Prototyping Of Precission Farming Hydroponic Garden Using Arduino Using Design Thinking Method At Puriponic Greenhouse Depok

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Abstract
This research discusses precision farming in hydroponic greenhouse using design thinking methods and sensors to ensure process control and monitoring in hydroponic greenhouse. The place of research was conducted at Puriponic Greenhouse Depok. During the Covid-19 pandemic there were social problems with many employee quarantines. Quaranitine occurs, activities are carried out at home, and there also many effect of unemployment. This will cause food problems for the community to be disrupted. This hydroponic system designs a system using an Arduino device with 6 sensors to control and monitoring hydroponic greenhouse. The methodology used is Design Thinking, the research time is 2022. The systems uses 6 sensors and 6 actuators. The result of this study are the design of hydroponic system prototype along with an actuator to guarantee hydroponic control and monitoring. The novelty of this system is the actuator of each sensor in guaranteeing control and monitoring of the greenhouse.

Keywords: *Hydroponic, system, Design-Thinking and sensor.*

I. INTRODUCTION

Precision farming is the application of technology that has the concept of an integrated agricultural system with the principle of managing spatial and temporal variability based on information data which has the aim of increasing and making agricultural production efficient [1]. Monitoring of locations and land in precision agriculture is carried out to obtain data and information under certain conditions and to monitor the growth activity of hydroponic plants. The application of a monitoring system for hydroponic plants has the aim of obtaining information on certain plant conditions[2, 10]. In the era of the industrial revolution 4.0, the term precision farming became the main key in the development of more advanced agricultural technology. Precising farming seeks to use inputs such as water, nutrients, fertilizers to a minimum to produce maximum agriculture and not damage the environment.Research related to technology development in the era of the industrial revolution 4.0 by utilizing the internet of things (IoT) in the field of hydroponics has een carried out a lot. The first study was conducted by [4] The aim of the study was to monitor and control all water levels. The sensors used in this study were pH, humidity, temperature, LDR, DHT-11, pH sensor, ESP32 microcontroller. The second study conducted by [4] in this study carried out irrigation automation using a low-cost sensor, by measuring the pH level of nutrients, the sensors used were pH sensors, and wireless nodes. The third research was conducted by [5] this research was to compare traditional agriculture with agriculture that already uses technology. The fourth study was conducted by [6] this study applied IoT in agricultural applications which are a vital part for improving soil quality, optimizing water use and improving the environment.

The fifth research was carried out by [7].this study was to control pH and peristaltic pumps in a hydroponic system using the SKU SENE01061 sensor, Arduino Mega 2560 microcontroller. Observation of hydroponic lettuce growth results by entering data on nutrient temperature, EC, pH, DO, ORP and the output is Photosynthesis Rate using water temperature, air temperature, humidity, EC, pH, DO, ORP, and Arduino mega sensors. [8, 12]The components needed in IoT are IoT modules, equipment for connecting to the internet, routers, modems and databases that will collect data. This research was conducted to provide information related to measuring water temperature, air temperature, water level, pH, PPM, air humidity which can be monitored and controlled automatically using an android-based application with the application of the internet of things (IoT). The monitoring system which consists of several sensors is carried out with a microcontroller device, so that it can become the basis for the application of precision farming in cultivating hydroponic vegetable plants to obtain high efficiency, to increase agricultural productivity. [9, 10, 11]

II. METHODS

Design Thinking is a methodology that supports processes within companies. In design thinking, there is an approach to problem solving that focuses on innovation.Empathize is the research stage that develops knowledge about what users want, think, feel, say, and do. The goal of this stage is to improve the experience for new users. This phase has to be performed on actual users directly. It should be observed what they want, think about and ask what are the motivations or complaints from use or what experiences made them this forest is to get a perspective from the user's side.Define is a stage that combines observation and research to provide opportunities for innovation. In this phase, data is collected from the empathize phase to be clarified. Organize all the observations written in parallel about the user experience. This period also identifies the wants and needs of the user.Ideate. In this phase, brainstorming is carried out to create extraordinary creative ideas according to user needs and identify the define phase. Total freedom is given to the team. It is ensured that there are no ideas that are confined and generated in quantity and quality as desired by the user. In this ideate phase, all team members work together to design different ideas, then they will share ideas with one another, mix or combine and build a new idea.Prototype. This phase divides some of your big ideas into objective parts, creates components for the work idea and determines what is necessary and what is not.Testing. Make sure whether the proposed solution and the solution to be made are in accordance with the user's needs? Has what was proposed provided an increase in the solution and in terms of the sense of thought or work (Fig1.)

