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Research Article

Smart Sustainable System Development for Indoor Planting Prototype

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Abstract

The past decade has seen significant advancement in the field of agriculture industry. Various smart appliances such as cellular phones, moisture sensors, humidity sensor and smart irrigation are set to realize the concept of a new smart farming with the help of latest technology. In Malaysia, farmers experience crop damage and decrease in plant quantity and quality because they unable to monitor the crop all day. The development of a monitoring system that can helps farmer grow crops is enticing demand for busy individuals with physical limitations. Global System for Mobile Communication (GSM) technology, which has emerged in the late 1970s, is an ideal solution for this problem. In this paper, a development of intelligent system for alert notification in indoor planting is presented. This paper describes an application of GSM technology for monitoring light system in indoor planting with the use of hardware component like Arduino board, GSM SIM900A, LDR and LED strip. The major role of this system is to enable farmers to get notified when the light system for their plants is down through GSM SIM900A. Each time the light system is light on and light off, the farmers will receive an SMS to notify them. System functional testing was carried to evaluate the performance of implementing GSM SIM900A whether the prototype is free from error or there are a few errors occurs. The results shown that, the system is well functioning for alert notification in indoor planting monitoring. In conclusion, the development of intelligent systems for alert notification in indoor planting was developed using Arduino and GSM SIM900A to able farmers notified about their indoor planting when to be monitored.

Keywords: GSM Technology; Monitoring; Indoor Planting; Intelligent System; Arduino

Introduction

In agriculture, the very important things are first to get information about soil fertility, second to measure soil moisture content and the third is the analysis of the light needed by plants to ensure healthy growth. Light is one of the most important factors for the growth and development of plants, which in essence is an electromagnetic radiation that can be radiated from a natural or artificial origin. When using artificial light, it is possible to expose and add more interesting features to control plant growth and development [1]. There are different techniques available for supply light to plant that are used other than depend on sunlight. In a modern world, we are trying to introduce and use the new light management techniques to effectively supply light to plants. Automatic light sensor is a replacement for traditional lighting, which is the sunlight. This lighting system will automatically turn on when no light is detected while when the system detects light, the light will automatically turn off. Indoor planting is often proposed as a passive approach to air quality improvement [2]. This system is suitable for indoor planting that have limitation to get sunlight.

On the other hand, indoor planting is a way of growing the plants entirely indoors and it is usually related to the greenhouse. This is because this planting method mostly deploys the artificial lights to replace the sunlight and implements some growing methods such as hydroponics to provide the plants nutrients and other basic requirements for growth. This planting method has a significant improvement, then before as the plants and crops are not exposed to the uncontrollable natural environment. Moreover, the scale can be large or small, and a wide variety of plants can be grown indoors such as the vegetables, herb, spices and fruits.

With a more advanced way, indoor planting nowadays is mostly related to the concept of precision agriculture. Theory explained that plant could be grown hydroponically but however in gardening practice, it is usually reserved for exotic plants and culinary herbs. Hydroponics allows plants to be grown in a completely controlled environment, soilbornt-pests-free and free from diseases as well. Delicious product can be obtain without using dangerous herbicides and pesticides by carefully monitoring nutrients, temperature, lights level and nutrient water level or solutions level. As described above, precision agriculture (PA) is a theory of farm management based on observation, calculation and response to variability in crops. For example, predictive analytics can be performed to make a more intelligent decision based on real-time data on environment, soil and air quality, plant maturity and even equipment, labor costs and availability. PA is provided for improving yields, reducing pollution by misuse of chemicals, and providing better management decision information. However, there is a key enabler to the previous mentioned PA in order to make the PA to function well. It is the sensor. Undeniably, the PA will use numerous types of data, such as the temperature, light intensity, air and soil humidity and even the nitrogen content of the soil to perform the predictive analytics and also some follow-up action. Thus, the sensor is playing the most important role in the PA and cannot be replaced or ignored.

