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Smart water control system based on internet of things technology on android operating system for durian garden

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Abstract The IoT systems can reduce the gap between farmers' orchard management. This research focused on designing and developing a smart watering system in durian orchards and evaluating the system's performance. System Development Life Cycle (SDLC) was used to design the system operation, user interface development on the Android operating system with Kotlin language, and connect notification information via Line message API. Result proved to be the effective design and development of a smart watering system on the Android operating system. The receiver device, control device, and signaling device could work according to the function that had been set. The system was stable in operation. Developing a watering control system on the Android operating system displayed the operational status of watering scheduling and real-time monitoring display. The collected data displayed as graphics on the device screen. Farmers could control their works through the smartphone application screen. Alerts could be sent via Line application when soil moisture was less than 20% (critical point). The system performance evaluation found that the water pump is operated automatically and accurately. Moreover, the technology acceptance that affects farmers' satisfaction found that the perceived utilization and ease of use reveaed an excellent level ($\overline{X}$= 4.3 and SD = 0.55).

Keywords: IoT, Mobile application, Watering, Automatic watering

Introduction

Labor management in the agricultural sector by focusing on innovation and technology to apply, focusing on an economy driven by innovation (Value based economy) by modern farmers (Smart Farming), farmers earn more (do less, get more) by enhancing skills and potential of farmers to develop and transfer agricultural innovation technology for greater utilization (Office of

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Agricultural Economics, 2021). To transform traditional agriculture into a combination of cutting-edge technology, the Internet of things (IoT) has been used in many studies (Talavera *et al*., 2017). For example, to use agriculture to improve yield quality, IoT can be connected to various tools and equipment to facilitate control.

The majority of the population of Chanthaburi province is engaged in agriculture. Khao Khitchakut District and has an agricultural area of approximately 82,000 rai, and the average annual rainfall is about 2,500-3,000 millimeters (Climate center, 2022). Most areas are durian orchards where the growth factor is watering. Watering durians has 3 important factors: water, soil, and air. The main factor affecting crops for farmers is soil moisture that is unsuitable for crops. As a result, it may cause damage. Therefore, innovation and technology have been used to help plan farming (Pinnok, 2020). IoT technology has powerful applications in many areas, such as education, Smart Agriculture (Prasetyo and Yusuf, 2020), Smart City, Smart Home, and Smart Farming. The development focuses on information and communication technologies used in machines, equipment, sensors in the networked hi-tech farm care cycle and Cloud Computing (Dhanaraju *et al.*, 2022). From the problem of needing to manage the water supply appropriately and in order to comply with the policy of reforming farmers to modern agriculture.

Therefore, the research project was designed and developed an intelligent watering control system based on the Android operating system through wireless sensors that used the IoT technology to help facilitate automatic watering control, according to the environment suitable for the durian orchard. The research aimed to design an Android-based smart watering system architecture and user interface design to evaluate the performance of an Android-based smart watering system and the Technology Acceptance Model (TAM) that affects the satisfaction of smart irrigation systems for farmers.

Materials and methods

A smart watering system on the Android operating system is developed. The research project was conducted to study the system development life cycle (SDLC)which used in system development according to Bhavsar *et al*. (2020) which consisted of planning phase that started from planning operations, analysis phas that gathered the user needs from the interview and analyzed the watering problem of the farmers, design phase that concerned modeling, database structure, design input, and the user interface,and implementation support phase that developed automatic watering control system, system development, testing the automatic watering control system on android operating system, and installing that configured the watering system control kit and watering system application on the smartphone.

Research tools

The research tools were divided into the smart watering system on the android operating system, the evaluation form of a smart watering system on the android operating system from semi–structured interviews of 20 people, the technology acceptance assessment form affecting satisfaction with the intelligent watering system is based on the operating system by questionnaires of 30 farmers in Moo 10, Phluang Sub-district, Khao Khitchakut District, Chanthaburi Province.

