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Plant Monitoring System for Vegetable Growers

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Abstract: The study aimed to design and develop a Plant Monitoring System for Vegetable Growers with android application. The developed system help farmers to water their plants according to its needs, determining the soil moisture, temperature and humidity with their respective sensors. A descriptive-development design was applied in the study. For the development of the system, the Systematic Engineering Process was employed. It deals with the development of hardware prototype, while Android Studio and Arduino Integrated Development Environment (IDE) were used to develop the software of the system to make use of its hardware. The functional acceptability of the system was assessed by one hundred twenty (120) evaluators consisted of farmers and agriculturists and IT professionals in compliance to hardware quality standards. The system was assessed in terms of functionality, durability, economy, safety, and saleability. The findings of the study revealed that the system performed its functionality well, with obtained adjectival rating of very good across three (3) groups of system evaluators. In terms of durability the system needs to be more durable to make it steadier and more substantial. In terms of economy, the system needs to use materials that are suited to make it more durable. The system is safe and ready to use by end user. The findings implied that the system was able to meet the criteria, specifically in safety, where the system exhibited an absence of harm when in use. The development of plant monitoring system could harness its power in sustaining production of plants or vegetables of farmers, thus, will contribute to the betterment of their lives through automated assistance in watering and monitoring plants or vegetables.

Keywords ***: Plant monitoring system, vegetable growers, system engineering process, sustainable production***

I. INTRODUCTION

The Philippine agriculture economy has been its backbone in contributing to the development of the country which employ about 40 percent of the labor force and 20 percent of GDP [1]. The advancement in agricultural sector has been pushed by introducing and implementing several new systems, practices, technologies, and approaches to augment to the national GDP [2]. To cope with the demand for food requirements, [3] reported that production must be increased by 70 percent to provide sufficient food for the fast-growing population and urbanization. It is expected that the rapid increase in the population will result to decrease in agricultural land, climate change and exacerbation of water resources [2]. Rapid industrialization and urbanization will lead to scarcity of food and production of agricultural production. With these, technology modernization could address the issues in agriculture, with prospective developments in technology and investments in the agricultural sector [4].

Technology makes people independent and makes lives easier. It helps people realize its importance in the environment. One of the boons to utilize and make profit from the environment is to produce plants and vegetables. Plants are very beneficial to all human beings in many aspects. It gives all creatures' oxygen to breathe and food to eat. Many people love to have plants and make a business out of it but due to financial constraints, lack of knowledge and the need of manpower can yield to an undesirable result. Food production may soon be affected due to limited water availability. The use of agricultural water is not sustainable in many locales around the world because of oil sanitization, ground water overdraft, and the over allocation of available surface water supplies [5]. This is aggravating the current situation about the sufficiency of water resources and allocation to support the needs on a long-term basis [6].

To monitor field parameters, there are technologies with sensors available which are embedded with microcontrollers in monitoring and measuring plants and vegetables. Interfacing devices with sensors have been reported but an embedded system for monitoring, measuring and controlling plants and vegetables required proper system implementation. Likewise, the data display should be available to farmers in a manner that is easy to access. This can be in a form of handheld devices which can be operated without great effort by a non-technical person like farmers. Through this, various ways of maximizing technologies available surrounding vegetation is optimized.

It is very essential to utilize the water resources in proper way. Thus, a system is required to handle this task automatically. The developed plant monitoring system has presets for different kinds of vegetable and then supplies the desired amount of water needed by the plant. It minimizes the excess use of water as well as keeping the plants healthy.

II. METHODOLOGY

The methodology used in this project was Systematic Engineering Process. This process deals with the development of hardware products for Arduino projects.

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It helped the developer to properly produce a better quality and more functional product. This process has four processes. This includes the planning, design, building, maintenance.

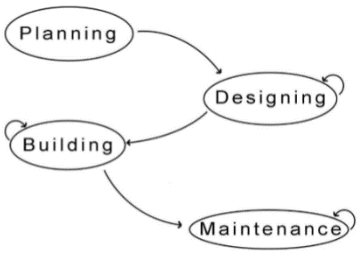

Figure 1. The System Engineering Process

As illustrated in figure 1, the Systematic Engineering Process is one of the most accurate approaches which are very essential for the development of embedded systems. The Systematic Engineering Process begins with specification of the requirements. Every process needs to be checked over and over until it satisfies the developer before it moves on to the next process. The planning process starts with the gathering of system requirements of the prototype and made sure that the system requirements was understood couple with the continued communication between and among the developers. In designing the prototype, the architectural, logical and the physical product output was finalized.

