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DESIGN AND FABRICATION OF IOT SMART FARM

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ABSTRACT

This project will help farmers stay connected with their farm from anywhere. It can help to observe the temperature, humidity, and potential of hydrogen (pH) in the land. Most farmers will have difficulty keeping watch on the farm when traveling far away for work. The constant hot weather in Malaysia supports this. So, this project aims to design and fabricate an automatic plant watering system that helps farmers keep the farm in check at any place and time. The project will use a few sensors such as a temperature, pH, and soil humidity sensor to get the information needed and send the information to the farmers' phones through Arduino Internet of Things (IoT) Cloud. When the information has been received, farmers can activate the water sprinkler system with just a button from the phone to water the plants. The results from the project show that an automatic plant watering system has been successfully fabricated to water plants when the soil is dry. Besides, the project also successfully activates the automatic irrigation system when the soil humidity requirements are met. Finally, it is hoped that this project will help the farmer to be more efficient in keeping the farm in check and increase the quality of the product produced.

Keywords: *Automatic Plant Watering System, Arduino Internet of Things (IoT), Soil Humidity.*

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1. Introduction

Internet of Things (IoT) smart farming is a system that is used to monitor the crop field with the help of sensors like light, humidity, temperature, etc. It can also make the irrigation system automatic (Akhter et al., 2021; Muangprathub et al., 2019). Many people will gain many advantages if they are willing to adapt to this style of farming. If farmers use this method of farming, information like soil humidity and temperature can be obtained accurately(Alipio et al., 2019). With that information, farmers can activate the water pump with just one click of a button. This will help reduce manpower and also the cost of hiring people. Also, more accurate data will increase plant growth and quality, which can help feed more people in the future(Fashoto et al., 2021; Jamil et al., 2018; Li & Niu, 2020). IoT smart farms can help farmers overcome common challenges in the farming industry and increase farm productivity (Chen & Yeh, 2020).

Most farmers need to travel far away for work. For this occasion, farmers must hire people to watch over the farm, increasing the cost. Leaving the plants unattended will lead the plant to wilt. So, using a smart Internet of Things can help these farmers keep track of the conditions at the farm without being there (Dhruva et al., 2023; Nóbrega et al., 2019; Shin & Jeon, 2020). The inconsistent rainfall in Malaysia can also lead to problems for plant-loving people. Not having enough water when watering the plant may make it wilt, while too much water can also damage the plants. It can also lead to water wastage. Finally, Malaysia is a country with constant hot temperatures. This will lead to plants needing more water to counter the heat, and people with little experience might not know this.

Based on the problem stated, two main objectives can be outlined: first, to design and fabricate an automatic plant watering system that waters the plants when the soil is dry; and second, to activate the irrigation system automatically when conditions, such as a certain level of soil moisture, are met. In terms of the project scope, the Arduino Uno will be the main system used, particularly for controlling the motor pump's activation and deactivation. The motor pump, which will be used to water the plants, will be analyzed in terms of its flow rate to determine the optimal watering duration. The target market for this project includes small-scale farmers and individuals who want to create a small garden, so the design will be kept simple. The product design will be developed using SolidWorks software, while the coding will be done using Arduino IDE software.

The significance of this study from this project is to create a system that can water the plants automatically when it reach certain soil humidity (Chen & Yeh, 2020) (Lakshmanan et al., 2020). Traditional gardening requires a significant amount of a person's time to care for the garden. So this project can help a person do gardening while having time to do other stuff. The other is to ensure that this project can work all day but also consume less electrical energy (Rayhana et al., 2020). From a safety standpoint, this project will eliminate any possibility of getting an electric shock. Furthermore, the environment and user's safety will be guaranteed as no air or noise pollution is produced from this project (Haryanto et al., 2019).