Research process

The smart irrigation systems on android operating systems were conducted by interviews on durian water demand from 20 durian farmers.

A system based on IoTs technology was designed into 3 layers:-input layer i.e. environmental data through sensors (humidity & temperature sensor and soil moisture sensor), control layer consisted of a control panel of microcontroller NodeMCU, Relay, and database management and output layer consisted of watering control notifications via Line application with Line message API and information display for farmers. The control box device was used IoTs to connect to the relative humidity, air temperature sensor (DHT22) and the soil moisture sensor (Table 1). The soil moisture sensor sent a signal to control the opening-closing of the solenoid. A valve was used to control the water flow in the durian plots. The mobile application was designed to control the watering after analyzing the data. There were two ways of working through the application:-manual watering control and automatic watering on-off system according to the data obtained from the system processing (Figure 1).

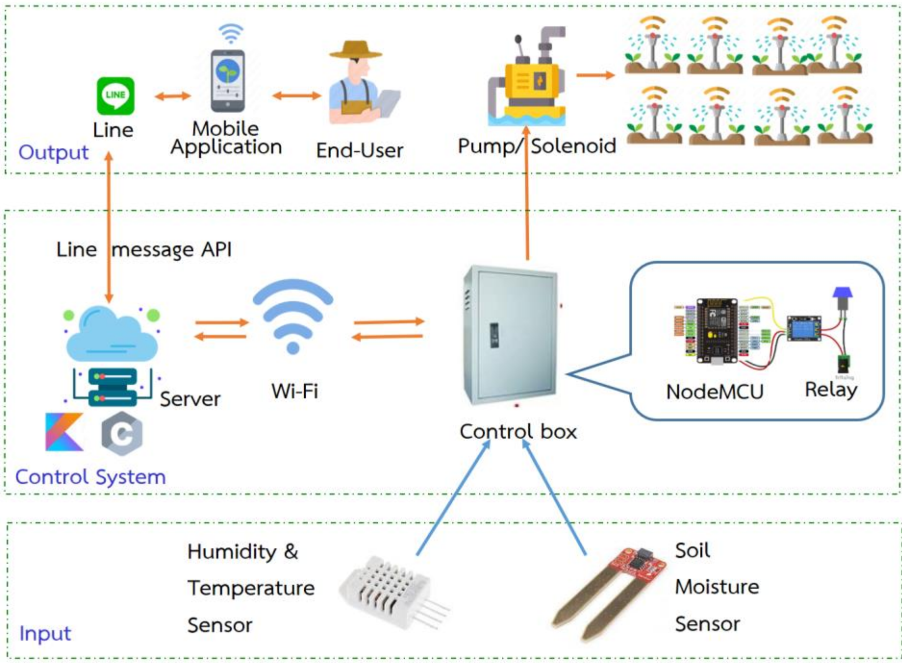

Figure 1. Overview architecture design of smart water System

Table 1. Deployment parameters

Parameter	Value	Voltrage/Power
NodeMCU	ESP8266	70-80mA
Soil Moisture sensor	LM393	3.3V - 5V
Temperature and humidity sensor	DHT22	2.5mA
Relay Module	1 Channel	5V, 5.0mA
Adapter	-	5VDC, 1mA
Solenoid	½ pastic	12VDC

Information system was analysed and designed a smart watering on the android operating system by using a case diagram and sequence diagram. The user is statred to log into the system, the manual operation may be selected which the user placed turn off the water at the specified time. The auto-operation is selected and the sensor will read. The soil moisture value was forwarded to the control section for processing with the condition that the moisture value in the soil was less than 20%, the program for watering the durian plots forwarded to Line and the users would know the problem. Then the data in the database are displayed to the application. The display shows a real-time soil moisture monitor (Figure 2, Figure 3).