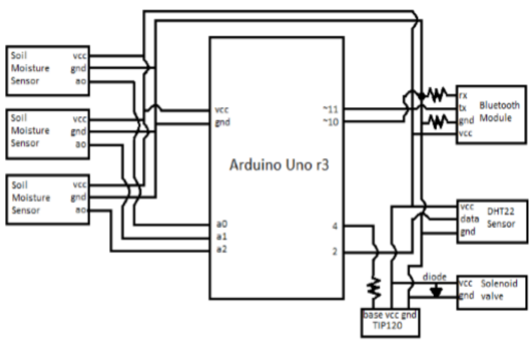

Figure 2. Schematic Diagram form for Plant Monitoring System for Vegetable Growers

Figure 2 presents the connections of the system. Strategic positioning of wires and resistors were designed to avoid short circuit and potential damage of the system. Although low voltage, there is still a chance that a sensor/module might be damaged since they have different ratings so further protection and safety measures were added. The Plant Monitoring System for Vegetable Growers was mainly designed for securing and monitoring the plants status.

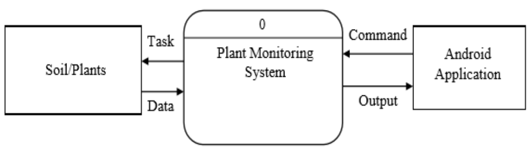

Figure 3. Context Diagram of the Plant Monitoring System for Vegetable Growers

The system gathers data from the soil and plants then display it through the android application. The application then sends a command to the system based on its received data and user input to water the plants accordingly.

After planning and designing of the prototype, the building process proceeded to the production of the actual system. In this process, the product has been visualized and the design is being developed. And the last phase is maintaining the system which included estimation and monitoring the technical feasibility and development risks.

III. RESULT AND DISCUSSION

The developed prototype was intended to help farmers know the soil moisture, temperature and humidity. The system controls the duration of watering the crops via android application. It assigns a schedule of watering the plants that can also be saved as a preset for every type of crop as illustrated in Figure 4.

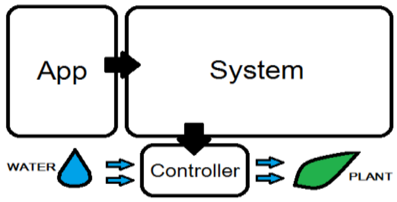

Figure 4. Structure and operation of the Plant Monitoring System for Vegetable Growers.

The android application receives the data that is sent by the system then displays them. It also sends the schedule to the system for it to follow. It all happens when both devices is connected via Bluetooth. The system has a soil moisture sensor and DHT22 temperature/humidity sensor for automatic adjustments of watering duration which is displayed in the android application as shown in Figure 5.

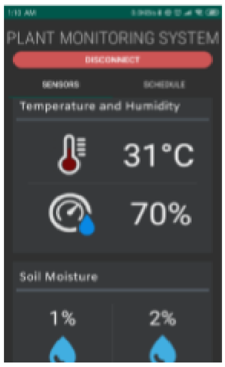

Figure 5. The android application with the data display.

Figure 6 shows the prototype of the Plant Monitoring System for Vegetable Growers. The system contained a soil moisture sensor which acts as a sensing element in the system. It was based on the embedded platform for water sprinkler system [7]. The project used Arduino micro controller which is used to process the information. The prototype is capable of sensing the moisture present in the soil and is powered by solar panel. The Arduino Uno R3 microcontroller controls the sensor. The YL-69 soil moisture sensor reads the set points associated to the system and will trigger the LED indicator.

Raw data ranges from 0-1023 where 0 indicates wetness and 1023 indicates dryness of the soil. The type of soil moisture content is measured in m3. Alternately, the volumetric soil moisture content can be referred to as a % of volume which the student researchers also used. The set-point is based on the converted digital inputs that are processed by the microcontroller unit. The soil is considered dry and in need of adequate water if it reaches the volume of 0-20%, 30-75% is considered normal and it is considered wet if the volumetric soil moisture content is 45-75% and higher.

Figure 6. The setup of the Plant Monitoring System for Vegetable Growers. The solenoid valve is connected to a water source then distributes it to the drip line hose that waters the plant sideways.

Evaluation Result

The study adapted a questionnaire for hardware quality instrument [8]. The acceptability of the system was assessed in terms of functionality, durability, economy, safety and saleability by three groups of respondents; farmers, IT experts and professionals from the Department of Agriculture (DA). The assessments of the developed hardware, the following results are illustrated:

Table 1. Summary Result of the Plant Monitoring System from the evaluation of Subject Matter Experts, IT Professionals and Potential Users of the prototype.

