Hydruinoponics: An Automated Arduino Based Hydroponics with Solar Tracker System

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Abstract

Throughout history, hydroponics has played an important role, whether it was from helping create a massive garden in the desert or letting wondrous people find a new way to grow crops. Hydroponics is the cultivation of plants without using soil. Vegetables including pechay are planted in inert growing media and supplied with nutrient-rich solutions, oxygen, water, and solar tracker. And when the temperature rises to the point it starts harming the plants, it will automatically send a notification to the owner and the system will control the temperature of the plant containers. The system fosters rapid growth, stronger yields, and superior quality. When a plant is grown in soil, its roots are perpetually searching for the necessary nutrition to support the plant. If a plant's root system is exposed directly to water and nutrition, the plant does not have to exert any energy in sustaining itself, rather it will focus its energy for growing. Plants do not need soil to photosynthesize. When nutrients are dissolved in water, they can be absorbed directly to the plant's root system. The system is self-powered with the use of solar panels and batteries, not only yielding more produce but also saving energy. The researchers will use the descriptive method since it focuses more on the why's and how's questions. It also focuses on gathering, analyzing and presenting the collected data. All in all, the system should be useful and effective for the farmers and for the plant enthusiasts as an alternative way of growing crops.

Keywords: *hydroponics, sunflower algorithm, plants, IoT*

Introduction

Considering the growth of the human population in the Philippines is constantly increasing at an alarming rate, the population will continue to grow and would reach over 140 million by the year 2040 (Annealuben, 2015). Moreover, food and agricultural products demands would also increase having the same agricultural process and constant deforestation, agricultural crops might not be enough to accommodate the people considering the population size. In this modern time, climate change is the main reason why many agricultural productions are being threatened (Bailey, 2015). In particular, the largest impact of climate change would be on agriculture and food supply (Baldos et al., 2017). Since the country is already experiencing the effects of climate change, a high portion of it is relying on its agricultural goods. In fact, the Philippines produces a variety of crops and agricultural goods but due to the effects of climate change, severe drought or excessive downpour for several days are being experienced (Flores, 2019).

The traditional farming system might not meet the current demand of food and will be questioned by the public and conventional farmers in regards to their sustainability. Another factor of this is the alarming rate of farmers that are growing old and their children have shifted into other careers and most schools are prioritizing office-oriented field to their students (Guzman, 2018). Accordingly, the researchers are trying to overcome this dilemma by developing a prototype and innovating a new

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system that could produce quality agricultural goods without worrying about effects of the climate on the crops (Agcaoili, 2019).

Hydroponics cultivation is the art of growing plants without soil. It allows to alter the environmental conditions, lessen water irrigation, increase agriculture production and limit crop infestation. In this case, the research can maximize the productivity of Hydroponics together with IoT (Internet of Things) which is perfect way to avoid heavy work, such as tilling the soil, watering the plants, removing weeds. Pests, diseases and weeds are generally much easier to control. The application of Internet of Things to grow crops gives the potential of saving labor and resources, more fine-grained control in watering and fertilization, and more accurate gathering of information about planting environment (Changmai, 2018).

Over the past few decades, hydroponics has proven an ideal method for both keen amateur gardeners and commercial growers looking for an alternative way of producing plants. The hydroponically grown crops can be just as nutritious as those grown in soil (Gashgari, Alharbi, Mughrbil, Jan, & Glolam, 2018). Traditionally, plants obtain nutrients from the soil, but with hydroponics, the plants get its nutrients from a water solution filled with all the necessary nutrients needed instead such as: Nitrogen, Phosphorus, Potassium, Calcium, Sulfur, Magnesium (Max, 2021). The amount of nutrients can vary depending on the plant that will be grown. Yamasaki Solution will be nutrient solution that the researchers are proposing to use; it is a formula for specifically for hydroponics. It contains Iron, Manganese, Zinc, and Copper, Boron, Chlorine, Manganese, Iron, Nickel, Copper, Zinc, Molybdenum. Using these fields can be a huge benefit for producing good quality products and lessening the hassle of farming. Automation of hydroponics can maintain possible circumstances such as sunlight, temperature and humidity. These urban farmers can gain more profits by generating quality products (Pitakphongmetha, et al., 2016). On the other hand, third world countries tend to have an unreliable supply of electricity, it is one of the concerns of hydroponics practitioners (Bajpaye, 2019). That is why solar power system provides renewable energy making it a suitable winning combination for hydroponics. Therefore, by combining these two systems the production of crops will greatly improve (Arizona, 2019).

Method

The conceptual framework is shown in Figure 1.

