Faculty of Engineering

THE DESIGN OF IOT BASED AUTOMATED VERTICAL HYDROPONIC FARMING SYSTEM

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Final Year Project Report ☑

Masters ☐

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THE DESIGN OF IOT BASED AUTOMATED VERTICAL HYDROPONIC FARMING SYSTEM

CHRISPER CHANG

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT

OF THE REQUIREMENT FOR THE DEGREE OF

BACHELOR OF ENGINEERING

ELECTRICAL AND ELECTRONICS ENGINEERING

WITH HONOURS

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2022

My humble effort I dedicate to my beloved parents whose affection, love, encouragement and prays of day and night make me able to complete this thesis, along with my respected supervisor who gave me endless guidance, Associate Professor Ir. Ts. Dr Kismet Anak Hong Ping, and lastly my supportive fellow friends

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ABSTRACT

One of the most pressing concerns confronting human civilization is how to meet food demands. According to the United Nations' Food and Agriculture Organization (FAO), the world's population will reach 9.1 billion by 2050. It means that between 2005 and 2050, food production must increase by 70% to feed a global population of 9.1 billion people. Malaysia has not yet achieved self-sufficiency in basic food. According to the Ministry of Agriculture and Food Industries' (MAFI) Agrofood Statistics 2019, Malaysia's self-sufficiency level for main food commodities such as rice, vegetables, fruits, beef, and liquid milk in 2019 was 63%, 44.4%, 78.2%, 22.3%, and 63%, respectively. By 2030, the United Nations (UN) expects that 60% of the world's population will be living in cities. This will result in the city's urban area expanding and, conversely, agricultural land shrinking. The issue at hand is how to boost agricultural output. In addition, how might pesticides be used more sparingly so that they do not damage humans? Hydroponics has gained popularity in recent years due to its capacity to create nutrient-rich crops with little resources. The goal of the project is to create a flexible growth environment using a hydroponic system based on Internet of Things technology (IoT). By creating a smart greenhouse system is one answer to this challenge. The concept of pesticides is not used in this smart greenhouse system's farming as the basic factor can be control inside the greenhouse. The DHT11 sensor, pH sensor, and a EC sensor were all used in this project. The ESP8266 Wi-Fi module serves as the system's controller. The real-time database Arduino Cloud IoT stores data on temperature, humidity, electrical conductivity of nutrients solution, pH, and actuator conditions (DC water pumps). Environmental conditions for this project can be monitored and the actuator can be controlled using a smartphone application or using laptop. The result for the project shows that the plants grow healthy and produce big yield as the temperature and humidity are at the optimum value at the average of 29.5°C to 32°C. For the pH value, it was at the range of 6.80 to 7.0 while the EC value for the hydroponic plants is at the range of 1.2 mS/cm to 2.0 mS/cm.