In the past, the common indoor planting system required to set up, the steps for installation is many as well, and it required daily monitors to ensure proper growing conditions. When growing plants, pests and bacteria can significantly affect the health of the plants. It will definitely involve environmental predators that can cause harm. To avoid this harmful pests, UV light as a grow light is used in indoor planting. However, UV has its own drawback which is harmful to human skin. That is why LED as grow light is the best tools to use as an artificial sunlight [3]. It is very important for the owner to manage their plant growth as indoor planting needs different management compare to infield planting. Thus, if the owner has work to do outside from home for more than one day, it will be burdened for them to monitor their light system. The intelligent system for alert notification in indoor planting is developed aims to address the following problems.

First, the owner did not alert when their system is breaking down. When the light system for indoor planting is broken down, the plant will be loss source of light. So the growth of the plant will interrupt and the yield will also decrease. Second, the labor feels burdened to always supervise and monitor the functionality of the system. A lot of time needed to manually check the light system. For larger industry, labor work to check light system manually is not efficient and contribute to ignorance. This project invents an automatic light sensor for indoor planting to ensure the plant gets sufficient lighting for growth and will notify the farmer through SMS in order to help farmer monitoring their indoor planting in an easier way that less time consuming.

As a summary, this project proposes a development of intelligent systems for alert notification in indoor planting with the use of hardware component like Arduino board, GSM SIM900A, LDR and LED strip. The projection system is expected to perform some automatic processes such as maintain sufficient light for plant growth and give notification for the farmer. Although the installation of light system for indoor planting cost high, but it will be used again and again in the future to balancing the food crops for a growth of population and profitable way for farming [4].

Method

Table 1 below shows the project phase that involves during the development process, and all the development implementation of intelligent systems for alert notification in indoor planting are followed by this methodology. Before starting the system development, a lot of information needs to be gathered, such as understanding the problem statements, defining the benefits, defining the feasibility studies, analyzing user [5] requirements and assigning a task in the sub-task to develop a suitable system and functioning as user needs. Finally, it will generate a project range and move to the next stage, that is, information gathering after completing all the process involved in this phase.

Phase	Activity	Objective
Planning	Understanding problems and opportunity Sub-task allocation Identify the current problems solving requirement	To design intelligent systems for alert notification in indoor planting using Arduino board and SIM900A GSM
Information gathering and requirement	Identify the current problems solving requirement Enforcement and locating data Develop project specification for current problem solving Develop project specification for current problem solving	
Information analysis and design	Analyse the information gathered Understanding the purposed of project Design prototype Create flowchart Design interface	
Implementation	Install the software requirement Create system layout based on database design Develop a user interface and database using information from design documentation	To develop an intelligent systems for alert notification in indoor planting that has a connection with GSM SIM()A to notify when the light sensor is on and off
Performance evaluation	Testing the functionality of each user requirement to meets the objective Ensure that all the requirement been match with prototype development	To test the functionality of each systems requirement for ensuring the project is giving benefits to user

Table 1: The project methodology.

Planning

In this phase, it involves the process of planning for this project. Before starting the system development, a lot of information needs to be gathered, such as understanding the problem statements, defining the benefits, defining the feasibility studies, analyzing user requirements and assigning a task in the sub-task to develop a suitable system and functioning as user needs. Finally, it will generate a project range and move to the next stage, that is, information gathering after completing all the process involved in this phase [6].

Information gathering and requirement

In this phase, the process would concentrate more on the initial stage of development by gathering all the necessary information such as defining the problem statement and determining which issue is more relevant and needs to be more centered. Besides that, the necessity to collect information using the observation technique, where it is one of the available methods to obtain the information.

Information analysis and design

In this phase, it involves the process of analyzing data gathered. Review of the collected data is very critical as it includes the process of understanding the project's intent before designing the framework in this stage. This process is important because it will not give a clear picture of the user's requirements without analyzing the data and information. Thus, it can help to get a clear picture of user problem by using analysis of the current situation issue. All the data will be reviewed to meet specific criteria for the next step. Eventually, it will be delivered in project proposal after completing all the activities that are evaluating and highlighting the important data in this process [7, 8].

In this phase, it involves the designing of system flow or flowchart where it will fully describe the flow of the system. In order to develop this project, the system flow is divided into three parts which are LDR, LED strip, and GSM SIM900A. All those three parts of the system have a different flow and task assigned. Figure 1 below shows the combinations of all the three parts. The figure shows the exact system flow for development of intelligent systems for alert notification in indoor planting. The system will detect light by using a light dependent resistor (LDR). When the LDR detect light, automatically the LED light strip will turn off. After that, the user will receive a message that informs them that the indoor planting light system is off.

