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HYDROPONICS SYSTEM FOR AEMILIANUM COLLEGE INC.

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Abstract. Hydroponics crop production is gradually gaining popularity around the world because of efficient resource management and quality food production. Soil-based farming is now facing various challenges such as urbanization, indiscriminate use of harmful chemical, climate change, and natural disaster which affects global food security. World wide spread of the novel coronavirus 2019 (COVID-19) pandemic has aggravated food insecurity because of the disruption in the food supply chain, aggravating the physical and economic challenges that restrict access to food, and disastrous increase in food waste. Hydroponics System was developed to improve food and nutrient security while reducing waste, reducing greenhouse gas emissions, and water use, the system can promise food security through a steady supply of fresh fruits and vegetables to urban neighborhoods. There is a need to integrate Information technology tools in Agriculture, which could help maintain food supply during and after the pandemic, as well as make agriculture more sustainable.

The proposed Hydroponics System would greatly assist in providing a steady food supply during and beyond the pandemic. It possesses features that can be used to measure the water level and detect the ambient temperature and humidity which will help crop production.

The Hydroponics System was evaluated by three sets of respondents. It was tested against an Industry accepted quality model – the ISO 25010. It has withstood the criteria in functional suitability, efficiency, compatibility, usability, reliability, security, maintainability, and portability. The result is pointing toward the attainment of the objectives of the proposed system. It is therefore declared acceptable and suitable to the needs of the client. Recommendations of the IT Experts signified that the system is ready to be deployed**.**

Key Words: *Agriculture, Arduino, Humidity Sensor, Hydroponics, Microcontroller, Ultrasonic Sensor, Urban Farming, Vegetable Farming*

INTRODUCTION

Global food security addresses the need for reliable sources of quality food, food security ensures that every nation has the ability to feed its people with nutritious food. The COVID-19 pandemic disrupted the supply chains, countries are facing growing levels of acute food insecurity, and the world population is increasing every day and it is expected to reach 9.3 billion in 2050 (Resh, 2016).

Because of the changes in the supply chain, people are facing starvation, the impact on food supply has been devastating, especially on border restrictions, some of the fruits and vegetables began to spoil, prices on these commodities have been soaring, and the populace has to be aware on the lack of nutritious food.

According to Sharma (2019), Hydroponics cultivation is gaining popularity all over the world because of efficient resource management and quality food production.

In hydroponic gardening systems, plants are placed in a growing medium and nutrients are provided directly to the roots. By providing constant and readily available nutrition, hydroponics allows plants to grow up to 50% faster than they do in soil. (Schmautz, et al, 2016). This study showed how hydroponics would be a great help to increase food production for all urbanized people. Hydroponics was used as a device that detected if the plants needed water and how much amount of water was needed. Using this device, the work in food production was made easier and the time allotment for the plants to grow was lessened.

Once the hydroponic using Arduino Device is programmed and successfully attached to all the sensors to monitor air, humidity, and nutrition, the device starts to operate. This project was developed to determine the comparison between soil and soilless in planting fruits and vegetables and it also determined the suitability of different mineral nutrient solution formulations for their growth, development, yield, and marketable quality. The proposed project Hydroponics using Arduino Device used in particular the Arduino Uno which provided codes and everything needed to the microcontroller by simply connecting it to a computer. It used different sensors to make this project.

Specific Objectives

Specifically, the study aimed to:

1. develop a Hydroponics system using:
   1.1 DHT 11 Module

1.2 Ultrasonic Wave Module
1.3 Relay Switch Module
1.4 Servo Motor Module
1.5 Arduino Integrated Development Environment (IDE)

2. evaluate the system using ISO 25010 industry quality standard tool in terms of:
   2.1. functional suitability;
   2.2. performance efficiency;
   2.3. compatibility;
   2.4. usability;
   2.5. reliability;
   2.6. security;
   2.7. maintainability; and
   2.8. portability

Outline Planning and Architectural Design

In the first phase, gathering data was conducted to evaluate the existing hydroponics system that was used by Albay Provincial Agricultural Office (APAO), This was significant to further understand the needs and to have a deeper insight into the use of Hydroponics in growing plants and vegetables A subjective or Purposive sampling method was employed in this study, this method is a form of non-probably sampling which researcher rely on their own judgment when choosing members of the population participate in the study (Alchemer, 2018). The proponent believed that to accurately distinguish the needed information, the researcher must carefully identify the type of respondents for the study.

