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Design of a Solar Tracker for Monitoring Smart Farming Hydroponics Based on the Internet of Things

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Abstract— The use of Internet of Things (IoT) technology in agriculture is growing rapidly. One of the IoT technologies that can be utilized in agriculture is smart farming. Smart farming is an agricultural method that uses information and communication technology to increase productivity and efficiency in the agricultural sector, one of which is hydroponics. Hydroponics is a farming technique without using soil media, which uses water as a medium for plant growth. However, in the application of smart farming Hydroponics, some obstacles still need to be overcome. One of these obstacles is plant monitoring which is still done manually, requiring a lot of time and effort. In addition, energy use is also a problem in smart farming Hydroponics applications. One solution to these obstacles is using a solar tracker to monitor smart farming hydroponics. A solar tracker is a technology used to follow the movement of the sun to increase energy efficiency. By using a solar tracker, maximum energy can be generated, so that it can be used for monitoring smart farming hydroponics.

Keywords— Monitoring, Smart Farming, IoT, Hydroponic, Solar Tracker

I. Introduction

Hydroponic farming is a farming method that is increasingly popular in the world because of the advantages it can get such as faster and higher quality yields, more efficient use of water, and can be planted in various places with smaller land areas compared to traditional farming. However, even though hydroponic farming has many advantages, there are still challenges in optimizing its productivity, especially in terms of efficient and adequate use of energy. In practice in the hydroponic SMART FARMING field, there are still several obstacles that need to be overcome. One of these obstacles is plant monitoring which is still done manually, so it requires a lot of time and effort. In addition, energy use is also a problem in SMART FARMING Hydroponics applications. The development of technology is increasing rapidly, giving birth to new technologies, one of which is the Internet of Things (IoT). According to Wasista (2019), the Internet of Things is a term that appears with the notion of access to electronic devices through Internet media. Access to these devices occurs as a result of the relationship between humans and devices or devices with devices by utilizing the internet network. Access to these devices occurs because there is a desire to share data, share access, and also consider security in access.

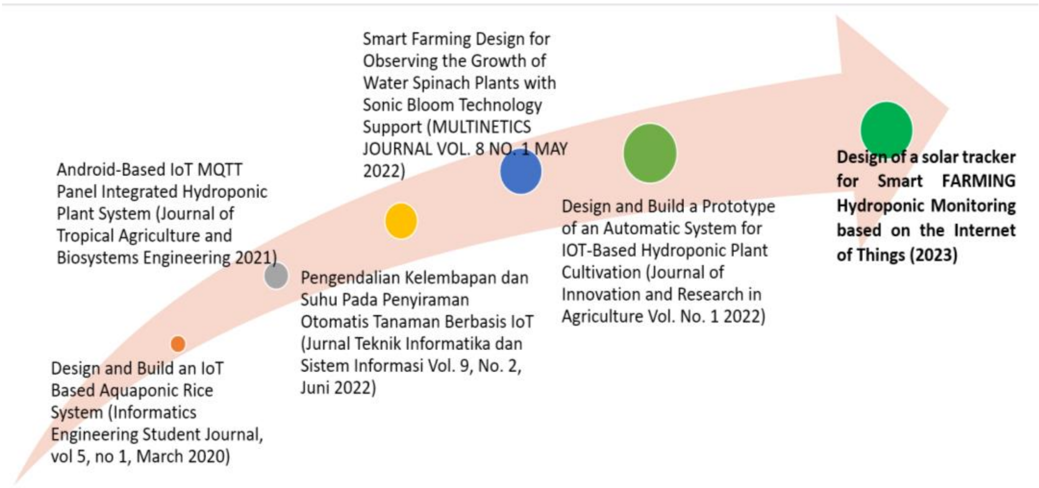
Problem Formulation to overcome this challenge is to utilize the Solar Tracker which can direct solar panels towards the sun automatically to maximize the collection of solar energy. By integrating Solar Tracker technology with the SMART FARMING Hydroponics system that is connected to the Internet of Things (IoT), real-time and effective monitoring and control of environmental conditions for growing hydroponic plants can be carried out. In addition, 3 sensors will be used for monitoring, including a Ph sensor to find out the Ph value of water, a DTS sensor to detect nutrients in plant water, and a transistor water level sensor to detect the water level in hydroponic irrigation reservoirs. Therefore, this study aims to explore the use of Solar Tracker in SMART FARMING Hydroponics and integrate it with Internet of Things (IoT) technology to maximize hydroponic farming productivity with more efficient energy use. It is hoped that the results of this research can contribute to the development of more sustainable and environmentally friendly hydroponic farming.

