Faculty of Electronics and Computer Technology and Engineering

DEVELOPMENT OF ANDROID APPS FOR HYDROPONIC MONITORING SYSTEM

HAIQAL BIN IDRIS

Bachelor of Computer Engineering Technology (Computer Systems) with Honours

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DEVELOPMENT OF ANDROID APPS FOR HYDROPONIC MONITORING SYSTEM

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A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Computer Engineering Technology (Computer Systems) with Honours

Faculty of Electronics and Computer Technology and Engineering

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FAKULTI TEKNOLOGI KEJUTERAAN ELEKTRIK DAN ELEKTRONIK

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DEDICATION

I dedicate this project to my parents, whose unwavering support and sacrifices have been the cornerstone of my academic journey. Heartfelt thanks for the financial support that made my aspirations a reality. I extend my deepest gratitude to my dedicated supervisor, Ts Ahmad Fairuz bin Muhammad Amin. His guidance, patience, and steadfast support from project initiation to completion were instrumental in its success. I am grateful for the knowledge and skills acquired under his mentorship. To my friends, your strength and companionship made overcoming challenges possible. Your moral support has been a constant inspiration, making this semester at Universiti Teknikal Malaysia Melaka truly memorable. This achievement is a collective effort, and I appreciate the invaluable contributions from everyone involved in this endeavor

ABSTRACT

The project aspires to revolutionize agricultural practices by harnessing cutting-edge technology, specifically employing the ESP32 microcontroller and Wi-Fi connectivity. With a keen focus on optimizing fertigation and hydroponics, the initiative seeks to address urgent environmental challenges in Malaysia, stemming from deforestation and climate change. Inspired by the government's tree replantation initiative, the system seamlessly integrates ESP32 and Wi-Fi modules, establishing a connection to an Android app through Blynk. This comprehensive approach not only enables real-time monitoring of crucial parameters such as temperature, humidity, and pH levels in hydroponic systems but also provides user-friendly controls and automation features to mitigate resource inefficiencies. The overarching goal is to elevate agricultural productivity, foster sustainability, and promote responsible resource management. The Blynk app enhances accessibility, offering intuitive tools for effective control and decision-making. Notably, the project confronts prevailing limitations in hydroponic systems, including the absence of real-time monitoring capabilities, inefficient resource utilization in traditional agriculture, and challenges associated with manual monitoring. Through its technological integration and automation, the initiative aims to surmount these obstacles, ushering in a new era of precision, efficiency, and sustainability in agricultural practices.

ABSTRAK

Projek ini berhasrat untuk merevolusikan amalan pertanian dengan memanfaatkan teknologi termaju, khususnya menggunakan mikropengawal ESP32 dan sambungan Wi-Fi. Dengan tumpuan yang mendalam untuk mengoptimumkan fertigasi dan hidroponik, inisiatif ini bertujuan untuk menangani cabaran alam sekitar yang mendesak di Malaysia, yang berpunca daripada penebangan hutan dan perubahan iklim. Diilhamkan oleh inisiatif penanaman semula pokok kerajaan, sistem ini menyepadukan modul ESP32 dan Wi-Fi dengan lancar, mewujudkan sambungan kepada apl Android melalui Blynk. Pendekatan komprehensif ini bukan sahaja membolehkan pemantauan masa nyata parameter penting seperti suhu, kelembapan dan tahap pH dalam sistem hidroponik tetapi juga menyediakan kawalan mesra pengguna dan ciri automasi untuk mengurangkan ketidakcekapan sumber. Matlamat menyeluruh adalah untuk meningkatkan produktiviti pertanian, memupuk kemampanan, dan menggalakkan pengurusan sumber yang bertanggungjawab. Aplikasi Blynk meningkatkan kebolehcapaian, menawarkan alat intuitif untuk kawalan yang berkesan dan membuat keputusan. Terutamanya, projek ini menghadapi had semasa dalam sistem hidroponik, termasuk ketiadaan keupayaan pemantauan masa nyata, penggunaan sumber yang tidak cekap dalam pertanian tradisional, dan cabaran yang berkaitan dengan pemantauan manual. Melalui penyepaduan teknologi dan automasinya, inisiatif ini bertujuan untuk mengatasi halangan ini, membawa kepada era baharu ketepatan, kecekapan dan kemampanan dalam amalan pertanian.

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I express profound gratitude to my supervisor, Ts Ahmad Fairuz bin Muhammad Amin, for his invaluable guidance, wisdom, and unwavering patience throughout this project. The financial support from University Technical Malaysia Melaka (UTeM) has played a pivotal role in the successful completion of this endeavour. I extend special thanks to my fellow classmates at UTeM for the open exchange of thoughts and ideas, contributing significantly to the project's development. This final year project would not have been possible without the crucial roles played by various individuals, and I sincerely thank my parents for their unwavering emotional and financial support, serving as the foundation of my academic journey. Lastly, my thanks go to all the staff, colleagues, and classmates at University Technical Malaysia Melaka, as well as faculty members and other individuals who, although not mentioned here, have been cooperative and helpful throughout this endeavour

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CHAPTER 1

INTRODUCTION

1.1 Background

Embarking on the development of a user-friendly mobile app for hydroponic systems holds the promise of revolutionizing the monitoring and control aspects of this innovative farming method. The advantages of hydroponics, such as increased agricultural yields, higher crop quality, and efficient resource utilization, can be further optimized through the integration of a dedicated app. This application would serve as a comprehensive tool, allowing users to seamlessly track and adjust critical parameters in real time, including pH levels, electrical conductivity, water temperature, air temperature, and light intensity. One of the key features of this app would be its ability to provide users with instant alerts and notifications when any of the monitored parameters deviate from the optimal range. This ensures that users can promptly address issues and maintain the ideal growing conditions for their hydroponic plants. Real-time data visualization features would empower users to easily interpret trends, enabling informed decision-making regarding nutrient adjustments or environmental modifications.Crucially, the app aims to cater to a diverse user base, accommodating both seasoned hydroponic farmers and those new to the practice. The user interface would be intuitively designed, offering simplified controls and informative displays. By bridging the gap between precision farming and user accessibility, this app seeks to make hydroponic farming more manageable and accessible. In doing so, it not only addresses the challenges associated with hydroponic systems, such as the need for constant attention, but also enhances the overall user experience, ultimately maximizing the potential for consistently high-quality vegetable crop production.

1.2 Addressing Development of Android Apps for Hydroponic Monitoring System

In the preceding paragraph, the user-friendly mobile app emerges as a comprehensive solution to streamline the complexities associated with monitoring and controlling crucial parameters in hydroponic systems. In light of the precision, endurance, and close attention required in hydroponic farming, the app's real-time capabilities become indispensable. By incorporating features that enable users to monitor pH levels, electrical conductivity, water temperature, air temperature, and light intensity on an ongoing basis, the app acts as a vigilant ally for farmers. The inclusion of instant alerts and notifications serves as a proactive measure, ensuring that deviations from optimal conditions are swiftly addressed to prevent subpar plant growth. Moreover, the app's emphasis on user-friendliness is not only aimed at seasoned hydroponic farmers but also seeks to attract and assist beginners in navigating the intricacies of this innovative cultivation method. The intuitive design and simplified controls are tailored to enhance accessibility, making it a valuable tool for individuals at various levels of expertise. In essence, the app provides a user-centric platform that empowers growers to make informed decisions, thereby optimizing the potential for achieving consistently high-quality vegetable crop yields. The marriage of technology and agriculture in the form of this mobile app is poised to redefine and elevate the efficiency of hydroponic farming practices.

1.3 Problem Statement

Hydroponic plants utilize an advanced gardening method that eliminates the necessity for soil in plant cultivation. In traditional gardening, it is well-established that plants need three essential elements to thrive: sunlight, water, and soil. Nevertheless, alternative mediums are now available beyond traditional soil..

Plants in a hydroponic garden grow in water enriched with nutrients, providing an effective delivery system to their roots. Instead of using solid fertilizer or compost, liquid fertilizer is employed. The efficiency of water in delivering nutrients promotes accelerated growth and reproduction in hydroponic plants. Furthermore, this method allows for the cultivation of crops even during off-seasons.

Hydroponic gardens employ a planting system submerging plant roots in water. Although hydroponic plants are generally low-maintenance, occasional issues like root rot may arise. This problem occurs when disease carriers enter the hydroponic system, with contaminated transplants and inactive spores being common causes. To minimize the risk of root rot, it's essential to maintain the pH level of the nutrient solution below 8 for hydroponic plants. Hence, the utilization of pH sensors, temperature, and humidity sensors enables farmers to consistently monitor the condition of their hydroponic plant fertilization system. This ongoing monitoring ensures the system remains in optimal condition, reducing the likelihood of root rot and maintaining sufficient nutrient levels for the plants.

1.4 Project Objective

The primary goal of this project is to suggest a methodical and efficient approach.. Specifically, the objectives are as follows:

a) To develop an automated hydroponic farming system.

- Manages the crops in the hydroponic system automatically with minimal human intervention.

b) To create a cost-effective sensor for hydroponic farming design

- Employ the ESP-32 as the central controller to collect data from sensors, publish the data, and analyze the information.

c) Enable users to access environmental data for plant growth at any time through the application.

d) To allow users to monitor remotely, adjusting them according to the requirements of the plants, such as activating a water pump to meet the pH level needs for hydroponic plants.

1.5 Scope of Project

The scope of work for the project includes the following areas::

a) A smart hydroponic system is utilized to automate hydroponic agriculture, with complete control managed by ESP32. It retrieves data from sensors and sends it to a mobile app for monitoring the plant's condition..

b) Implementing a user-friendly interface to display real-time data in a visually appealing manner.

c) Integrating the application with a hydroponic system to gather real-time data on parameters such as temperature, humidity and Ph level.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Hydroponics is a process of growing plants without soil by using water solutions that have nutrients. This approach continues gaining ground due to its numerous benefits like high crop yields, reduced water consumption and higher-grade crops. The monitoring of both plants and nutrient solution is one problem in hydroponics. This process might take a lot of time and effort. Yet, the ability to create Android apps has allowed much of this monitoring process to automate. They can be also used to gather information about a wide range of elements ranging from plant development, nutrient content and temperature. This information can then be used to determine, how the plant needs to be treated. Android apps can also serve in controlling hydroponic systems. This can be done through remote control of nutrients levels, water temperature and other key parameters. Hydroponic monitoring systems development, the automation and remote control of hydroponics are now completely automated through Android apps for such processes. This has increased the accessibility of hydroponics to more growers, and it also led to better crop production in terms of yield as well as its quality.

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2.2 Related Project Research

2.2.1 Remote Monitoring System for Hydroponic Planting Media

The research paper titled "Remote Monitoring System for Hydroponic Planting Media" presented at the International Conference on ICT for Smart Society (ICISS) in 2017[1]. The paper discusses the design and implementation of a monitoring system for hydroponic planting media using various sensors and Arduino as the main microcontroller. To address this need for monitoring, the authors propose a system that utilizes sensors such as pH sensor, Electro Conductivity Sensor, water temperature sensor, air temperature sensor, and light sensor. The use of several sensors and Arduino helps in remote monitoring of various factors such as pH level water temperature electrical conductivity air temperature and light intensity that affect hydroponic planting mediums.. The system offers real-time monitoring of pH level water temperature electrical conductivity air temperature and light intensity in the hydroponic planting medium, and visual representation of data is achieved using graphs while user alerts regarding exceeding of set limits are sent through notifications.A remote monitoring setup for hydroponic planting medium is introduced in the research paper by employing Arduino and several sensors. This system offers real-time monitoring of essential parameters that aid in the development as well as optimization of hydroponic crop quantity and standards.

Figure 2.1 NFT hydroponic monitoring system[1]

2.2.2 Hydroponic Management and Monitoring System for an IoT Based NFT Farm Using Web Technology

The paper titled "Hommons: Hydroponic Management and Monitoring System for an IoT Based NFT Farm Using Web Technology" presents a hydroponic farm management system that utilizes Internet of Things (IoT) technology[2]. The system aims to monitor and control various parameters such as water temperature, water level, pH, and nutrient concentration in a Nutrient Film Technique (NFT) hydroponic system. Authors point out that due to declining agriculture land people are turning towards popular solutions like NFT in hydroponics to grow crops in limited urban spaces. However, the typical approach to regulating hydroponic systems is ineffective and takes up a lot of time. The solution proposed by the authors involves utilizing a monitoring and automation system integrated with sensors supported via Arduino Uno microcontroller ,ESP8266 Wi-Fi model for connectivity,and Raspberry Pi 2 Model B as the web serverThe system utilizes a responsive web framework, including Bootstrap, jQuery, and JavaScript, to develop a user-friendly web interface for monitoring and controlling the NFT hydroponic farming. The system allows farmers to remotely monitor and adjust parameters using the web interfaceThe paper concludes that the developed system enhances the effectiveness and efficiency of monitoring and controlling NFT hydroponic farms. It enables farmers to remotely manage the system, leading to improved productivity and resource management.

