoT has been currently used in agriculture for different purposes. Kiruba and Vimaladevi [5] designed the precision farming to manage related resources by using wireless sensor network (WSN), and Hwang et al. [6] proposed an agricultural environment monitoring server system to manage information through wireless sensor network. The system consisted of related sensors CCTV, GPS, solar cell and etc. It is connected through internet. The result has shown that the system can increase the amount and the quality of productions. Arduino microcontroller was used to monitor automatic irrigation system in many case studies [7], [8], [9]. For example, Joaquín Gutiérrez et al. implemented the android application to monitor irrigation in agricultural fields [10]. In addition, the integrated management system for agriculture production by using a mobile device, sensor and GPS was used to support farmers to handle document tasks, and products in real time [11]. A remote monitoring system investigates temperature, moisture, and water level in the paddy crop field and analyzed data to a central server [12].

According to V. Gruhn and A. K¨ohler [13], the architectural framework for a mobile phone includes four main types as follows: web-based always-online architecture; rich client always-online architecture; rich client hybrid architecture and fat client offline architecture. SonaliTembekar and AmitSaxena [14] implemented the android application to monitor WSN from various WSN nodes and forward to the centralized database server.

3. The System Overview

Rapid Application Development (RAD) is used to implement this project, one of the system development techniques to speed up the development process and focuses on verification and validation [15]. RAD includes four basic steps as follow: planning requirement, user design, rapid construction, and cut over. In planning requirement phase, interview and questionnaires were used as a major instrument to get user's requirements and focus the boundary of this application. The prototype is used as an apparatus to communicate and design user interface design to define what features or functions user needs. However, this project which is based on mobile application consists of the presentation, business, and data layers to access and communicate with real-time cloud Service, was applied to easily connect easily to the database management and IOT equipment.

The system can be divided into 4 parts as follows: a user profile part, a learning and recommend part, a pH measurement part, and a water management part. Every subsystem is integrated with different sensors, devices and wireless communication modules, which are used to interconnect between server and computing devices. User control, the user interface board through the mobile and web-based application and database are an interactive function used to manage microcontroller. Figure 1 was presented in the system overview. In a user profile part, the system provides basic information for farmers including learning, and it is a recommend part that suggests the information and knowledge regarding rice crop. An automatic rice water quality monitoring system has been designed to be inspection sub for pH sensor and temperature sensor to remind farmers through a mobile application.

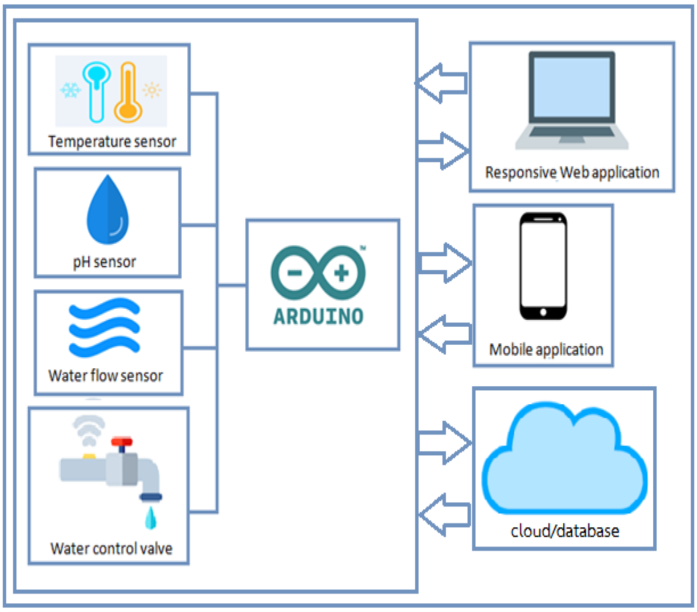

Figure 1. System overview

Also, a water management part controls and measures the level of water in a rice field. It will alert farmers when the level of water is exceeded at the indicated level. However, a mobile capability is limited to processing and cloud computing is adapted to serve this ability. Data is stored in the local, in order to prevent the loss of data, and it will be sent to the server computer immediately through the Internet connection. Moreover, the data is sent to the host computer, in which the data is managed and stored in the database. When users need to access the information, it can be requested via web service.