ABSTRAK

Salah satu masalah yang dihadapi oleh tamadun seluruh dunia zaman ini tanpa mengira bangsa dan agama adalah masalah permintaan makanan yang tidak stabil. Berdasarkan United Nations' Food and Agriculture Organization (FAO), jumlah penduduk dunia akan dijangka mencapai 9.1 bilion pada tahun 2050. Malaysia masih belum lagi mencapai sara diri yang mencukupi dalam penghasilan bekalan makanan. Berdasarkan Kementerian Pertanian dan Industri Makanan (MAFI), perangkaan 2019 menunjukan bahawa Malaysia hanya mengeluarkan bahan mentah seperti beras, sayur-sayuran, buah-buahan, daging and juga susu lembu sebanyank 63%, 44.4%, 78.2%, 22.3% dan 63% masing-masing. In bermaksud bahawa pada tahun 2005 dan 2050 pembuatan makanan mestilah meningkat kepada 70% untuk memenuhi permintaan makanan yang mempunyai penduduk berjumlah 9.1 bilion orang. Oleh hal yang demikian, United Nations (UN) menjangkakan bahawa 60% daripada populasi dunia akan menentapkan kehidupan mereka di kawasan bandar. Perkara ini akan memberikan kesan terhadap pembesarakan kawasan bandar dan seterusnya akan memberi impak terhadap pengkecilan terhadap tanah pertanaman di kawasan bandar. Oleh hal yang demikian, masalah terhadap penanaman sayur-sayuran akan terjejas terutama kawasan yang kecil. Tambahan pula, penjagaan sayur-sayuran daripada pengunaan racun serangga/perosak juga akan menimbukan masalah terhadap manusia jika tidak mempunyai ilmu terhadap pengunaan racun serangga/perosak. Penanaman sayur-sayuran secara hidroponik telah meningkat dari tahun ke tahun kerana kebaikan dalam meghasilkan tanaman yang mengandungi nutrient yang sihat. Matlamat project ini adalah menghasilkan penanaman sayuran secara hidroponik sistem berdasarkan Internet Pelbagai Benda (IoT). Membuatan sistem rumah hijau juga dapat memberi kesan yang positif dan juga dapat membantun dalam sistem hidroponik. Pelbagai pengesan pengesan elektronik digunakan dalam projek seperti pengesan *DHT 11*, pengesan *pH* dan pengesan *Electrical Conductivity.* Pengunaan *ESP8266 Wi-Fi module* sebagai sistem pengawalan bagi hidroponik. Semua data dan maklumat seperti suhu, kelembapan, *Electrical Conductivity* dalam larutan nutrien, pH, dan sistem penggerak (pump air) akan dipaparkan secara *real-time database Arduino Cloud IoT*. Keadaan persekitaran dalam projekini boleh dikawal dan dipantau melalui aplikasi telefon pintar termasuk sekali dengan sistem penggerak. Project ini berjalan dengan sempurna dimana tumbuhan membesar dengan baik dan tumbuh besar disebabkan dengan kawalan suhu dan kelembapan iaitu dalam angkaran 29.5°C hingga 32°C. Manakala untuk nilai pH adalah dalam lingkuran 6.80 hingga 7.0 dan untuk nilai EC adalah dalam lingkuran 1.2 mS/cm to 2.0 mS/cm.

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CHAPTER 1

INTRODUCTION

1.1 Background of hydroponic

The name hydroponics is taken from two Greek words as the first words is 'hydro' which means water, and while the second words is 'ponos' which means labor. Based on the statement by Dr. Gericke who is a California professor where he began to develop what had formerly been a laboratory technique into a commercial means of producing plants, coined the term in 1929. During World War II, the United State Army employed hydroponic agriculture to produce fresh food for groups stationed on barren Pacific islands. America, Europe, Africa, and Asia all had profitable commercial farms by the 1950s. The concept of hydroponics is the practice of growing plants in water rather than the user of soil, with the goal of meeting the nutritional requirements of the plants. In regions where green space is scarce, hydroponics is more efficient. As a result, hydroponics is a viable option for urban farming. On a big-scale industrial scale as well as a small-scale domestic one for self-consumption. Plants are grown in a nutrient solution rather than dirt in hydroponic gardening. The benefit of this planting techniques is that it eliminates various of the issues that plague soil-grown plants, for example are soil-borne and cutworms infections, which may damage your harvest. This eliminates the need for herbicides and insecticides. Hydroponics also have better control over the nutrients of types of plants consume. To guarantee optimum growth, the ideal way to achieved and good growth of plants is to change the nutrients that the plant receives at different phases of its development.

Figure 1.1 Hydroponics Farming

A porous growing aggregate is utilized instead of soil such as vermiculite, clay balls, gravel, sand, coconut coir, or perlite are examples. These enables for more free circulation of air and nutrients, allowing for improved oxygen and nutrition distribution to every plant. Nutrients and water are sent straight to the roots, allowing the plant to focus its energy on growing above the soil instead of pushing through it in search of nutrients. Plants may be grown closer together since the roots are smaller, which saves space. This might imply that everything grows, develop quicker and produces more in a smaller space.

There are a few kinds of agriculture for the soilless medium not only hydroponic but like aeroponics, and aquaponics are contemporary agricultural techniques that nurture plants with nutrient-rich water rather than soil [1]. Aeroponics is a type of hydroponics in which the plants are grown by spraying high nutrients water rather than using a growth medium. In this technique, roots of the plants are hung in a dark container and sprayed with a nutrient-dense fluid at regular intervals. For the preserve a constant aquatic environment with slight difference in ambient oxygen levels and nutrients, where this aquaponics systems mostly are dependent on an integrated interaction between the animals and the plants. Aquaponics is the combination of aquaculture or raising fish and hydroponics system part is where the fish and plants are grown together in one integrated system. The fish excrement supplies organic food for the growing plants, while the plants act as a natural filter for the fish's water [2]. The good microorganisms to be specific nitrifying bacteria and composting red worms that flourish in the growth media are the third players for the growth of plants. Those microorganisms change the presents of ammonia in fish waste into nitrites, then next into nitrates, and lastly the sediments into compost, which is used as plant nourishment [3].