2. Literature Review

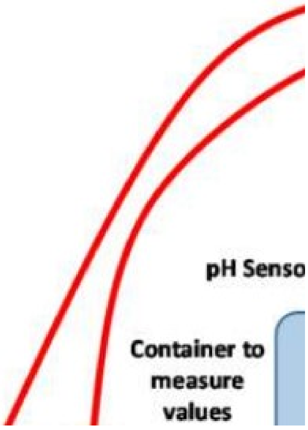


Figure 1. Hydroponic IoT smart farm

Based on the literature studies that have been published, several products already exist in the market. The first product is the Hydroponic IoT smart farm as shown in Figure 1. This product only involves using pH sensors as the value of pH in the water is very important in this kind of farm as it doesn't use any soil. The pH sensors will detect the pH value in the water and send it to the wireless node. Then, the information will be sent to the user when the pH value is too high or too low. The next product is the aquaponic IoT smart farm, as shown in Figure 2. The aquaponics farm will have more sensors as it will involve the usage of fish. For the design in Figure 2, pH and temperature sensors are used for the fish as they play the most important role in this farm. The information from the sensors will be sent to the Raspberry Pi Microprocessor. Then it will be sent to the Web or Mobile app for the user to see.

Figure 2. Aquaponic IoT smart farm

In Figure 3, after obtaining the information, users can take action using the remote control. This sends the user's command through the gateway to the controller. Upon receiving the command, the controller will activate the necessary actuators, such as the heater, valves, or sprinkler. All the data sent will be stored in a remote tracking system, allowing the user to analyze the data and determine the most efficient way to care for the plants (Chen & Yeh, 2020).

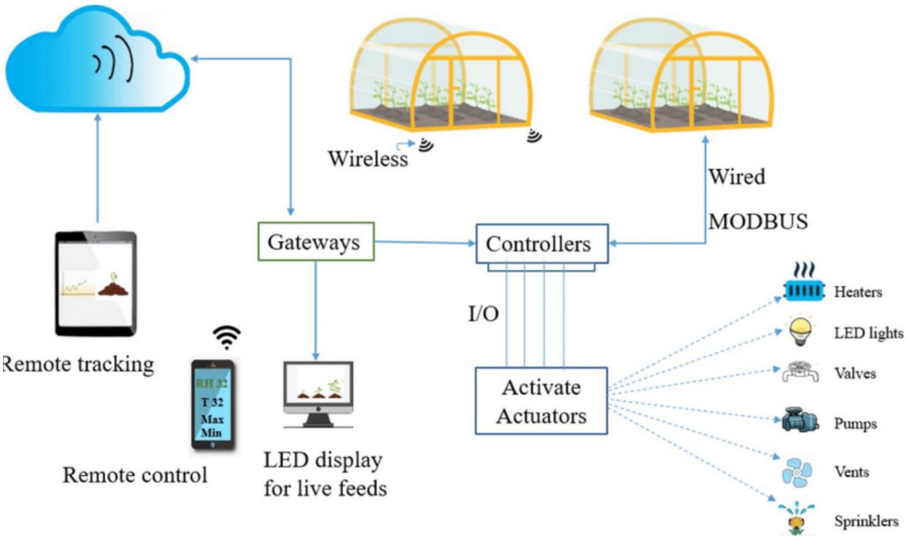


Figure 3. Greenhouse IoT smart farm

In addition to the products currently available on the market, there are also several products that have registered patents and intellectual property rights. One such product is the Hydroponic IoT Smart Farm, shown in Figure 4, with patent number US9603316B1. This system and method for managing a hydroponic IoT smart farm was developed by Mansey et al. (2017). The system includes a hydroponic reservoir sensing device and a multi-outlet power delivery device. The multi-outlet power delivery device features multiple power outlets and a communication system, along with a controller that can selectively turn the outlets on or off in response to commands received through the communication system.