II. Literature Review

A. Literature study

Research on information on Hydroponic Smart Farming places include:

1. Design of an IoT-Based Aquaponic Rice System
2. Humidity and Temperature Control in IoT-Based Automatic Plant Watering
3. Design of Automated System Prototypes in IOT-Based Hydroponic Plant Cultivation
4. Smart Farming Design for Observation of Kale Plant Growth with the Support of Sonic Bloom Technology
5. Smart Farming: Android-Based IoT MQTT Panel Integrated Hydroponic Plant System



Picture 1. Roadmap research

The roadmap above describes research related to Smart Farming Design on the Internet of Things-based Hydroponic plants that have been made, and will further be developed by researchers in the following year.

Design of an IoT-Based Aquaponic Rice System (Journal of Informatics Engineering Students, vol 5, no 1, March 2021). This research was conducted by Desvianty Ayu Wahyudi, Suryo Adi Wibowo, and Renaldi Primaswara P from the Bachelor of Informatics Engineering study program, Faculty of Industrial Technology, National Institute of Technology Malang. This research was conducted to make a remote monitoring tool for monitoring water pumps, soil moisture. Pond water turbidity and rice pest control.
Smart Agriculture: Humidity and Temperature Control in IoT-Based Automatic Watering of Plants (Journal of Informatics Engineering and Information Systems Vol. 9, No. 2, June 2022) This research was conducted by Fhizyel Nazareta, Fauziah, Gatot Soepriyono from the Informatics study program, Faculty of Communication and Informatics Technology, National University. This research was conducted aiming to control humidity and temperature when doing automatic watering on plants.
Design of Prototype Automated Systems in IOT-Based Hydroponic Cultivation (Journal of Innovation and Research in Agriculture Vol. No. 1 2022). This research was conducted by Angga Adriana Imansyah, Melissa Syamsiah, and Melki Jakaria from the Faculty of Applied Science, Suryakancana University. The research was carried out aiming to help maintain hydroponic plants with an automatic water control method using a microcontroller. This study used a method of controlling water conditions automatically by checking the nutrient content of the water and the acidity level of the water.
Smart Farming Design for Observation of Kale Plant Growth with the Support of Sonic Bloom Technology (Jurnal Multinetics Vol. 8 No. 1 May 2022). This research was conducted by Putri Ayu Rezeki, Favian Dewanta, and Sri Astuti from the Telecommunications Engineering Study Program, Faculty of Electrical Engineering, Telkom University. This study aims to compare the results of three types of music that affect swamp cabbage without sonic bloom technology and to test the results of network performance.
Smart Farming: Android-Based IoT Panel MQTT Integrated Hydroponic Plant System (Journal of Engineering Tropical Agriculture and Biosystems 2021). This research was conducted by Imelda Zahra Tungga Dewi, Muhamad Faqih Ulinuha, Wahyu Ajis Mustofa, Ade Kurniawan, Frida Agung Rakhmadi from the Physics Study Program, Faculty of Science and Technology, Sunan Kalijaga State Islamic University, Yogyakarta. This research aims to facilitate remote control in hydroponic farming by creating a monitoring and controlling digitalization system using an application without the owner being at the hydroponic location.

