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IoT-based Hydroponic Plant Monitoring System

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Abstract

The Industrial Revolution 4.0 has an impact in the form of changes in various fields of human civilization, one of which is the agricultural sector. By applying IoT technology, hydroponic plants will effectively be accurate. IoT has room for improvement in the quality and quantity of agricultural production because it facilitates the automation of monitoring various processes with high precision This research uses the prototype method. Which uses the concept of direct monitoring and allows iterative changes to be made until the desired results are achieved. So this prototype method makes it possible to display the display directly. The microcontroller used is ESP32 which is connected to 3 sensors, namely the TDS sensor, DHT11 sensor and HC-SR04 sensor which are directly updated in the blynk application. In making the software program used is the Arduino IDE. Implementation of the tool is carried out on a floating raft installation. This iot-based hydroponic plant monitoring system has been successfully made and is able to monitor well. Because the system made is related to water, it is necessary to design a tool that is safer and has more protection so that it can't only run well but also safer for users and a high level of durability.

Keywords: *Hydroponic, ESP32, TDS sensor, DHT11 sensor, HC-SR04 sensor*

1. Introduction

The implementation of the curriculum for independent learning is generally different from the previous Indonesian curriculum. Implementation of the independent learning curriculum independently, learning is more focused on practical activities in the form of projects with the theme of raising the profile of Pancasila students and creating a pleasant learning atmosphere for students. In addition, learning in the independent curriculum is also carried out in a differentiated manner. To support this, the Mardhiyah Education Foundation is a school that has a green school program in Binjai city. Green school is an educational activity that leads to awareness and wisdom of the surrounding environment. Where to realize the program, the school established an agricultural education laboratory in which there is hydroponic farming. The Industrial Revolution 4.0 has an impact in the form of changes in various fields of human civilization, one of which is the agricultural sector. Agriculture is a sector that has an important role to support national economic development in Indonesia. By applying IoT technology, hydroponic plants will effectively be accurate. IoT has room for improvement in the quality and quantity of agricultural production because it facilitates the automation of monitoring various processes with high precision[1].

2. Theoretical basic

2.1. Internet of Thing

The Internet of Thing is a concept where certain objects have ability to transmit data over a network and without a network. IoT began to develop rapidly after the availability of wireless technology, microelectromechanical systems (MEMS), and of course the internet. The Internet of Thing is also often identified using RFID as a communication method. The history of the development of the Internet of Thing began in 1989, then 1990 and so on. A scientist named John Romkey developed a device that was no less sophisticated than a toaster that could be turned on or off via the internet. In 1994 WearCam was created by Steve Mann. Then in 1997 Paul Saffon briefly explained his invention of sensor technology and its future. Then in 1999 Kevin Ashton created a concept for the Internet of Thing. In 1999, machines based on Radio Frequency Identification (RFDI) were discovered around the world. This is the invention that is the beginning of the popularity of the IoT concept. Then in 2000, the famous brand LG announced its plans and released IoT technology, namely smart cabinets. Then in 2003, the already mentioned FRID began to find an important place in the era of technological development in America through Savi. IoT came back in 2005 when famous media such as The Guardian and Boston Globe began to quote a lot of scientific articles and the development process of IoT. By 2008 several companies had agreed to launch IPSO to market the use of IP on the target network taking over the IoT itself [2].

2.2. ESP32

The ESP32 microcontroller is manufactured by a company called Espressif Systems in Shanghai, China. One of the advantages of ESP32 is that it already has WiFi and Bluetooth, so it is very easy to learn how to create IoT systems that require wireless connections. This module can be used for other applications such as system control, monitoring and other applications. ESP32 has a deep sleep function that saves power by turning off the module when not in use [3]. Compared to Arduino Uno and Nodemcu ESP8266, ESP32 is relatively better because it has more pinouts and analog pins. In addition, the ESP32 has a large memory, Bluetooth module, and WiFi module, which makes it very useful for creating Internet of Thing applications.

2.3. TDS Sensor

The TDS (Total Dissolved Solid) sensor is a sensor that detects the conductivity of a solution, the more conductive the solution, the more the value changes, so if the liquid contains a lot of minerals, the greater the conductivity, the greater the production, and vice versa if the liquid contains few minerals, the less the production [4]. In hydroponics, this sensor is used to measure the hydroponic solution or nutrient concentration. Measuring hydroponic nutrients is very important because if the nutrient solution is not measured, the plants can lack nutrients or excess nutrients, resulting in poisoning for the plants themselves. This TDS sensor unit uses PPM (Parts Per Million), which is a unit of measure for the amount of dissolved substances. Each type of plant requires nutrient content, for example leafy vegetables require nutrient solution concentrations between 900-1200 ppm.

