Development of a Robotics System for Automated Monitoring and Maintenance of Hydroponic Farms

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ABST RACT
Automated monitoring hydroponics Soil-based planting supports a variety of plants, however, there are many challenges such as increased water consumption, vulnerability to pests and fungi, and a higher dependence on chemicals. This study explores the semi-automation of hydroponic systems through a programmed time frame in the circulation of water. A hydroponics system made from PVC pipes, hoses, and cups was set up where the water flows through the system. The tank was filled with 20 liters of the water solution. The foam with seedlings was placed in plastic cups and after a week they were set in the holes of the hydroponics system where they absorbed the water solution. The cord of the Arduino system was connected to an adapter linked to the solar battery where the outlet with the relay was connected to the battery. The 5-volt motor is connected to the hydroponics system and is plugged into the Arduino. The system activated the pump at 8:00-11:00 am and 1:00-5:00 pm. The soil and hydroponics system had an average height of 5.12 cm and 5.32 cm and an average length of 0.99 and 1.35cm respectively, their leaf count had the same average of 2.8 cm. Both the control and the hydroponic groups had only slight differences in height and length with a negligible difference in leaf count. Hydroponics may also save on water as it recycles the solution, and minimizes fertilizer use as it only needs the A and B solution as a supplement

Keywords: Automated, monitoring, hydroponics

I. INTRODUCTION

Hydroponics was invented by William Gericke in 1929, he named it hydroponics using the Greek words “Hydros” meaning water, and “ponos” meaning work. It was described as an efficient way to produce more food as it only needs water and nutrients (Bryce, 2023). Based on historical archives, many civilizations have used hydroponics systems however, these were primitive compared to modern hydroponics as it does not use a synthetic formula. The formula for the solution was invented by Julius von Sachs, Professor of Botany at the University of Wurzburg. This solution is comprised mostly of nitrogen, sulfur, phosphorus, magnesium, potassium, and calcium. (“The History of Hydroponics, Everything You Need to Know,” 2024). Hydroponics is a system where water and water solution are used instead of soil and other growth media, this system is commonly used by hobbyists, gardeners, and smaller enterprises due to its simplicity (Hydroponics | National Agricultural Library, n.d.). Plants generally do not need soil to survive, instead, they need the nutrients in the soil. Hydroponics substitutes soil through nutrients mixed in with the water which flows through the pipes and is absorbed by the plants (What Are Hydroponic Systems and How Do They Work?, n.d.). Hydroponic farming has a lot of benefits starting with lesser water consumption. Soil needs more water for watering compared to hydroponic planting as the water used in hydroponic planting is recycled to be used again and again until the A and B solution needs to be added again (Dupuis, 2024). Hydroponics also reduces the risk of soil-based pests and fungi as it runs on water and nutrients instead of soil (McCray, 2024). This study focuses on making the hydroponic system more effective by having intervals where the pump is shut off and then turned on again. It also helps automate hydroponic farms where it only needs minimal human intervention as the Arduino itself turns the pump off and on. This study is also expected to be off-grid to be used in remote areas.

II. METHODOLOGY

Materials For this experiment, a hydroponic system was used, a pre-built Arduino-powered device (comprised of: Real Time Clock sensor, Arduino Uno R3, Relay module, 830 Tie Point breadboard, and an LCD screen), A and B solution, 16 liters of water, and 10 Black behi (Brassica napus L.).

Phase 1: Developing the hydroponics setup.

A hydroponics system is usually home-built from scratch using PVC pipes, hoses, and Styrofoam cups. For this experiment, a pre-built hydroponics system was bought from Citi Hardware in Davao City. The hydroponics system was set up on a level location where the water can flow through the system.

The Arduino system was programmed to activate a relay placed inside the outlet which cuts off power to the USB-powered 5- Volt water pump at a programmed time. The Arduino receives input from the real-time clock sensor which determines when the relay is turned on or off.

In the study, the Arduino time was set from 8:00-11:00 am and 1:00-5:00 pm where it would circulate the water and its nutrients throughout the system. The time was set based on when the temperature would be the highest in a day. The Hydroponics A and B solution comprised of nutrients like Phosphorus, Potassium, and nitrogen as well as trace minerals such as Iron, calcium, and Magnesium This solution is then mixed with the 20 liters of water with a measure of 10 ml of both the A and B solution per 1 liter of water

Phase 2: Testing the Functionality of the Arduino Device.

The Arduino was set up by connecting the cord to a
charger adapter which was then connected to the solar battery. After that, the outlet with the relay is then plugged into the battery. The Arduino system was then left plugged on the solar battery where it would start circulating the water and solution at a given time providing plants a period where they can rest and they
can feed on the nutrients

Control group

Of the 10 plants, we planted 5 seedlings in a separate soil-based plot to compare the two groups in terms of height, number of leaves, and leaf length. Both used the same fertilizer solution

Preparation of Plants

The plants are put in soil for one week where they germinate and grow false leaves. After one week the plants put in the hydroponics system are taken out from the soil and are then put in absorbent foam placed in cups. These cups are placed along the cut-in holes in the hydroponics system. The plants planted in the soil are planted on a larger pot

Cost Analysis

Arduino Uno upgraded kit This kit has every necessary sensor and parts for this project (i.e RTC sensors, 5v relay, etc.)	1	PHP 1,499
The Hydroponics system is the system used for plants to grow in	1	PHP 1,500
Electric outlet is where the relay is housed, this is also where the pump will be connected	1	PHP 125
Solar Battery and Panel This will be what powers the Arduino system and the pump	1	PHP 6,500
Materials	Quantity	Price

III. Results and Discussion

The system was able to do the programmed task which was to activate the pump at 8:00 am to 11:00 am and then from 1:00 pm to 5:00 pm. Both the control group and the hydroponic group were still alive but with only slight differences regarding the size and a negligible difference in leaf count.

Recomendations

The experiment was more or less a success, it showed how an automated timer-powered hydroponic system would work and how it would make hydroponic systems more energy efficient. However, a factor to improve this system would be sensors to monitor the plant's health and the water level. These additions would be useful in fully monitoring and maintaining plants and farms on a larger scale

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