4. Experimental Setup

This section presented the related equipment and experimental processes adjusted to collect the data and control the system presented in this paper. In addition, studying the relevant theories and related research, the related sensors measure the environment of soil and water, which were used by plugging the sensors with the board, and the lab equipment were consisted of the following: Arduino is an open source AVR family of microcontrollers, with hardware and software disclosures. The Arduino board is simple to implement and apply to other fields. Temperature and humidity sensors were adopted in this project to measure temperature, humidity a capacitive humidity sensor and a thermistor spit out a digital signal on the data pin. Table 1 was described the percentage value. pH sensor is a sensor for indicating the pH of the solution. The measured values display the ranges from 0 to 14 pH as it is described in table 2.
pH sensor module measures the pH from 0 to 14 and operates in the temperature range of 0 ◦ −80◦ C, and plugs via BNC connection and fig 2 was shown the pH value.

Table 1. The measurement levels of the soil's moisture

condition	indicated value
Dry soil	0 32 –%
Humid soil	33 – 74 %
In water (soil soggy)	75 – 100 %

The water flow sensor is a significant sensor, designed to evaluate the level of water. Moreover, the experimental performance of automation control soil and water management system was elaborated in figure 2 (a) and (b).

Moreover, the system still records the values obtained from the sensors according to a user setting, and the application retrieves and displays information from the database through the web application. Cloud-based system is used to store data and service, in the manner that users can manage and monitor the information and function as user's requirements.

Table 2. The output of pH electrode [16]

VOLTAGE (mv)	pH value	VOLTAGE (mv)	pH value
414.12	0.00	-414.12	14.00
354.96	1.00	-354.96	13.00
295.80	2.00	-295.80	12.00
236.64	3.00	-236.64	11.00
177.48	4.00	-177.48	10.00
118.32	5.00	-118.32	9.00
59.16	6.00	-59.16	8.00
0.00	7.00	0.00	7.00

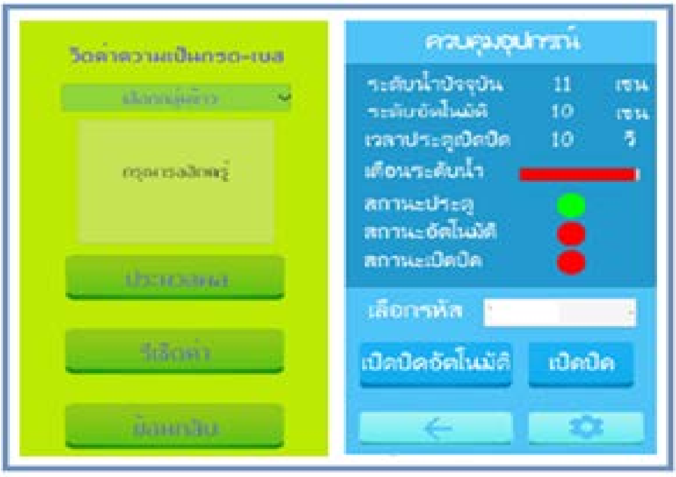

Figure 2 (a). The user interface of the application

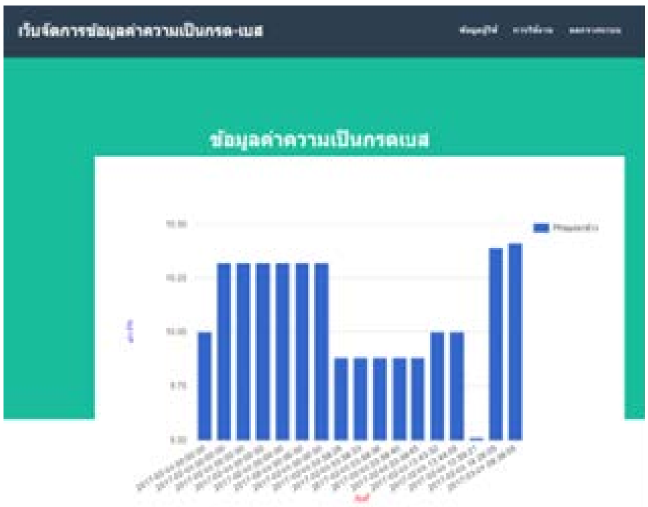

Figure 2 (b). The user interface of the application

5. Experimental Results

As far as testing and evaluating the prototype of automation system to control soil and water management in paddy fields are concerned, black box testing and questionnaires with experts were applied [17]. Black box testing approach is tested without regard to the internal structure, and it evaluates functions according to user's requirements. User's satisfaction was evaluated by the questionnaires by the mean (x) and standard deviation (SD) to assess the qualities of the project, and table is exemplified the result of user's satisfaction.