The process of existing hydroponics system uses boxes made of expanded polystyrene (EPS) known commonly as “Styrofoam box” or simply “Styrobox” to make excellent materials for grow box (or growing box), the Agriculturist then apply plastic around the grow box to prevent water leak, then make holes on the cover of the strongbox where the Styrofoam cups or plastic cups with the plants inside it can be inserted, the Agriculturist place 10 liters of water into the growing box then they would be adding 25 ml of both Simple Nutrient Addition Program (SNAP) A and B solution into the water. Which should be replenished from time to time.

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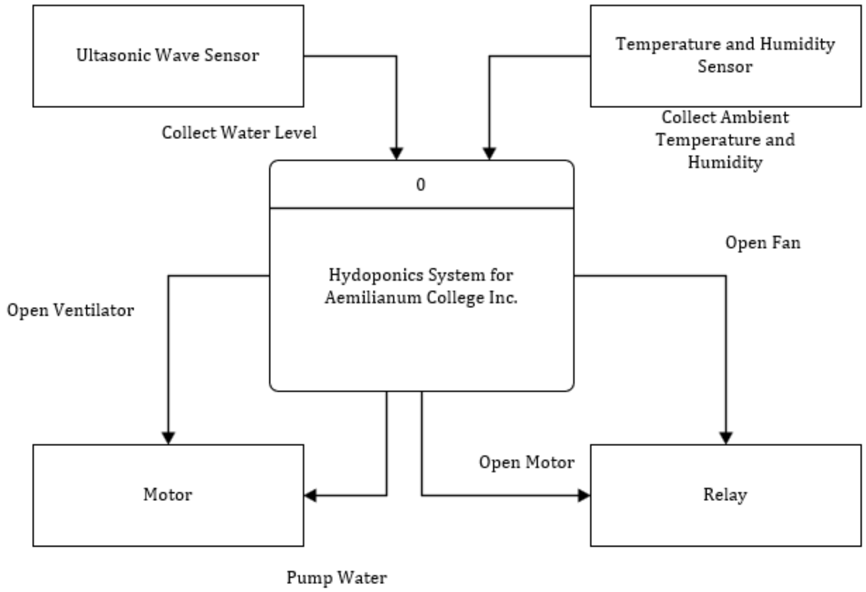

Figure 4.1. Context Diagram of the Developed System

A context Diagram is a data flow diagram, with one massive central process that subsumes everything inside the scope of the system. It shows how the system will receive and send data flows to the external entities involved.