Figure 1.2 Horizontal Hydroponic

Figure 1.3 Vertical Hydroponic

Figure 1.4 Dutch Bucket Hydroponic

There are a few plantings system for hydroponic which are the farmer can plant their crops either Vertical, Horizontal hydroponic and Dutch bucket hydroponic. These planting systems have the same concept for the water to flow around the crops however each system have their own benefit for different types of plant. For example, for vertical and horizontal can plant a lot of crops such as lettuce, spinach, celery, bok choy and many mores. The only different for these two is that the size for the farmer want to implement the system. For the Dutch bucket hydroponic is look alike with horizontal but instead using tube it uses a bucket for the pot of the crop. These buckets contain at least 2 plants per buckets and the suggested plant for farming using this system is tomatoes, cucumber, pepper and beans.

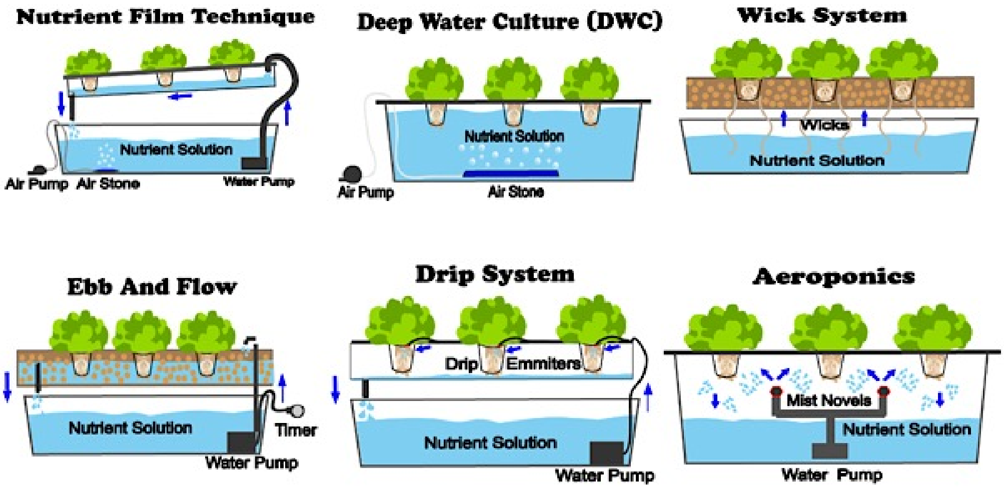

Figure 1.5 Hydroponics techniques

For the details of the techniques that used in hydroponic are based on Figure 1.5 which each technique has their own advantages and disadvantages. Nutrients Film Techniques (NFT)s are commonly employed in commercial hydroponics, especially for crops with short harvest times. The nutrition solution is continuously fed from the reservoir to the grow tray. The growth chamber has a little downward slope, which allows the solution to flow from the tray's top to the bottom, then the water or solution return back into the nutrient reservoir. Next for Deep Water Culture (DWC) systems are the most basic hydroponics approach used by farmer. They are frequently used in classes to demonstrate how a hydroponics system works. Since the nutrient solution in this system is not circulated, an air stone is required to keep the water oxygenated. The drip system is the most prevalent hydroponics system where it is used to build a nutrient reservoir distinct from the plants as vital nutrients are given to a tank of water. Next the water is then pumped through the connection of tubes and delivered to the plants one by one. Moreover, a nutrient reservoir is also used in an ebb and flow arrangement, with the water kept in a separate tank from the plants, which are kept on a grow tray above. A timer is programmed to operate a pump in the nutrient reservoir on a regular basis.