2.4. DHT 11 Sensor

The DHT 11 sensor is one of the sensors that can be used to obtain temperature and humidity data. The DHT 11 sensor can easily communicate with many types of Microcontrollers that are popular today [5]. The DHT 11 sensor only has 1 data pin, so it can communicate with the controller in one of the following ways. Microcontrollers that use the serial communication method (single wire bi-directional) the data sent from the DHT 11 sensor to the microcontroller is 40 bits of data, the first 16 bits of data are binary humidity data, the next 16 bits are binary temperature data and the last 8 bits of data are the sum of the temperature and humidity values. If the procedure sends up to 40 bits of data in the temperature and humidity data set. The DHT 11 sensor no longer needs to be calibrated, the temperature and humidity data can be read convert the 40 bit binary data sent by the DHT 11 sensor into decimal data.

2.5. Ultrasonic Sensor (HC-SR04)

Ultrasonic sensors are sensors that can convert the size of a sound wave to an electrical quantity. This ultrasonic sensor consists of two main components, namely an ultrasonic wave transmitter (transmitter) and an ultrasonic wave receiver (receiver). Ultrasonic waves belong to a group of acoustic waves that have a range of wave frequencies between 20 kHz and 20 MHz. Ultrasonic sensors work based on waves sent by the transmitter and then recaptured by the receiver. The transit time of ultrasonic wave reflection can be used to determine the distance between the transmitter and the obstacle [6].

2.6. Breadboard

Breadboard is a printed circuit board that serves as a place for electronic assembly. Generally, Breadboard is widely used for prototyping. According to research [7] Project boards or Bread Boards are the basis for making electronic circuits and also electronic design prototypes. In modern times, the term often refers to a specific type of board on which components are mounted, and this board requires no soldering (direct connection). Bread Board acts as an electrical conductor where jumper wires/pins are attached to allow power to be connected from one element to another. decentralized.

2.7. WI-FI

"Wireless Fidelity" or abbreviated as WiFi is a technology that uses radio waves to connect a device (PC, Laptop, Smartphone) to a computer network. Or the definition of WiFi is a technology that uses radio waves so that computers can access the internet. In connectivity, WiFi uses wireless to connect to user devices, which generally use the 2.4 GHz / 5 GHz frequency. Initially, WiFi was only used as a wireless device on a LAN (Local Area Network) network, however, due to technological developments and user needs, it is currently also used to access the Internet network [8].

2.8. Mobile Communications

A mobile phone can be defined as an electronic device used for two-way radio communication via a cellular network of base stations known as cellular sites. A cell phone is different from a landline phone, which only provides telephone service in a limited area via a base station connected to a fixed telephone, such as a home or office. In addition to telephones, modern cellular phones also support many additional services and accessories, such as SMS (or text) messaging, e-mail, Internet access, games, Bluetooth and infrared short-range wireless communications, cameras, radio players, MP3 players and GPS. Low-end phones are often referred to as feature phones, while high-end phones with more advanced processing capabilities are referred to as smartphone [9].

3. Results and Discussion

The implementation method in this study is generally divided into 5 stages as shown in the following diagram:

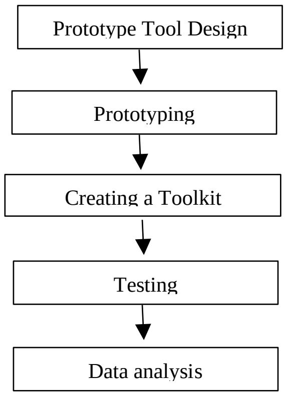

Fig 1: Research Workflow

2.1. Tools and materials used

The tools and materials used for the IoT-Based Hydroponic Plant Monitoring System are as follows:

1. The hardware used in this study is as follows:
   1) ESP32
   2) TDS sensors
   3) DHT11 sensors
   4) Sensors HC-SR04
   5) Breadboard Power Supply Module
   6) Breadboards
   7) Box Case
   8) Jumper Cables
   9) 1 set hydroponic floating raft system
   10) AB mix hydroponic nutrition
   11) WiFi network
   12) Smartphones
   13) Some bolts and nuts