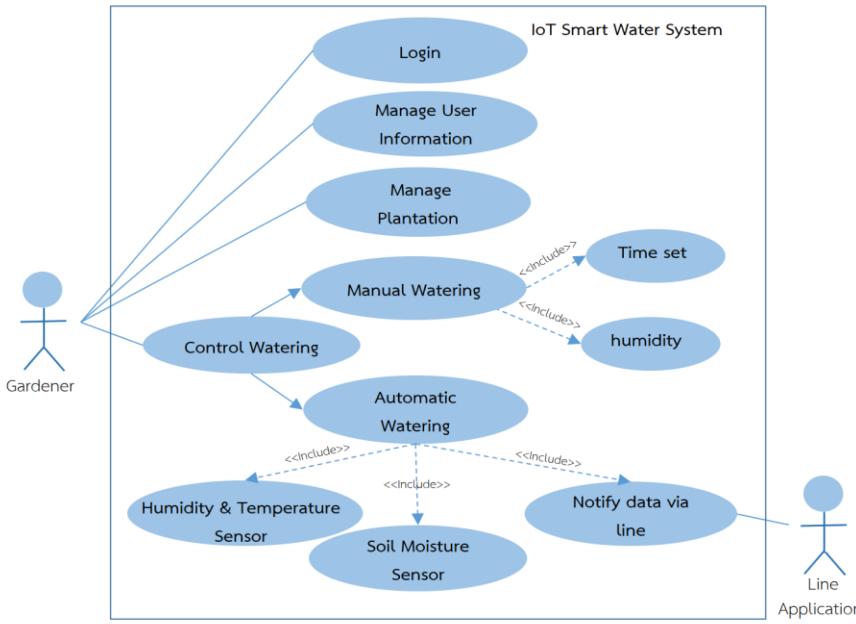

Figure 2. Using case of Smart water system

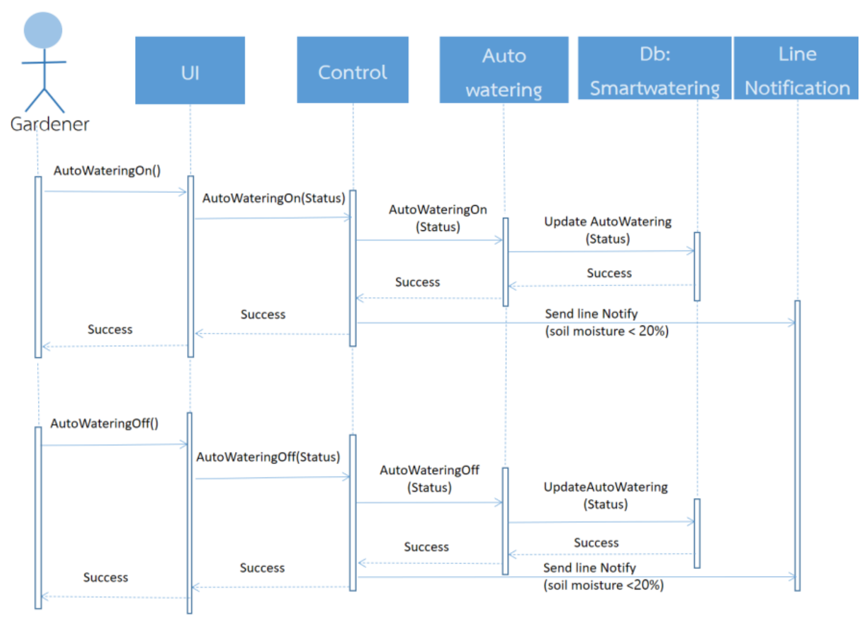

Figure 3. Sequence diagram of smart water: automatic watering

An automated water control system prototype was developed which based on the android operating system to monitor, control and operate both manual and automatic watering with an application-developed system.The IoTs are connected the board to various devices and sensors to be developed in C language, which is stored the data in a MySQL database.API (Application Programming Interface) was accessed the environment through the Line application to notify when the environment drops to the specified criteria. For this criterion, the durain farmers were interviewed by determining the measurement of the temperature sensor, relative humidity and soil moisture. The data were transformed to the server to be suitable for the durian orchard.