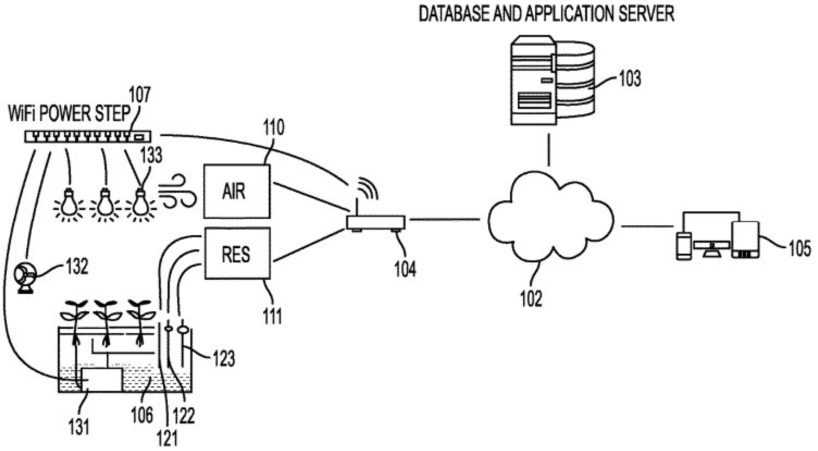


Figure 4. Hydroponic IoT smart farm patent

Figure 5 illustrates patent US8643495B2, which describes a greenhouse IoT smart farm. The system comprises mobile inspection devices, data acquisition units, data receiving devices, RFID devices, and data storage servers. Together, these form a greenhouse monitoring and alarm management system based on the Internet of Things (IoT), providing real-time monitoring of environmental parameters (Lan & Ma, 2014). This system is designed to monitor and manage the growth of crops in the greenhouse. It can automatically measure environmental parameters such as air temperature, humidity, lighting, soil temperature, and soil moisture, among others. Additionally, the system can detect when any parameter reaches a critical threshold and sound an alarm. Wireless sensors and data collection modules integrated with ZigBee chips are utilized for data transmission. By providing these inspection tools, the system reduces the need for highly skilled professionals and lowers the cost of automating farm greenhouse management.

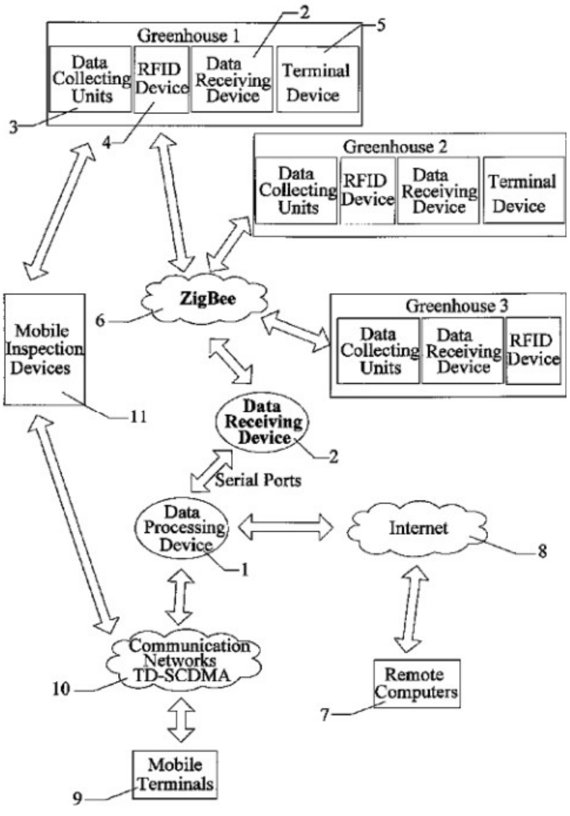


Figure 5. Greenhousec IoT smart farm patent

3. Methodology

As shown in Figure 6, the flowchart illustrates the process flow of the project. This project begins with a few brainstorming sessions to find some great ideas for the project. After a whole week of brainstorming, it was decided that making an automatic plant watering system would be a great project. Farmers and ordinary citizens alike can benefit from this project. Next, parameter design was conducted to identify the appropriate targets for this project while varying subsidiary factors.

After the parameters for this project were decided, the process of material selection begins. In addition, strong materials were needed to make the frame of the tray. The fabrication process could begin once all the materials needed for this project had been purchased. The process involved a few processes such as welding, cutting, wiring, and coding. Finally, a test run was conducted when all the parts had been assembled into one component. If the test run succeeded, then the preparation for the project presentation could begin. If not, then the assembly process needed to be done again to identify the problem. After that, the test run would be repeated continuously until a successful result achieved.