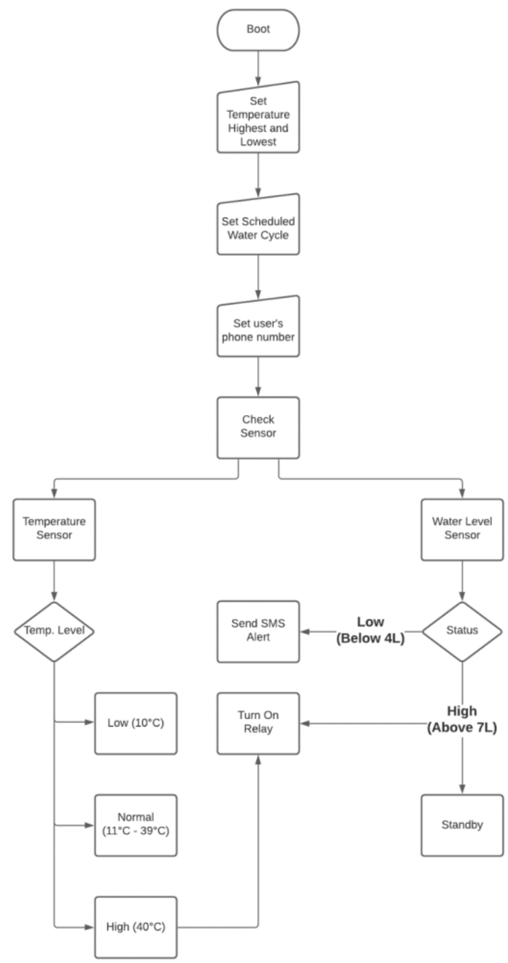

Figure 1. Conceptual Framework

First, the system will require the user to set the highest temperature of the selected plant can tolerate. Second, it will check the real time with the RTC Module, and check the SD Card if it is working. Then, it will then proceed to test if all the sensors are working starting with the Humidity Sensor. Here the system will only get the data for future reference. Third, the system will then check for Temperature Sensor and after that, it starts to scan for the temperature and check if it is high. Afterward, the system will turn on the relay for the water to flow in and stabilize the temperature. Finally, the system will check the Water Level Sensor and the status of the water which stored in the water tank below. If the system confirmed that the level of the water is low, it will send an SMS alert to the user that the water solution is running low.

The researchers used Sunflower Optimization Algorithm. A population based natural inspired and new metaheuristic algorithm which mimics the movement of the sunflower towards the sun (Fouad, 2019). This algorithm was coded on the servo for the solar panels as to simulate the movements of the sunflower following the sun, and to charge the battery for the whole system use.

The Agile Development Methodology it is the process in which a team breaks down the whole project into several stages, continuous improvements and iterations upon it, while at the same time also taking feedback from the clients.

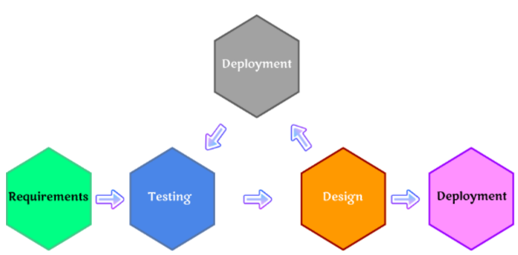

Figure 2. Agile Development Methodology

The requirements of the project are prioritized and delivered in a 2-3 weeks cycle; otherwise known as iterations or sprints. The researchers did four (4) iterations that started in February, and the total of prototypes that was made were three (3). The workflow in Agile is flexible and encourageable in constant improvement in every iteration. The researchers will use this methodology to accomplish the objectives of the study.

The Arduino will be booted up it will start by promptly ask the user to input the highest temperature the plant can withstand, followed by checking the Real Time Clock Module, the SD Card Module. The sensors will be: Temperature Sensor, the Arduino will check if it is working. If no, it will show an error message in the LCD and restart the device. If yes, it will proceed to determine the temperature: if high, it will turn on the relay which will circulate the water, then it sends data to the database; if low, it will send an SMS alert to the user, and the data on the database; if normal, it will send data to the database. Humidity Sensor, checks if working; no, it will show error in the LCD and restart the device. Yes, then it will send data to the database. Water Level Sensor check the status of the water: high, then it will send SMS alert to user and turn on the relay for the water to flow in. Low, it will be put on standby

Using the Sunflower Optimization Algorithm, condition was already programmed in the Arduino to move the servos. The micro controller measures each photoresistors value; the value will come from how much light does each is receiving. The value is first measure for both lower/upper and left/right photoresistors, if upper is more than lower, the process will initiate the upward movement until equal and vice versa to downward movement. If left is more than right, the process will initiate the leftward movement until equal and vice versa to rightward movement. All of these processes will continuously repeat throughout the day. The fifth photoresistor will be the sensor for the grow light, if the light it is receiving go down to a certain limit, it will turn on the relay to turn on the grow light for the plants. Figure 3 represents the flowchart for the solar tracker.