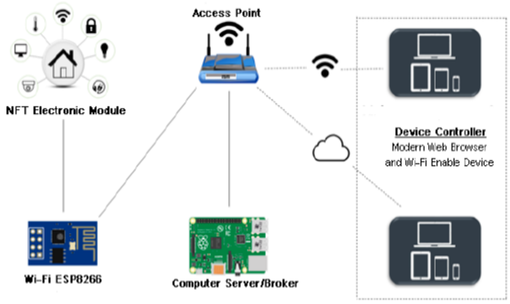

Figure 2.2 Hydroponic Monitoring and Management System Flow[2]

2.2.3 Design of a Hydroponic Monitoring System with deep flow technique (DFT)

The paper titled "Design of a Hydroponic Monitoring System with Deep Flow Technique (DFT)" presents the design and implementation of a real-time hydroponic monitoring system using the deep flow technique[3]. The paper was published in the AIP Conference Proceedings (Volume 2217, 030195) in 2020 by Subuh Pramono, Arif Nuruddin, and Muhammad Hamka Ibrahim. The purpose of the study described in the paper was to develop a hydroponic monitoring system that allows for real-time monitoring of parameters such as pH, TDS (Total Dissolved Solids), EC (Electrical Conductivity), and temperature. The system also includes the capability to control the solution pump and spray pump automatically based on the measured parameters. The paper discusses the advantages of hydroponic farming, such as its suitability for urban areas with limited land availability, controlled nutrient and water management, easier pest control, land and energy savings, and cleaner plant and environmental conditions.Overall, the hydroponic monitoring system described in the paper provides a practical solution for monitoring and controlling hydroponic systems using real-time data collection, display, and remote access through a mobile application.

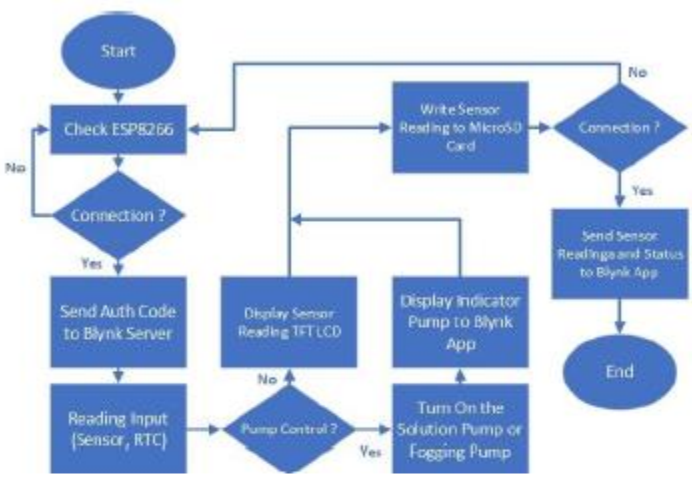

Figure 2.3 Flowchart of System Mechanism of Blynk App[3]

2.2.4 Mockup as Internet of Things Application for Hydroponics Plant Monitoring System

Research paper titled "Mockup as Internet of Things Application for Hydroponics Plant Monitoring System." It was published in the International Journal of Advanced Science and Technology, Vol. 29, No. 5, in 2020[4]. The authors of the paper are Fitria Hidayanti, Fitri Rahmah, and Ahmad Sahro from the Engineering Physics Department at Universitas Nasional in Jakarta, Indonesia. The paper proposes a mockup of an internet of things (IoT) application that can remotely monitor these parameters and automate the maintenance of hydroponic plants. The materials and methods section of the paper describes the calibration process of pH and ultrasonic sensors, testing of solar panels, and the design of a remote hydroponic monitoring system. The results and discussion section presents the mockup application interface, the analysis of relationships between temperature and pH, and the growth of plants in the hydroponic system. The conclusion summarizes the findings, including the successful regulation of pH within the desired range, the relationships between different parameters, and the functionality of the Hydro Eyes application for monitor

2.2.5 Nutrient Film Technique (NFT) Hydroponic Monitoring System

The provided text is an abstract from a research article titled "Nutrient Film Technique (NFT) Hydroponic Monitoring System" published in the Journal of Applied Information and Communication Technologies, Vol.1, No.1, 2016. The authors of the paper are Helmy, Arif Nursyahid, Thomas Agung Setyawan, and Abu Hasan.[5]. The abstract introduces the topic of hydroponic plant cultivation and focuses specifically on the Nutrient Film Technique (NFT) hydroponic system. The NFT system is widely used for indoor and outdoor plant cultivation, and it requires monitoring of parameters such as pH, TDS (Total Dissolved Solids), and temperature to ensure optimal plant growth. The system utilizes sensors submerged in the nutrient solution reservoir, an Arduino UNO microcontroller to collect sensor data, a GSM/GPRS shield to transmit data to a server via the internet, and a web hosting and database server to display the data online.The abstract concludes by mentioning that the system's performance was evaluated by measuring the delay in data transmission. It presents average delay times during different periods of the day and states that the system showed the highest delay during daylight and afternoon but lower delay during the night and morning

2.2.6 Enhanced Hydroponic Agriculture Environmental Monitoring : An Internet of Things Approach

The paper titled "Enhanced Hydroponic Agriculture Environmental Monitoring: An Internet of Things Approach" by Gonçalo Marques, Diogo Aleixo, and Rui Pitarma presents an IoT-based monitoring system for hydroponics called iHydroIoT[6]. The system aims to provide real-time monitoring and analytics of various environmental parameters in hydroponic cultivation. The iHydroIoT system consists of a prototype for data collection and an iOS mobile application for data visualization and real-time analytics. The prototype utilizes an Arduino Uno microcontroller, a Bluetooth Low Energy (BLE) module for wireless communication, and several sensors including light, temperature, humidity, CO2, pH, electroconductivity (EC), and water level sensors. The collected data is stored and analyzed using Plotly, a data analytics and visualization library. The mobile application, called iHydroMobile, provides users with real-time access to temperature, CO2, humidity, pH, light intensity, and EC data. It also offers historical data logging, water pump management, and push notifications to alert the hydroponic farm manager about unfavorable conditions. Overall, the iHydroIoT system offers a valuable tool for enhanced hydroponic agriculture environmental monitoring. It combines IoT, mobile computing, and data analytics to provide real-time insights and support decision-making processes in hydroponic cultivation.

Figure 2.4 iHydroIoT system prototype[6]

2.2.7 Front-End Development of Nutrient Film Technique for Hydroponic Plant with IoT Monitoring System

Research paper titled "Front End Development of Nutrient Film Technique for Hydroponic Plant with IoT Monitoring System" by Raja Siti Nur Adiimahbinti Raja Aris et al. The paper was published in the International Journal of Advanced Trends in Computer Science and Engineering, Volume 9, Issue 1.3, in 2020[7]. The paper aims to develop a front-end system that allows users to monitor and control two important parameters in plant growth, namely electrical conductivity (EC) and pH, using IoT technology. The system utilizes an ESP32 microcontroller board, an LCD display, and an IoT platform. Users can control and monitor the system remotely using a smartphone application. The front-end development section discusses the specific design and components of the hydroponic system developed in the research project. The section highlights the ESP32 microcontroller board and its role in transferring data to a web hosting and database server for remote monitoring and control. In summary, the research paper focuses on the front-end development of a hydroponic system using the NFT method and IoT technology. The system allows users to monitor and control the EC and pH parameters remotely, providing a convenient and automated solution for hydroponic plant growth.

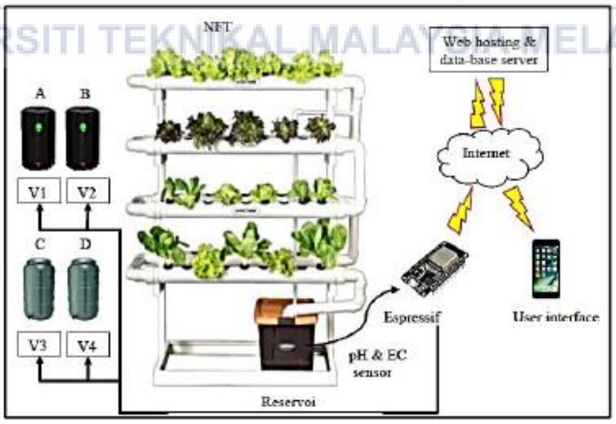

Figure 2.5 System Setup[7]

2.2.8 Reliable IoT-Based Monitoring and Control of Hydroponic Systems

The research titled "Reliable IoT-Based Monitoring and Control of Hydroponic Systems" by Konstantinos Tatas, Ahmad Al-Zoubi, and Nicholas Christofides presents the design and implementation of iPONICS[8]. The system consists of several components, including a sensing and control unit, environment sensing unit, and greenhouse security unit. The sensors used in the system are compatible with Arduino microcontrollers and have advantages such as low recalibration frequency, easy integration, and reasonable cost. One of the main advantages of the iPONICS system is its low cost, which makes it an attractive investment for farmers. The sensors used in the system require infrequent recalibration and are long-lasting, contributing to cost-effectiveness. However, the initial investment costs for farmers to purchase and install the system may be a disadvantage. Another potential disadvantage of the system is its reliance on technology and sensors, which can be subject to errors and failures. The research addresses the issue of reliability analysis, highlighting the need for robustness and potential risks associated with sensor technology. Overall, the research focuses on the design and implementation of an IoT-based system for hydroponic monitoring and control, highlighting its advantages in terms of cost-effectiveness and sensor performance.

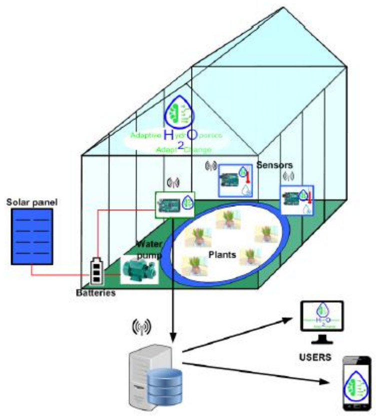

Figure 2.6 iPONICS system concept[8]

2.2.9 Red Onion Growth Monitoring System in hydroponics Enviroment

The paper titled "Red onion growth monitoring system in hydroponics environment" discusses the use of hydroponics as an alternative method for cultivating red onions[9]. Hydroponics involves growing plants without soil by providing water, nutrients, and oxygen directly to the roots. The paper highlights the importance of monitoring environmental conditions such as air temperature, light intensity, plant temperature, and humidity, as these factors greatly impact the growth of hydroponic plants. The authors address the challenge faced by hydroponic farmers in accurately assessing the conditions of their planting media, which can lead to failures in plant growth. To overcome this challenge, the paper proposes a monitoring system that utilizes various sensors, including water temperature sensor, air temperature sensor, light sensor, and a microcontroller (Arduino Uno) to collect data on the environmental parameters. The system was tested for eight weeks, considering water temperature, humidity, air temperature, and light intensity. The results showed that the monitored red onion plants had 12 leaves with a height of 29 cm. The paper provides valuable insights into the application of hydroponics for red onion cultivation and presents a practical monitoring system to assist hydroponic farmers in optimizing plant growth.

Figure 2.7 System Testing on Red Onion Plant[9]

2.2.10 Automatic Monitoring System for Hydroponic Farming: IoT-Based Design and Development

The article titled "Automatic Monitoring System for Hydroponic Farming: IoT-Based Design and Development" The article was published in the Asian Journal of Agriculture and Rural Development, Volume 12, Issue 3, in October 2022. The authors are Huu Cuong et al.,[10]. The proposed monitoring system consists of three layers: a perception layer, a communication layer, and an application layer. Sensors are used to collect data on parameters such as temperature, humidity, light intensity, water temperature, pH, and electrical conductivity of the nutrient solution. The data is processed and transmitted to the cloud through an IoT gateway. A web interface allows users to access and visualize the sensor data, as well as control farming equipment remotely. The study contributes to the field by providing a practical solution for monitoring and controlling parameters in hydroponic farming. The IoT-based system enables farmers to monitor and adjust farming conditions remotely, leading to improved production and quality. The collected data also facilitates analysis and evaluation by agricultural experts.

Figure 2.8 Experimental hydroponic rig[10]

2.2.11 Implementation IoT in System Monitoring Hydroponic Plant Water Circulation and Control

Usman Nurhasan et al.,[11] research paper titled "Implementation IoT in System Monitoring Hydroponic Plant Water Circulation and Control." The abstract provides an overview of hydroponics, which is the cultivation of plants without using soil by supplying nutrients through water. It highlights the importance of maintaining optimal plant growth elements such as water circulation, light intensity, temperature, humidity, and pH for the successful growth of hydroponic plants. The paper proposes the use of IoT-based monitoring and control system to address these challenges. The authors describe the use of sensors integrated with Raspberry Pi to collect data on plant growth elements such as pH, temperature, humidity, and water level in the hydroponic reservoir. The research methodology section explains the data retrieval methods, development process, and design tools used in the study. It mentions the software and hardware specifications required for the system implementation, including Raspberry Pi, sensors (DHT11, SEN0161, HC-SR04), and a water pump. The authors provide flowcharts, block diagrams, and circuit schematics to illustrate the system design and implementation process.

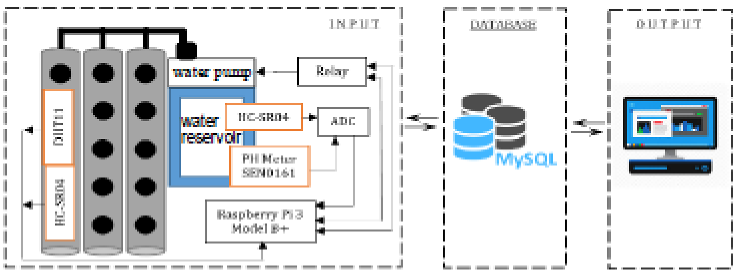

Figure 2.9 Block Diagram[11]

2.2.12 Development of Automated Monitoring System for Hydroponics Vertical Farming

G W Micheal [12], titled "Development of Automated Monitoring System for Hydroponics Vertical Farming" discusses the design and development of an automated system for monitoring and maintaining the nutrient solution in hydroponics vertical farming. The project aims to reduce water and electricity consumption while ensuring the growth of plants is supervised without constant human presence. The paper highlights the importance of monitoring key measurements such as Electrical Conductivity (EC) and pH level in hydroponics systems. It discusses different hydroponics techniques, including the Nutrient Film Technique (NFT) system and the Ebb and Flow system. The methodology section describes the hardware setup using SolidWorks software, which includes reservoirs, sensors for measuring EC, pH, and temperature, and nutrient pumps. The electronic design involves using Arduino Mega for data logging and NodeMCU for sending data to the Ubidots cloud platform. In summary, the paper outlines the development of an automated monitoring system for hydroponics vertical farming, focusing on nutrient solution management. The system aims to optimize resource usage and enhance plant growth in a controlled environment.