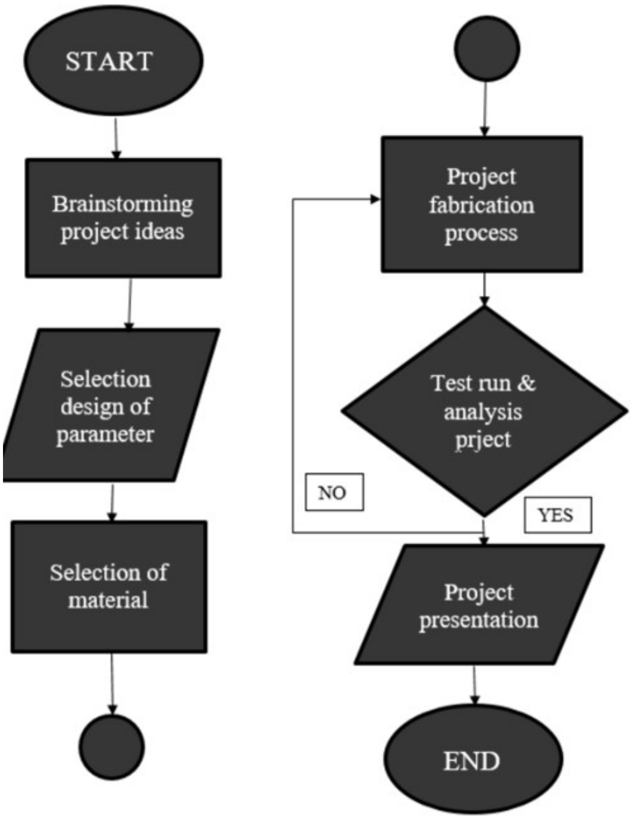


Figure 6. Flowchart of process flow

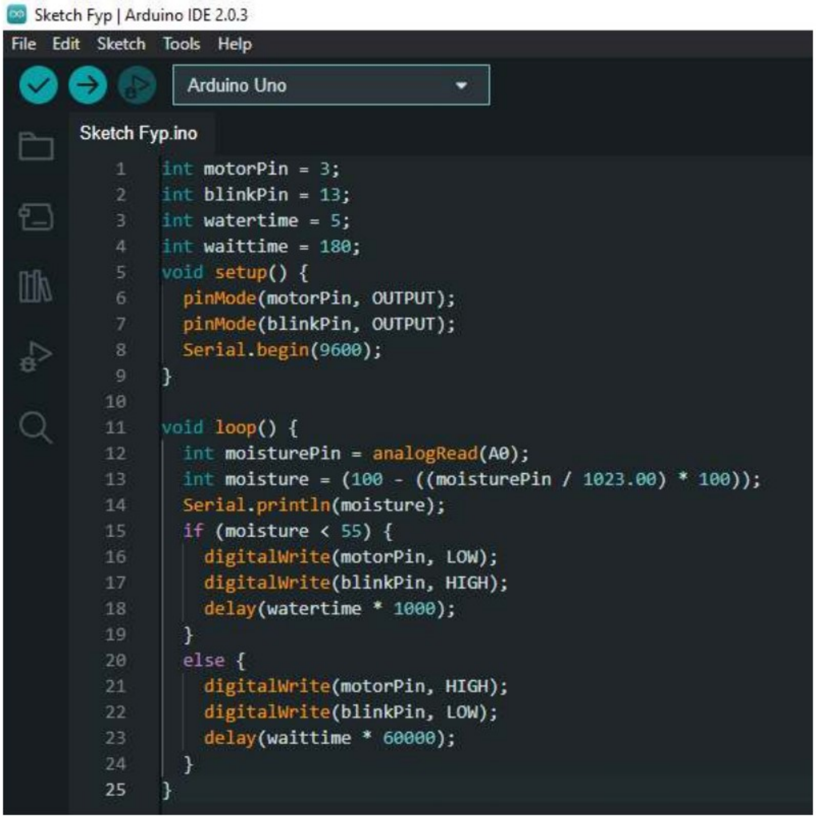
4. Result and Discussion

4.1 Experiment Apparatus

The project started with the cutting process, which was done using a hacksaw to cut the 6m hollow steel into the desired length. The length of the cut steel is (4 x 400 mm), (3 x 360 mm) and (2 x 700mm). The total length of hollow steel used for this project is 4.08 m. Next, the welding process is done after the 6m hollow steel has been cut into the desired length. The welding process is done using Shield Metal Arc Welding (SMAW). The process is done by combining the hollow steel that has been cut to make it into a table frame.