B. Theoretical Foundations

1. *Solar Panel*

Solar panels are devices consisting of solar cells that convert light and photon energy into electricity. They are called solar upper solar or "sol" because the Sun is the strongest source of light that can be utilized. Solar panels are often called photovoltaic cells, photovoltaic can be interpreted as "light electricity". "Solar cells or PV cells depend on the photovoltaic effect to absorb the sun's energy and cause a current to flow between two oppositely charged layers" Solanki (2013:15). The excess supply that has been stored in the battery can be used if the solar panels stop supplying electrical energy. The easiest case example is if at any time the sunlight is dim or dark (rain). Of course, solar panels are impossible for us to get sunlight. Then use the electrical energy stored in electrical energy devices.

2. *Controller Panel Surya*

The solar charge controller is a component for solar power generation, has a function as a battery

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charger (when the battery is charged and keeps the battery charged), and regulates the incoming electric current from the solar panels as well as the outgoing load current. The solar charge controller usually consists of 1 input (2 terminals) connected to the output of the solar panel, 1 output (2 terminals) connected to the battery or battery, and 1 output (2 terminals) connected to the load. DC electric current that comes from batteries is usually not possible to enter the solar panel because there is a protection diode that only passes DC electricity from the solar panel to the battery. With the solar charger controller, the electrical energy that has been generated by the solar cells will automatically be charged to the battery and keep the battery in good condition, then the solar charger controller also has energy from solar cells that can be used directly (Jauhari, 2018).

Picture. 2. Controller Panel Surya

3. *Hydroponic System*

A hydroponic system(hydroponics) is a planting cultivation technique that does not use soil media (Soil Culture). This includes farming models using pots or other containers that use water or materials porous such as cotton, sand, gravel, and tile fragments. In the past, several researchers in the plant physiology laboratory often interacted with water-growing media as an alternative to farming without soil. Some people think of it as aquaculture (growing in water). This trial turned out to be successful so many agronomists developed the method (Phallus, 1984).

4. *Light Dependent Resistor (LDR)*

A solar charge controller is a component for solar power generation and has a Light Dependent Resistor (LDR) consisting of a plate of semiconductor material with two electrodes on its surface. LDR can experience changes in resistance when experiencing changes in light reception. The resistance value of the LDR depends on the size of the light received by the LDR itself. (Cahyo, 2017)

Picture. 3. Light Dependent Resistor (LDR)

5. *Solar panels*

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Picture. 4. Solar panels

6. *Sensor Ph*

One way that can be used to determine the level of pH content in a solution is to use a pH sensor. If the solution is alkaline, then the probe electrode on the sensor will be negatively charged. Vice versa, probe the electrode will be positively charged when the detected solution is acidic. The sensor measures the water content using an electrode in contact with the fluid. In measuring the water content, it consists of 2 parts, namely the Ph sensor and the pH sensor signal conditioning circuit. Signal coding using an analog Ph meter kit from robot (Amani, 2016). In this study, the pH sensor used was a pH sensor V1.1 with MSP340 Shield as shown in picture 5.

Picture. 5. Sensor Ph

7. *MIT App inventor*

App Inventor for Android is a web application open-source originally provided by Google and is now maintained by the Massachusetts Institute of Technology (MIT). MIT App Inventor is an introductory innovation for beginners to program and create applications that transform the complex language of text-based coding into visual form, by dragging and dropping building blocks. It is a simple graphical

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interface that gives even novices the ability to create a fully functional application in an hour or less. The App Inventor program can be accessed via ai2.appinventor.mit.edu and is used to create and design web page-based Android applications and Java interfaces. This App Inventor uses a graphical interface, just like using Scratch, users only drag and drop visual objects to create applications that can run on Android devices. So with coding, in using this program, there is no need to write very, very long program code, just simply drag and drop like composing puzzle (Computer, Wahana, 2013).