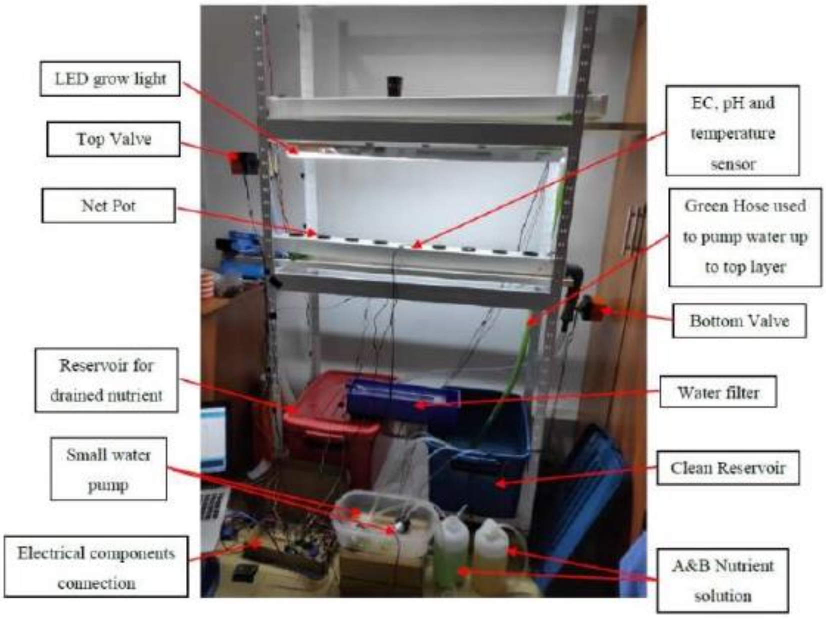

Figure 2.10 Hardware Implementation[12]

2.2.13 Design and implementation of a hydroponic strawberry monitoring and harvesting timing information supporting system based on nano ai-cloud and iot-edge

Sun Park et al.,[13] created the hydroponic strawberry monitoring and harvesting timing information supporting system described in the article utilizes a combination of nano AI-Cloud, IoT-Edge, and Raspberry Pi 3B+ and Arduino Mega 2560 devices. The system collects and analyzes environmental data and photos to determine the optimal time for strawberry harvesting. The setup includes an IoT-Edge device, a GPU workstation device, and a private AI-Cloud-based analysis station module..The analysis station module, designed based on the concept of AI-Cloud, allows for easy scalability by increasing the number of container servers when expanding the strawberry cultivation area. The system's module architecture focuses on collecting, storing, and analyzing strawberry cultivation environment information, facilitating future function expansion and analysis.However, it is important to note that ongoing maintenance and updates are necessary to ensure the system's continued functionality and accuracy. The effectiveness of the system may also depend on the quality and reliability of the sensors used for environmental data collection, as sensor errors or malfunctions could affect the system's performance.

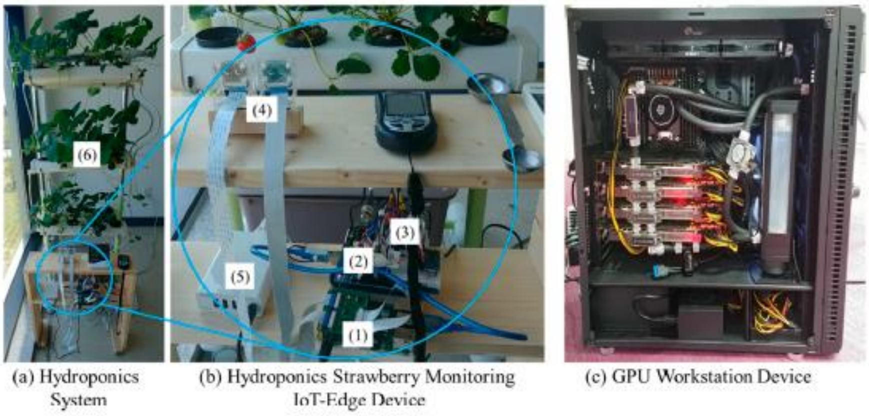

Figure 2.11 The hydroponic strawberry monitoring and harvest decision system[13]

2.2.14 The prototype of the greenhouse smart control and monitoring system in hydroponic plants

Arif Supriyanto et al,.[14] The prototype of the greenhouse smart control and monitoring system for hydroponic plants includes hardware components such as sensors for monitoring temperature, humidity, pH, TDS (Total Dissolved Solids), and water level. These sensors are connected to a microcontroller, such as Arduino, and a Wi-Fi module, such as ESP8266, for data transmission. The software component of the system includes a monitoring system with features for recording farming activities and predicting harvest results. With this prototype, farmers can monitor the real-time conditions of their hydroponic system, including temperature, humidity, pH, TDS, and water level. This allows them to quickly identify and address any issues that may arise, ensuring optimal growing conditions for their plants. The system also provides features for predicting harvest results based on the data collected from the sensors. The prototype's sensor testing indicates good accuracy with small average offsets, suggesting reliable measurements for monitoring the hydroponic environment. However, it's important to note that while this technology offers significant benefits for agricultural practices, its accessibility and feasibility may be limited for farmers in developing countries or those with limited resources. Implementation of such systems may require upfront investment, technical expertise, and access to reliable internet connectivity.

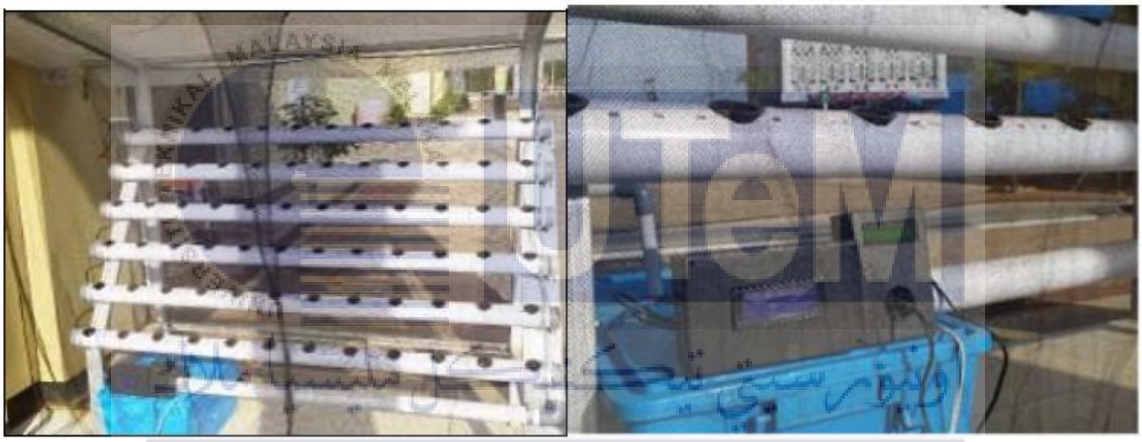

Figure 2.12 The smart greenhouse implementation[14]

2.2.15 Smart agriculture monitoring system for outdoor and hydroponic environments

Bijolin Edwin et al.,[15] created Smart agriculture monitoring system for outdoor and hydroponic environments. The proposed smart agriculture monitoring system aims to use IoT technology to monitor various natural aspects such as soil moisture, temperature, humidity, gas quality, and atmospheric pressure using sensors. By doing so, the system intends to reduce human error and enhance farming precision. It would achieve this by sending alert messages to the user's mobile phone if any of the sensor values exceed predefined threshold values. While the system offers several benefits, such as improved accuracy and error reduction, there are also challenges associated with implementing it. These challenges include the need for a significant initial investment in terms of hardware, software, and infrastructure. Additionally, farmers may require technical expertise to set up and maintain the system, which could be a hurdle for those unfamiliar with technology. Furthermore, managing and analyzing the large amount of data generated by the sensors may necessitate specialized software and expertise.

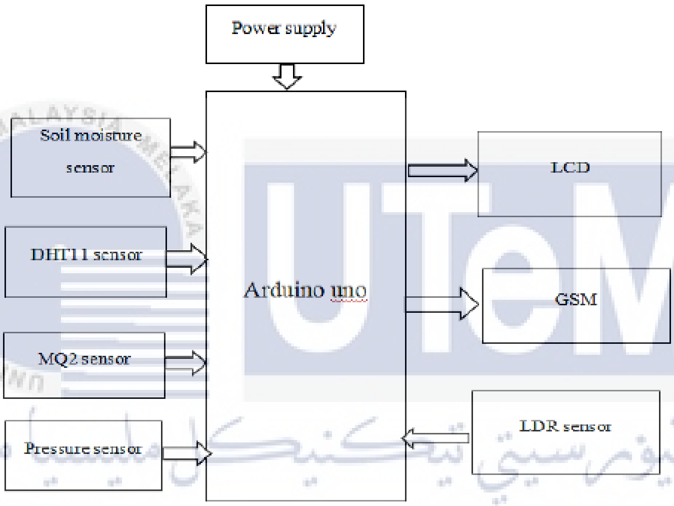

Figure 2.13 Block diagram of the proposed system[15]

2.2.16 Development of IoT at hydroponic system using raspberry Pi

A research paper titled "Development of IoT at hydroponic system using Raspberry Pi" published in TELKOMNIKA journal, Vol.17, No.2, in April 2019[16]. The authors of the paper are Rony Baskoro Lukito and Cahya Lukito from the Computer Science Department at Bina Nusantara University in Jakarta, Indonesia. The abstract of the paper highlights the advantages of hydroponics systems and the need for remote monitoring and observation of hydroponic systems using Internet of Things (IoT) technology. The paper focuses on the development of hardware and software to monitor temperature, pH, and conductivity of water in hydroponic systems using a combination of Raspberry Pi, Arduino-based IoT devices, and sensor modules. It describes the research methodology used in the study, including the stages of problem identification, system architecture and algorithm research, hardware and software development, testing, evaluation, and potential pilot projects.

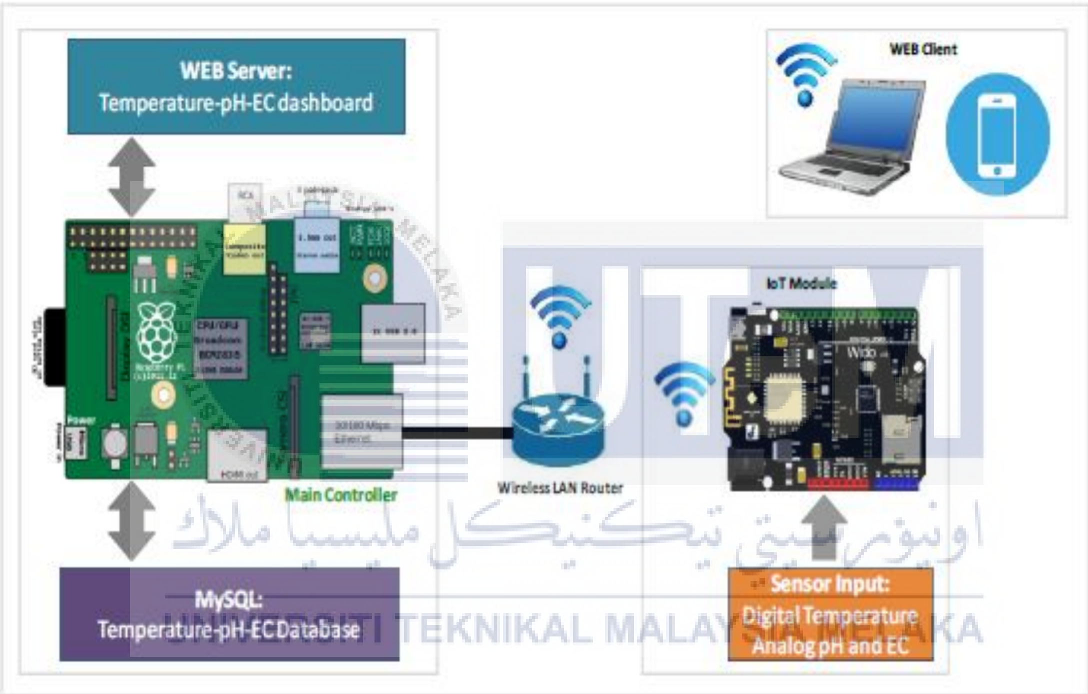

Figure 2.14 Hydroponic IoT Hardware System Architecture[16]

2.2.17 Fully Automated Hydroponic System for Indoor Plant Growth

Research paper titled "Fully Automated Hydroponic System for Indoor Plant Growth" presented at the 2017 International Conference on Identification, Information, and Knowledge in the Internet of Things (IIKI2017)[17]. The paper describes a system that utilizes hydroponics, a soilless method of growing plants, to address the challenge of growing plants and vegetables in extreme environments such as deserts and polar regions.

The system is designed to operate independently of the outside climate and relies on a combination of microcontrollers, sensors, and an Internet of Things (IoT) network for automation, monitoring, and control. By setting initial parameters and planting a seedling, the user can establish the desired conditions for plant growth. The system then maintains these parameters, promoting healthy plant growth while minimizing the need for human intervention.