Fig 1. Hasto Plattner's Design Thinking

III. RESULT AND DISCUSSION

System Requirements Analysis

Formulate system requirements and tools that will be needed in the system. From the analysis of the running system that has, the following system requirements are needed:

1. An automatic system is needed that will fill the water automatically when the water level decreases by 5 cm and the system will automatically turn off the water when it reaches a height of 18 cm.
2. A system is needed that can control the water temperature. As the water temperature increases, it turns on the venturi pump which introduces additional oxygen.
3. Required a system that can control the air temperature. High air temperature will turn on the exhaust fan or turbine circulation fan to lower the air temperature.
4. A system is required that controls the pH of the water. When the pH decreases, it will flow the pH up liquid to increase the pH. And the flow will stop when it reaches the specified pH. Vice versa.
5. Nutrition control is required. When nutrients are reduced, the nutritional liquid will automatically increase and will stop when the nutrients have reached the specified maximum nutritional limit.
6. When the humidity decreases, the system will automatically turn on the sprayer to increase the humidity.

Block Diagrams Of System Design

From the results of observations made on the greenhouse, the information needed to design the system application is obtained as shown in Fig 2. the block diagram. The size of the hydroponic tub that will be designed is 150 x 300 x 20 cm.

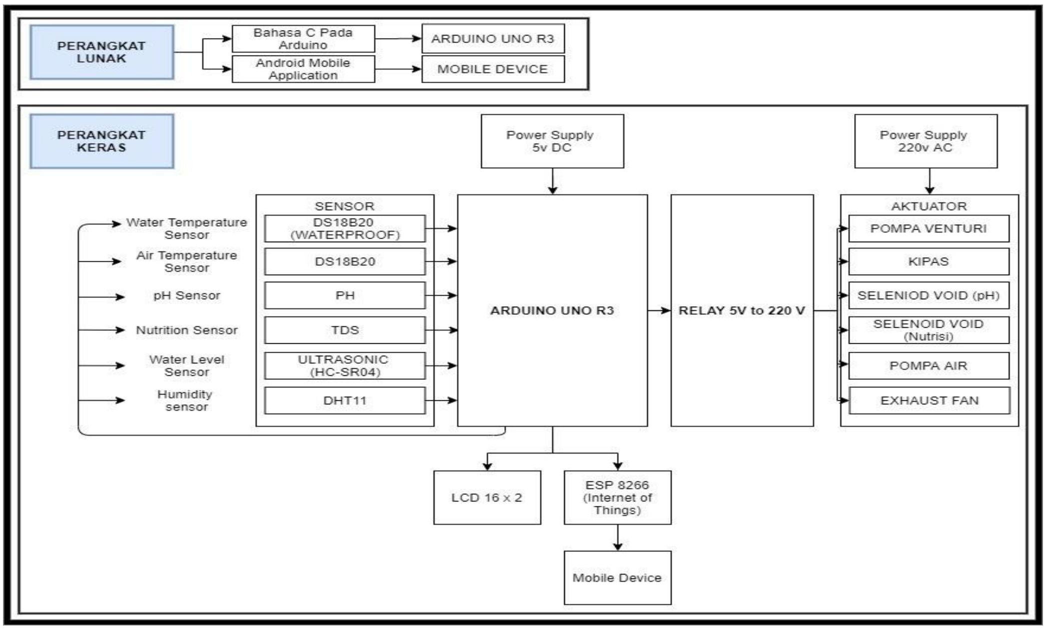


Fig 2. Block Diagam of System Design

Above it can be seen that there are 6 sensors to identify the hydroponic plant environment in the greenhouse. The sensors are water temperature sensors, air temperature sensors, Ph sensors, nutrient sensors, water level sensors and humidity sensors. The sensor will be input to the Arduino Uno R3 microcontroller. Arduino Uno R3 gets input from a 5V DC power supply adapter.