Prototype installation and run the prototype is shown in Figure 4, operation control unit (A) water pump for testing(B), and test plot and system(C), which were evaluated in 2 durian plots in Phluang Sub-district, Khao Khitchakut District. Quality measurement of smart water control systems on the Android operating system and the tool's efficiency were evaluated.

Figure 4. Control unit (A), water pump (B) and test plot and system(C)

Results

The efficiency of the smart watering system

Result showed that a smart watering system on the android operating system on the farmer's agricultural plot in a durian orchard found that a smart watering system on the android operating system was configured to function according to needs.

The accuracy test of the irrigation system showed that if the soil moisture value were lower than the specified value or the soil moisture percentage was less than 20%, the system would command the water pump to work and alert with the lamp would be expressed on and stopped working when the soil moisture was higher than 20%, the system would deliver the signal to stop water pump and alerted with the lamp in off status (Table 2).

Table 2. Accuracy test of the system

No	Soil Moi (%)	Signal LED	Water pump	Via Line	Accuracy (%)
1	18	on	on	on	100
2	21	off	off	off	100
3	25	off	off	off	100
4	30	off	off	off	100
5	34	off	off	off	100
6	28	off	off	off	100
7	25	off	off	off	100
8	22	off	off	off	100
9	17	on	on	on	100
10	19	on	on	on	100
Average					100

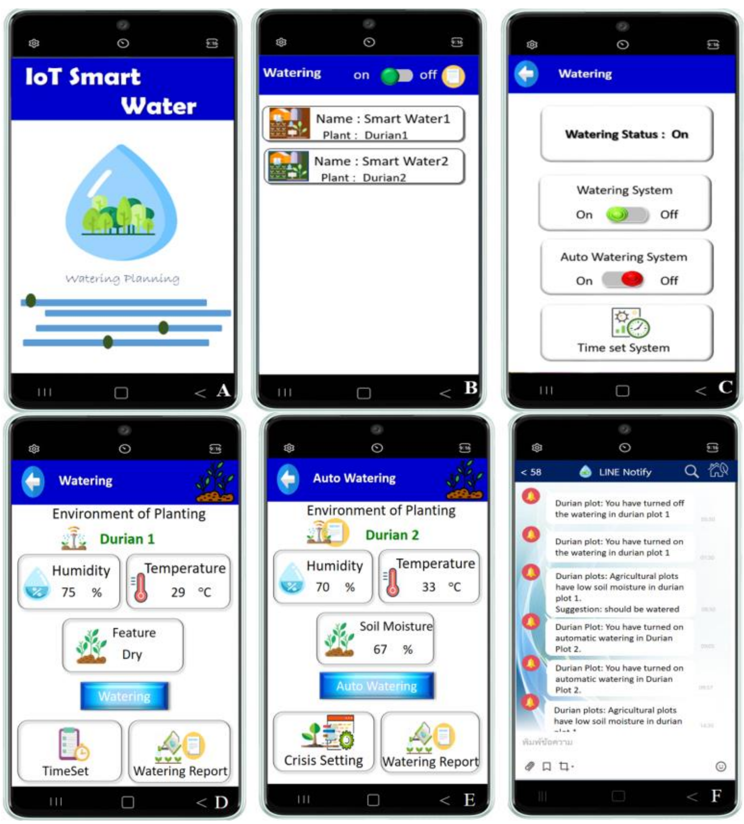

Figure 5. Using interfaces of watering control, screen (A) on - off the system B) status of watering or automatic watering (C), manual control (D), automatic control (E) and Line notify (F)

Design and development of automatic irrigation control system

System design and development (Dashboard) resulted to display the working status. For example, the watering time is set to be a real-time.

Furthermore, the collected data was displayed as graphics on the mobile device screen. The initial screen, opening order on - off the system, setting the active status of watering or automatic watering with timing displayed the functional status of the manual control device, the functional status of the automatic control device (E), and the notification result report via Line (F) are shown in Figure 5.