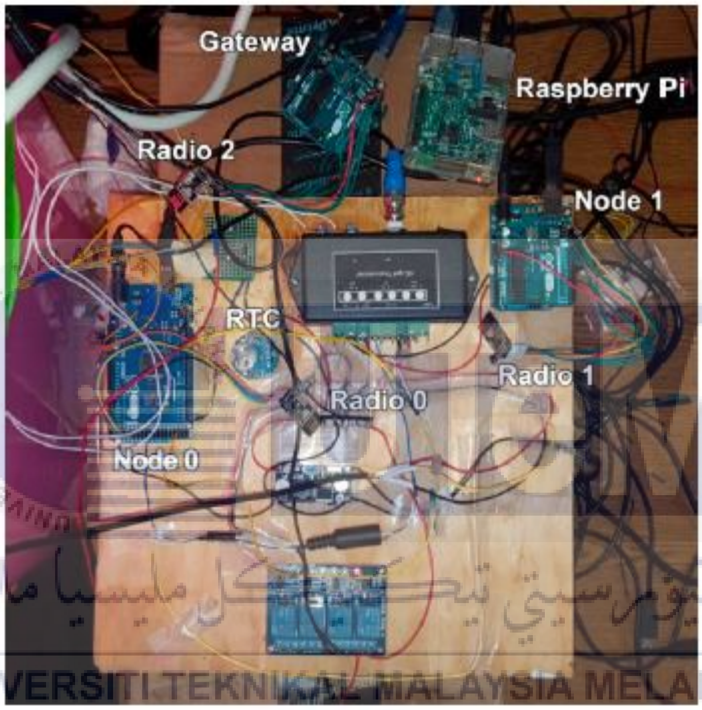

Figure 2.15 Hardware component of the system[17]

2.2.18 IoT-Based Hydroponic Plant Monitoring and Control System to Maintain Plant Fertility

The research article titled "IoT-Based Hydroponic Plant Monitoring and Control System to Maintain Plant Fertility" was published in the INTEK Jurnal Penelitian, Volume 9, Issue 1, in April 2022[18]. The authors of the article are Meida Cahyo Untoro and Fathan Rizki Hidayah from the Informatics Engineering Department of the Institut Teknologi

Sumatera in Indonesia. The research involved testing the system's performance in monitoring the conditions of hydroponic plants. The results showed an average error of 1.8% for air temperature, 4.8% for water pH, 6.6% for plant color, and 7% for water nutrient levels. The monitoring of hydroponic plants using the TCS3200 sensor achieved an opportunity of 53.3%. The article also discusses the use of the fuzzy Mamdani method for tool control related to nutrient improvement and pH adjustment of the hydroponic water. Overall, the research presents a system that integrates IoT technology with hydroponic plant cultivation, allowing cultivators to remotely monitor and control various parameters of the system. The article provides insights into the design, testing, and results of the system, highlighting its potential for enhancing hydroponic farming practices.

Figure 2.16 Hardware Implementation[18]

2.2.19 Smart Hydroponic Greenhouse (Sensing, Monitoring and Control) Prototype Based on Arduino and IOT

Research article titled "Smart Hydroponic Greenhouse (Sensing, Monitoring and Control) Prototype Based on Arduino and IoT."[19] The article discusses the development of a smart hydroponic greenhouse prototype that utilizes sensing, monitoring, and control systems based on Arduino and IoT technology. The Arduino Mega 2560 microcontroller was programmed to control different sensors and actuators, and the data collected by these sensors was transmitted every 30 minutes to the internet via Node MCU ESP 8266 for real-time monitoring and hosting on the Google Firebase platform. The authors concluded that integrating monitoring and control systems with IoT technology provided a wireless sensor network capable of accessing large amounts of data from anywhere and at any time.

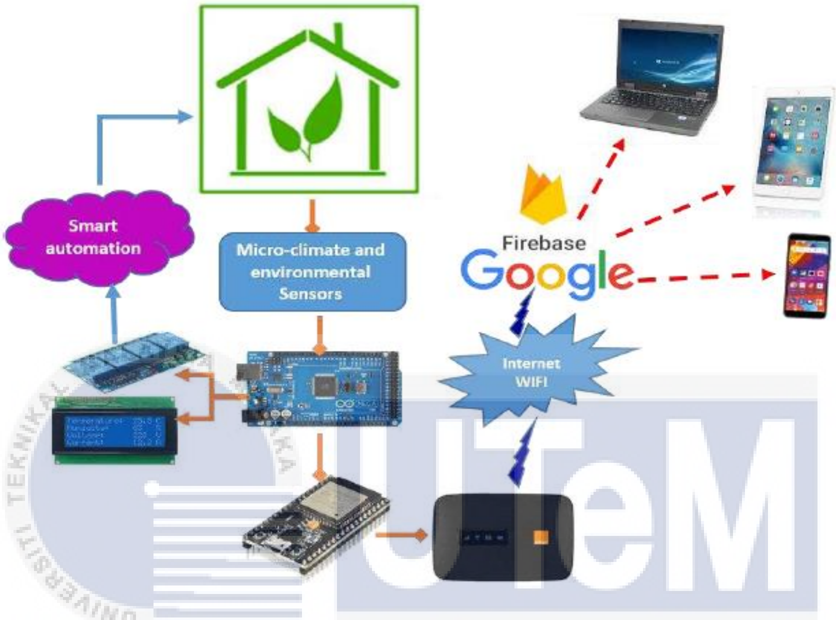

Figure 2.17 Schematic of smart hydroponic greenhouse based on Arduino IOT[19]

2.2.20 An Automated Hydroponics System Based on Mobile Application

The research discussed in the abstract focuses on designing and developing an automated hydroponics system based on IoT (Internet of Things) and mobile application technology[20]. The research methodology section describes the hardware and software components used in the proposed system. Arduino boards, sensors (such as temperature, humidity, light, and pH sensors), relay modules, solenoid valves, and a microcontroller unit (MCU) are mentioned as the hardware components. The software components include the Arduino IDE for programming, edge computing for processing data at the edge of the network, MQTT protocol for lightweight messaging, and Firebase for real-time data synchronization and storage. Overall, the research aims to contribute to the advancement of agriculture in Thailand by implementing IoT and automation in hydroponics. The proposed system has the potential to improve plant growth, optimize resource usage, and provide data-driven insights for decision-making in hydroponic farming.

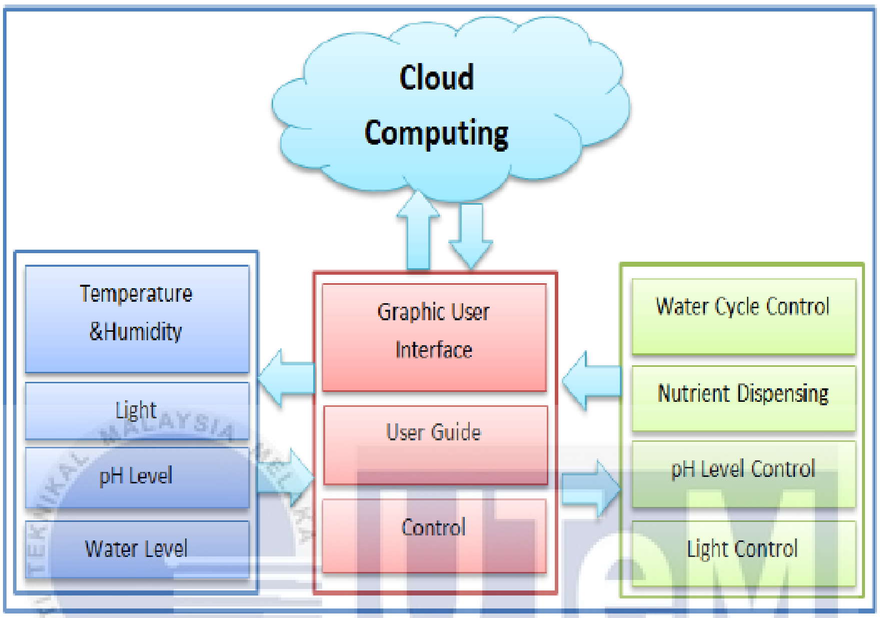

Figure 2.18 System Overview [20]

2.2 Previous work of hydroponic monitoring system

Table 2-1 Comparison of hydroponic monitoring system

NO	TITLE	AUTHOR	PURPOSE	ADVANTAGES	DISADVANTAGES
1	Remote Monitring System for Hydroponic Plating Media	-Baihaqi Sireger -Heru Panoto -Ulfi Andayani	The goal of this project is to grow plants without the need of soil, only water, nutrients, and oxygen.	- increased output in both number and quality - cleaner - more efficient use of fertilizers and water - easier in pest and disease control	-accuracy, patience, and close monitoring continuously -if not carefully monitored regularly and periodically, plant growth will not be optimal, which can affect the quality of vegetable crops.
2	Hydroponic Managemen t and Monitoring System for an IOT Based NFT Farm Using Web Technology	-Padma Nyoman Crisnapati	to show how the Hommons system works for monitoring and regulating a hydroponic system's water temperature, water level, acidity, and fertiliser content.	-The physical design of the NFT hydroponic farming system, which uses PVC pipes and a plastic box reservoir to make it easier to assemble and manage -The ability to detect changes in the physical or chemical environment using environmental sensors and adjust the system accordingly	- controlling the concentrations of nutrient has to be done at least once a day -control process still uses the conventional way or human power, which can be time-consuming and less efficient
3	Design of a Hydroponic Monitoring System with deep flow technique (DFT)	-Subuh Ramonoo -Arif Nurudin -Muhd Hamka Ibrahim	In order to monitor pH, TDS, EC, and temperature in real-time, a hydroponic monitoring system was designed and tested. This article describes that system's design and testing.	-Does not require a large area of land, so planting in a hydroponic way can be done indoors. -No special treatment is required, such as loose soil because the planting media is not soil. These advantages make hydroponic farming a viable option for both	-hydroponic systems require a consistent supply of electricity and water, which may be a challenge in areas with unreliable infrastructure. -

				household and industrial scale farming	
4	Mockup as Internet of Things Application for Hydroponics Plant Monitoring System	-Fitria Hidayanti -Fitri Rahmah -Ahmad Sahro	Mockup for an internet of things application to remotely monitor a variety of factors and maintain the perfect conditions for the hydroponic fluid	-Efficient use of water: Hydroponics uses up to 90% less water than traditional soil-based agriculture -Hydroponic systems can be designed to take up less space than traditional soil-based agriculture, making them ideal for urban farming	-need for daily manual inspection and control of plant nutrients, including pH values, and other parameters such as brightness, temperature, and liquid level -can be challenging to use hydroponic systems in locations far away from electric terminals
5	Nutrient Film Technique (NFT) Hydroponic Monitoring System	-Helmy -Arif Nursyahid -Thomas Agung Setyawan -Abu Hasan	Measurement of system delay and sensor calibration. The goal of the article is to inform readers about the conception and execution of the NFT hydroponic monitoring system as well as any future changes that could be made to it.	-development of a monitoring system for the NFT hydroponic system, which allows farmers to monitor pH, Electrical Conductivity (EC), and temperature of the nutrient solution online -more efficient and sustainable agriculture practices.	-need for precise control of nutrient levels and pH, as well as the potential for system failures due to power outages or equipment malfunctions -requires a slope in the grow tray and a powerful water pump to maintain proper water levels, which may be difficult to achieve in certain settings
6	Enhanced Hydroponic Agriculture Environmental Monitoring: An Internet of Things Approach	-Goncalo Marques -Diogo Aleixo -Rui Pitarma	-present an IoT-based monitoring system for hydroponics called iHydroIoT, which uses various sensors to collect real-time data on light, temperature, humidity, CO2, pH, electroconductivity, and water level.	-The system provides real-time data on various parameters such as light, temperature, humidity, CO2, pH, electroconductivity, and water level, allowing for timely interventions to ensure optimal conditions for enhanced productivity -The system is modular, allowing for the addition of new modules over time according to the needs of the plant	-sensors was made focusing on the cost of the system, and there was no great concern regarding the selection of energy-efficient sensors

7	Front-End Development of Nutrient Film Technique for Hydroponic Plant with IoT Monitoring System	-Raja Siti Nur Adiimah -Khairul IrwanFikri	development of a hydroponic system that uses IoT technology to monitor and control the growth parameters of plants. The system is designed to be automatic and hassle-free for farmers, and it includes sensors for monitoring parameters such as conductivity, pH, temperature, and flow rate	-The system can be monitored and controlled remotely via the internet, making it more flexible for farmers -The system is designed to automatically regulate the pH value and nutrient concentration of the nutrient solution, ensuring that the plants receive the required nutrients for growth -The vertical cultivation design of the hydroponic garden allows for a higher number of plants to be cultivated in the same area compared to traditional horizontal cultivation	-farmers may need to have some technical knowledge and expertise to operate and maintain the system effectively -vulnerable to technical issues such as connectivity problems or sensor malfunctions, which could affect the accuracy of the data and the performance of the system.
8	Reliable IoT-Based Monitoring and Control of Hydroponic Systems	-Konstantinos tatas -Ahmad Al-Zoubi -Nicholas Christofides	present the design and implementation of iPONICS, an IoT-based control and monitoring system for hydroponics greenhouses. The document discusses the various components of the system, including the sensing and control unit, environment sensing unit, and greenhouse security unit, as well as the sensors used in the system\	-system is designed to be low-cost, making it an attractive investment for farmers -the sensors used in the system require infrequent recalibration, are easily integrated into an Arduino-based microcontroller system, and are long-lasting at a reasonable cost	-investment costs for farmers to purchase and install the system. -system relies on technology and sensors, which may be subject to errors and failures, as discussed in the reliability analysis section of the document.
9	Red Onion Growth Monitoring System in	-R F Rahmat	The system aims to improve the quality of hydroponic crops and provide an alternative solution for farmers to monitor their	-The system allows farmers to monitor changes in air temperature, water temperature, light, and moisture in real-time mode, which	-require regular maintenance and calibration to ensure accurate readings and reliable performance.