System Design Architecture

Hydroponic system architecture is a representation of a hydroponic system. This is an arrangement of devices designed for a hydroponic system. The microcontroller is the center of the hydroponic system. Works as the brain in controlling the system and will communicate with sensors to control the parameters of the system requirements. In addition, this system is to reduce human involvement. The platform used is the Internet of Things. IoT function to measure, store, transmit and display the measured parameters. System design architecture shown at Fig3.

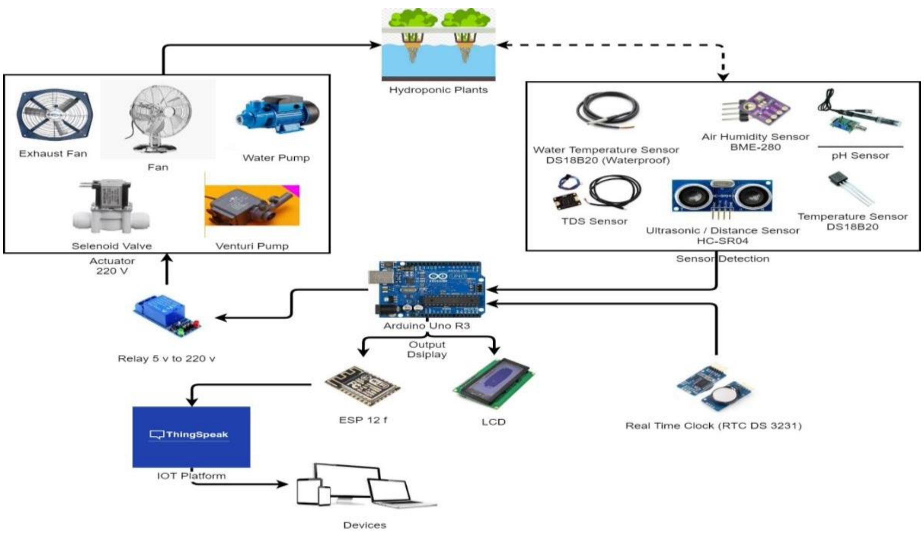
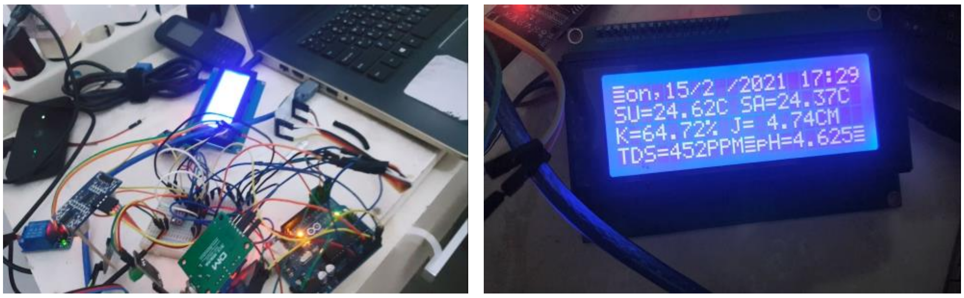


Fig 3. Architecture Design

Hardware Design

The following is the result of designing the overall device/prototype. Figure 4. below is an initial design in testing sensors and components to run well before being implemented. The figure shows that the LCD displays the results of data processing by the sensors that have been assembled. The top line shows the day, date and time. The second line is an interface that shows SU is the air temperature, SA is the water temperature, K is the humidity, J is the water level, TDS is the PPM (part per million) nutrient content in the water, and PH is the PH value of the wat.

Fig 4. Hardware design



Product Design

The product design of the smart hydroponic system will be made of 4 sides which are used namely

1. Actuator side
2. Monitoring side
3. Input connector side
4. pH connector side.

The product design that is being worked on is still limited to a product prototype that will be made in the next stage. The prototype tool is made of cardboard with a design that describes the function and layout of the sensor input and actuator output of the product. Prototype product packaging can be shown below.

