UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF ARDUINO-BASED HYDROPONIC SYSTEM WITH USER INPUT FUNCTION

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Automation and Robotics) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Electrical and Electronic Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Automation and Robotics) with Honours. The member of the supervisory is as follow:

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DEDICATION

To my beloved parents and my family where their unyielding love, support and encouragement that drives me to pursue and complete this project

ABSTRACT

Planting has always been a hobby that many adopt due to it provide relaxation and a great pass time. However, restrictions such as hectic working hours, expensive lands and limited space makes people relinquish the idea. This project proposes an automated hydroponic system controlled by an Arduino-based microcontroller that can monitor and control pH level as per user input. This system does not require soil to cultivate, thus reduces used space and hydroponics can provide water infinitely. The most tedious task for hydroponics is maintaining pH level but it can be solve by implementing a microcontroller that acts as pH controller. The system shall operate independently for task such as mixing hydroponic solutions with correct proportion, water circulation and pH regulation after inputting the desired value into the system. The results of this project development shows that Arduino-based hydroponic system functions as per objective requested. The controller uses an Arduino Mega 2560 and the pH regulation was controlled by interacting with a pH sensor and peristaltic pump that dispenses pH reducer. As stated, the Arduino-based hydroponic system is a successful attempt at solving the problems above but the external factor must take into consideration when trying to evolve the system.

ABSTRAK

Bercucuk tanam merupakan sesuatu hobi yang banyak diamalkan oleh masyarakat kerana ia memberikan ketenangan dan merupakan aktiviti yang baik. Walau bagaimanapun, halangan seperti waktu kerja yang sibuk, harga tanah yang membebankan dan ruang yang terhad menyebabkan masyarakat melepaskan idea ini. Projek ini mencadangkan penggunaan sistem hidroponik automatik yang menggunakan pengawal mikro Arduino. Sistem ini memantau tahap pH dalam larutan hidroponik dan juga mengawal tahapnya mengikuti permintaan pengguna. Sistem hidroponik tidak memerlukan tanah yang luas untuk diaplikasikan dan teknik hidroponik dapat memberikan bekalan air sepanjang masa. Tugas yang paling mencabar ialah mengekalkan tahap pH sistem hidroponik. Dengan menggunakan sistem hidroponik ini, ia boleh diselesaikan dengan adanya pengawal mikro yang bertindak sebagai pengawal pH sepanjang sistem ini berjalan. Sistem ini boleh menjalankan tugasan seperti mencampurkan larutan hidroponik dengan kadar betul, kitaran air dan mengekalkan tahap pH secara automatik selepas memasukkan nilai yang dikehendaki. Hasilan daripada projek ini ialah sistem hidroponik yang berdasarkan Arduino Mega 2560 yang melaksanakan semua tugasan berdasarkan matlamat projek. Pengawalan tahap pH dijalankan oleh pengawal mikro bersama dengan sensor pH dan pam peristalsis. Pengawalan tahap pH dilakukan dengan pam peristalsis mengepam cecair penurun pH. Seperti yang dinyatakan, sistem hidroponik ini berjaya menyelesaikan masalah yang dihadapi tetapi perlu mengambil kira faktor luaran bagi menambahbaik teknologi sistem ini.

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EC	-	Electrical Conductivity
pH	-	Potential of Hydrogen
TDS	-	Total Dissolved Solids
DC	-	Direct Current
AC	-	Alternating Current
mS/cm	-	milliSiemens per centimetre

CHAPTER 1

INTRODUCTION

1.0 Introduction

The unending country development has cause the rise of total population around the world. The challenge for agricultural scientist to research new agriculture technologies for increasing the production rate to reach the demand. However, high production rate requires an expansive land in order to meet the quota and currently the cost of cultivating land suitable for different type of crops is pricey. Expansion of agricultural land may have negative environmental impact and together with the urbanization, available lands are shrinking and scattered. Recently, hydroponic farms have been setup in vacant buildings that can't be sold and more hydroponics technologies had been introduced. By gathering resources, hydroponic system can be applied at home and automation can be implemented onto it to make a fully home automated hydroponic system.

1.1 Project background

This project is about the development of a hydroponic system into a fully automated system with the ability to consistently monitoring the condition of hydroponic nutrient solution. The user input function expands the function of the system for the availability of planting different type of plants that requires different pH and EC values rather than fixating on a single type of plant. By using a user input function, the user can set the required nutrient concentration and acidity of the hydroponic solution that can promote faster plant growth. The main hardware for this system is Arduino Mega 2560, which is a microcontroller that utilizes its own open-source programming software, Integrated Development Environment (IDE). The main parameter that is constantly monitored was acidity of the nutrient solution, which is the potential of hydrogen ions (pH). pH sensor will monitor the nutrient acidity and relay the condition of the nutrient to the Arduino microcontroller. If the nutrient solution pH is higher than the user input pH value, the microcontroller will send a signal to the discrete peristaltic dosing pump to pump in pH down solution. The user also needs to input required electrical conductivity (EC) value suitable for different type of plants. The independent dosing pumps for solution A and solution B will pump in the required amount depending on EC value.