	hydroponics Enviroment		crops. The article also presents the results of a test conducted using the system, which showed that the plant requires continuous nutrients to grow, and different circumstances will occur if the level of humidity is too high	can affect the quality of plant growth - The device automates the monitoring process using sensors and a microprocessor, making it simpler for farmers to keep an eye on their crops. -The system stores the data in an online database, making it easier for farmers to access and analyze the data	-not be suitable for all types of hydroponic crops or growing environments, and farmers may need to adapt the system to their specific needs and conditions
10	Automatic Monitoring System for Hydroponic Farming: IoT-Based Design and Developme nt	-Huu Cuong Nguyen -Bich Thuy Vo Thi	The system uses sensors to collect data on environmental and nutrient solution parameters such as temperature, humidity, light intensity, pH, and electrical conductivity. The collected data is transmitted to an IoT gateway and stored in a database for analysis	-The system allows farmers to monitor environmental and nutritional parameters in real-time and use the collected data to analyze and evaluate the impact of the environment and cultivation methods on the growth of plants so that appropriate adjustments can be made in subsequent seasons -The system allows users to remotely monitor their crops and control the operation of pumps and fans by interacting with the web interface via a mobile device to change these parameters	-The cost of implementing such a system may also be a concern for small-scale farmers who may not have the financial resources to invest in such technology. -the system may require technical expertise to set up and maintain, which may be a challenge for some farmers who are not familiar with IoT technology.
11	Implementa tion IoT in System Monitoring hydroponic	-Usman Nurhasan -arief Prasetyo -Gilang Lazuardi	present a system for monitoring and controlling the water circulation in hydroponic plant systems using IoT technology. The system uses sensors to	-uses IoT technology to monitor and control the water circulation in hydroponic plant systems, which can lead to more efficient and effective plant growth	-require technical expertise and resources, which may be a barrier for some growers.

	Plant Water Circulation and Control		collect data on plant growth elements such as pH, temperature, humidity, and water level, and applies fuzzy logic to control water circulation based on temperature and humidity parameters	-the system uses sensors to collect data on plant growth elements such as pH, temperature, humidity, and water level, which can help growers to optimize plant growth conditions	-the cost of the hardware components and sensors may be a consideration for those on a tight budget -the system may require regular maintenance and calibration to ensure accurate sensor readings and optimal performance
12	Development of Automated Monitoring System for Hydroponics Vertical Farming	-G W Micheal	monitor and control the pH, EC, temperature, and water level of the hydroponic solution, and to provide real-time data to the user. The project provides a detailed description of the system's hardware and software components, as well as the results of testing and validation.	-Minimizing the use of electricity and water when growing plants -Providing real-time monitoring of the pH, EC, temperature, and water level of the hydroponic solution -Allowing for remote monitoring and control of the system through the use of Ubidots cloud platform	-The lack of daily observation and maintenance can cause the plants' growth to slow down or even die -The mechanical design of the monitoring system can be improved, particularly with regards to the way the nutrient solution is drained back to the reservoir
13	Design and implementation of a hydroponic strawberry monitoring and harvesting timing information supporting system based on nano ai-	-Sun Park -JongWon Kim	-The system collects and analyzes environmental data and photos to determine when to harvest strawberries. The article explains the setup of the system, including the IoT-Edge device, GPU workstation device, and private AI-Cloud-based analysis station module. The article also discusses the data handling and analysis of the system, including the use of the YOLO algorithm for strawberry classification and the calculation of the normalized difference vegetation index	-The analysis station module was designed with the concept of AI-Cloud, so the number of container servers based on virtualization can be easily increased whenever the strawberry cultivation area increases -The system module architecture was designed to collect, store and analyze strawberry cultivation environment information from a software point of view for functions' implementation, which facilitates function expansion and analysis	-the system may require ongoing maintenance and updates to ensure its continued functionality and accuracy -the system's effectiveness may depend on the quality and reliability of the sensors used to collect environmental data, which may be subject to errors or malfunctions.

	cloud and iot-edge		(NDVI) to determine strawberry maturity		
14	The prototype of the greenhouse smart control and monitoring system in hydroponic plants	-Arif Supriyanto -Fathuraahmani	The prototype includes hardware components such as sensors for monitoring temperature, humidity, pH, TDS, and water level, as well as a microcontroller and WiFi module. The software includes a monitoring system with features for recording farming activities and predicting harvest results	-The prototype allows for real-time monitoring of temperature, humidity, pH, TDS, and water level in the hydroponic system. This can help farmers to quickly identify and address any issues that may arise -The software includes features for predicting harvest results based on the data collected from the sensors. This can help farmers to plan and optimize their crop yields According to the results of sensor testing, the sensors used in making the smart greenhouse prototype show good accuracy with small average offsets	-the use of technology in agriculture may not be accessible or feasible for all farmers, particularly those in developing countries or with limited resources.
15	Smart agriculture monitoring system for outdoor and hydroponic environments	-Bijolin Edwin -Ebenezer Veemara -Pradeepa Parthiban	propose a smart agriculture monitoring system that uses IoT technology to monitor natural aspects such as soil moisture, temperature, humidity, gas quality, and atmospheric pressure using sensors. The system aims to reduce human error and improve the precision of farming by sending alert messages to the mobile phone if any of the sensor values are not	-The use of sensors and IoT technology can help farmers monitor natural aspects such as soil moisture, temperature, humidity, gas quality, and atmospheric pressure with greater accuracy -Reduction in human error: The use of IoT technology can help reduce human error in agriculture by eradicating unknown segments in agricultural practice.	-Implementing an IoT-based system in agriculture may require a high initial investment in terms of hardware, software, and infrastructure -Farmers may require technical expertise to set up and maintain the IoT-based system, which may be a challenge for those who are not familiar with technology -The large amount of data generated by the sensors may be difficult to

			under already specified threshold values		manage and analyze, requiring specialized software and expertise
16	Development of IoT at hydroponic system using raspberry Pi	-Rony Baskoro Lukito - Cahya Lukito	The purpose of the article is to describe the development and implementation of an IoT system for hydroponic farming, including hardware and software specifications, methodology, and test results.	-Client-server architecture model allows for easy integration into any monitoring system for hydroponics -Real-time monitoring of temperature, pH, and conductivity of water in the hydroponic system	- For some farmers who are unfamiliar with IoT technology, setting up and maintaining the system may need technical skills.
17	Fully Automated Hydroponic System for Indoor Plant Growth	-Vaibhav Palande -Adam Zaheer	- The purpose of the article is to describe the development and features of a fully automated hydroponic system for indoor plant growth that can operate independently of outside climate conditions	- the system is cost-effective, small, and simple to use, making it accessible to the average consumer - The system is also fully automated, requiring minimal human interaction after placing the germinated plant into the system	- The monitoring system's mechanical design may be made better, especially with regard to how the nutrient solution is drained back to the reservoir.
18	IoT-Based Hydroponic Plant Monitoring and Control System to Maintain Plant Fertility	- Meida Cahyo Untoro - Fathan Rizki Hidayah	The purpose of the article is to present the development and testing of an IoT-based hydroponic plant monitoring and control system that allows cultivators to remotely monitor and control plant conditions such as color, temperature, nutrients, and pH through a smartphone application. The ultimate goal is to provide a more efficient and automated way of maintaining plant fertility in hydroponic systems.	- Efficient and automated: The system provides a more efficient and automated way of maintaining plant fertility in hydroponic systems, reducing the need for manual monitoring and intervention - The system uses the Mamdani fuzzy logic method to automate the improvement of hydroponic plant water nutrients.	- The design and implementation of the system require technical expertise in hardware and software development, which may be a barrier for some cultivators.

19	Smart Hydroponic Greenhouse (Sensing, Monitoring and Control) Prototype Based on Arduino and IOT	- M. A. Abul-Soud - M. S. A. Emam	The purpose of the article is to describe the development and implementation of a smart hydroponic greenhouse prototype that uses IoT technology to monitor and control micro-climate and environmental conditions, as well as to compare the efficiency of two hydroponic culture systems (NFT and DFT) in cultivating lettuce plants	- Reduction of human errors and mistakes in monitoring and controlling the hydroponic system - Flexibility and adaptability to changing environmental conditions	- In terms of hardware, software, and infrastructure, implementing an IoT-based system in agriculture would need a significant upfront investment.
20	An Automated Hydroponics System Based on Mobile Application	- Kunyanuth Kularbphettong - Udomlux Ampant	The purpose of the paper is to present the development and evaluation of an automated hydroponics system based on IoT and a mobile application, which can control and monitor environmental factors affecting plant growth	- The ability to automatically control and monitor environmental factors affecting plant growth, such as temperature, humidity, and water - The ability to adjust and control important environmental factors that affect plant growth, leading to better plant growth	- The quality of water and nutrient solutions used in hydroponics plays a vital role in plant health and productivity. Contaminated water sources or imbalanced nutrient solutions can lead to nutrient deficiencies, plant stress, and reduced crop yields.

2.3 Review of the comparison of work for hydroponic monitoring system

The literature review "Development of Android Apps for Hydroponic Monitoring System" explores the advancements made in the field of hydroponic farming and the integration of Android apps with monitoring systems. The review examines the utilization of Android apps to enhance the monitoring and control of hydroponic setups. It investigates various aspects such as the design considerations, implementation challenges, and potential benefits of developing Android apps for hydroponic monitoring. The review also analyzes relevant research papers, articles, and technological developments in this area. The primary focus of this review is to highlight the features and functionalities of Android apps in improving convenience and efficiency in hydroponic farming practices.

2.4 Summary

The literature review, "Development of Android Apps for Hydroponic Monitoring System," investigates the integration of Android apps in advancing hydroponic farming. It explores design considerations, implementation challenges, and benefits of using Android apps for monitoring hydroponic setups. The review analyzes research papers and technological developments, focusing on how Android apps enhance convenience and efficiency in hydroponic farming practices.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The methodology for developing the user-friendly mobile app for hydroponic systems centers on its real-time capabilities to monitor and control key parameters. With precision being crucial in hydroponic farming, the app's features enable continuous tracking of pH levels, electrical conductivity, water and air temperatures, and light intensity. Instant alerts address deviations, ensuring timely responses to maintain optimal conditions for plant growth. The user-centric design, emphasizing accessibility for both beginners and seasoned farmers, incorporates an intuitive interface and simplified controls. This methodology aims to empower growers by providing a comprehensive platform for informed decision-making, ultimately enhancing the efficiency of hydroponic farming practices through the marriage of technology and agriculture.

3.2 Block Diagram

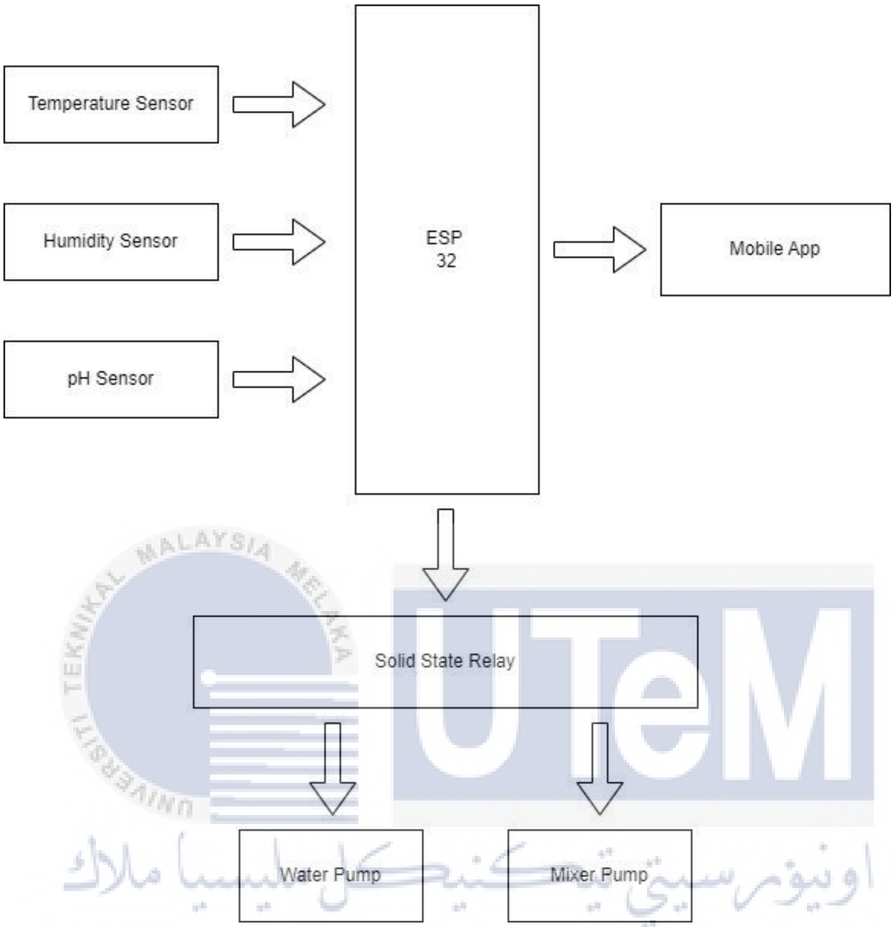

Figure 3.1 Block Diagram Project

In the block diagram presented in Figure 3.1, the ESP32 assumes a central role by receiving diverse data inputs from sensors, including temperature, humidity, pH, and water level sensors. Subsequently, the ESP32 functions as a data hub, transmitting this acquired data to a mobile application, specifically the Blynk app. The Blynk app serves as a graphical interface, visually representing the received data for user convenience and monitoring. Additionally, the ESP32's functionality extends to its connection with a solid-state relay, providing the capacity for manual or automatic control over the water pump and mixer pump. This strategic integration allows users not only to remotely monitor environmental parameters through the Blynk app but also to exert precise control over the water and mixer pumps, either manually or through automated processes facilitated by the ESP32. The comprehensive nature of this system enhances user accessibility and control in managing both data visualization and operational aspects of the water and mixer pumps.

