PaperOne

by Augustinus Bayu Primawan

Nutrition Control in Nutrient Film Technique Hydroponic System Using Fuzzy Method

Augustinus B. Primawan[1*], and *Novadi* D.L. Kusuma[2]

[1,2] Electrical Engineering Department, Universitas Sanata Dharma, 55283 Yogyakarta, Indonesia

Abstract. Hydroponics is a method of growing crops without using soil media, instead it utilizes water or other porous materials. The automation system that is applied for measuring nutrient concentration, water level, water supply, and water volume controlling can be done by Arduino Mega microcontroller. Temperature, TDS, and ultrasonic sensors are installed on the microcontroller for data measurement. The results of the data are processed using the Mamdani fuzzy logic method. The results of the fuzzy logic are used in controlling nutrition and water volume. The system can be monitored remotely with the aid of the Blynk app. The results of the automation system are concluded that the desired condition reaches an average time of 13 minutes 49 seconds. The results of the fuzzy logic processing of the system have an accuracy value of 94.24% after being compared with the MATLAB simulation.

* Corresponding author: bayu@dosen.usd.ac.id

1 INTRODUCTION

Indonesia is a country with a tropical climate and has very high rainfall which can be very supportive for the growth of many types of fruits and vegetables. The need for food for humans such as vegetables is increasing along with the rate of population growth. However, this is contrary to the availability of land for plantations.

Hydroponics is a way of growing without using soil as a growing medium. Hydroponics has several systems including the Nutrient Film Technique (NFT), Deep Flow Technique (DFT), Aeroponic, and Drips System. NFT hydroponics is a system that utilizes a layer of water that contains a solution of nutrients needed by plants. This 1-3 mm thick water flow is pumped and flowed in PVC pipes and passes through the plant roots continuously at a flow rate of about 1-2 liters per minute. In NFT hydroponic cultivation, nutrients are given in the form of a solution containing macro and micro elements [HYPERLINK \l "Pan20" 1].
The difficulty in the hydroponic system is measuring and adding the volume of water and nutrients in the reservoir which is done manually. The microcontroller connected to the sensor can read the volume and nutritional value in the reservoir. The fuzzy logic method is used in processing water and nutrient volume data to determine the duration of the solenoid valve, drain pump, and nutrient pump. A microcontroller connected to the internet can facilitate remote monitoring using the Blynk Application.

2 NUTRITION CONTROL IN NFT HYDROPONIC SYSTEM DESIGN

Hydroponic Nutrient Film Technique (NFT) is a special type of hydroponics that was first developed by Dr. A.J Cooper at the Glasshouse Crops Research Institute, Littlehampton in England in the late 1960s and commercially developed in the early 1970s1]. In the NFT system, plant seeds are planted first in rockwool. The NFT system can produce plants with less space, less water, and fewer nutrients [HYPERLINK \L "SET18" 2].

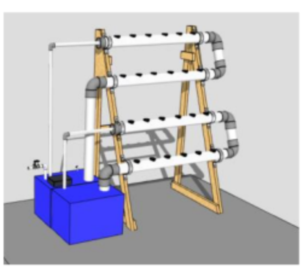


Fig. 1 Hydroponics Plant NFT.

The design of the NFT hydroponic system can be seen in figure 1. The TDS sensor is used to read the nutritional value in the reservoir and the DS18B20 temperature sensor is used to determine the water temperature in the reservoir and the temperature reading results help the accuracy of the TDS sensor reading. To determine the volume of water in the reservoir and the volume in the nutrient containers A and B using the ultrasonic sensor HC-SR04. These sensors are connected to the Arduino Mega 2560 which is used as a microcontroller and performs data processing using the Mamdani fuzzy logic method.
The results of the TDS sensor readings and the HC-SR04 ultrasonic sensor in the reservoir will be processed using the Mamdani fuzzy logic method to get the duration of the water drain pump, solenoid valve, and nutrition pump working. The ESP-01 is used to connect Arduino Mega 2560 with Wi-Fi and Blynk networks. Sensor readings and fuzzy logic results can be monitored using the blynk application. The block diagram of the system can be seen in figure 2.

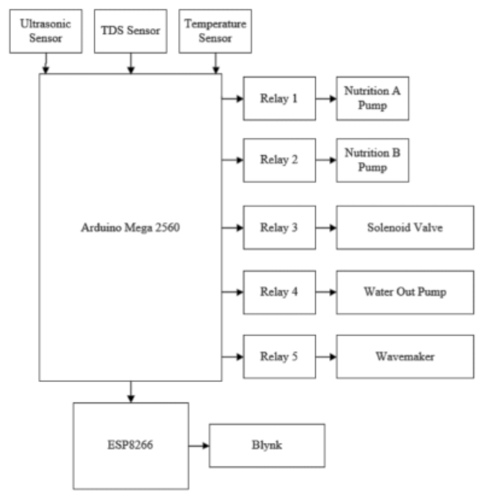


Fig. 2 System block diagram.