1.2 Problem Statement

Technological advancement has allowed the possibility of installing automated hydroponic in residence. Today, lots of people are trying their hands on home-grown vegetables by making a homemade hydroponic system. However, the initial setup of the system requires a lot of time and effort and thus most of the hydroponic system was later abandoned. For those who have hectic lifestyle, replacing and monitoring nutrient solution was view as a meddlesome chore. Different types of plant have their own respective growing environment which typically means the condition of the nutrient solution. The parameter that should always be monitored are water acidity (potential of hydrogen ions, pH), concentration of nutrients (electrical conductivity, EC or total dissolved solids, TDS), water temperature and water level. Busy lifestyles tend to make growers ignore or overlook these parameters that can change the solution quality and affecting the plants they grow.

1.3 Objective

The main objective of this research in concentrated on aspect was listed below:

a) To develop an automatic hydroponic system using Arduino-based microcontroller.

b) To monitor and control pH value as per user input.

1.4 Scope of Project

a) Focus on plants with an EC range between 2 milliSiemens per centimetre to 3.5 milliSiemens per centimetre.

b) Growing only one type of plant at a time.

c) Using concentrated nutrient solution A and concentrated nutrient solution B as the only nutrient solution for the automated hydroponic system.

d) The range of pH controlled is between 5 to 6.

e) The pH of the hydroponic solution will be regulated to its required value by decreasing and through the use of pH down solution only.

f) Use Arduino IDE to program user input function into Arduino Mega 2560 that choose electrical conductivity (EC) value and pH value for different kind of plants.

g) Fabricate hydroponic hardware to demonstrate the concept of the project

h) Testing the hardware functionality by planting a real plant starting from seed.

1.5 Thesis Outline

There are a total of five chapters in this thesis which comprise of introduction, literature review, methodology, result and discussion, and conclusion and recommendation. The project outline and work progress are discussed and written in detailed corresponding to each chapter.

In Chapter One, the main purpose is to introduce the project to the public by specifying the reasons and kick-starter of starting this project. This chapter thoroughly explains about the project's background with their associated real-life problems and the

method to solve this problem through the project's objective and scopes. Furthermore, this chapter specifies the targeted audience that can implement this project for their needs.

In Chapter Two, past research journal and related study case were reviewed. This chapter mainly discusses and surveys the literature that covers automated hydroponic systems and its equivalent. Information from different research papers related to the hydroponic system prior to this project critically analyses and summarised. The summarised information is integrated into the design of an automated hydroponic system.

Chapter Three focuses on the project's methodology and process taken to finish the project. The implementation of the software program and the development of the hardware are elaborated in this chapter. This chapter also highlights the equipment involved in this project together with the specification for each piece of components used.

Chapter Four highlights the acquisitions of data for all parameter involved in this project. The detailed methods used for data acquisition are elaborated in this chapter together with proper figures, tables and charts. The acquired data were analysed and discussed to further understand about this project.

Lastly, Chapter Five concludes the findings and the completion of the project. True results were highlighted once more to show that the result is drawn based on fact and proper data. The recommendation was drawn to give suggestions for future case study relate to this project.

1.6 Project Significant

The main target audience of this project was for community needs. This project is aimed toward people with hectic schedules but still wants to commit part of themselves for their hobby of growing plants. This hydroponic system was also good for people having to travel away for a long period of time. The system constantly monitors the changes in solution pH so that it maintains in the suitable range for the plants to grow and availability of uptake nutrients. Apart from that, the user interface was designed to be easy to use as it requires just to input the EC value and pH value. As for the operating process, the users just input the parameter value and the hydroponic system will fill the water itself, mix the hydroponic solution by itself while circulating the hydroponic solution between the reservoir tank and growing tray until the user request for harvesting. This greatly reduce the time need for the user to change out the water and refill everything back to normal while also allowing the system constantly monitor the change in pH of the solution.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter, case study and research was done by reviewing past research paper, journal and related project titles. The information obtained was summarized to essentially describe what is agriculture, the method and type of modern agricultural technique used and the impact of practicing these agricultural methods. Apart from that, studies about past project titles related to automated hydroponic system was conducted and it contributes to the base design and guidelines to make the automated hydroponic system. Information gather from various journal and research paper contributes to the understanding of the project concept and the understanding of implementing hydroponic technologies using modern solutions. Recommendations and suggestions on past project gives insight on how to approach the project and were used to greatly improve the stability and functionality of the system. Therefore, the project concept is supported with justifiable past studies.