III. RESEARCH METHODS

A. Methodology Research

The concept of the research methodology used is to approach goal-based solutions (literature study), identify problems and motivations, determine the focus of research, design and develop solutions, build simulations, test, discuss, and draw conclusions. This approach uses a concept introduced by Ken Peffers, Tuure Tuunanen, Marcus A. Rothenberger, and Samir Chatterjee in a journal entitled "A Design Science Research Methodology for Information Systems Research". The flow diagram uses the concept of the Design Science Research (DSR) method.

Based on this concept, research methods that are adapted to the research conducted have stages of literature study, problem identification, and motivation, determining the focus of survey tools, analysis of research and testing methods, design, testing, analysis of test results, and reporting of research results.

The description of the method used based on the stages of the research is as follows:

1. Analysis of hardware requirements. The analysis was carried out to find the availability of any components in the study.
2. Analysis of design and testing methods. Determination of focus is determined based on the results of problem identification and the motivation that drives the research. Proposing is done as a guideline in conducting research.
3. The design of electronic schemes and mechanical designs is made based on the focus of the research that will be carried out using the prototype development method. To support monitoring using a smartphone, the tool used is NodeMCU esp 8266.
4. Making Arduino tools and programs
5. Assemble and connect all the tools that have been determined according to the design scheme.
6. After the design and demonstration/simulation have been obtained, testing of the prototype is carried out to be evaluated while assessing the achievement of objectives. Prototype testing was carried out in the Mulia University campus trash bin.
7. Analysis and Reporting. Analysis was carried out on the test results obtained. The analysis aims to provide an overview of the condition of the prototype and input regarding the direction of further development. Reporting of Research Findings Reports of research findings based on existing data and analysis results are made and reported as research by novice lecturers.

B. Data Collection Techniques

The data collection method is a technique or method used to collect data [11]. In this study, researchers used data collection methods by:

1. Observation is a data collection technique by going directly to the field to observe problems that occur directly at the scene systematically events, behavior, objects that are seen and other things needed to support ongoing research.
2. Interview is a data collection technique that is carried out through face-to-face and direct question and answer between data collectors and data sources/sources. The research data source is the hydroponic farming community.
3. Literature study is a method of collecting data by reading books and journals according to the required data. In this study the authors chose to study the literature to collect references from books on microcontrollers and journals that discuss microcontrollers.

C. Diagram Tracker solar Panel

Solar panel Tracker work process :

1. Sunlight as input, sunlight is received by solar panels and will be converted into electrical energy.
2. LDR Light Sensor as input, sunlight will be received by 4 LDR each LDR will provide an analog output to the microcontroller.
3. The Voltage Sensor will measure the amount of voltage on the battery and then provide an analog output to the microcontroller.
4. Arduino as a process, the input received will be processed by Arduino in the form of an analog value from the LDR sensor and an analog value from the voltage sensor.
5. The solar cell controller will balance the voltage received by the solar panel so that it can charge the 12v battery.
6. Charge voltage as output because it outputs a voltage that will be used to charge the battery
7. Motor Driver as output, when the sun light source moves, the microcontroller will drive the dc motor through the motor driver.
8. The LCD as an output, the amount of voltage received and the movement of the solar panels that follow the direction of the sun will be informed to the LCD.

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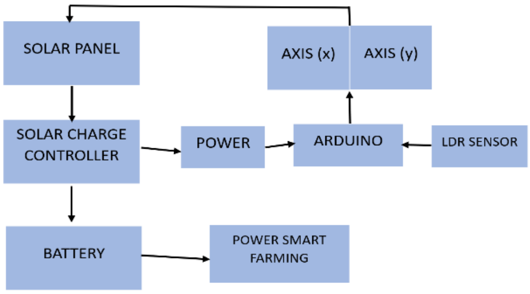
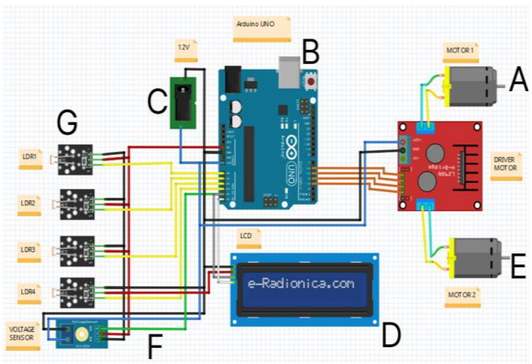