Fig 5. Product design

Looks at the actuator (output) that is used for action when the sensor requires action due to exceeding the specified conditions. The front is the brand that will be assigned and will be filed in the brand rights. The brand has not yet been determined. The top is attached to the LCD as monitoring at the hydroponic location. The LCD will provide information about the data sent by the sensors. The front consists of 7 sockets which are the flow to the actuator output of each sensor. There are 6 sensors, but the number of sockets consists of 7 sockets. This is because the PH sensor will send 2 signals, namely to the PH up and PH down solenoid channels

Android Side Graphics View Design

The display design using ThingSpeak in Figure 6 shows all data on the incoming sensors and is declared successful. For system monitoring and control, see https://thingspeak.com/channels/1303269-

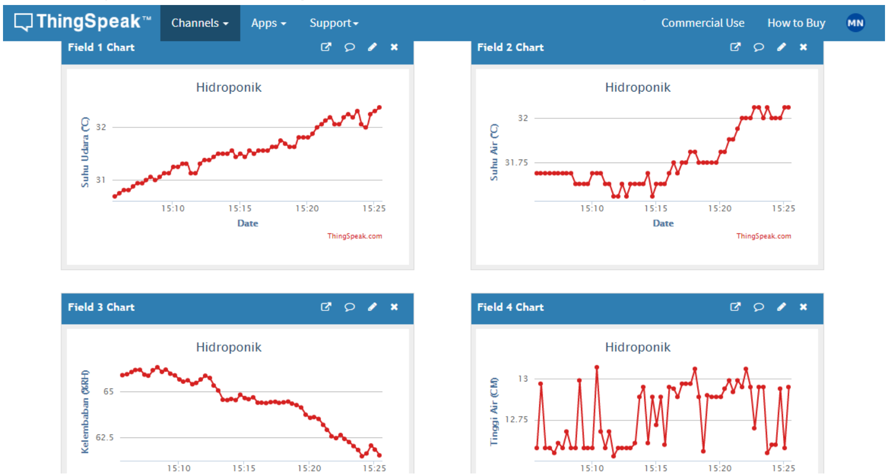


Fig 6. Graphical design from android view

How The System Works

How the system works is shown in the flowchart to design the system work.

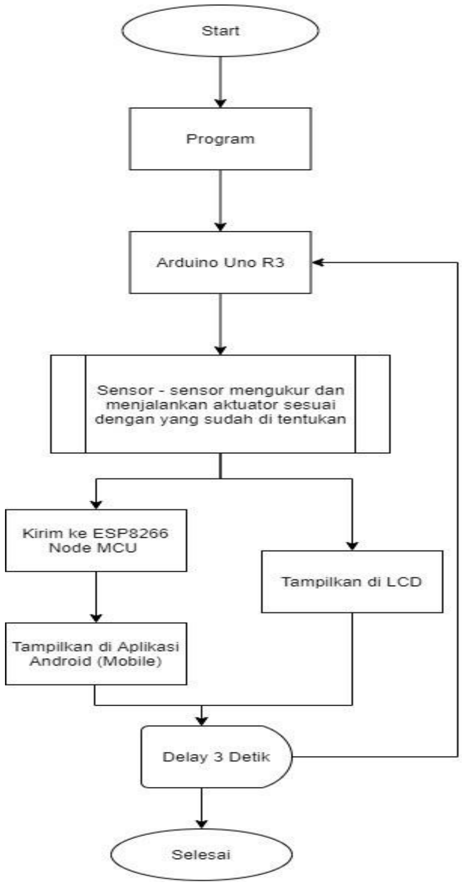


Fig 7. Flowchart of how the system works

Here is how the system works as shown in Figure 7 above.

1. The software has defined the control range given to the system to set the allowable limits.
2. When the system is activated, the system works, the system does things according to what has been set.
3. Measurements of temperature, humidity, Ph, water level, nutrition are obtained from sensors that are connected as inputs to the Arduino Uno R3 microcontroller. As long as the measurement is within the set range, the actuator is not active.
4. On the temperature sensor, if the air temperature is greater than 25°C and less than 28°C, the actuator is not active. If the air temperature is > 28°C it will activate the fan in the greenhouse. The fan will turn off when the air temperature is <25°C
5. For other sensors, the way of working is the same as number 4,
6. If you want to reset, press the reset button if you want to return to the settings from the beginning.