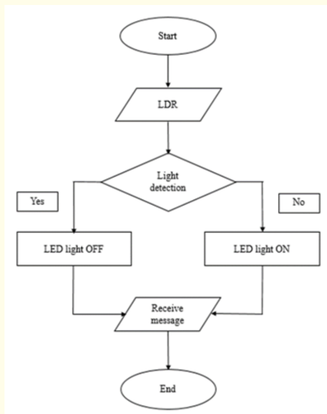

Figure 1: The system flow.

Development of intelligent system for alert notification in indoor planting is a hardware tool that can be used as a standalone system. Figure 2 below show the early hardware prototype interface design. This figure shows the early version of hardware prototype that will be developed using the Arduino board. All the circuit board and wiring are placed in the circuit box to ensure the comfortable look and more reliable while the aquarium is used as a medium that represent an indoor room. All the hardware will be configured and program so that it will fully function, meets the objective and can be used.

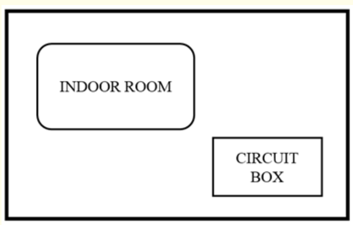

Figure 2: Hardware prototype interface design.

Implementation

In this phase, it involves the process of converting from the design phases into the system. It will also include coding to execute the process of converting. The method will create the actual system based on the design phase and its own coding. The implementation phases will be developed by using the Arduino microcontroller platform and GSM SIM900A. The Arduino platform has been used for the prototype project where it's able to provide all the needs for this project [9].

Performance evaluation

In this phase, it involves the process of testing all the functionalities of the system. The system functionality testing is conducted in two different ways which are in-lab testing and field testing. The functional testing is carried out to ensure that the device implementation performs well and works according to the requirements of the model. At last, functionality testing must check that after being completed, the system is fully functional. The system will be tested to evaluate the performance, whether it meets user requirement or not. If this system meets user requirements, then the system able to continue to the next phase where it will be enhanced. While if this system does not meet user requirements, improvement need to be done to ensure that the systems meets user needs and expectations.

Results and Discussion

This project focuses more on the stand alone project, where in real working prototype, it can be properly working without any intention using the computer. Figure 3 below show the real prototype of the project.

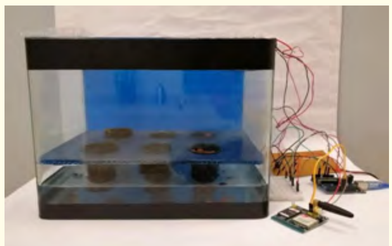

Figure 3: Prototype project interface.

Assessment of system functional testing

System functional testing has been made to ensure that the function meets the requirement and do not have errors. The functional testing being conducted after the development and implementation has fully completed in order to give more accurate and free from any error mistake. Functional test required user to evaluate whether the prototype is free from error or there are a few errors occurs [10-12].

Hardware	***User***	
	Free from error	***Error***
GSM SIM900A		
i.Receive message	28	2
LDR		
i.Able to detect light	29	1
LED Strip		
i.Able to emit light	30	0

Table 2: Result of system functional testing.

Based on Table 2, it shows the result of functionality for the whole hardware module. The project is being tested for 30 times to get a better result. Based on the result, there are three times that has an error occurs during the functionality testing. Two errors occurred during the receiving message process. Another error is occurring when the LDR cannot detect the light. Regarding to all errors, error during the receiving message process are due to the GSM SIM900A not ready yet and not establish connection with mobile networks. This error can eliminate by waiting the GSM SIM900A to establish a connection first by observing the LED status that continuously blink every 3 seconds.

Lastly is when the LDR cannot detect the light. Since LDR operate via sending the wave, thus it is impossible to control the wave signal because it cannot be seen by human eye. This error can only eliminate by upgrading the LDR with the most accurate module and precise. Since this project using the cheapest hardware module, thus it will may result in inaccurate performance [13].

