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Prototype Automatic Maintenance System on Hydroponic Plants Using Fuzzy and Arduino Uno Methods

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ABSTRACT

Hydroponic planting media is a planting medium that is currently increasingly popular among the community, with its advantages, namely that it does not require large areas of land because it does not use soil media to plant it but uses water media. Farming using hydroponic techniques has drawbacks, namely the need for persistence to be able to control plant nutrients, water pH, and sufficient water volume so that plants can grow properly. The purpose of this research is how to make a water pH control system, filling water reservoirs, automatic provision Arduino-based nutritional fluids so that it can help facilitate the cultivation process with this hydroponic media. Fuzzy logic helps overcome the intrinsic vagueness of human thinking patterns and natural language, so that it can help understand and respond to unclear human concepts such as heat, cold, big, small, and others. This research begins with the process of designing a tool using Arduino Mega 2560, Logo pH Sensor v1.1, 100 psi DC 12 V 3.5 A pump, and a 12 V DC diaphragm pump, then the process of testing the tool using planting media and yielding a success value of 100% for the water level controller, 80% for the nutrient control, and 75% for the PH control system with an average success value of 85% with the experimental mass for 2 weeks using kale.

1. Introduction

Hydroponic planting media is a modern method of gardening that has many fans and is becoming increasingly popular among the community, especially in the New Normal era like this, this hydroponic plant has the advantage of not needing large land because it does not use soil media for its planting process but only water water, so suitable for people who do not have large land. Hydroponics is a plant that utilizes water without using soil with an emphasis on meeting the nutritional needs of plants[1]. The need for water in hydroponics is less than the need for water in plants with soil. Water is water that contains certain substances that can help the process of growth and development of plants. In addition to the small amount of land in urban areas hydroponic plants can also save water, so it is suitable to be applied in areas with limited water supply.

The advantages of hydroponic cultivation systems include the use of land more efficiently without land use, while the disadvantages of hydroponic systems, namely, are in their maintenance, namely hydroponic plants need a lot of attention especially including temperature, air humidity, water circulation, light intensity and water temperature. If all this is not noticed it can affect the growth, and quality of vegetable crops[2].

In general, the Arduino Uno R3-based sensor system can be defined as a technology related to mechanical, electronic applications and computer-based systems[3]. (PLC or Microcontroller) which all combine into one to give a function to a mechanical manipulator so that it will have a specific function[4].

In this study, Fuzzy logic can overcome the intrinsic ambiguity of human thought and natural language and recognize its nature which is different from randomness[5]. Using the Fuzzy Logic Algorithm, machines are used to understand and respond to obscure human concepts such as hot, cold, large, small, etc.[6].

Fuzzy Algorithm has the ability to develop Fuzzy system in the form of intelligent system to changing environment[7]. There are several stages in the process of forming a fuzzy algorithm, among them is the analysis of inputs or outputs, determining the input and output variables, determining the function of each membership in its fuzzy set, determining system rules based on experts or experience implemented in fuzzy systems using mathematical concepts which is simple that is easy to understand and has a tolerance for data that is inaccurate or less accurate.

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2. Research Methods

The implementation of this research begins with the identification of existing problems through field observations, then continued by conducting literature studies based on books, journals and previous research that have the same relevance in the problem to be solved, The next stage is the design of the system that begins with collection of supporting devices to build hardware systems such as Arduino, servo, breadboard, sensor, male to male cable, female to female cable etc. which is required for the tool to be in such a way, followed by creating an Automatic Plant Care Prototype Model. Once the prototype has been successfully compiled the next step is the creation of programs and algorithms and implementation on the system,