The purpose of this study is to create an Internet of Things (IoT) system which can control temperature, pH level, air humidity, water flow of hydroponic, and fertilizer solution that being used in a hydroponics system. The importance of hydroponics is that allow normal people to grow their own vegetables which can help them to produce their own food soilless especially beneficial for those who live in apartments and urban environment. In hydroponics, the pH level, ambient temperature, air humidity, nutrition content of the water, and proper water irrigation are all vital. As a result, the assistance of a management and monitoring system that monitors these parameters is vital and will assure the grower's achievement and proficiency. The Hydroponics Management System or also known as HMS is a web-based hydroponics system that allows users to handle various processes such as replenishing, sprinkling, draining, and many more [4]. The pH level, relative humidity, ambient temperature and water level can be controlled and monitor using data received from the sensor that is installed in the hydroponic system [5]. In short, the users or farmers have the ability to monitor and manage these IoT from anywhere as long as there is an internet connection.

Several research employing IoT for autonomous greenhouses have recently been published [6-9]. Based on [6], they described the development of a simple, low-cost Arduino-based system for monitoring environmental parameter readings. Temperature, humidity, soil wetness, light intensity, and soil pH are all monitored in a greenhouse and relayed using an Arduino Ethernet Shield and a GSM module. The authors of [7] suggest that managing greenhouse climatic conditions using Android-activated control actions and the software of ThingSpeak platform to observe the variables. In addition, utilizing a Raspberry Pi 3 and the ThingSpeak platform which is an actuator control system is created to maintain ideal humidity and temperature conditions [8]. Finally, in [9] a monitoring system is described that uses a Raspberry Pi, a local server, and the Node-RED programmed to collect data on air humidity, air temperature, soil humidity, soil temperature and light intensity.

Greenhouse is defined as an isolated building that uses transparent materials in its construction to provide artificial microclimate conditions for indoor harvest production [10]. As shown in Table 1.1, greenhouses are classed in a variety of ways based on the features of their construction parts.

Figure 1.6 Lean-to greenhouse

Figure 1.7 Flat greenhouse

Figure 1.8 Sawtooth greenhouse

Figure 1.9 Gothic arch greenhouse

Table 1.1 Different Styles of Greenhouses

Greenhouse Types	**Details**
Lean-to greenhouse	This structure has a one slanted roof and shares a wall with another structure such as house or building.
Pit greenhouse	It is design for four feet below ground level, with retaining walls and a concrete foundation which make it energy efficient.
Geodesic greenhouse	Th design is based on triangles that are connected in a network. Construction is simple and portable for the strengthening of the structure.
Flat greenhouse	The structure is made up of two parts which is vertical and horizontal. The design is used for dry locations.
Sawtooth greenhouse	Side walls that are quite wide where at least two greenhouses are linked by gutters. It is usually used in deserts and tropical regions.
Uneven greenhouse	Built on a mountainous site. The ceilings are of varying heights.
A-frame greenhouse	This is secured in place by stakes or rods. It has a straightforward design that warms up rapidly.
Arch roof type tunnel greenhouse	Design that is simple and affordable. Plantations are protected from frigid temperatures and severe rains by these structures.
Gothic arch greenhouse	The top construction is in the shape of an expanded arch. Inside, there is more space and mostly in use in harsh climates

Ridge-and-Furrow greenhouse	Greenhouses with a consistent reach that are linked to gutters. The greenhouse's efficiency is maximized through the use of ridges and furrows.

1.2 Problem Statement

Today's fast expansion of the country has an impact on agriculture, since agricultural land has been lost to make way for new buildings and residential areas. Plants are frequently dissolved in water rather of having their nutrients absorbed from the soil, and their roots are suspended, inundated, or incorrectly treated with nutrient solution, depending on the type of hydroponic system utilized which is necessary for development. Due to limited space or surrounding, hydroponics can be practice at home with different shape of the hydroponic either vertical or horizontal hydroponic. If the farmer does not have the expertise or management system for the hydroponics plant, the use of chemical pesticides or the right nutrients might be detrimental to the plant. Therefore, the management system with the present of IoT will help farmer manage their plant perfectly. The limited space may limit the farmers for variety of plant they want to grow thus with the IoT the system able to separate variety of plant the farmer preferred to plant as different plants have the range of pH water thus it will be easier for the system to help the farmer to manage their plant separately.

1.3 Objectives

The goal of this final year project is to design and construct a hydroponics management system that able to be done by everyone and anywhere. This project can be accomplished by completing the following objectives:

i. To investigate the hydroponic management system with present of IoT
ii. To design a vertical hydroponic system for different types of potential vegetables (Salted Indigenous Mustard Green and Mustard Green)
iii. To evaluate the effect of temperature, humidity, pH value and the EC value toward the growth of hydroponic vegetables.