Assessment in-lab testing

In-lab testing has been made to ensure that the function meets the requirement and do not have errors. The in-lab testing being conducted after the development and implementation was fully completed in order to give more accurate and minimize error. In-lab testing required user to evaluate whether the prototype is free from error or there are a few errors occurs.

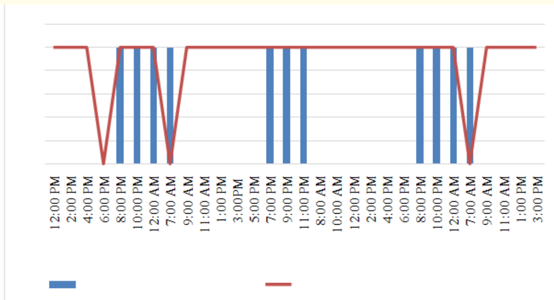

Figure 4: Result of in-lab testing.

Based on Figure 4, it shows the result of in-lab testing. The project is being tested for 30 times randomly to get a better result. Based on the result, there are three times that has an error occurs during the in-lab testing. A first error occurred during the fourth trial. The second error is occurred during eighth trial and last one is when the twenty sixth trials [14].

An error that occurs during the trial process are due to the GSM SIM900A not ready yet and not establish connection with mobile networks but the LED strip light still well function. At that time, the system is just activated and not well stabilized. When the connection is not established, the user will fail to receive messages that inform the status of the indoor planting light system [15]. This error can eliminate by waiting the GSM SIM900A to establish a connection first by observing the LED status.

Overall, there is 10% error occurring during in-lab testing and no error occur is 90%. This error is occurring on the GSM part only while the LED strip is well functioning. In order to avoid error occur in the future, user need to ensure that the GSM SIM900A already establish a connection and the wiring do not have any problems such as a loose wire installation.

Assessment of field testing

Field testing has been conducted in the real indoor planting environment for a week to ensure that the system functions well. The data are collected during the peak time and the attribute recorded include the Lux light meter and the weather at that time. Field testing required user to evaluate whether the prototype is free from error or there are a few errors occurs [16, 17]. The indications are did the user receive or not receive the SMS and did the LED strip are light on or light off.

Peak time	LED Status		Average LuxLight Meter
	Light ON	Light OFF	
7:00 AM	100% (7)		23.86
7:30 AM		100% (7)	172.43
8:00 AM		100% (7)	421.57
12:00 PM		100% (7)	1887.86
12:30 PM	14.29 % (1)	85.71% (6)	1705.71
1:00 PM		100% (7)	2251.29
6:00 PM	14.29 % (1)	85.71% (6)	398.57
6:30 PM	14.29 % (1)	85.71% (6)	165.14
7:00 PM	100% (7)		6.86
12:00 AM	100% (7)		0
12:30 AM	100% (7)		0
1:00 AM	100% (7)		0

n = 7

Table 3: Result of field testing.

Based on Table 4.5, it shows the result of field testing. The data are collected during the peak time and the attribute recorded include the light meter and the weather at that time. Based on the result, there is no error occurs at 7:00 AM and 100% the LED strip is light on. The average Lux light meter is 23.86. At 7:30 AM, the LED strip is 100%light off and the average Lux light meter is 172.43 while at 8:00 AM, the LED strip is 100% light off and the average Lux light meter is 421.57. The average Lux meter at12:00 PM is 1887.86 with 100% LED strip light off. However, at 12:30 PM and 6:00PM, the status of LED strip light on is 14.29% and LED strip light off is 85.71%. The LED strip is light on even the Lux meter recorded is above 50 because there is an error occur at that time.

Next, the average Lux light meter recorded at 1:00 PM is 2251.29 and the LED status is 100% light off. However, at 6:30 PM, the status of LED strip light on is 14.29% and LED strip light off is 85.71%. This is because there is one time in the week that the LED strip is light on in that day due to rain and the Lux light meter recorded is below50. When the surrounding environment record low Lux, the LDR will send a signal, thus the LED strip will light on [18].