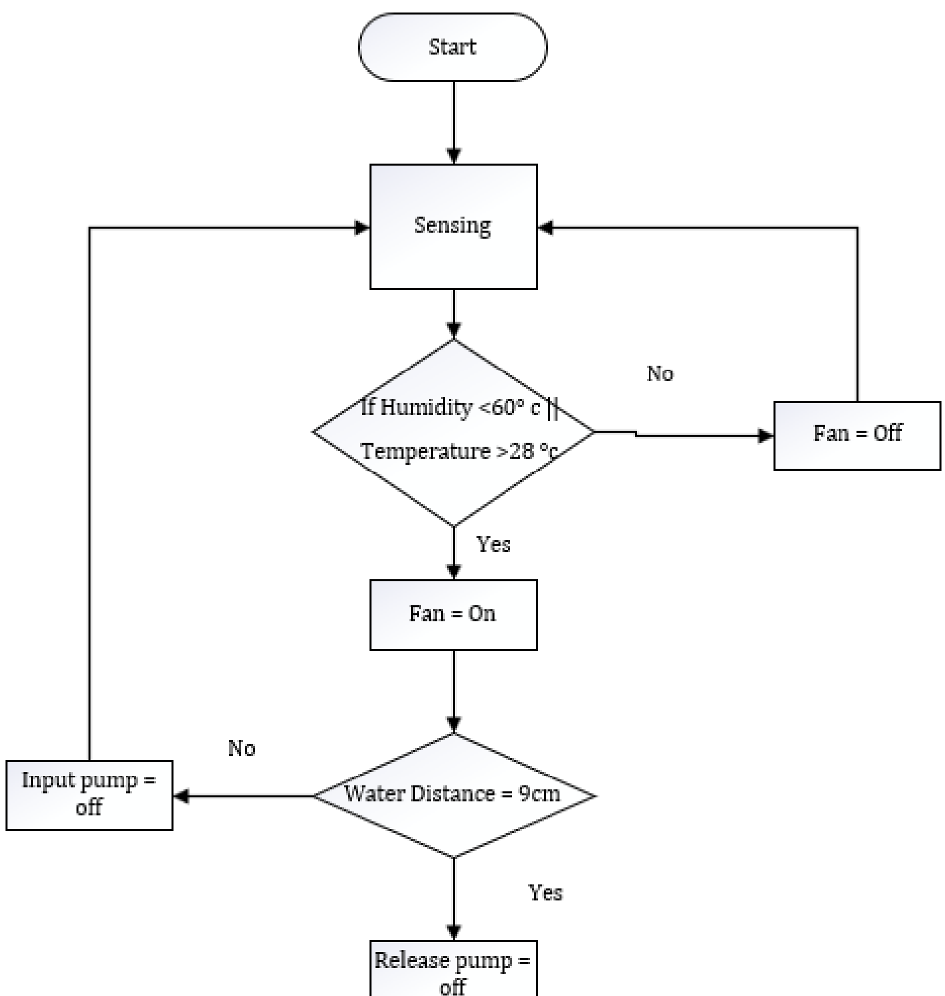

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Figure 4.2. Flowchart for the Hydroponics System

Figure 4.2 showed how the hydroponics system senses the ambient temperature, humidity, and water level. The flowchart reflected the flow of execution from data gathered from the sensor to its decision to open the fan or water pump.

Figure 4.3 presented how the temperature and humidity sensor works. The flowchart showed the flow and execution of the fan. First, the sensor checks if the temperature is greater than 28°c and the humidity is less than 60°c. The fan will blow off the excess heat.

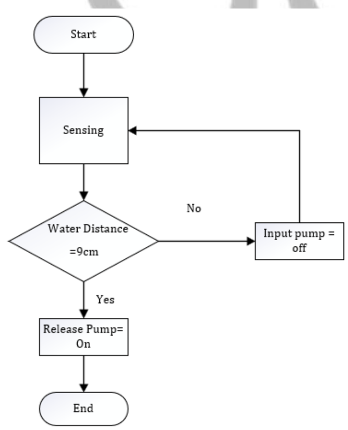

Figure 4.4. Flowchart Water Distance

Figure 4.4 presented how the ultrasonic sensor works. The flowchart showed the flow and execution of the water pump. First, the sensor checks if the distance of the water is equal to 9 cm the water pump will infuse water into the growing box.

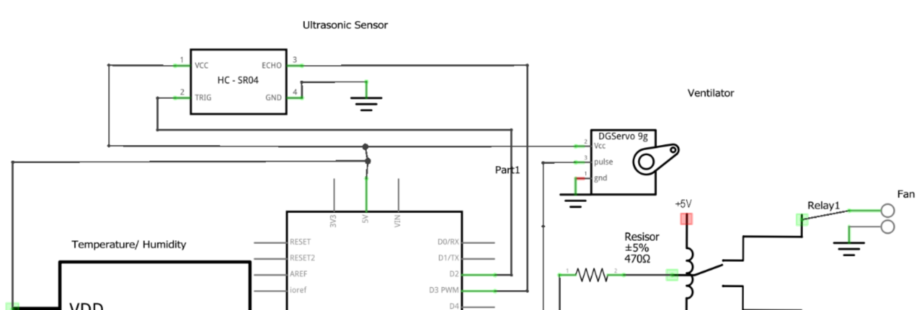

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Figure 4.5. Schematic Diagram

Figure 4.5 implied how the different sensors, water pump, servo motors, and Arduino Uno fit together. The schematic diagram showed the two-dimensional circuit representation showing the functionality and connectivity of different components used in the developed system. All the sensors like the temperature and humidity sensor (DHT11), ultrasonic wave sensor, water pumps, and ventilator are connected to the Arduino Uno.