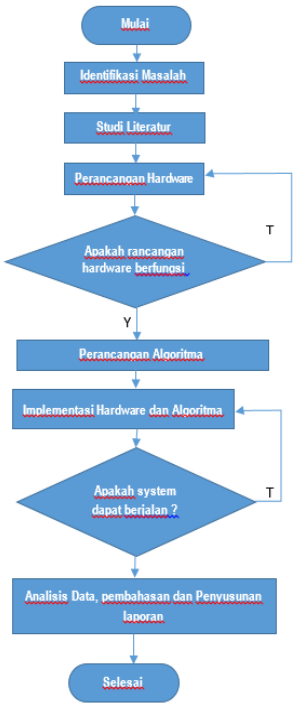

Fig. 1. Research Flowchart

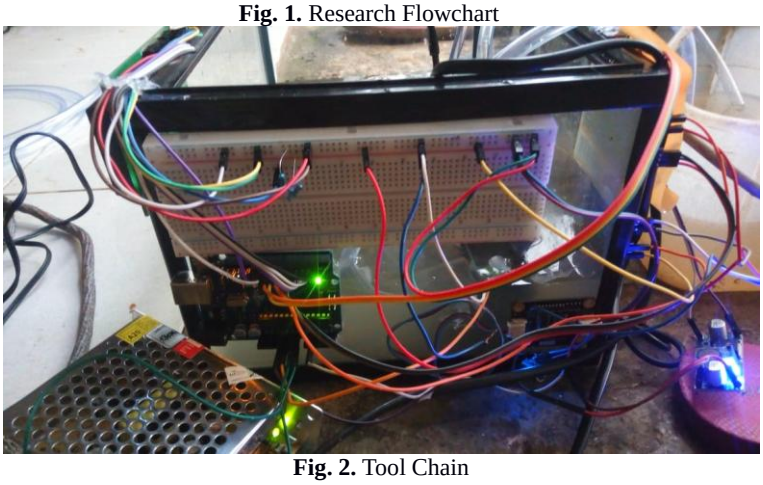

Fig. 2. Tool Chain

3. Results and Discussion

A. Fuzzy Logic Algorithm Design

Fuzzy logic is a great way to map an input space into an output space. The fuzzy method is one of the methods of the fuzzy interference system, the decision-making system. In the fuzzy method use rules or routes in the form of "cause-effect" or "if-then".

There are three main processes to implement fuzzy logic in figure 1, namely:

1) *Fuzzy* Fiction, is a process of transforming a firm input or input (Crips) into a form of fuzzy linguistic variables with their respective membership functions.

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2) Inference system, is as a way to explain the relationship between input variables and outputs which variables are processed and produced in the form of fuzzy. To explain the relationship between input and output usually use "IF-THEN".

3) *Defuzzy* Fiction, is the process of converting output-fuzzy from the interference system into a firm form (crips) using a similar membership function that becomes a value.

B. Tool Planning

1) Hardware Design

In the tool design method consists of 2 stages, namely software design (Software) and Hardware Design (Hardware).

The tools used in hardware design include:

a) arduino Mega 2560,
b) Logo pH Sensor v1.1,
c) Ultrasonic Sensor HC-SR04
d) Flow sensor, RTC (Real Time Clock) DS1307,
e) 4 channel channel relay module,
f) 2 channel SSR relay module,
g) I2C LCD OLED 1.3, 6x1 membrane matrix keypad,
h) water flow sensor,
i) solenoid valve,
j) 100 psi DC pump 12 V 3.5 A,
k) grow light 220 V 10 W,
l) DC 12 diaphragm pump.

The hardware design of this automatic maintenance system on hydroponic farms is shown in the block diagram below:

