UNIVERSITI TEKNIKAL MALAYSIA MELAKA

SMART AQUAPONICS MONITORING SYSTEM BASED ON IOT

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

by

MUHAMAD NAFIS BIN MOHD KHARIL @ HAMZAH

B071610566

970717-02-5625

FACULTY OF ELECTRICAL AND ELECTRONIC ENGINEERING TECHNOLOGY (FTKEE)

2019

DECLARATION

I hereby, declared this report entitled "Smart Aquaponics Monitoring System Based on IoT" is the results of my own research except as cited in references.

Signature :

Author's Name : MUHAMAD NAFIS BIN MOHD KHARIL @ HAMZAH

Date :

APPROVAL

This report is submitted to the Faculty of Electrical and Electronic Engineering Technology (FTKEE) of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours. The member of the supervisory is as follow:

…………………….

(Project Supervisor)

ABSTRAK

Sistem pengawasan aquaponics berdasarkan IoT ditubuhkan dan disajikan dalam karya ini. Projek ini memberi tumpuan kepada bagaimana untuk memantau parameter sensor yang berkaitan dengan menggunakan aplikasi IoT ke dalam telefon pintar. Kepentingan projek ini adalah untuk memberi perhatian kepada pengguna tentang parameter yang perlu dipantau dan memudahkan pengguna membaca data dari jauh. Kesukaran kawasan ini adalah sensor tidak boleh didedahkan kepada hujan. Dalam kes ini, sensor kalis air digunakan untuk memudahkannya didirikan di luar. Sekiranya projek ini berjalan dengan lancar, ia memberi impak besar kepada pengguna untuk memotivasi mereka untuk terus menerus dalam aquaponics. Masalah yang telah diselesaikan dalam projek ini adalah pengguna aquaponics dengan mudah boleh merakam data mereka walaupun dari jauh. Sensor yang mengesan parameter yang diperlukan digunakan dalam projek ini. Pengekodan untuk setiap sensor dan aplikasi IoT direka dengan menggunakan Arduino IDE Software dan MIT App Inventor 2 masing-masing. Kemajuan dalam projek ini adalah papan ESP32 akan menghantar data sensor yang dikesan ke webserver dan akhirnya diambil dari MIT App Inventor 2. Pembolehubah penting yang telah diukur dalam projek ini ialah suhu, kelembapan, suhu air, jarak, kadar aliran air dan pH air. Hasil akhir yang telah dicapai adalah pengguna dapat memantau data dalam telefon pintarnya sendiri dari jauh dengan menghubungkan Wi-Fi ke papan ESP32. Hubungan antara suhu dan kelembapan tanaman dan lain-lain juga telah dikaji. Antara muka pengguna grafik pemantauan parameter yang dikehendaki dicapai melalui MIT App Inventor 2. Pengguna boleh memuat turun dari laman web MIT App Inventor 2. Implikasi projek ini adalah untuk mengesyorkan pengguna lebih berminat dalam sistem aquaponics.

ABSTRACT

Aquaponics monitoring system based on IoT is set up and presented in this work. This project focuses on how to monitor the parameters of related sensors by applying the IoT application into the smartphone. The importance of this project is to alert users about parameters that need to be monitored and to make it easy for the people to read the data from far away. The difficulty of the area is the sensors cannot be exposed to the rain. In this case, waterproof sensors are used to make it easy to set up at outdoor. If this project goes smoothly, it will give a huge impact on users to motivate them to keep going in aquaponics. The problem that has been solved in this project is aquaponics users can easily record their data even from far away. The sensors that detect the required parameters are used in this project. The coding for each sensor and IoT application are designed by using Arduino IDE Software and MIT App Inventor 2 respectively. The progress in this project is ESP32 board will send the detected sensor data to the web server and finally retrieved from MIT App Inventor 2. The important variables that have been measured in this project are temperature, humidity, water temperature, distance, water flow rate and pH of the water. The final result that has been achieved is users able to monitor data in his own smartphone from far away by connecting Wi-Fi over ESP32 board. The relationship between temperature and humidity of the plant and others also has been studied. The graphical user interface of monitoring the desired parameters has been achieved through MIT App Inventor 2. User can download it from the MIT App Inventor 2 website. The implication of this project is to recommend users more interested in an aquaponics system.