3.3 Flowchart for Project

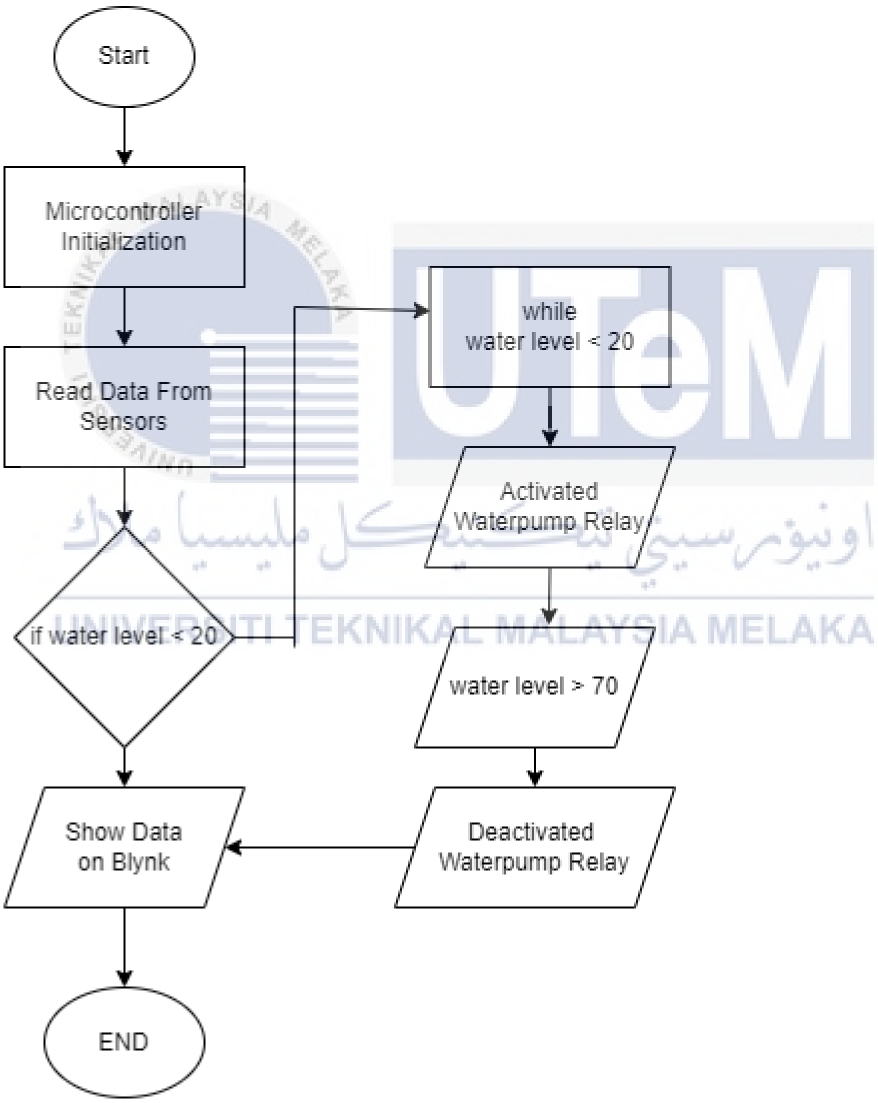

Figure 3.2 Flowchart Project

In Figure 3.2, the flowchart illustrates the operational sequence after the initialization of the ESP32. Following initialization, the ESP32 reads data from multiple sensors, encompassing pH, water level, humidity, and temperature sensors. Subsequent to this, the system checks the water level; if it falls below 20, the water relay is activated, turning on the water supply. Conversely, if the water level exceeds 70, the water pump relay is automatically deactivated, ensuring precise control over the water pump. Simultaneously, the collected sensor data, including pH, water level, humidity, and temperature, is transmitted to the Blynk application. This seamless integration facilitates remote monitoring and visualization of the system's parameters, providing users with a user-friendly interface to oversee and manage the water control system effortlessly.

3.3.2 Gantt Chart PSM 1

Table 3-1 Gann Chart PSM 1

ACTIVITY	WEEK													
FYP (1)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Determination of tittle														
Meeting and Discuss with Supervisor														
Registration of tittle														
Online meeting with JK PSM														
Project Planning with Supervisor														
Discuss the flow of the project														
Discuss the component will be applied														
Discuss the expected output														
Writing Report														
Abstract														
Chapter 1: Introduction														
Background														
Problem Statement														
Project Objective														
Scope of Project														
Visit the plantation site and observe the structure with Supervisor														
Chapter 2: Literature Review														
Do research about the project														
Comparison of Previous Chapter														
Submit Draft of Literature Review														
Chapter 3: Methodology														

Block Diagram														
Flow chart of the project														
Research about software and hardware														
Chapter 4: Results and Discussion														
Preliminary Results														
Chapter 5: Conclusion														
Future Works Recommendation														
Submit Report														
Check Plagiarism at Turnitin														
Presentation PSM														

3.3.3 Gantt Chart PSM 2

Table 3-2 Gann Chart PSM 2

	W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W1 11	W1 11	W1 12	W1 13	W1 14
Planning and Research														
Define Requirements and Features														
								MIDTERM BREAK						
Research Components														
Create Schematics														
Material Acquisition														
Circuit Assembly														
Wiring and Connections														
Verify Circuits														
Install Development Environment														
Develop Sensor Readings														
Develop Blynk Apps														
Test Communication														
Integration of Hardware														
Functional Testing														
Performance Testing														
Documentation														
Presentation and Finalization														

3.4 Hardware and Software specifications

The hardwares and software used in this project are as follows:

3.4.1 ESP32

Figure 3.3 ESP-32

The ESP32 is a versatile system-on-a-chip (SoC) widely used in IoT and embedded systems applications. It features a dual-core processor, built-in Wi-Fi and Bluetooth, flexible GPIO pins, various peripherals, and a range of memory options. With low power consumption and support for popular programming environments, the ESP32 enables developers to create diverse IoT projects, from home automation to industrial applications, with ease and efficiency.

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3.4.2 Water Level Sensor

Figure 3.4 Water Level Sensor

This sensor operates by employing a set of five exposed traces which are linked to system ground. Scattered between every two ground trace is a sense trace; five of them and make the total. 1 Megaohm pull-up resistor is used to link the sense traces. That is, the sense traces are pulled high until a drop or plane of water shorts out-the sense trace to ground. This sensor would theoretically provide an analog signal of 0-1024. The Water Level Sensor is simple and affordable device with a high level / drop recognition sensor by have a row of parallel wires exposed traces measure droplets or water volume to determine the water level.

3.4.3 DHT11

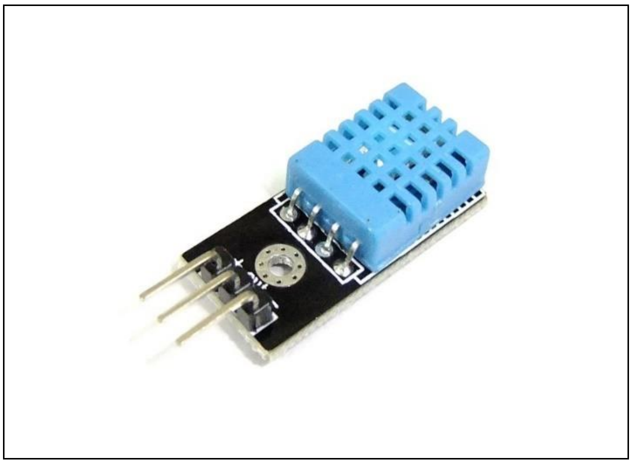

Figure 3.5 DHT 11

The DHT11 is an inexpensive basic digital temperature and humidity sensor. 5 senses – It uses a capacitive humidity sensor and thermistor to sense the surrounding air, spitting out digital signal on data pin no analog input pins required. It’s quite easy to operate but it needs proper timing t o acquire data. The single real drawback of this sensor is that new data from it can only be received every 2 seconds so when our library was used, the readings obtained may have been up to two seconds old.

3.4.4 5V Solid State Relay 2

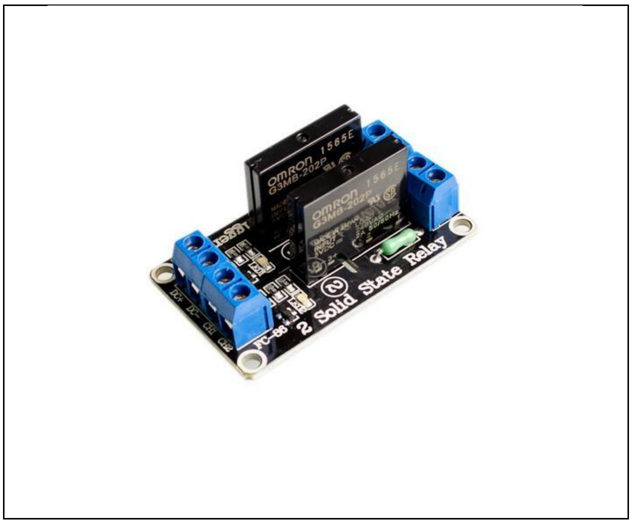

Figure 3.6 Solid State Relay

Compares with the traditional mechanical relay, the Solid State Relay (SSR) has many advantages: it has longer life, much higher on-off speed and no noise. Furthermore, it has also enhanced resistance to vibration and mechanical shock as well performance in protection against moisture. This can be used in so many fields like computer peripheral interfaces, temperature/speed light adjustment, medical instrumentations, meters, traffic signals, etc.

3.4.5 Ph Sensor

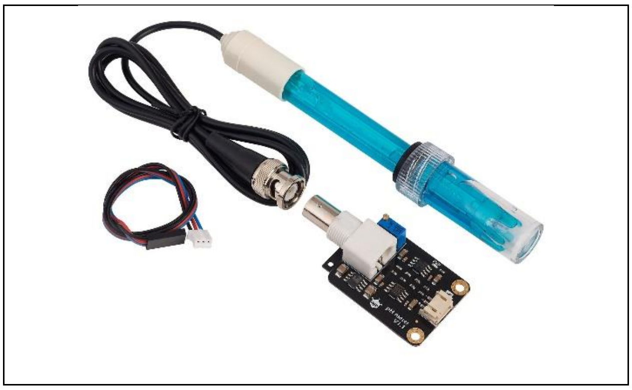

Figure 3.7 pH Sensor

A pH sensor is basically a device used to detect the level of acidity or alkalinity in a solution. It functions on the principle of sensing hydrogen ion concentration in solution that determines pH level. Generally, pH sensors are a probe that has some particular membrane to interact selectively with hydrogen ions. The membrane produces a voltage signal proportional to the pH of medium and these signals transformed into numerical scales with the help of sensor’s electronics. These sensors are widely used in a range of fields such as environmental monitoring, water quality assessment, laboratory experiments and industrial processes where their data provides useful information to maintain optimal conditions within these different applications.

3.4.6 3 Pin Plug

Figure 3.8 3 Pin Plug

3-pin plug is an ordinary electrical connector having live (L), neutral N and earth E pins that supply a current to devices. Live or brown pin carries current, neutral or blue helps to complete the circuit and an earth for safety connects with ground wire. It is necessary to pay attention to the regional electrical standards such as wire color coding, voltage and frequency in many countries while designing a manufacturing process since it ensures safe operation of devices.

3.4.7 Arduino IDE

Figure 3.9 Arduino IDE

Arduino IDE is a software platform used for programming microcontrollers. It provides an easy-to-use interface to write, compile and upload code onto Arduino boards. It is based on C and C++, it supports several Arduino models to both beginners and experienced developers. The IDE has a code editor, compiler and inbuilt serial monitor for debugging while encouraging the creation of large communities with shared libraries even resources used to build diverse applications including robotics & home automation.

3.4.8 Blynk App

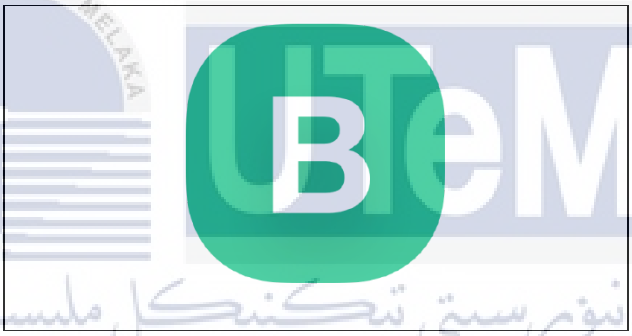

Figure 3.10 Blynk Apps

Blynk apps which are a part of the core IoT development platform with intuitive drag-and-drop interfaces on both Android and iOS. These mobile apps let users to create graphical controls such as buttons and sliders without much programming. Blynk apps interact with the cloud server, enabling communication between it and connected hardware to control IoT projects via mobile interfaces accessible for hobbyist developers.