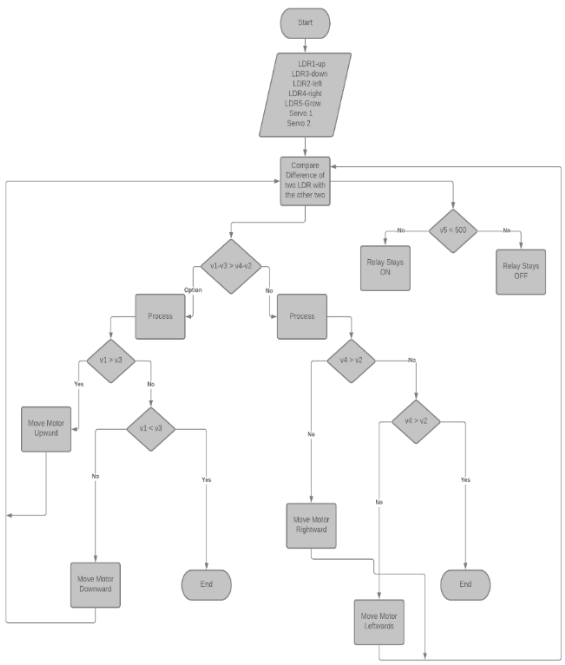

Figure 3. Flowchart of the Solar Tracker

Figure 4. Controllers (left) and water tubings (right) makes up the system

The user interface main page contains seven buttons that leads to different table that contains data that was gathered within the device. The first button leads to the table where it shows when the data gathering starts and end time. The Temperature button leads to the table that shows what temperature level was gathered within the specific date and time. The humidity button leads to the table that shows how humid on the environment within the given time. The water cycle button will show a data table that records if the instruction that was inputted in the device was successfully initiated. The pressure buttons show the pressure data of the submersible pump. The phone number shows history of the user details that previously used the device and the table button show all the data where the user can use to conduct statistics.

Results

The evaluation was conducted using the ISO 25010 or the Software Quality Assurance as the metrics. with two (2) groups. The study involves the populace of five (5) IT Experts, five (5) Garden Enthusiasts, and five (5) Local Farmers.

Table 1. Evaluation Results of IT Experts

Criteria	Mean	Descriptive Rating
Functionality Suitability	4.23	Excellent
Performance Efficiency	3.89	Very Good
Compatibility	3.34	Good
Usability	4.17	Very Good
Reliability	3.66	Very Good
Security	1.14	Poor
Maintainability	2.67	Good
Portability	3.55	Very Good
OVERALL	3.33	Good

Table 2. Evaluation Results of the Respondents

Criteria	Mean	Descriptive rating
Functional Suitability	4.50	Excellent
Performance Efficiency	4.10	Very Good
Usability	4.30	Excellent
Reliability	3.60	Very good
Maintainability	3.50	Very Good
OVERALL	4.00	Very Good

Discussion

The researchers have succeeded in making a hydroponics system equipped with sensors to control the water circulation, monitor the temperature and humidity, and power itself by solar power. Overall, the researchers found out that the device is very capable of shortening crops growth duration, increase crops quality and provide a more effective way of farming to lessen the effort and work of users which are the main objectives of the study. With the device being self-sustained with the help of Solar power, the device was rated very good by the evaluator which validate the result of the statistic which is very good.

Conclusion

The researchers opted to equip the hydroponics system with a solar tracker system which is utilizing the Sunflower Optimization Algorithm to simulate the movements of a sunflower facing the sun and power it by itself. After the development and testing, the researchers finalized the device and conducted an evaluation with the specific target being farmers and garden enthusiasts, and for the IT experts to evaluate the device. After this, the researchers successfully found out that the hydroponics with an IoT is indeed an effective alternative way of farming for the potential users. The evaluation from the said individuals and with the critics and advice of IT Experts exercising their expertise resulted to its very good rating. It is user friendly, regardless of the user's knowledge with hydroponics. Despite the costly materials of the device, the users concur that it is a necessary investment but it is a cost-effective. Meaning even if the materials that will used on the device are pricey, the return will be much more.

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