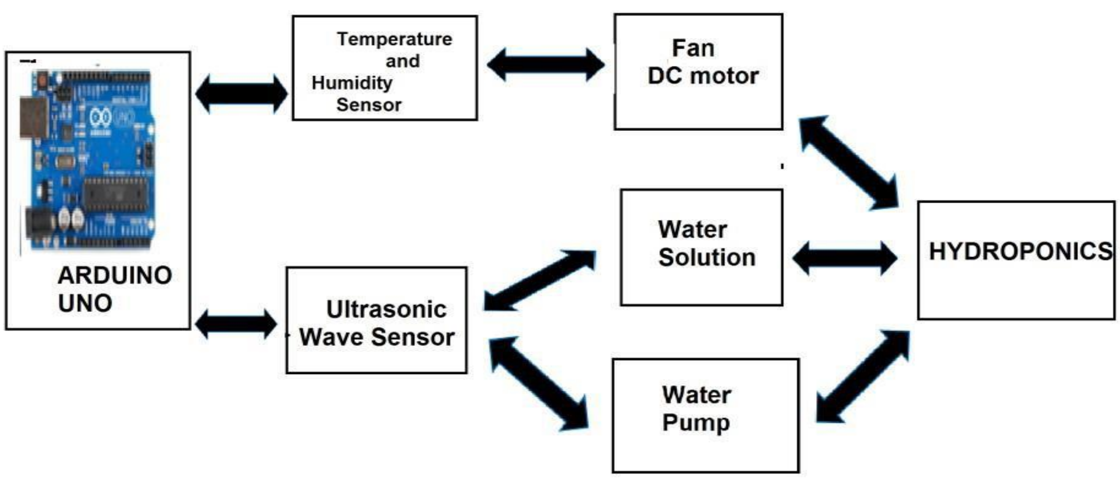

Figure 4.6. Block Diagram

Figure 4.6 showed how the graphical representation of a system. The block diagram shows the squares connected with arrows to depict hardware and software interconnection.

Sprint Cycle

Assess. This phase assigned the details of estimated deadlines and priority levels of the developed system and the unfinished task was cited on the project backlog. The system was designed to identify the needed requirement in the outline planning and architectural design phase. The proponent estimated the duration of the prototype and allocates a priority level for the critical process that is needed for designing the model.

Select. This phase is all about choosing the components needed to present the functionality and feature of the prototype. The DHT 11 – temperature and humidity sensor detects the ambient temperature and humidity of the surroundings. The Ultrasonic wave sensor measures the water in the tank which signals the motor to pump water if deemed necessary.

Develop. This phase is all about constructing the Hydroponics System for Aemilianum College Inc. according to SCRUM methodology. As described in the methodology Figure 3.1, the design cycle is closed in a loop producing a new part of the hardware/software design for each sprint. The development process should continue after the test, and the loop continues with refinement until the project owner agrees to the outcome of the prototype, and the necessary configuration of the system is also being implemented in this stage, as prescribed by the project owner.

Review. This phase is about sprint reviews concentrating on the product becoming made, precisely the increment of the product shippable during the sprint. The proponent and the project owner analyze what fit as was prescribed in the planning and designing phase. Error encountered during this phase, are debugged and tested and will be compiled and considered as a finished product.

Project Closure

At this phase, reports on the sprint were tested for implementation, and taking into consideration all of the required components were present and presented to the respondent, wherein the result is "more than what is expected". Moreover, an interval using a scale was used to show the description in the interpretation of the average response in the system.