IV. CONCLUSION

The conclusions that can be drawn from research on the design and implementation of hydroponic systems using the Arduino Uno R3 microcontroller and the Internet of Things (IoT) based on the research described in the previous chapter are:

1. This research is still in the form of design up to the making of a prototype of an automatic hydroponic system using the Internet of Things (IoT) when the implementation trials have gone well so that it can make it easier to control the greenhouse environment automatically.
2. No human intervention is needed because everything is automated in monitoring and controlling the condition of the hydroponic garden, namely by providing an actuator to take action on changes in the greenhouse environment.
3. Using the ThingSpeak software will make it easier to control and monitor the hydroponic and greenhouse environment remotely.

REFERENCES

[1] Pitono, J. (2020). *Pertanian Presisi dalam Budidaya Lada (The Precision Farming on Pepper Cultivation). Perspektif*, 18(2), 91. https://doi.org/10.21082/psp.v18n2.2019.91- 103.

[2] Mustar, Muhamad Yusvin. (2017). *Implementasi Sistem Monitoring Deteksi Hujan dan Suhu Berbasis Sensor Secara Real Time (Implementation of Rain Detection and Temperature Monitoring System Based on Real Time Sensor). Semesta Teknika*, 20(1), 20–28. https://www.arduino.cc/en/Main/arduinoBoard

[3] Ullah, A. *et al.* (2019) *Cost Effective Smart Hydroponic Monitoring and Controlling System Using IoT*, Intelligent Control and Automation, 10(04), pp. 142–154. doi: 10.4236/ica.2019.104010.

[4] Cambra, C. *et al.* (2018) *Smart system for bicarbonate control in irrigation for hydroponic precision farming*, Sensors (Switzerland), 18(5). doi: 10.3390/s18051333.

[5] Almadani, B. and Mostafa, S. M. (2021) *IoT based multimodal communication model for agriculture and agro-industries*, IEEE Access, 9, pp. 10070–10088. doi: 10.1109/ACCESS.2021.3050391.

[6] Saydi, Royhan. (2021). *Monitoring Curah Hujan dan Kelengasan Tanah Lahan Peranian Menggunakan Sensor Berbasis Internet of Things (IoT) sebagai dasar pertanian presisi.* ***Jurnal Ilmu Teknologi Pertanian***,4(1),25-32.

[7] Mehboob, W. Ali, T. Rafaqat, and A. Talib. 2019.*Automation and Control System of EC and pH for Indoor Hydroponics System*, in 4th International Electrical Engineering Conference.

[8] Adhau, R. Surwase, and K. H. Kowdiki. 2017 .," in *2017 IEEE International Conference on intelligent Techniques in Control, Optimization and Signal Processing* (INCOS), pp. 1–4.

[9] Tabuenca, B. *et al.* (2020) *Fostering environmental awareness with smart IoT planters in campuses*, Sensors (Switzerland), 20(8). doi: 10.3390/s20082227

[10] Al Tahtawi, A. R. and Kurniawan, R. (2020) *PH control for deep flow technique hydroponic IoT systems based on fuzzy logic controller'*, ***Jurnal Teknologi dan Sistem Komputer,*** 8(4), pp. 323–329. doi: 10.14710/jtsiskom.2020.13822.

[11] Lenni, L. *et al.* (2020) *Development of a control system for lettuce cultivation in floating raft hydroponics*', in *IOP Conference Series: Earth and Environmental Science*. Institute of Physics Publishing. doi: 10.1088/1755-1315/542/1/012067.

[12] Rusli, Sergius Jimmy. (2021). *Implementasi Konsep Smart Farming Berbasis IOT dan Manfaatnya*. ***Jurnal Ilmu Teknik dan Komputer***, 5(1), 233-237

[13] Mehboob, W. Ali, T. Rafaqat, and A. Talib. 2019.*Automation and Control System of EC and pH for Indoor Hydroponics System*, in 4th International Electrical Engineering Conference.