DEDICATION

To my precious parents, Mohd Kharil bin Abd Majid and Suryani Binti Samat, for their trust, time and effort on me. To my beloved sibling especially Muhamad Nabil bin Mohd Kharil for the supports and beliefs, also to all of my friends for their help and motivations.

ACKNOWLEDGEMENT

Final year project was a long and arduous journey. Support from family, friends, course mates and lecturers gave me unlimited energy to move forward and finally complete this project. Firstly, I would like to express my gratitude to my supportive Supervisor, Sir A Shamsul Rahimi bin A Subki and my Co-Supervisor, Sir Wan Norhisyam bin Abd Rashid for his endless support, boundless guidance and advices on this project. Secondly, In addition I would like to express my appreciation to the support and help offered by my friend, course mates. Finally yet importantly, thanks to my family who had supporting me all the way spiritually and financially which are greatest motivation in this project.

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURES

LIST ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

ESP32	Wi-Fi UNO Based ESP32
pH	Potential Hydrogen
GUI	Graphical User Interface
NH3	Ammonia
NO2-	Nitrites
NO3-	Nitrates
℃	Celsius

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter is discussed about the project introduction, background of project, problem statement, objectives and the scope of the project.

1.2 Project Background

Agriculture has become the main agenda of a number of Asian countries and this includes Malaysia. Agricultural sector has recorded a significant achievement and its role has been reinforced. Considering global trends such as climate change and resource shortage, a major challenge of future cities will be to reduce urban footprints. So in order to reduce urban footprints, people tend to build their own farm in the city. This will lead to a greener environment as oxygen released from the crops that they harvest indirectly will reduce global warming in the city. Aquaponics is one of the types of urban farming. Aquaponics is a system that operated between aquaculture and hydroculture. In aquaponics, an unknowledgeable people always make some mistakes in taking care of such as too excessive fish food, the neglect of flow rate of water that can affect the filter, and others. So basically, people must always monitor their own farm to avoid any undesirable happens. To monitor the data, MIT App Inventor 2 has been used in smartphone as shown in figure 1.1.