Table 4.1 Table of Verbal Interpretation

Mean	Verbal Interpretation
0 – 1.0	Absence of the expectation
1.1 – 2.0	Less than what is expected
2.1 – 3.0	Presence of the expectation
3.1 – 4.0	More than what is expected
4.1 – 5.0	Far more than what is expected

Table 4.1 presents the table of Verbal Interpretation utilized in order to interpret and describe the user satisfaction level to the system's efficiency and effectiveness.

Table 4.2 End-Users' System Rating

Quality Characteristics		End Users (5)	Interpretation
1.0	Functional Suitability	3.63	More than what is expected
2.0	Efficiency	3.50	More than what is expected
3.0	Compatibility	3.20	More than what is expected
4.0	Usability	3.20	More than what is expected
5.0	Reliability	3.00	Presence of Expectation
6.0	Security	3.50	More than what is expected
7.0	Maintainability	3.00	Presence of Expectation
8.0	Portability	3.90	More than what is expected
Overall Mean		**3.36**	**More than what is expected**

Furthermore, during the testing phase, the system was evaluated and used ISO 25010 as a basis. The areas that were evaluated in the developed system were its functional suitability, efficiency, compatibility, usability, reliability, security, maintainability, and portability. Three (3) sets of respondents provided understandings on the overall quality of the system, these respondents were composed of ten (10) IT Experts, five (5) End-Users, (5) Agriculturists of Albay Provincial Agriculture Office. The respondents evaluated the system using the five-point scale system reflecting one (1) as the lowest and five (5) as the highest. The system using the five-point scale system reflecting one (1) as the lowest and five (5) as the highest.

Thus, the result of the evaluation from Aemilianum College Inc., Agriculturist, and IT Experts is presented below.

Table 4.2 shows the results of the evaluation from the end-user respondents with an overall mean of 3.36, the system is deemed to be "more than what is expected" in terms of functional suitability, efficiency, compatibility, usability, reliability, security, maintainability, and portability. This implies that the system meets the quality characteristics of ISO 25010.

Table 4.4 IT Experts' System Rating

Quality Characteristics		IT Experts (5)	Interpretation
1.0	Functional Suitability	4.70	Far more than what is expected
2.0	Efficiency	4.78	Far more than what is expected
3.0	Compatibility	4.78	Far more than what is expected
4.0	Usability	4.70	Far more than what is expected
5.0	Reliability	4.44	Far more than what is expected
6.0	Security	4.60	Far more than what is expected
7.0	Maintainability	4.80	Far more than what is expected
8.0	Portability	4.89	Far more than what is expected
Overall Mean		4.71	Far more than what is expected

Table 4.3 exhibits the result of the evaluation from the mean of the Agriculturists on functional suitability, efficiency, compatibility, usability, reliability, security, maintainability, and portability. With an overall mean of 4.80. The respondents concluded that the system is "far more than what is expected".

Table 4.3 Agriculturists' System Rating

Quality Characteristics		**Agriculturists (5)**	**Interpretation**
1.0	Functional Suitability	4.80	Far more than what is expected
2.0	Efficiency	4.80	Far more than what is expected
3.0	Compatibility	4.80	Far more than what is expected
4.0	Usability	4.80	Far more than what is expected
5.0	Reliability	4.80	Far more than what is expected
6.0	Security	4.80	Far more than what is expected
7.0	Maintainability	4.80	Far more than what is expected
8.0	Portability	4.80	Far more than what is expected
Overall Mean		**4.80**	**Far more than what is expected**

Table 4.4 exhibits the result of the evaluation from the mean of the IT Expert on functional suitability, efficiency, compatibility, usability, reliability, security, maintainability, and portability. With an overall mean of 4.71. The respondents concluded that the system is "far more than what is expected".

Table 4.5 exhibits the result of the evaluation from the overall mean of five (5) End-Users, ten (10) IT Expert and five (5) Agriculturist on the functional suitability, efficiency, compatibility, usability, reliability, security, maintainability, and portability. With an overall mean of 4.29. The respondents concluded that the system is "far more than what is expected".