Picture 6. Diagram Tracker solar Panel

D. Schematic Electronics for Tracker Panel Surya

The following is an explanation of the components of a solar tracker

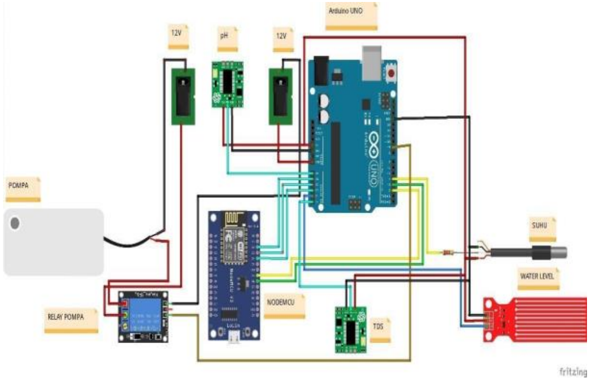
1. Arduino Uno
   Functions as a microcontroller that performs data processing from the incoming LDR sensor and voltage sensor and then drives the DC motor through the solar panel driver
2. LDR sensor
   Functions to transmit analog values of the amount of sunlight received
3. Voltage Sensors
   Functions to transmit the amount of voltage entering the battery
4. LCD
   Functions to display the battery voltage, whether the direction of the solar panel is up, turn, or left and right
5. Motor Drivers
   Function to drive a DC motor
6. DC motors
   Functions as a solar panel mover up-down and left - right



Picture. 7. Schematic Electronics for Tracker Panel Surya

E. Schematic Electronic for Smart Hydroponic

At this stage, it is carried out to design a system scheme according to the needs of the system to be built based on the results of the analysis that has been carried out. The author makes a system design and makes a schematic of how the system works in diagrammatic form to provide an overview of the flow of the system being made, as well as create a schematic of the series of tools that will be used to build this monitoring system using the Fritzing application. More details can be seen in picture 8.



Picture 8. Schematic Electronics for Smart Farming

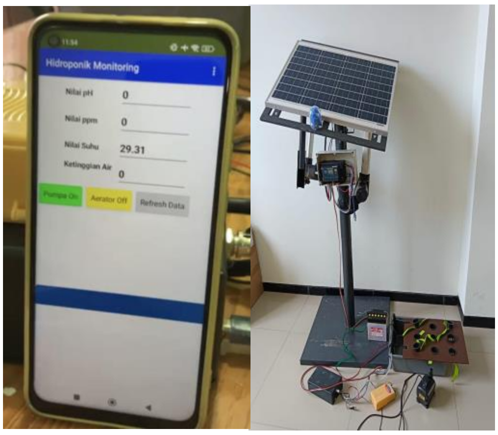
Explanation of the tool modeling scheme

1. The pump functions to pump water
2. The Pump Relay acts as an electric switch/switch to replace the workload of switches on automatic water pumps which are on average small and there is only 1 switch.
3. NodeMCU is in charge of sending data to the application
4. Arduino uno is in charge of reading sensor data and sending the data to NodeMCU
5. The pH sensor serves as a water pH data detector
6. The temperature sensor serves as a detector of temperature data
7. The TDS sensor serves as a detector for the level of water turbidity
8. The water level sensor serves as a measure of the water level