The LED status at 7:00 PM, 12:00 AM, 12:30 AM and 1:00 AM record 100% LED strip light off respectively with low average Lux light meter recorded. Basically, the LED strip will light on when the Lux light meter is below 50 and will light off when the Lux light meter recorded is above 50. Based on the result, we can conclude that there are two times that has an error occurs during the field testing. First error occurred during the day 4 while second error is occurred during day 5 of field testing. Regarding to the errors, error during day 4 and day 5 are due to lose wire installation. Since the prototype is using a lot of wires and the installation of wires being conducted by untrained students, it has lower quality comparing to conduct by professional one. The wires interrupt the LDR to detect the surrounding light accurately. So even the surrounding light is high, the LDR cannot detect it thus LDR sending wave and LED strip is light on. This error can eliminate by conduct a proper installation of wires by solder it properly or assign the task to the trained person. A good installation of wire will not interrupt the LDR even the weather is rainy and windy.

The error can detect by user because the system notified the user through the SMS. At12:30 PM and 6:00 PM, the weather is fine at the Lux light meter recorded also above 50 [19]. So, when the LED strip light on and the user receive a notification, an error that occurs can be detected although there are there or far away. This result shows that the development of this system function well and proved that this system helps user to monitor their indoor planting system.

Conclusion

An intelligent system for alert notification in indoor planting had been developed in this project. The main goal of this system is to help an individual who conducts indoor planting, monitoring their light system more convenient and easier. The objectives of this system is to get notified when the light system down through Arduino GSM SIM900A and to reduce the burden of labor work to monitor the light system. The most importantly, intelligent system for alert notification in indoor planting should be user-friendly and even can be operated by the non-technical person. All the objectives are achieved by this developed intelligent system for alert notification in indoor planting.

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References

1. Y Xu. "Chapter 2.1–Nature and Source of Light for Plant Factory. M. Anpo, H. Fukuda, & T. Wada (Eds.), Plant Factory Using Artificial Light". Elsevier (2019): 47-69.
2. OA Abbass., et al. "Effectiveness of indoor plants for passive removal of indoor ozone". Building and Environment 119 (2017): 62-70.
3. A Nissim-Levi., et al. "Effects of blue and red LED lights on growth and flowering of *Chrysanthemum morifolium*". Scientia Horticulturae 254 (2019): 77-83.
4. M Boström. "Mind the Gap! A quantitative comparison between ship-to-ship communication and intended communication protocol". Safety Science 123 (2020): 104567.
5. YD Chuah., et al. "Implementation of smart monitoring system in vertical farming". IOP Conference Series. Earth and Environmental Science 268 (2019): 012083.
6. E De Keyser., et al. "LED light quality intensifies leaf pigmentation in ornamental pot plants". Scientia Horticulture 253 (2019): 270-275.
7. KO Flores., et al. "Precision agriculture monitoring system using wireless sensor network and Raspberry Pi local server". IEEE Region 10 Conference (TENCON) (2016): 3018-3021.
8. Fritzing (2019).
9. Ginger Software. Grammar and Spell checker (2019).
10. VD Gonçalves., et al. "Combination of Light Emitting Diodes (LEDs) for photo stimulation of carotenoids and chlorophylls synthesis inTetradesmussp". Algal Research 43 (2019): 101649.
11. Introduction to the Arduino IDE (2019).
12. A Jacobsson., et al. "A risk analysis of a smart home automation system". Future Generation Computer Systems 56 (2016): 719-733.
13. J Kim., et al. "The effects of indoor plants and artificial windows in an underground environment". Building and Environment 138 (2018): 53-62.
14. Maker lab Electronics. Distributor Electronic Product and Equipments (2019).
15. https://stats.idre.ucla.edu/sas/modules/sas-learning-moduleintroduction-to-the-features-of-sas/
16. TIP120 Transistor Pin out, Datasheet, Equivalent & Features (2019).
17. H Tnunay., et al. "Distributed nonlinear Kalman filter with communication protocol". Information Sciences 513 (2020): 270-288.
18. GM Toschi., et al. Home automation networks: A survey. Computer Standards & Interfaces 50 (2017): 42-54.

19. Y Zhou and J Duan. "Design and Simulation of a Wireless Sensor Network Greenhouse-Monitoring System Based on 3G Network Communication". International Journal of Online Engineering (iJOE) (2016).

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