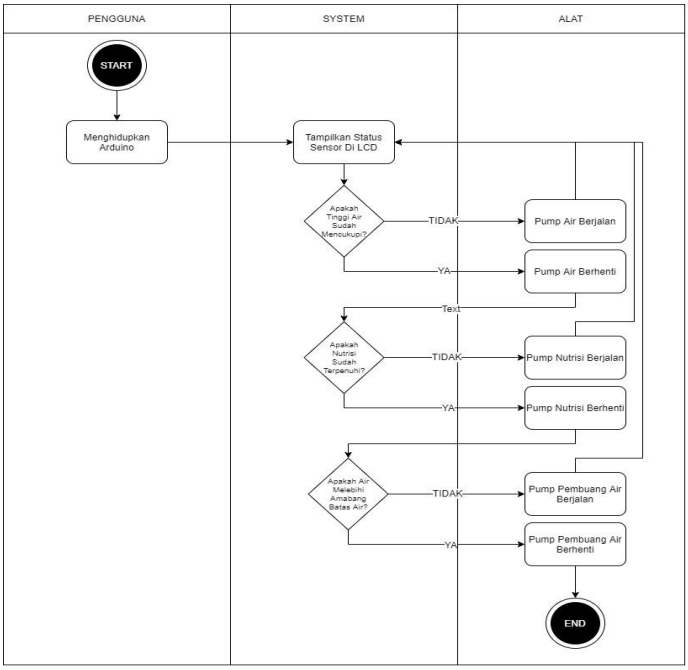

Fig. 3. Hardware Design System Block

The creation of a system block diagram of this tool aims to facilitate in understanding the working principles of this tool. The block diagram of this system consists of several parts, each of which has a different function. In the system block diagram is divided into 3 parts namely Usage, System, and Tools. Each block section has several components that have their respective roles in the working process of this tool.

The Usage section has the Buttom key role to turn on the Arduino so that the system and tools can work. Once the Arduino is turned on automatically the Sensor status display on the LCD will turn on.

The System section has a role as a data processor received from the Arduino. The data processed in this tool, among others, detects the water level to see if there is enough water filling in the water storage tank is done through the interface menu. Automatically if the tank is not yet full then the valve will open and water will flow towards the water storage tank. Once the tank is full then the valve will close automatically and the

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flow of water to the reservoir will stop., If the nutritional value is met, the tool will automatically determine the amount of nutrients to be provided and choose to fill the nutrients into the reservoir, the nutrition pump will be ON and nutrients will flow through the flow sensor. Flow sensor will compare the amount of nutrient fluid flowing through the sensor and the amount of nutrients that have been determined by the user. Once the amount of nutrients is met, the nutrition pump will turn OFF automatically and stop the flow of nutrient fluid. and the value of water height exceeds the water threshold. The component that serves as the processor of the data is the Arduino Mega 2560. Arduino reads the data received from the input and then processes it according to the program that has been uploaded into it, after which the results of processing the data are continued to the output.

The Tools section plays a role in displaying and applying the data processing results that occur in the process section to the Hardware components on the Output. The result of the appearance of the data processing in the form of Interface (interface) on the LCD screen where User (user) can know the water height, nutrient level and water limit.

C. Implementation and Testing

The result of this research is an automated maintenance control system built to detect the water level of hydroponic plants from water volume, nutritional threshold value and also the PH value of water, based on the value obtained through the sensor used.

1) Water Pump Detection Test

The water level that has been detected in this study is a low level between 0 to 5 cm. medium level 5 to 10 cm and height level 10 to 14 cm. When the sensor detects low level water then the system will automatically order the pump to fill with water up to a height of 14 cm. In its application if the water sensor detects a height of 14 cm then the system will automatically order a pump to suck water on the hydroponic planting media.

Table 1.
Water Pump Test Results

Experiment	High Water Level	Pump Condition	Tool Fit
1	1 cm	On	Appropriate
2	2 cm	On	Appropriate
3	3 cm	On	Appropriate
4	4 cm	On	Appropriate
5	5 cm	On	Appropriate
6	6 cm	On	Appropriate
7	7 cm	Dead	Appropriate
8	8 cm	Dead	Appropriate
9	9 cm	Dead	Appropriate
10	10 cm	Dead	Appropriate

Based on the results of research can be seen that the system can work 100% in detecting the level of hydroponic planting media water level and can control the inflow and outflow of water so that the hydroponic planting media water condition is always in normal and stable condition. The water level that has been detected in this study is a low level between 1 to 4 cm. medium level 5 to 6 cm and height level 7 to 10 cm. The water filling pump will be active when the system detects the low level sensor is active and will stop when the sensor level is stable or the water volume is sufficient.