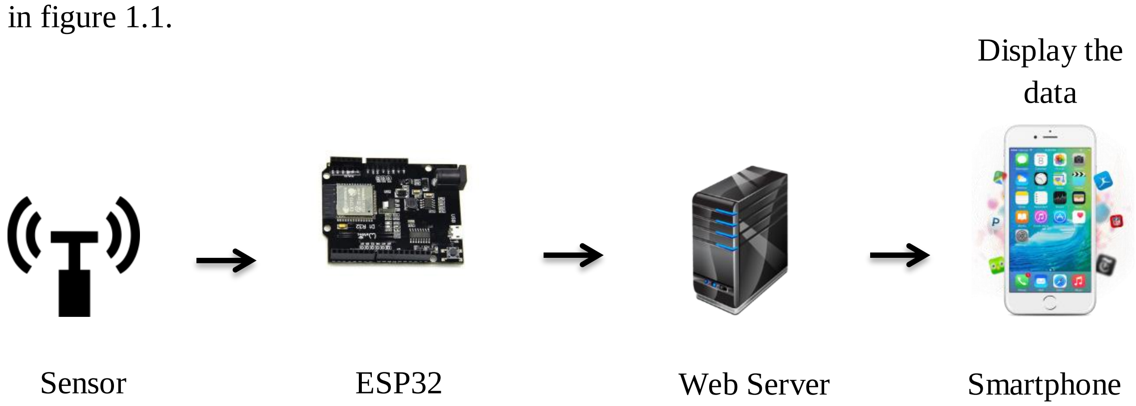

Figure 1.1 Overview of aquaponics monitoring system process

1.3 Problem Statement

Nowadays, the city grows up as a society develops day by day. Many individuals, community groups, environmentalists, city planners and gardeners interest to growing or producing food in a city. This is called an urban farming. Urban farming has two ways that popular among the people which are hydroponics and aquaponics. Hydroponics is simple than aquaponics which is a method of growing plants without soil and a subset of hydroculture while aquaponics is a combination of aquaculture (raising fish) and hydroponics that grows fish and plants together in one integrated system. Besides hydroponics, people tend to build aquaponics more. The problem is people do not monitor its system which leads to the death of fishes and plants frequently. This is because daily maintenance is not practiced in aquaponics system which is involving water temperature, humidity of the surrounding, pH water level and others related to the basic needs of fish, plant and bacteria. Besides that, modern people have been always engaged in work and they have no more extra time to look after the fish and hydroponic plants on the spot. On the one hand, fish requires contaminated water to be treated regularly and it is also boring to replenish oxygen, maintain temperature and humidity, and knowing the time it takes to harvest matured plant. On the other hand, plants need watering and fertilization frequently. The whole process is so complicated and time-consuming. In order to overcome this problem, an aquaponics monitoring system is proposed. This project should be able to alert the people to monitor the aquaponics system. The expected result should be the condition of fish and plants will be secured in terms of its health, food and others. Besides that, the aquaponics system will be run more smoothly due to daily operation of the electronic devices.

1.4 Objective

1. To integrate between ESP32 board, Wi-Fi module, and input output devices.

2. To monitor the pH and temperature of the water pool, temperature and humidity of the plants' environment, the flowrate of the water at filter pump and the time taken for the plants to be harvested.

3. To alert the people to monitor the data of aquaponics system.

1.5 Scope

The scope of this project is MIT App Inventor 2 will be used for the Graphical User Interface (GUI) between user and electronic devices. For monitoring an aquaponics system, a smartphone will be used. Besides that, ESP32 board will be used as a device to view the data in smartphone which gained from electronic devices. For measuring pH water level, pH analog sensor will be selected. Furthermore, waterproof temperature sensor and ultrasonic sensor will be used to measure temperature of the water and the heights of the plants for harvesting time purpose respectively. Besides, water flow sensor will be used to measure the flowrate of water at water filter. Lastly, DHT22 sensor will be used to measure temperature and humidity in order to keep the plants’ environment stable and controlled.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this part, the object is to make an audit of the past studies that have been finished by other analysts that related and applicable to the aquaponics monitoring system. This part additionally will talk about the upkeep required for the aquaponics system to ensure it ready to dependable and work with no issue. Other than that, the conditions that lead to upkeep issue and what the support ought to try to forestall and maintain a strategic distance from the issue likewise will talk about in this part. Other than that, the significant of periodical upkeep additionally will be talked about.

2.2 The Relationship between Urban Farming and Built Environment

Urban farming has a comparable relationship to the built environment since it can add to the decrease of carbon impression in the city. Carbon impression is the aggregate sum of ozone-depleting substances delivered to, directly or indirectly, support human activities. The advantages of a local food system can restrain the transportation of nourishment through straightforwardly disseminate the agriculture item to the local market and other industries. This will diminish the recurrence of nourishment transportation from another district or outside nation and after that immediate lessening the carbon dioxide transmitted by the vehicle. Urban agribusiness has biological advantages by diminishing the city squander, improving urban biodiversity and air quality, and by an overall lessening the natural effect identified with both sustenance transport and capacity (INRA and Springer-Verlag France, 2013).

Moreover, urban cultivating can likewise control urban temperature and improve the microclimate. The vegetables can expand the encompassing moistness through the transpiration process. Alongside the expanding of humidity, the environment temperature will be decreased.

In 2016, the Food Aid Foundation (Food Aid) announced that Malaysian has squandered just about 15,000 tons of sustenance including 3000 tons of palatable nourishment consistently (Sulaiman, N. F. A. R., and Ahmad, A, 2018). Notwithstanding, nourishment squander is potential manure that can use in urban farming after changed over into fertilizer. Manure is characterized as the natural compost delivered from the sustenance squander at a lower cost (Harris, n.d.). The utilization of sustenance squander as crude material for urban farming can lessen the aggregate sum of nourishment waste and diminishing the travel distance and recurrence for discarded sustenance squander (HB Lanarc - Golder, 2013)

2.3 An Aquaponics System

An aquaponics system is one kind of urban farming that has a blend of aquaculture and hydroponic system. This mix can make another system which empowers the creation of fishes and yields can accomplish in one system. The aquaponics system is comprised of three principle essential segments which are fish, nitrifying bacteria, and plant. For the most part, the little scale aquaponics system is well known among the general population because of the extent of the aquaponics system is fixed to their lodging region. A developing number of urban farming ventures exist in and on urban structures, including open housetop ranches, housetop nurseries and indoor cultivating (Thomaier et al., 2015).