2. The software used in this study is as follows:
   1) Arduino IDE
   2) Fritzing
   3) Microsoft Word

2.2. Circuit Block Diagram

The block diagram of the designed system, as shown in Figure 2

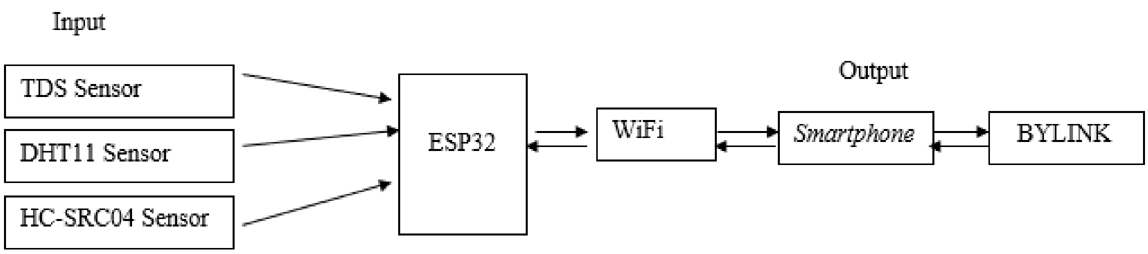

Fig 2: Circuit Block Diagram

The description of the block diagram above is as follows:
1. TDS sensor, DHT11 sensor, and HC-SR04 sensor take measurements.
2. The measurement results are sent to the ESP32.
3. Then ESP32 will connect to Wifi on the smartphone.
4. Then the smartphone will display the measurement results on the blynk application.

2.3. Flowchart System

The flowchart system of the designed system, as shown in Figure 3

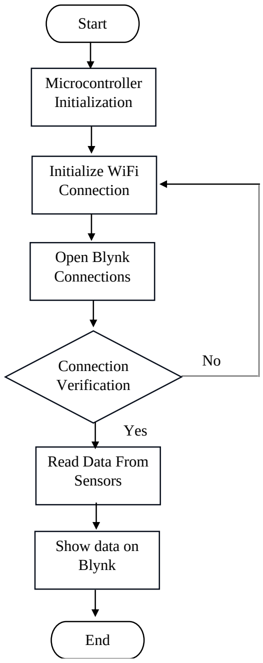

Fig 3: Flowchart System

Algortima flowchart in Figure 3 flowchart of connection to Blynk:

1. Start, shows the starting point of the program logic flow.
2. Microcontroller initialization, this step is to initialize the ESP32 microcontroller, before connecting to the Wi-Fi network and Blynk.
3. WiFi connection initialization, set up Wifi connection on Esp32 and connect to available WiFi network.
4. Open connection to Blynk server, this step is to open Blynk connection between ESP32 and Blynk server.
5. In connection verification, check whether the connection between ESP32 and the server is connected successfully, if the connection is successful then it will continue to the next process, but if the connection is not successful, then the process will be repeated from the WiFi connection initialization.
6. Read data from the sensor, retrieve data from the sensor on the microcontroller that will be sent or monitored to Blynk.
7. Display data on Blynk, update the display on the Blynk application after there is a change in data or commands received.
8. End, indicates the end of the logic flow in the program.

2.4. Display of the BLYNK Application on a Smartphone

The display of the blynk application on a smartphone of the designed system, as shown in Figure 4.

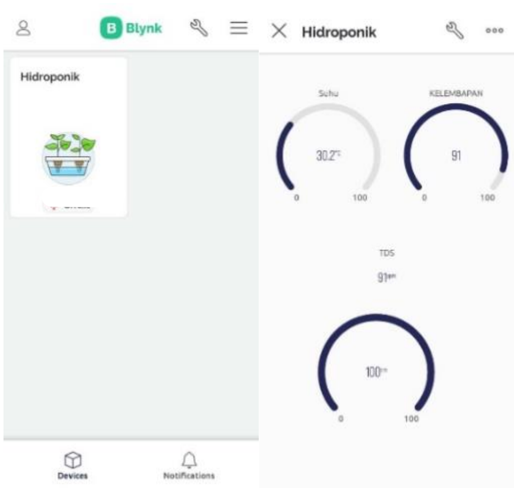

Fig 4: Display of the BLYNK Application on a Smartphone

In the design of the interface in the Blynk application, there are 3 indicators obtained from the measurements of the TDS sensor, DHT 11 sensor, HC-sr04 sensor. this interface is designed with the aim of providing clear and intuitive visualization of information about the data obtained by the three sensors. through this interface, it is hoped that users can easily monitor and understand the condition of the water based on the measurement results of the three sensors used.