2.1 Agriculture

Agriculture is a science about cultivating plants and raising domesticated livestock to become food, feed, fibre and many other products as demanded by the population around the world. The main practice to agriculture was known as farming, while there were also

organisation and independent research group devoting their efforts to improve farming methods and implement into modern agricultural practice. There are two type of farming practice which make up to modern day agriculture and those two types are subsistence farming and industrial or commercial farming (Sedaghat *et al.*, 2017).

Subsistence farming means that a farmer or grower farms a small plot of land with limited resources and inputs. The product from this type of farming can only be produced enough for his or her family needs. On the other end, industrial agriculture or commercial farming involves a large plot of field and maybe a large number of livestock. This type of farming practice has extensive resource input to own proper farming machine, mechanization of farming practices and farming equipment. Industrial farming generally attempts to maximize their financial income from meeting demands by selling grains, produce and livestock (Hobbs, 2007).

Modern agriculture does not only involve farming and rearing livestock. Agricultural chemistry and genetic engineering has entered the fray since the green revolution that spread the changes in agricultural practices throughout the world. Agricultural chemistry involves in the research, development and application of chemical fertilizers, pesticides, fungicides, soil conditioning and nutritional needs of livestock. Analysis of agricultural products dictates the change in agricultural chemistry to proceed the research in a favourable direction. Genetic engineering involves in modifying the genes of plants to go beyond their capabilities like allowing the plant to grow faster or produce more yield than the natural state (Hobbs, 2007).

Recent changes to agricultural practice includes plant breeding, hybridization of plants, soil nutrient management, improved weed control and hydroculture. The most noticeable change is hydroculture or can be introduced as soilless farming technique. This

method completely eliminates the need of soil to grow plants thus eliminates of huge of field to grow commercial crops. There are two common hydroculture practice that is currently applied in both subsistence farming and industrial agriculture. The first practice is hydroponic and the basis of the hydroculture. Plants are grown with their roots directly inside water and the nutrient uptake was controlled by the grower. Aquaponics is a variation to hydroponic that includes aquatic life to provide nutrients for the plants. Hydroculture completely eliminates bothersome chores like weed control, soil treatment of contaminated soil and watering plants (Orsini *et al.*, 2013).

Urban agriculture also becomes the norm of modern agriculture as lands are becoming more expensive and cause a lot of competition among agricultural sector. This type of agriculture is defined that crop production at available plot at home in any urban area and only operates in limited space and the crop growth was affected by urban environment. Resources in urban area such as water supply, sewage system, labour force can indirectly the progress of urban agriculture but it will still contribute to the society in a long term (Orsini *et al.*, 2013).

2.1.1 Hydroponic Method

Hydroponic method is one of the techniques in hydroculture, which use a soilless method to grow plants by replacing soil and manure. The plant roots are submerged inside a hydroponic nutrient solution and the process of watering plants can be removed. Modern hydroponic system uses a two tank system to allow irrigation and the circulation of hydroponic nutrients to prevent the build-up of residuals and forming moss and algae. The first tank was used as a reservoir or troughs to contain hydroponic solution that was premix

with required amount of nutrient concentration and pH value. The solution was supplied to the second tank, the plant tray through a pump and operate endlessly until harvesting and water changing (Alshrouf, 2017).

In soilless agriculture, growing medium was used by farmers to replace soil or dirt so that it can hold the plants upright while supporting the plant weigh. The general function of the growing medium was to retain water and oxygen that the root system requires to grow. The growing medium can either be porous or non-porous with the main disadvantages of growing plants in non-porous growing medium requires frequent watering cycle. Although growing medium was used as an alternative to sprout seeds and growing plants, they do not provide the plants with nutrients and that is the sole reason for it to be water with nutrient solution (Sedaghat *et al.*, 2017).

There was different type of system that uses the concept of hydroponic plantation and these are call framework. Modern hydroponic framework such as Ebb and flow system, water culture system, drip system, Wick system and nutrient film technique (N.F.T.) system are the most commonly used hydroponic methods available in commercial farming while also suitable for home farming. Ebb and flow system, also calls as flood and drain system will flood the growing tray with nutrient solution through a pump from the reservoir. When the nutrient solution at growing tray reaches the height limit of pre-set overflow tube, it drains the nutrient solution back down to the reservoir and recirculate back to the growing tray again (Son, Kim and Ahn, 2015).

Water culture system was the simplest among the five hydroponic framework as the plant was suspended in a basket or mesh cup right above the nutrient solution. The mesh cup was usually place in the holes of a floating Styrofoam with the roots outside the mesh cup dip directly into the nutrient solution. There is no suffocation by the roots because the