Transition

After modification, improvement, and evaluation using ISO 25010 (Software Product Quality) and testing several times, the developed Hydroponics System for Aemilianum College Inc. is ready for deployment at any time wished by the End Users. The researcher is confident that the developed system will serve its purpose.

Summary of Findings

The following findings were obtained from the study:

1. The current system used by Albay Provincial Agricultural Office and Bicol University College of Agriculture and Forestry does not have the temperature and humidity feature on their hydroponics, which will enhance the growth of the short-rooted plants and vegetables. Furthermore, the agriculturist keeps on monitoring the temperature and manually changes the location of the plants and vegetables. Therefore, based on the evaluation from the user, and agriculturist the temperature and humidity feature of the developed system got positive feedback from the user/agriculturist. The newly developed system improves their perception as well as their experience when using the new hydroponics system.

Table 4.5 Overall Ratings of the Developed System

Quality Characteristics		End-Users (5)	Agriculturists (5)	IT Experts (10)
1.0	Functional Suitability	3.63	4.80	4.70
2.0	Efficiency	3.50	4.80	4.78
3.0	Compatibility	3.20	4.80	4.78
4.0	Usability	3.20	4.80	4.70
5.0	Reliability	3.00	4.80	4.44
6.0	Security	3.5	4.80	4.60
7.0	Maintainability	3.00	4.80	4.80
8.0	Portability	3.90	4.80	4.89
	Mean	**3.36**	**4.80**	**4.71**
Overall Mean		**4.29**		

2. The current Hydroponics of Albay Provincial Agricultural Office and Bicol University College of Agriculture and Forestry does not have a feature that will help dissipate excess heat. This includes the ability to pump the growing box with nutrient-enhanced water from the reservoir. Furthermore, the developed system can detect if the water level is enough for the plant and or vegetables to grow. Hence, based on the evaluation the developed system got a positive impression and feedback from the

user/agriculturist for integration of features such as maintaining temperature and humidity, and water control were useful in crop production.

3. The proposed system was evaluated and tested in terms of its functional suitability, efficiency, compatibility, usability, reliability, security, maintainability, and portability. In the same way, it was validated by three (3) sets of respondents ten (10) IT Experts, one (1) School Administrator, four (4) Aemilianum College Inc. staff, and five (5) Agriculturists of Albay Provincial Agriculture Office. The result is extensive pointing towards the attainment of the objectives of the proposed system with a **4.29** overall rating from the evaluators.

Conclusions

Based on the findings of this study the following conclusions are formulated:

1. Based on the evaluation result and feedback from the user, the proponent conclude that the temperature and humidity feature provided a significant value to the Hydroponics System as it created an innovative way of crop production, which helped users/agriculturists reduce the complicated manual monitoring and controlling process.
2. In relation to the evaluation and feedback from the user, the proponent concluded that the additional features from the developed Hydroponics System which is the water control provide a new opportunity for IT and Agriculture in automating the hydroponics system.
3. As stated in the overall evaluation results with a mean of 4.29, the developed Hydroponics System passed ISO 25010 – which has been the primary concern when it comes to the definition of quality characteristics to be used in the evaluation of the software product. It is therefore declared as acceptable and suitable to the needs of the College.

Recommendations

Based on the conclusions, the following recommendation is hereby offered:

1. The user of the current Hydroponics System may be improved by integrating sensors that maintain the ambient temperature and humidity of the short-rooted plants/vegetables.
2. The current Hydroponics System of Albay Provincial Agricultural Office and Bicol University College of Agriculture and Forestry may be improved through the implementation of the developed Hydroponics System with the addition of water control so as not to waterlog the plants/vegetables.
3. The respondent's viewpoint of the developed system turned out to be "More than what is expected" based on the overall mean of 4.29, therefore the system is considered to be very applicable in terms of functional suitability, efficiency, compatibility, usability, reliability, security, maintainability, and portability. Therefore, the developed Hydroponics System is ready to be deployed to improve the growth of plants/vegetables.
4. Additional functionalities and improvements to the system may be studied and integrated into the new Hydroponics System to significantly improve the system's service.

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