For the electronic parts, the process is done by connecting all the electrical parts of the irrigation system, such as the 5V relay, soil humidity sensor, switch, and motor pump.

All of the electronic boxes will be connected to the Arduino Uno R3 board as the board will contain all the commands that will be inserted in the coding. In terms of its coding, the programming is done using the app Arduino IDE, which is for PCs or laptops as shown in Figure 7. The coding can also be done on a smartphone using the Arduino Droid app. The coding is done to make the irrigation system activate automatically when the requirement is met. Also, the code can be used to implement a timer to activate the water pump only when necessary (Saqib et al., 2020).



```
int motorPin = 3;
int blinkPin = 13;
int watertime = 5;
int waittime = 180;
void setup() {
  pinMode(motorPin, OUTPUT);
  pinMode(blinkPin, OUTPUT);
  Serial.begin(9600);
}

void loop() {
  int moisturePin = analogRead(A0);
  int moisture = (100 - ((moisturePin / 1023.00) * 100));
  Serial.println(moisture);
  if (moisture < 55) {
    digitalWrite(motorPin, LOW);
    digitalWrite(blinkPin, HIGH);
    delay(watertime * 1000);
  }
  else {
    digitalWrite(motorPin, HIGH);
    digitalWrite(blinkPin, LOW);
    delay(waittime * 60000);
  }
}
```

Figure 7. Programming code

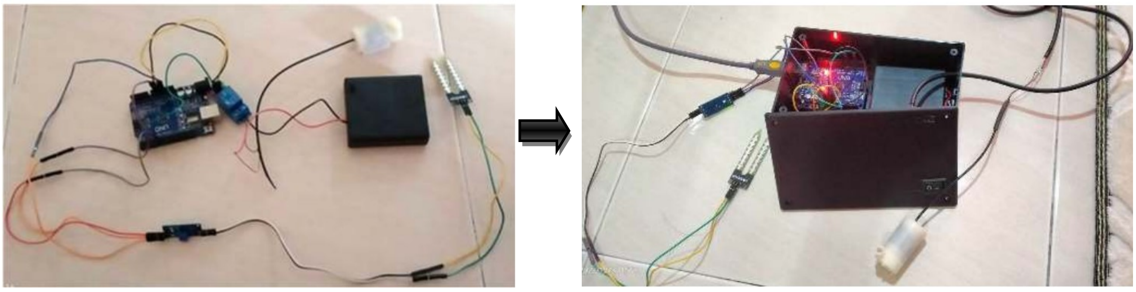

(a) (b)

Figure 8. (a) Testing the protype and (b) Part assemble stored in electronic box.

After all the parts had been installed as planned, the prototype testing need to be performed to ensure it can be operated as intended. The testing stage started by activating the motor pump. If the connection of the circuit and the coding implemented is correct then the pump should be running and the light on the relay should light up as shown in Figure 8. Then, when the moisture sensor is put in water, the pump and light should turn off, and the timer for cooling down begins (Karthikeyan et al., 2021). After the testing result has shown success, the parts of the project can be assembled. The electrical components will be kept in an electronic box to keep it tidy and also safe from outside hazards.

4.2 Experiment Apparatus

Figure 9 shows the final fabricated product. The product turns on the motor if the moisture sensor detects the moisture level below 55 volumetric water content (VWC), and water flows to the plant. The pump turns off when the moisture level is higher than 55 VWC. Then, the system waits for 3 hours before reading the soil moisture again. If the moisture is still higher than 55 VWC, it will wait for another 3 hours. If it's lower, the system will activate the motor to make water flow into the plant, and the 3-hour cooldown will start again.