In an aquaponics system, the water is siphoned off up by a water pump from the fish pond to the plants. The fish pond contains ammonia created by the fish in the ammonia structure. From that point onward, the water is coursing through the pipe, past the underlying foundations of the plants before depleting over into the fish pond. Amid the water cycling process, the way toward structure states of bacteria happens when these bacteria use fish waste, ammonia, and transform it into useable plant nourishment. Fish produce squander (ammonia, NH3), Nitrosomonas (bacteria 1) convert ammonia to nitrites

(NO_2^-), Nitrobacter (bacteria 2) convert nitrites to nitrates ($N0_3^-$), and nitrates are the useable type of supplements plants take-up as sustenance (Phil Cleric, 2016). This change is in term of "nitrogen cycle". In the meantime, the base of the plant will tidy up the contaminated water when it goes through (Mullins, Nerrie, & Sink, n.d.).

In this system, the fish is assuming a significant job in the nitrogen cycle. This is because the fish is act as an essential maker to create squander as compost for the plant to ingest. Accordingly, any adversity to the fish can cause the entire system breakdown. Essentially, fish is simpler to endure pressure when there was an adjustment in their living condition (Adams, Barton, & MacKinlay, 2002). In this manner, the aftereffect of natural change can prompt intense or unending mortality. Basic stressors experienced by hostage fish incorporate physical and mental injury related with catch, transport, dealing with, and swarming; lack of healthy sustenance; varieties in water temperature, oxygen, and saltiness; and fringe impacts of contaminant exposure or irresistible ailment (Harper C., 2009). The majority of this circumstance can be forestalled through the lead of water quality maintenance.

Catfish is one type of fish which are well known and appropriate development in an aquaponics system. Catfish is commonly a functioning fish and they will in general move up and down. Since they will, in general, be dynamic and move around, catfish blends the mixes in the water. At the point when the mixes are blended superbly with water, it very well may be caught up with the plants maximally. Another honorable quality is that catfish are tough, and flourish at helpful temperatures; a system that stays around 60-70 degrees is perfect, and catfish will continue eating to at temperature of 55.

The plant appropriate for the aquaponics can be seedling or seeds. They could be sprinkled over the develop media or covered into the develop media (Aquaponics, n.d.). Other than that, the plant for aquaponics has two primary classes which are verdant green vegetables and fruiting vegetables (Fisheriesaquaculture & Paper, n.d.)

2.4 Water Quality Upkeep

Water quality upkeep is preceding guarantee the whole living thing can be endure. The water quality upkeep is incorporated pH level control and temperature control.

2.4.1 PH Water Level Control

Fundamentally, the pH esteem is a decent marker of whether water is hard or delicate. The pH of unadulterated water is 7. Generally, water with a pH lower than 7 is viewed as acidic, and with a pH more than 7 is viewed as an alkali. The ordinary range for pH in a surface water system is 6.5 to 8.5.

In an aquaponics system, the pH level must be worked to keep it from winding up excessively high or excessively low. The standard pH level range for the aquaponics system is between 6-7, which is reasonable for the fish and plant. A hardly high pH is generally not an issue since when beginning up another aquaponics system, it will cycle. The cycling procedure is framed to urge useful nitrifying bacteria to relocate to the system. This procedure is totally centered on the bacteria and the fish, which both propose a higher pH. This implies water somewhat over a pH of 7 really gets the system cycled. Other than that, the low pH esteem may result in the uneven nitrogen cycle in this system. The low pH esteem will influence the microscopic organisms to decrease the transformation of ammonia to nitrate. From that point forward, the dimension of ammonia will start to increment.