2.5. Overall Tool Set

In this circuit, the mb102 power supply bradboard functions to provide the supply voltage of the entire existing circuit. The output of this mb102 power supply breadboad circuit is 5 volts. ESP 32 functions as a processor, data receiver, and WI-FI signal transmitter in the tool system and then the smartphone functions to provide command signals to monitor sensor values, where the sensor values are generated by the TDS sensor, DHT11 sensor and HC-SR04 sensor. So you can see the circuit in Figure 5.

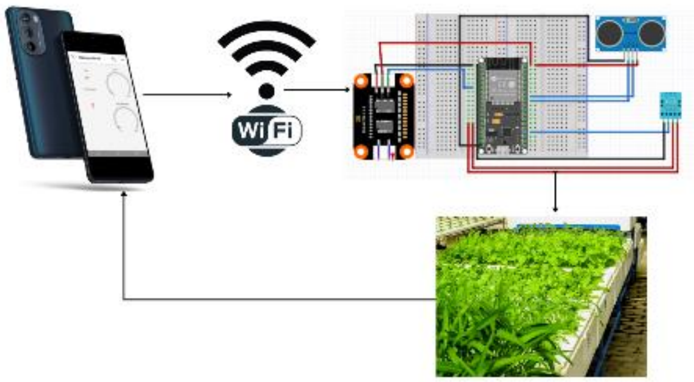

Fig 5: Overall Tool Set

4. Implementastion and Testing

4.1. Hardware Set

The hardware design consists of mechanical hardware in the form of a prototype that more or less represents the implementation in the field and electronic hardware. The mechanical hardware design consists of panels made of acrylic boards to place electronic components and hydroponics for planting media.

Fig 6: Hardware Set

4.2. Testing Tool Results

Testing the entire hydroponic system is done to determine the overall performance of the tool to find out the tool works well as expected. At table below shows the results of testing the entire floating raft hydroponic system.

Table 1: Testing Tool Results

No	TDS			Temperature			Humidity			Water level		
	Sensor	Gauge	Error (%)	Sensor	Gauge	Error (%)	Sensor	Gauge	Error (%)	Sensor	Gauge	Error (%)
1	325	356	9,6	28,78	28,91	0,115	89,93	90,95	1,03	1,23	1	0,23
2	383	397	4,7	28,85	28,97	0,110	90,38	91,41	1,04	2,10	2	0,1
3	470	509	4,8	28,83	28,95	0,115	89,73	90,78	1,06	3,15	3	0,15
4	557	596	2,9	28,88	29,01	0,105	89,45	90,45	1,00	4,31	4	0,31
5	543	588	3,5	28,93	29,04	0,115	89,50	90,54	1,04	5,23	5	0,23

6	631	660	1,77	29,00	29,10	0,120	89,93	90,96	1,04	6,12	6	0,12
7	755	724	1,07	29,05	29,14	0,190	89,95	90,98	1,03	7,13	7	0,13
8	793	789	1,11	29,18	29,30	0,105	90,10	91,12	1,02	8,26	8	0,26
9	870	873	1,6	29,20	29,27	0,130	88,93	89,95	1,03	9,16	9	0,16
10	1080	981	2	29,43	29,53	0,115	88,60	89,63	1,03	10,34	10	0,34

The data in the table is the comparison data between the sensor and the measuring instrument, this test aims to compare the value of the measuring instrument with the sensor. This test is carried out with the aim of ensuring that the overall system as shown in table 1 can work properly. Testing is done by checking the ppm value, temperature, humidity and water level.

5. Conclusion

After carrying out the design and manufacture stages of the system which is then continued with the testing and analysis stages, conclusions can be drawn. Implementation of the tool is carried out on a floating raft installation. This iot-based hydroponic plant monitoring system has been successfully made and is able to monitor properly. TDS sensor testing on the tool system works well, can read PPM values.This tool has the main components namely ESP32, TDS Sensor, DHT11 Sensor, SensorHC-SRC04.

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