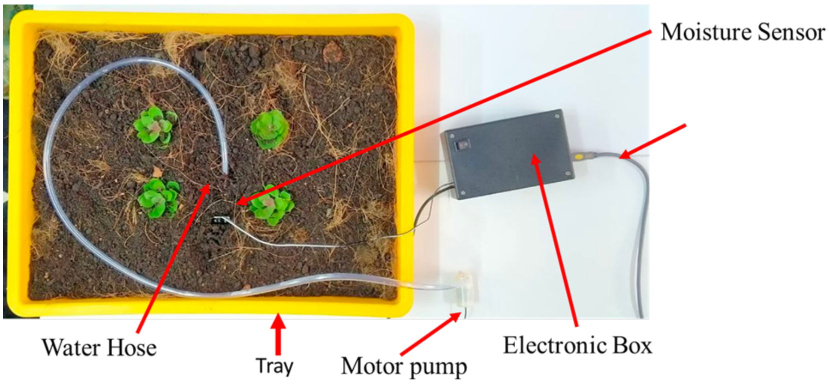


Figure 9. Final Fabricated Product

The electronic box, containing all electric parts like the 5V relay, Arduino board, and sensor, is placed near the tray, as indicated in Figure 9. The distance between the electronic box and the tray can be changed depending on the length of the wire used. The motor pump is placed inside a water tank to make the water flow from the tank to the plants through the water hose.

The moisture sensor is placed in the ground, near a plant, to detect the moisture percentage of the soil. It should not be buried fully, as this might affect the accuracy of the reading. The material used for the final fabrication includes 6 m hollow steel for the frame, 2 wooden boards as the base for the table, a 5V relay, a soil moisture sensor, a switch, and a water pump. An Arduino Uno R3 board is also used as the "brain" for this project. Finally, an electronic casing box is used to keep all the electronic components tidy and safe from outside hazards, such as water.

One of the main advantages of the prototype is its ability to water plants automatically, which helps conserve water. Additionally, the product operates independently, as the motor is powered by a 12V battery. During the initial testing phase, the prototype was able to transfer up to 500 ml of water in just 5 seconds. The prototype can operate continuously for up to a month if kept active at all times.

For maintenance, users should check the electronic box for any deformations, such as dents or holes, and replace them if necessary. Ensure that the box is protected from rain to prevent water from entering the circuit. Once a month, check the pump for any trash stuck inside it, and clean the water hose to avoid any disturbance to the water flow. Clean the sensor by wiping it with a wet towel before drying it to ensure the readings are consistent. Change the batteries for the motor pump every three months and change the water once a week to prevent any outside material from getting into the pump. Finally, check the wire for any wear and tear.

5. Conclusion

From the project, it can be concluded that the first objective, which is to design and fabricate an automatic plant watering system that can water the plants when the soil is dry, has been achieved. Next, it can also be concluded that the second objective, which is to activate the irrigation system automatically when certain soil humidity requirements are met, has also been achieved. Finally, it has been found that different soils have different moisture percentages, so the sensor needs to be recalibrated if the user wants to change the location or use different soil.

A few improvements have been identified that can make this project more efficient and consistent. The first improvement is to use a larger board that can accommodate more types of sensors, such as temperature and air humidity, so that the user can receive more data. Next, using an Arduino board with a Wi-Fi component would provide more accurate data and allow the user to receive it directly. This can help the user make more accurate decisions to ensure the plants grow healthily. Finally, if the user wants to use this project in a larger area, they can change the hose and water pump to a PVC pipe and a larger motor pump. A motor pump is used because it provides constant and strong water pressure, ensuring that water flows through the pipe to the plants.

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Author Contribution

Authors 1, 2, and 3 collaborated to craft the literature review and supervise the article writing process. Meanwhile, Author 4 and Author 5 drafted the project methodology and conducted fieldwork. Additionally, Author 1 compiled all necessary documentation, and finally, Author 5 delivered the paper presentation at the I-CReST 2023 conference.

Conflict of Interest

The authors have no conflicts of interest to declare.

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