2.4.2 Water Temperature Control

Temperature is the fundamental parameter in aquaponics. Water temperature influences all state of an aquaponics system. By and large, a general trade off the range is 18– 30 °C. The high water temperature can cause less disintegrate oxygen, more ammonia, and confine the retention of calcium in plants. There are three fundamental players in aquaponics which are plants, fish and microscopic organisms.

For plants, the appropriate temperature extend is 18– 30°C. Nonetheless, a few vegetables are unquestionably increasingly fit to developing in specific conditions. Numerous vegetables, for example, lettuce, Swiss chard, and cucumbers develop better in temperatures running from 8– 20°C. While different vegetables, for example, okra, Asian cabbages, and basil require temperatures of 17– 30°C. In higher temperatures of 26°C or more, the debasement of chlorophyll occurs. The corruption of chlorophyll lessens the force of the green shading and prompts yellowing which makes them severe and unmarketable.

Fish are cold-blooded and, consequently, their capacity to change in accordance with a substantial scope of water temperatures is low. By and large, tropical fish (for example tilapia, basic carp, and catfish) develop in higher water temperatures of 22– 32°C. However, cold-water fish, for example, trout lean toward 10– 18°C. Meanwhile some moderate water fish have wide ranges, for instance, normal carp and largemouth bass can endure 5– 30°C.

For bacteria, the perfect temperature run for its development and profitability is 17–34°C. The development rate will diminish by half at 18° C and by 75% at 8°C - 10°C. No action will happen at 4°C. Nitrifying microscopic organisms will pass on at the temperature beneath 0°C or above 49°C.

2.5 Other Upkeep Required for Aquaponics System

This theme is right away examined about the upkeep which isn't connected to water quality, for example, wind protection, pest management, disease management, and fertilizer source.

2.5.1 Wind Protection

Once in a while, the breeze can be a catastrophe for the plant particularly the strong breeze. This is because the high speed of wind speed can possibly remove the vegetable or decimate some portion of their body. Therefore, the aquaponics administrator must take the wellbeing measure to limit the impact of the breeze on their plant.

The shade cloth is a financially accessible stretch of texture that is ordinarily folded around aquaponics plants to guarantee they stay cool amid summer. Shade cloth is generally made from woven polyester. A few nursery workers go for aluminum shade cloth that is far more ultraviolet (UV) resistant. The thickness of a shade cloth may go somewhere in the range of 5% to 95% (*Shade Cloth*, 2019).

Figure 2.1: Shade Cloth wrapped over Aquaponics Plants

2.5.2 Pest Management

Pests are plants' common adversaries, for example, caterpillars, natural product flies, snails, and others. This is because that the pests like to eat the plant whatever what types of the plant are and at what development organize despite the fact that hasn't developed. Any piece of the plant can be eaten by insects like the organic product, leaf, stem, and root. This is an inconvenience for the proprietor to guarantee their crops (Dufour, 2000).

So as to have plants safe from the vermin, some particular cleansers, or natural pest sprays and insecticidal cleansers might be utilized to fend off bugs and little creatures. Other than that, full-range composts with high potassium to nitrogen proportion can be utilized. In any case, if the administrator tries too hard with the nitrate nitrogen, this can cause the debilitating of the plants which will make them increasingly defenseless against organisms and creepy crawly harm. In addition, expanding the calcium admission can likewise help empower the reinforcing of the plant cells and makes them increasingly impervious to high or low temperatures too.

2.5.3 Ailment Management

The ailment is showing to any physiological or basic variation from the norm that meddles with development rate, advancement, appearance or function of an organism. Indeed, the aquaponics system is disparate from the hydroponic system that ready to oversee under sterile conditions because it is comprised of a complex tiny biological system. Inside the aquaponics system, there can discover the presence of fish, plant, and microorganisms. The complex tiny biological system caused the plant and fish all the more effectively tainted by the infection brought about by a pathogen. In any case, reasonable ailment the executives can anticipate the impact of sickness and limit the misfortune. In this way, there are two kinds of infections that can be examined here which are plant and fish disease management.

2.5.3.1 Plant Ailment Management

There are two sorts of plant infection which are an abiotic and biotic ailment. The abiotic infection is typically brought about by non-living things, for example, encompassing temperature, dampness, nourishment, poisonous quality, and so on. In any