Table 3.The results of user's satisfaction in the ability of the system

	Experts and Users	
	$\bar{x}$	**SD**
The ability of the system		
1. to provide information	4.50	0.85
2. to display the linked menus	4.60	0.70
3. to search information of system	4.70	0.67
4. to response time as user needs	3.80	0.42
5. to work and access functions automatically	4.70	0.48
6. to manage the database	4.80	0.42

Table 4.The results of user's satisfaction in the accuracy of the system

	Experts and Users	
The accuracy of the system	$\bar{x}$	**SD**
1. to display information and knowledge	4.57	0.79
2. to information retrieval	4.57	0.53
3. to update information as user need	4.43	0.53
4. to store information	4.86	0.38
5. to report information and display in appropriate user friendly interface	4.00	0.52
6. the overall system functions	4.57	0.60

Table 5. The results of user's satisfaction in the suitability of the system

	Experts and Users	
The suitability of the system	$\bar{x}$	**SD**
1. to easily use the system	4.60	0.7
2. to display text and graphics clarity	4.7	0.67
3. to use a suitable colour theme	4.7	0.67
4. to present data presentation	4.5	0.53
5. to show user interface	4.4	0.52

Table 6. The results of user's satisfaction in the speed of the system

	Experts and Users	
The speed of the system	$\bar{x}$	**SD**
1.the speed of program as a whole of the system	4.50	0.71
2. the speed of time to search data	4.40	0.70
3. the speed of data presentation	4.60	0.70
4. the speed of access the related link	4.30	0.67
5. the speed of time to edit data	4.60	0.52

Table 7.The results of user's satisfaction in the security and verify data speed of the system

	Experts and Users	
The security and verify data of the system	$\bar{x}$	**SD**
1. the security and verify data to set the permissions for using	4.50	0.97
2. the security and verify data to determine a user account	4.50	0.85
3. the security and verify data to verify the accuracy of input data	4.60	0.70

The table (3-7) displays that assessment of the performance regarding the prototype system, which meets the needs of the user's requirements in the average of 4.52 and standard deviation of 0.59. Black Box testing has tested the error of the project as following: functional requirement test, function test, usability test, performance test and security test [18] as shown in figure 3.

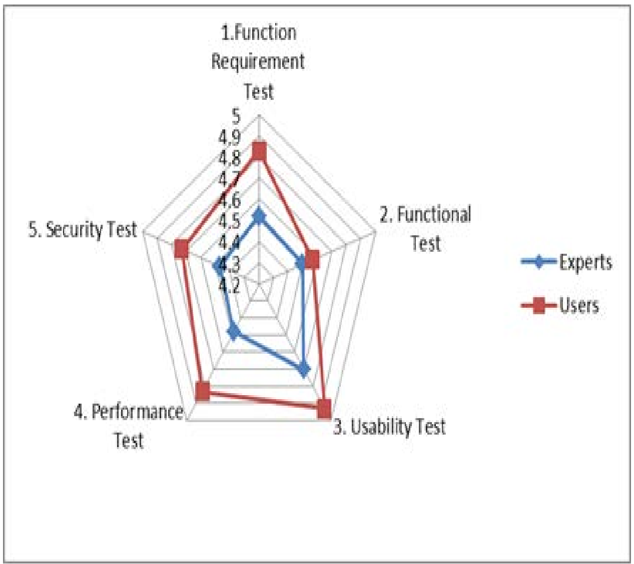

Figure 3. The results of Black box testing

The results of the research showed that, in terms of the ability of systems audited by experts and users, it is appropriate in all aspects and can be concluded that the prototype of automation systems for controlling soil and water management can be appropriately applied in the field.

6. Conclusion

With the emergence of an information-driven society regarding agriculture, the developed prototype system could monitor and control the pH of the water and the level of the water as well, in the rice field by using the Internet of Things (IoT), web-based and mobile application. The results found that data file indicated the instantaneous status of the level of water, and the system can solve the flood problem in the rice field during the rainy season, control the pH of water and soil for growing rice and suggest the farmers how to prepare the field to cultivate rice through mobile devices. However, future areas of this project will focus on the security aspect and advanced technologies in order to support accuracy within agriculture.

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