3.5 PSM Flowchart

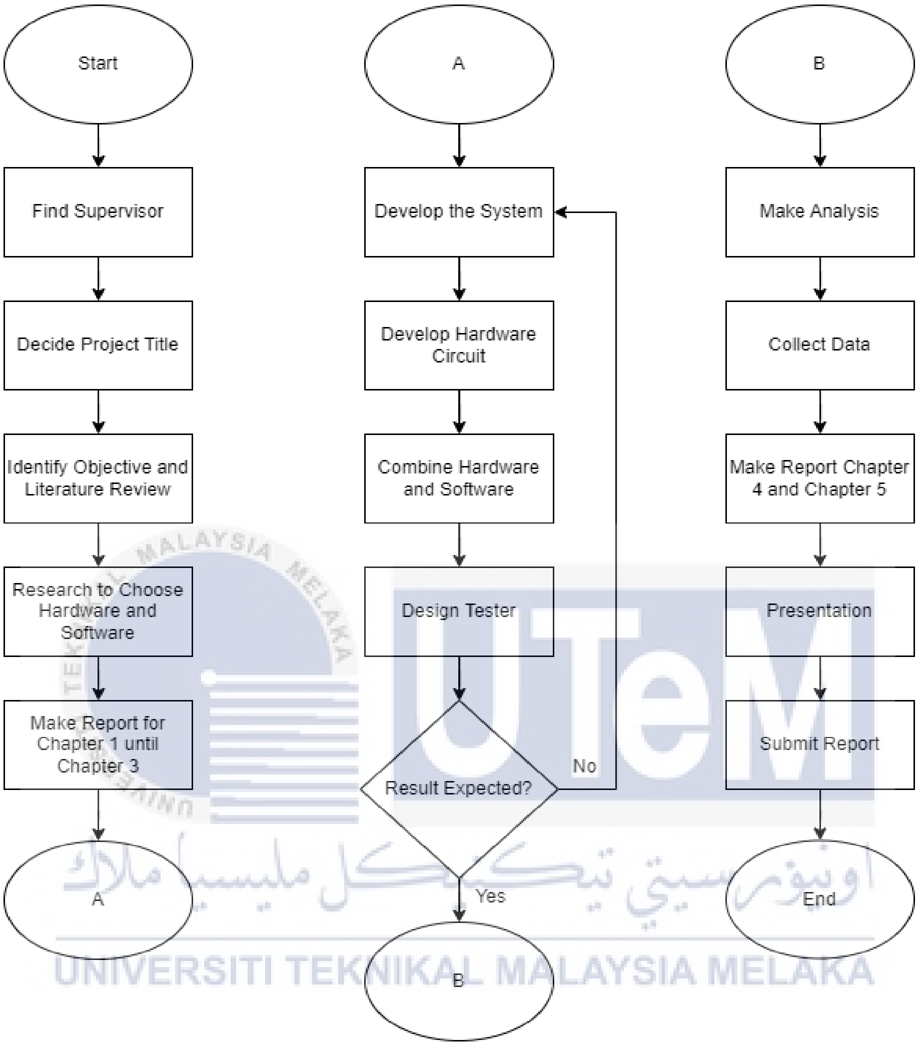

Figure 3.11 PSM Flowchart

3.6 Limitation of Proposed Methodology

The development and application of a hydroponic monitoring system with an Android app may encounter various constraints. These limitations are outlined in detail below:

1) Data Transmission and Security: The methodology involves the use of the Blynk App for data visualization and control. However, the security and privacy aspects of data transmission between the app and the hydroponic system need careful consideration.
2) Limited Sensor Capabilities: While the selected sensors (Water Level Sensor, DHT11, pH Sensor) serve their intended purposes, they may have inherent limitations. For instance, the DHT11 has a data acquisition delay of two seconds, which could impact real-time monitoring accuracy

3.7 Summary

The hardware and software specifications for the hydroponic monitoring system include the ESP32, a versatile system-on-a-chip with dual-core processors and built-in Wi-Fi; a Water Level Sensor utilizing exposed traces and a 1 Megaohm pull-up resistor for water level detection; the DHT11, a basic digital temperature and humidity sensor with a two-second data acquisition delay; a 5V Solid State Relay offering advantages like longer life and higher speed; a pH Sensor for detecting acidity or alkalinity in a solution; a 3 Pin Plug for electrical connection; Arduino IDE for programming microcontrollers; and the Blynk App, a part of the IoT development platform for mobile interfaces. These components collectively enable the creation of a comprehensive hydroponic monitoring system with diverse applications in IoT and embedded

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter introduces the initial phase of the "Development of Android Apps for Hydroponic Monitoring System," focusing on the implementation of a smart hydroponic system. The primary objective is to optimize the hydroponic setup using IoT technology, incorporating sensors for monitoring humidity, temperature, and pH levels. Unlike traditional soil-based systems, this hydroponic approach eliminates the use of soil. The technology aims to empower farmers and users by providing real-time monitoring of environmental conditions, ensuring the system's adaptability to hydroponic requirements. Preliminary results indicate successful integration of sensors, within the IoT framework. Ongoing investigations delve into system performance, energy efficiency, and user satisfaction, with the ultimate goal of advancing smart home applications and hydroponic fertigation systems, capable of automated water pump control based on monitored parameters.

4.2 Result

4.2.1 Hardware

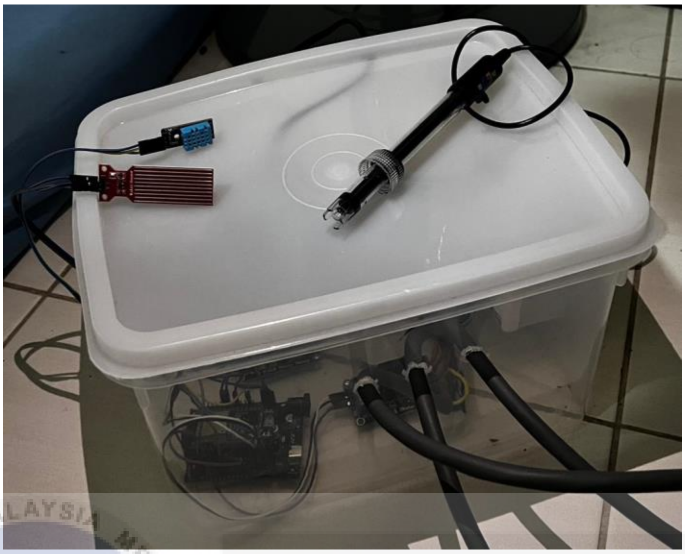

Figure 4.1 Prototype Hardware

Upon reviewing the graphical illustration, Figure 4.1 unveils details about the project's configured hardware. This configuration includes an array of electronic elements and components designed for the system on a deliberate basis. All elements have gone through an in-depth developmental cycle leading to a harmonious alignment that supports the physical framework of the project. This well thought out coordination is indicative of the project's dedication to cutting edge technology and avant-garde design, revealing an integrated synergy where all components mesh for superior system functionality.

4.2.2 Site Installation

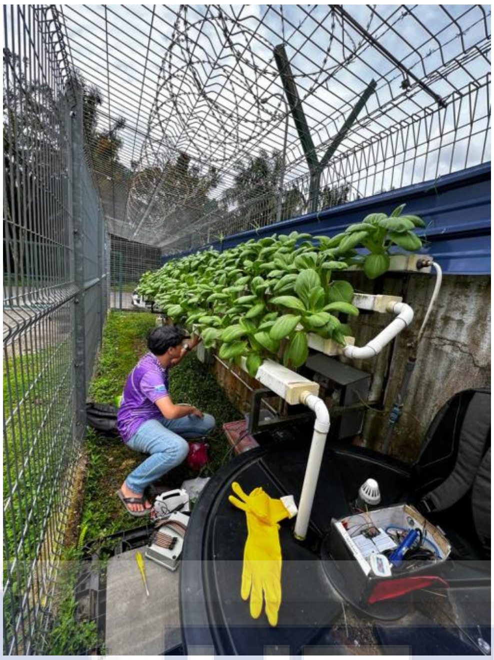

Figure 4.2 Installing Prototype at Project Site

Referring to the Figure 4.2, a proper site verification is taking place so that hardware setting goes smoothly and hassle free. This includes an in-depth study of the site's environmental factors and spatial considerations to ensure effective functioning. This is one preventive action aimed at assuring that during hardware installation all components are connected appropriately, strengthening the overall strength of any system.

4.2.3 Blynk Interface for Hydroponic Sytem

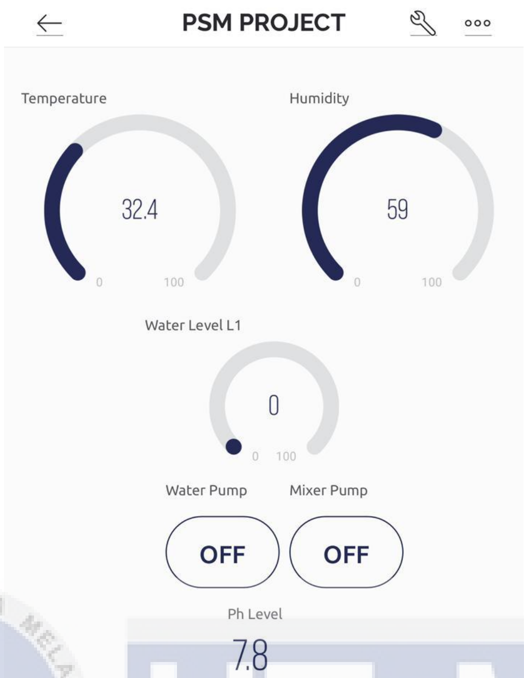

Figure 4.3 Blynk Application Interface

Referring to Figure 4.3, I encounter the Blynk interface designed for the hydroponic system. Noteworthy for its user-friendly design, the interface prominently displays crucial sensors essential to the hydroponic setup. These include parameters like temperature, humidity, water level, a button for the water pump, a mixer pump control, and a pH level indicator. The user-friendly nature of this interface is underscored by its simplicity, enabling effortless monitoring of vital data. Its intuitive layout facilitates ease of use, providing a streamlined experience for users engaging with the hydroponic system. The emphasis on user-friendliness is particularly pivotal, ensuring that individuals, regardless of their technical proficiency, can navigate and comprehend the displayed information with utmost convenience.

4.2.4 Testing Serial Monitor and Blynk Apps data tally

```
Temperature: 32.10 °C, Humidity: 61.00, Water Sensor Value: 25.50
, pH: 5.52
Solution Mixer Pump Relay State = 0, Water Pump Relay State = 0
```

Figure 4.4 Serial Monitor

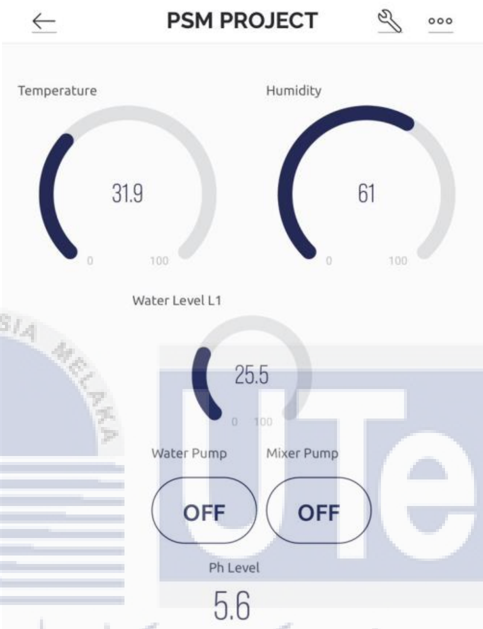

Figure 4.5 Blynk Interface

Figure 4.4 shown on Serial Monitor offers an all encompassing data set proving the system's high performance capabilities . 31.9°C as temperature, 61% humidity reading – both figures indicating the hydroponic environment's accuracy; constant value of water sensor at 25.5 and pH level hitting 5. Moreover, the relay status is both turned off and validates overall reliable control through Blynk's platform. This seamless fusion of sensor readings and relaystates not only allows for precise data capture but also enables remote monitoring, which reflects the system's ability to provide real-time insights in order to maximize hydroponic plant cultivation.

4.2.5 Water level when under 20

```
Temperature: 31.30 °C, Humidity: 64.00, Water Sensor Value: 15.70
Water Pump Relay activated automatically.
, pH: 5.60
Solution Mixer Pump Relay State = 0, Water Pump Relay State = 1
```

Figure 4.6 Serial monitor when water under 20

From the Figure 4.6 on Serial Monitor observations capture that touch sensor water level is reported as under 20 and exactly at At low measurement reading of It can be seen in Figure 4.6 As a consequence the automated system response is turned on and water pump relay activated automatically. This automatic activation is perfectly mirrored in the Serial Monitor output, demonstrating that control logic works well. It is therefore the proof that such a hydroponic control system functions with high precision and can operate automatically to maintain ideal water levels by interpreting the data of its sensors, triggering some relays accordingly.

4.2.6 Water level when above 70

```
Temperature: 31.60 °C, Humidity: 66.00, Water Sensor Value: 86.00
Water Pump Relay deactivated automatically.
, pH: 5.52
Solution Mixer Pump Relay State = 0, Water Pump Relay State = 0
```

Figure 4.7 Serial monitor when water above 70

In Figure 4.7, the touch sensor indicates a water level below 20, prompting the automated activation of the water pump relay. This seamless response, as observed in the Serial Monitor, underscores the control logic's precision in adapting to sensor data for efficient system operation.