Technology acceptance that affect satisfaction

The adoption of IoT Smart Water by farmers, the smart watering system on the Android operating system in terms of utilization perception was $\overline{X}$ = 4.33 and SD = 0.54) which explained to be a high level. The perceived ease of use showed ($\overline{X}$ = 4.52 and SD = 0.55) which shown to be the highest level. The system showed an excellent overall performance ($\overline{X}$= 4.43 and SD = 0.55) (Table 3).

Table 3. Technology acceptance affecting system satisfaction

Items	$\overline{X}$	**SD**	**Opinion Level**
1. Perceived utilization			
You have confidence when using IoT Smart Water.	4.23	0.63	Agree
Do you think that using the IoT Smart Water system to control automatic watering is not complicated.	4.33	0.55	Agree
Do you think the functionality of the IoT Smart Water system is properly integrated	4.17	0.38	Agree
Do you think that IoT Smart Water can help solve watering problems.	4.47	0.57	Agree
Do you think that IoT Smart Water is useful for watering farm fields.	4.47	0.57	Agree
Do you think IoT Smart Water can replace traditional watering methods.	4.47	0.57	Agree
Average	4.33	0.54	Agree
2. Perceived ease of use.			
Do you think IoT Smart Water is easy to install.	4.53	0.68	Strongly Agree
Do you think the Smart Water application is easy to use.	4.53	0.57	Strongly Agree
Do you think that IoT Smart Water is convenient for monitoring soil moisture.	4.47	0.51	Agree
Do you think IoT Smart Water is convenient to monitor relative humidity.	4.57	0.51	Agree
Do you think IoT Smart Water is more convenient than traditional watering.	4.50	0.49	Agree
Do you think you want to use IoT Smart Water continuously.	4.47	0.49	Agree
Average	4.52	0.55	Strongly Agree
Overall average	**4.43**	**0.55**	**Agree**

Discussion

Design and development of a smart watering system in a durian garden based on the Android operating system, connecting Embedded systems, sensors, and microcontrollers that can monitor and display the environment. The system can control the device to allow water to pass through the smartphone, and the acceptance of technology that affects the satisfaction of farmers who use the system.

System accuracy test resulted that the working order in the system is accurated and stable. It can be seen that if the moisture content in the soil is lower than the specified value, the system will work and alert with the lamp will be operated. On the other hand, the system will stop working when the moisture in the soil is higher than the preset, and the alert with the lamp will be in the off state which average working accuracy of 100%.

The results of the design and development of the automatic showed that the watering control system was designed to connect an IoT device (Node MCU) with an Arduino board and sensor system, along with application development (Punpitak *et al.*, 2021). The system uses language that is easy to understand, allowing users to understand the configuration and control of automatic watering easily. Farmers can use a wireless network to control their work through the smartphone application screen. The water supply will stop when the preset is reached (Ridwan *et al.*, 2020). The result can be monitored in real-time and notified via Line Application to the smart device according to the specified conditions (Muangprathub *et al*., 2019).

The results of technology acceptance affecting satisfaction with the system were divided into 2 parts. First, the study's utilization perception was high ($\overline{X}$= 4.33 and SD = 0.54). Second, the study's perceived ease of use was high ($\overline{X}$= 4.52 and SD = 0.55). It summarized that technology acceptance affected farmers' satisfaction with the system. The system's overall efficiency was at an excellent level ($\overline{X}$= 4.43 and SD = 0.55), which could reduce the problem of environmental management in the durian orchard and the problem of controlling the irrigation system, and an important factor of plant growth. plants (Patil and Shah, 2019; and Pinnok, 2020).

Design and development of a smart watering system in a durian garden on the Android operating system are developed. It can work accurately to meet the needs of actual users. It can be solved a solution to the watering process to promote the growth of durian, and enabled the farmers to save time and reduced labor costs.

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