IV. Results and Discussion

The results obtained in this study are that the development of a hydroponic plant monitoring system using Internet of Things technology has been successfully carried out. The solar power system developed is capable of transmitting electric current to power the hydroponic garden's nutrient water pump. In addition, the solar power system built is also capable of supplying electricity to the garden monitoring system, so that users no longer need to depend on a source of electricity from the National Electric Company. Controlling or monitoring garden conditions can also be done using a smartphone connected to the internet network. This can be done because the monitoring system built is also network-based, or in other words, it is already connected to the internet via a wireless network. The smartphone application interface for monitoring hydroponic gardens can be seen in the following

Implementation of a hydroponic monitoring system, this stage is carried out by assembling the system hydroponic monitoring, namely by assembling temperature and humidity sensors, TDS sensors, NodeMCU ESP8266 and other devices become a unified system that can work well.



Picture 9. Overall design of the tool

A. *Tool Testing*

The results of trials are experiments carried out by researchers covering various aspects such as input, process, and output.

Tabel 1. Temperature Reading Test

Second	Instrument Readable Temperature	Thermometer Reading Temperature	Difference
1	26.5	26.7	0.2
5	27.00	26.5	0.5
10	27.5	28.00	0.5
15	26.2	26.2	0
20	25.6	25.6	0
25	25.6	25.6	0

a. Input and process results

Testing the sensor input function is carried out to find out whether the sensor used is functioning properly according to its function or not. Testing is carried out by periodically applying heat to the sensor with medium heat over some time of 1, 5, 10, 15, 20, and 25 seconds. In Table 1, the test results from monitoring hydroponic plants are obtained. The temperature sensor used in designing the tool is a type of temperature sensor DS18B20. Saputra, (2020) in his research stated that the DS18B20 temperature sensor is a temperature sensor where the accuracy of temperature values and measurement speed has better stability than other temperature sensors, and is capable of measuring temperature in water (waterproof). For temperature readings, the sensor uses a 1 wire communication protocol. DS18B20 has 3 pins consisting of +5V, Ground, and Data Input/Output. Temperature sensors The DS18B20 operates at temperatures of -55 ° Celsius to +125 ° Celsius. The advantage of the DS18B20 is that the output is digital data with an accuracy value of 0.5ºC over a temperature range of 10ºC to + 85ºC, making it easier to read by the microcontroller.

Table 2. Hydroponic Monitoring Tests

Scenario	Yang results Expected	Conclusion
Reading Sensor pH	Display pH value on application monitoring	Succeed
Reading Sensor TDS	Show TDS value on application monitoring	Succeed
Reading Sensor temperature	Display Temperature Value on application monitoring	Succeed
Reading Sensor his height n water	Come on stage water level in monitoring applications	Succeed
Node MCU Succeed entering to databases firebase through connection Wi-Fi	Get the IP of the Wi-Fi router, and connected with databases firebase	Succeed

b. Output results

Output testing is carried out by testing monitoring and control applications on hydroponic plants. The application screen will show the pH, ppm, water level, and water temperature values. In the control menu, there are two outputs for running the relay, namely ON and OFF. the function of this relay is to turn on the water pump and aerator.

V. Conclusion

Based on the research stages that have been carried out and the results achieved, the author can draw several conclusions hydroponic plants have different nutritional levels based on the type of plant, such as watercress which has a nutritional value of 560-840 ppm. If the ppm value is below this range, the plants will wilt turn yellow, and die. Meanwhile, if the ppm value is above this range, the hydroponic plants will experience leaf scorch and rot due to too much nutrition.

The hydroponic garden monitoring system developed in this research is very suitable for use in hydroponic gardens in home gardens because it can control nutrient levels in real-time and 24 hours, without having to be there periodically to see the nutrient levels of hydroponic plants. The developed solar panel system is capable of replacing PLN in supplying electricity to gardens, both during the day and at night. The system developed can be used to support smart agricultural technology, which can operate without using PLN electricity.

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