Indicators	Subject Matter Experts (n=30)		IT Professionals (n=30)		Potential Users (n=60)		Overall	
Functionality	3.70	VG	3.78	VG	3.92	VG	3.80	VG
Durability	3.60	VG	3.70	VG	4.00	VG	3.77	VG
Economy	3.65	VG	3.72	VG	4.01	VG	3.79	VG
Safety	3.88	VG	3.71	VG	4.13	VG	3.91	VG
Saleability	3.47	VG	3.59	VG	3.82	VG	3.63	VG
Overall Mean	3.66	VG	3.70	VG	3.98	VG	3.78	VG

It could be gleaned from Table 1 that the functional acceptability of the hardware prototype obtained an overall mean score of 3.78 with a verbal interpretation of very good from the evaluation of subject matter experts, IT professionals and potential users. This means that the prototype meet all the requirement specifications of the system. The prototype's functionality, durability, economy and safety obtained an overall mean of 3.80, 3.77, 3.79, 3.91 and 3.63 respectively, to denote very good across three (3) groups of evaluators; subject matter experts, IT professionals and potential users. The prototype seems provided ease of operation, comfort, convenience and user-friendly.

For functionality, the result implies that the materials used, workmanship and design was constructed using materials that are strong enough to allow the prototype to function and meets its specifications.

For durability, the result means that the materials needed, labor spent, machines required and peripherals are free of faults. Further, the quality of materials used to produce the hardware was made from plastic to ensure water proofing of the system.

For economy, the result implies that the labor spend, materials accessibility and peripherals are free of faults. In producing the prototype, the costs used for the hardware are readily available and accessible.

For safety, the result implies absence of sparks from electricity, sharp edges and provision for protection of device. The electrical components of the system are safe to touch, free from sparks, and free from short-circuits that may cause fire since it is well soldered and uses a low voltage power. Also, it is in a package that protects it from getting wet in case of rain or accidental splash of water.

And for saleability, the result means that the prototype price is competitive when compared to what is available in the market, there is an accessibility to finish product and the demand is present.

Table 2. Summary of Differences of Result of the Plant Monitoring System from the evaluation of Subject Matter Experts, IT Professionals and Potential Users of the prototype.

Variables	Source of Variation	Sum of Squares	df	Mean Square	F	P	Decision
Functionality	Between Groups	0.10	2	0.050	1.725	0.31	Accept
	Within Groups	0.08	27	0.029			
	Total	0.18	29	0.079			
Durability	Between Groups	0.19	2	0.097	21.78	0.01	Reject
	Within Groups	0.01	27	0.004			
	Total	0.20	29	0.101			
Economy	Between Groups	0.32	2	0.161	20.68	0.00	Reject
	Within Groups	0.04	27	0.007			
	Total	0.36	29	0.168			
Safety	Between Groups	0.35	2	0.177	11.23	0.04	Reject
	Within Groups	0.04	27	0.015			
	Total	0.39	29	0.192			
Saleability	Between Groups	0.19	2	0.096	19.07	0.01	Reject
	Within Groups	0.01	27	0.005			
	Total	0.20	29	0.101			

For functionality, Table 2 shows that there is no statistical difference in the evaluation of the prototype from the Subject Matter Experts, IT Professionals and Potential Users between groups and within groups using one-way ANOVA. The computed value of P = 0.31 which is greater than the 0.05 level of significance accepts the null hypothesis. The result of the non-rejection of the null hypothesis indicates the homogenous perceptions given by three groups of evaluators.

For durability, economy, safety and saleability, Table 2 shows that there are differences in the evaluation of the prototype by three groups of evaluators. The computed value of P = 0.01, 0.00, 0.04 and 0.01 respectively are less than the 0.05 level of significance rejects the null hypothesis. The result of the rejection of the null hypothesis indicates that the three groups of evaluators have different perceptions on the prototype in the aforementioned variables.

IV. CONCLUSION

In light of the findings of the study, the following conclusions were made:
1. The stages undertaken in the development of the Plant Monitoring System for Vegetable Growers followed the system engineering procedure with the steps of Planning to identify the specification and needs of potential users system, coding, re- designing, until clients requirements and satisfaction are meet and then Maintenance of the prototype came into place.

2. The result of the evaluation of the prototype by the three (3) groups of evaluators; Subject Matter Experts, IT Professional and Potential Users. The prototype was evaluated in terms of Functionality, Durability, Economy, Safety and Saleability obtained an overall adjectival rating of Very Good. The result meets all the requirements and specifications and therefore recommended for production and implementation that may increase the yield of production of vegetable growers.

3. There is a significant difference in the evaluation of the Subject Matter Experts, IT Professionals and Potential Users on the Plant Monitoring System for Vegetable Growers in terms of Functionality. There are no significant differences in the evaluation of the Subject Matter Experts, IT Professionals and Potential Users on the Plant Monitoring System for Vegetable Growers in terms of Durability, Economy, Safety and Saleability.

4. The developed plant monitoring system help minimizes the water loss and reduces the constant supervision required for soil where plants grow. This prototype was developed as a low cost and provides alternative solution for efficient water management. This in turn helps the vegetable growers by managing the water supply to the crop fields and further maintains the moisture levels of soil that resulted in an effective production of plants and vegetables.

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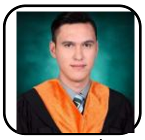

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