2) PH Sensor Detection Test

Based on the results of testing tests on the pH sensor device, the electric current can flow well all the components, the pH sensor can also function to detect the level of water acidity well with a success value of 85%. Table 2 shows the results of voltage measurements on the pH sensor for some pH concentrations of water.

Table 2.
Results of voltage measurement on pH sensor

No	Censor	Volt (voltage)
1	pH 5.7	2.8
2	pH 6.9	3.4
3	pH 4.8	2.59
4	pH 5.9	2.10
5	pH 7.4	2.73

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In experiments that have been done, it was found that the relay that will move the water pump is functioning normally. The relay works according to the instructions of the Arduino Uno microcontroller, LCD displays the text according to the pH measurement results[8].

Table 3.
Output Results Test the voltage measurement on the pH sensor

No	Censor	LCD	Relay	Buzzer	Water pump	Tool Suitability
1	air pH 5.3	The pH of water is = 5	On	Sounds	On	Appropriate
2	air pH 5	Water pH is = 5.3	On	Sounds	On	Appropriate
3	pH Air 6	The pH of water is = 6	Off	Off	Dead	Appropriate
4	pH Air 6.2	Water pH is = 6.2	Off	Off	Dead	Appropriate
5	pH Air 7.1	Water pH is = 7.1	Off	Off	Dead	Appropriate
6	Air pH 7.5	Water pH is = 7.5	Off	Off	Dead	Appropriate
7	pH Air 8	Water pH is = 8	Off	Off	Dead	Not Suitable

3) Nutrition Value Detection Test

In the nutritional value detection test the author conducted a nutritional test using objects on the spinach plant and the measurements and parameters used were also in accordance with the needs of the spinach plant (Table.4)[9]. Nutrient concentration is measured with a device called a TDS meter with a ppm unit. While the pH of the solution is pH meter[10]. Testing of this detection tool resulted in a success rate of 80%, this was done based on the pump flame and buzzer sound when detecting low or even excess nutrient levels.

Table 4.
Table of ppm and pH of Spinach

No	Vegetable Name	pH	PPM
1	Spinach	5.5-6.5	1050-1400

To calculate the TDS of a unit of solution then equation is used:

$$\text{PPM} = \frac{\text{Soluble Substance Weight}}{\text{Weight of Solution}} \times 1{,}000{,}000$$

At ppm, the concentration is expressed as the amount of soluble substance in 1,000,000 parts of the solution. Units worn weight per weight with the same weight unit for example gram per gram and so on.

Table 5.
Comparison Table for Growth

Trial To	Solution Sensor (ppm)	Lighting Pump	Buzzer	Tool Suitability
1	250	On	On	Appropriate
2	654	On	On	Appropriate
3	800	On	On	Appropriate
4	1009	Dead	On	Not Suitable
5	1112	Dead	On	Not Suitable
6	1200	Dead	Dead	Appropriate
7	1324	Dead	Dead	Appropriate
8	1398	Dead	Dead	Appropriate
9	1609	Dead	On	Appropriate
10	1698	Dead	On	Appropriate

4. Conclusion

After the design, implementation and testing process, some conclusions can be drawn as follows:

1) Automatic maintenance systems on hydroponic plants can improve the quality of proven crops with plants that grow fertile and healthy
2) Algortima Fuzzy logic is very helpful in resolving the values of uncertainty produced by plants so that they can be understood and understood by humans
3) LCD can display water volume condition and Ph value by% (percentage), meaning the program works according to design.
4) Logo pH Sensor v1.1, can walk and function to control the PH value of water with a success rate of 75%
5) The Nutrition Sensor can run according to its function with a success rate of 80%
6) Water pump runs well and gets maximum yield value

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