Continuing this functionality, as depicted in Figure 4.2.7, the water pump relay autonomously deactivates when the water level surpasses 70. This dual capability highlights the system's adaptability and automated control, ensuring a dynamic and optimal environment for sustained plant growth.

4.2.7 Graph for DHT11 Temperature Sensor

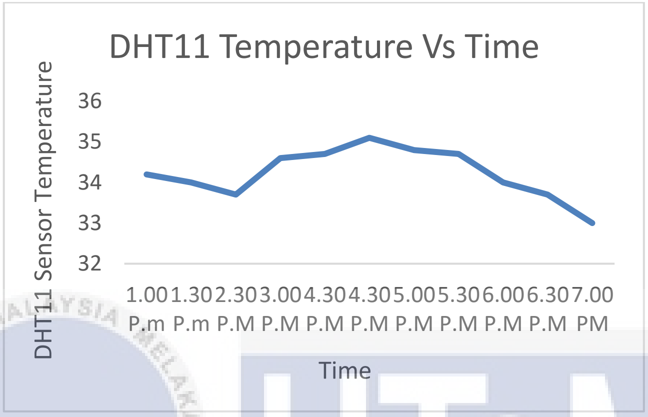

Figure 4.8 DHT11 Temperature Sensor Graph

In Figure 4.8, the DHT11 sensor is utilized for temperature measurements, capturing data at 30-minute intervals over a duration of 6 hours. The graph associated with this dataset visually represents the variations in temperature over the specified time period, providing a comprehensive view of the temperature trends observed by the sensor during the monitoring period.

4.2.8 Graph for Termometer Sensor

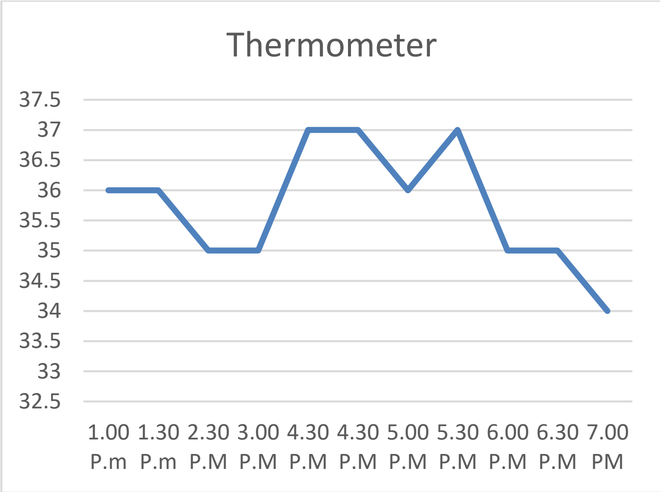

Figure 4.9 Termometer Sensor

In Figure 4.9, a thermometer is employed for temperature measurements, gathering data at 30-minute intervals over a span of 6 hours. The corresponding graph visually illustrates the temperature variations throughout the specified time period, offering a comprehensive depiction of the temperature trends recorded by the thermometer during the monitoring duration

4.2.9 Comparison between thermometer and DHT11 sensor

The Result of DHT11 Sensor			
Time	Sensor ©	Thermometer	Error
1.00 P.m	34.2	36	5.00
1.30 P.m	34	36	5.56
2.30 P.M	33.7	35	3.71
3.00 P.M	34.6	35	1.14
4.30 P.M	34.7	37	6.22
4.30 P.M	35.1	37	5.14
5.00 P.M	34.8	36	3.33
5.30 P.M	34.7	37	6.22
6.00 P.M	34	35	2.86
6.30 P.M	33.7	35	3.71
7.00 PM	33	34	2.94
Average Error			4.16

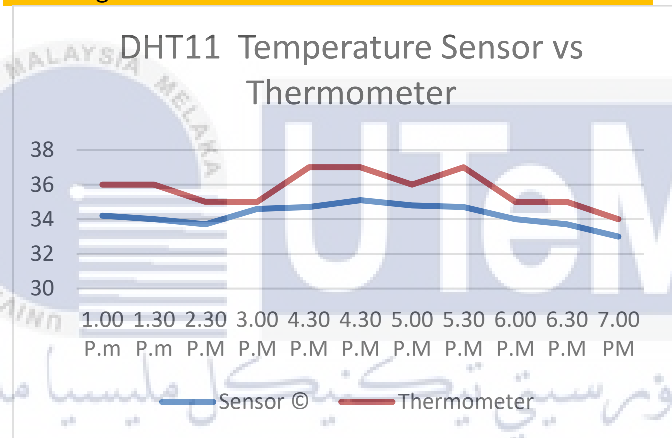

Figure 4.10 Comparison DHT11 and Termometer

In Figure 4.10, a comprehensive comparison is showcased, presenting data collected every 30 minutes over a 6-hour duration. This data originates from both the DHT11 sensor and a thermometer. The detailed analysis and research findings from this dataset computation unveil an associated error rate of 4.16%. This comparison offers valuable insights into the consistency and accuracy of temperature measurements between the two instruments, providing valuable information for further evaluation and refinement of the monitoring system

4.2.10 Graph for pH Sensor

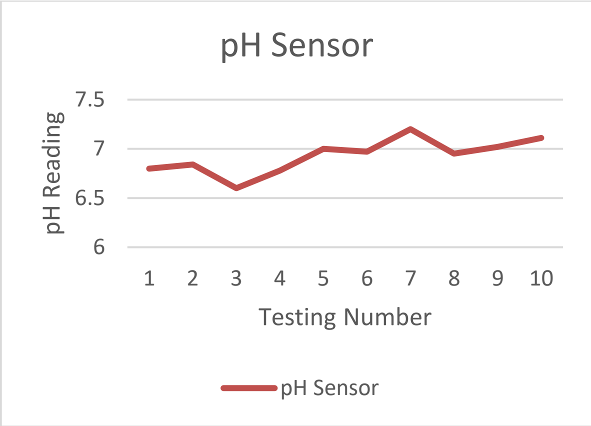

Figure 4.11 Graph for pH Sensor

In Figure 4.11, a detailed graphical representation unfolds as pH level measurements are meticulously acquired through ten iterations, employing a precision pH sensor. This extensive dataset provides a thorough exploration of pH variations, capturing nuances in the acidic or alkaline levels with each successive measurement. The graph not only serves as a visual record of the pH dynamics but also lays the foundation for a comprehensive analysis, offering valuable insights into the stability and fluctuations within the measured pH over the course of ten measurements

4.2.11 Graph for pH Meter

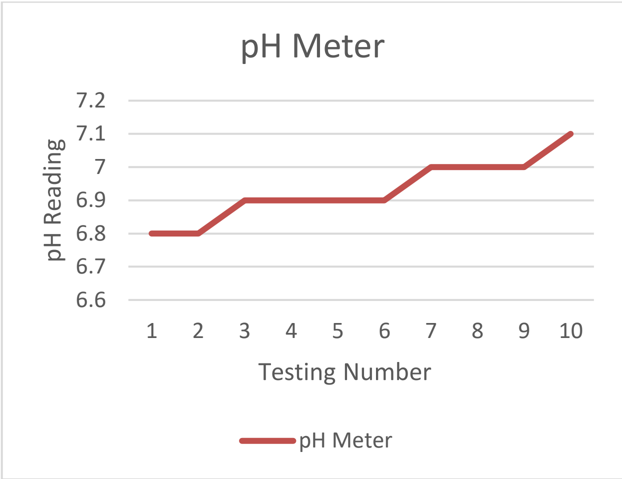

Figure 4.12 Graph for pH Meter

In Figure 4.12, a meticulous exploration into pH dynamics is presented through a comprehensive graphical depiction, showcasing ten iterations of pH level measurements utilizing a precision pH sensor. This detailed dataset not only captures subtle variations in acidic or alkaline levels with each measurement but also forms the basis for an in-depth analysis. Notably, in comparison to the previous sensor data (Figure 4.2.11), Figure 4.2.12 reveals a heightened stability in pH levels. The graph serves as a visual testament to the enhanced stability, providing valuable insights into the consistent and less fluctuating nature of pH measurements over the course of ten iterations.

4.2.12 Comparison between pH sensor and pH Meter

The Result of Ph Level			
Testing Number	pH Sensor	pH Meter	Error
1	6.8	6.8	0
2	6.84	6.8	0.59
3	6.6	6.9	4.35
4	6.78	6.9	1.74
5	7	6.9	1.45
6	6.97	6.9	1.01
7	7.2	7	2.86
8	6.95	7	0.71
9	7.02	7	0.29
10	7.11	7.1	0.14
Average Error			1.24

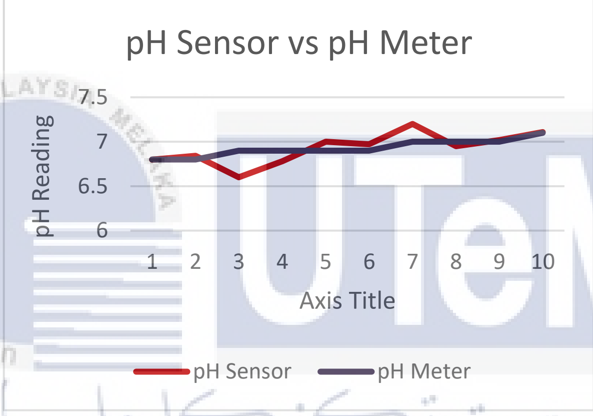

Figure 4.13 Graph comparison between pH Sensor and pH Meter

The average error between the pH sensor readings and the pH meter values across ten measurements is 1.24. This suggests a moderate level of variance between the two measurement methods, indicating that adjustments or calibrations may be considered for enhanced accuracy in future readings. The summary provides a quantitative assessment of the overall disparity between the pH sensor and pH meter, offering valuable insights for potential refinements in the measurement system.

4.3 Summary

This chapter introduces the "Development of Android Apps for Hydroponic Monitoring System," focusing on implementing a smart hydroponic system with IoT technology. Key hardware details are presented, emphasizing advanced technology. Site installation involves rigorous verification for hassle-free hardware settings, considering environmental factors. The user-friendly Blynk interface displays crucial hydroponic sensors, accommodating diverse user proficiencies. Serial Monitor and Blynk Apps testing highlight robust system performance, with an emphasis on remote monitoring capabilities. Automated responses of the water pump relay based on water levels affirm system precision and adaptability. Graphs for temperature sensors and thermometers capture temperature variations. A comprehensive comparison reveals a 4.16% error between DHT11 and thermometer readings, prompting considerations for system refinement. pH sensor and pH meter graphs depict pH level dynamics. A meticulous comparison shows an average error of 1.24, suggesting a moderate variance between measurement methods. These results collectively emphasize system precision, adaptability, and offer insights for potential enhancements in hydroponic monitoring

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The innovative Android app developed for hydroponic monitoring represents a significant stride in automating and enhancing the precision of the hydroponic process. With a strategic focus on critical parameters such as temperature, humidity, pH levels, and water level, the app ensures the creation and maintenance of an optimal environment conducive to robust and healthy plant development. Its unique feature lies in providing users with detailed statistics, particularly regarding pH levels and other essential environmental parameters, empowering growers with valuable insights for informed decision-making. The app further augments user control by offering real-time access to data, enabling prompt responses to changes and precise adjustments to the hydroponic system. Designed with a user-friendly interface, the application caters to growers of diverse expertise levels, making it accessible and intuitive. Through the automation of essential processes, it significantly reduces the need for manual intervention, thereby minimizing potential errors in system management. In essence, this Android app emerges as a comprehensive and invaluable tool for hydroponic growers, seamlessly integrating technology with agricultural practices and standing at the forefront of cultivating innovation for more effective and prosperous outcomes in hydroponic cultivation.

5.2 Potential for Commercialization

The development of Android apps for a hydroponic monitoring system represents a groundbreaking endeavor with immense potential for commercialization in the field of agricultural technology. This innovative system is designed to revolutionize hydroponic cultivation by automating and enhancing key aspects of the process. The primary focus lies on monitoring critical parameters that directly impact plant growth, including temperature, humidity, pH levels, and water level. By employing a comprehensive approach, the system aims to create and maintain optimal conditions for plants within hydroponic setups.

One of the key features of this Android app is its ability to provide detailed statistics on pH levels and environmental parameters. This functionality proves invaluable for growers, enabling them to gain deep insights into the growing environment. Armed with this data, users can make informed decisions, adjusting conditions as needed to maximize plant health and yield. The real-time access to growing environment data further enhances control, allowing growers to respond promptly to changes and maintain precision in managing their hydroponic systems.

The potential for commercialization stems from the system's ability to streamline and optimize hydroponic cultivation practices. The user-friendly interface makes the technology accessible to a wide range of users, from hobbyists to commercial growers. The automation of essential processes, combined with the detailed insights provided by the app, offers a powerful tool for growers looking to enhance productivity and efficiency in their hydroponic operations.

5.3 Future Works

In our relentless pursuit of continuous improvement, the Smart Hydroponic Monitoring System is poised for future enhancements, envisioning a more sophisticated, user-friendly, and technologically advanced system. This forward-looking perspective outlines the trajectory towards the next frontier of smart hydroponic cultivation. The roadmap includes the integration of EC sensors for enhanced precision in nutrient management, ensuring optimal plant growth. Simplicity and user-friendliness take center stage with a streamlined interface for improved accessibility, making the system more intuitive for users. Embracing technological advancements, the system is set to leverage cutting-edge technologies, ushering in a new era of innovation for smart hydroponics.

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DEVELOPMENT OF ANDROID APPS FOR HYDROPONIC MONITORING SYSTEM

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