2.1 Arduino Mega 2560

Arduino Mega 2560 microcontroller is used to process sensor data using fuzzy logic method. The choice of Arduino Mega as the microcontroller used in this system is because Arduino Mega has a storage capacity of 256KB and the number of digital pins is 54 pins3]. The physical form of Arduino Mega 2560 can be seen in Figure 3.

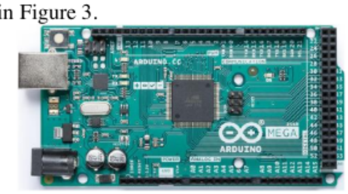


Fig. 3 Arduino Mega 2560

2.2 ESP-01

The ESP-01 Wi-Fi module developed by Ai-Thinker uses the ESP8266EX processor core [HYPERLINK \l "Dat17" 4]. Added the ESP-01 Wi-Fi module to the microcontroller so that it can connect to the internet network and Blynk via Wi-Fi.

The ESP-01 has the following features:

1. 802.11 b/g/n.
2. Integrated TCP/IP protocol.
3. Integrated 10-bit ADC.
4. Support a variety of antennas.
5. 2.4GHz Wi-Fi, and supports WPA/WPA2.
6. Supports STA/AP/STA+AP operation mode.
7. Support Smart Link Function for Android and iOS devices.
8. Operating temperature is about -40°C to 125°C.

2.3 Blynk

Blynk is designed for the Internet of Things (IoT). Blynk is an Android and iOS operating system platform as a control module for Arduino, Raspberry Pi, ESP8266, and other similar devices via the internet 5]. Blynk in this system is used to display sensor readings and Mamdani fuzzy logic calculations.

2.4 TDS Sensor

The TDS sensor is a sensor that measures the number of solids dissolved in the water. The TDS (Total Dissolved Solids) sensor shows the number of solids dissolved in water expressed in PPM (Parts Per Million) units. The TDS sensor module gets the measurement value from a probe that is immersed in water and is connected to the probe module. Analog data from the TDS sensor module will then be processed into digital data by Arduino Mega using ADC (Analog to Digital Converter). The TDS sensor uses the working principle of two separate electrodes to measure the electrical conductivity of the sample liquid. The nature of the electrolyte or the content of ionic particles of a liquid will affect the results of the electrical conductivity measurement on the TDS sensor [HYPERLINK \l "Wir19" 6]. An increase in the temperature of the solution will cause a decrease in viscosity and an increase in the mobility of the ions 7].

2.5 Ultrasonic Sensor HCSR-04

In this system, ultrasonic sensors used to measure the water level in water reservoirs, nutrient containers A and B. Ultrasonic sensors track the time between sending sound waves and returning sound waves. The distance of the reflected sound wave can be determined using the formula:

$$s = t\ x\ \frac{340m/s}{2} \qquad (1)$$

2.6 Temperature Sensor DS18B20

The DS18B20 sensor is a digital temperature sensor that provides 9-bit to 12-bit Celsius temperature measurements. The temperature reading resolution with 9, 10, 11, and 12 bits affects the temperature increase of 0.5°C, 0.25°C, 0.125°C, and 0.0625°C. The default resolution used is 12-bit. DS18B20 communicates or sends data to the microcontroller with only one data line. On the DS18B20 sensor, parasitic power mode requires only 2 pins for operation (DQ and GND)[HYPERLINK \l "DatMa" 8]. The temperature sensor plays a key role in the TDS sensor reading. Inaccurate temperature sensor readings can cause incorrect TDS sensor readings.

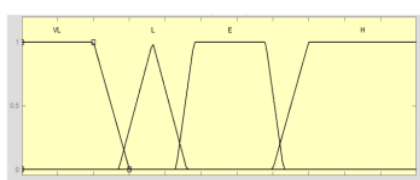
2.7 Relay Module 4 channel and 1 channel.

1 channel and 4 channel relay modules require 15-20 mA as control current. This relay module can control components with large currents. This relay module uses a relay that works at a voltage of 250 VAC 10A or 30 VDC 10 A. The 4-channel relay module is used to control the solenoid valve, water drain pump, and nutrition pumps A and B. The 1 channel relay module is used to control the wavemaker which functions to stir the water in the reservoir after the nutrient and water control process has been completed.

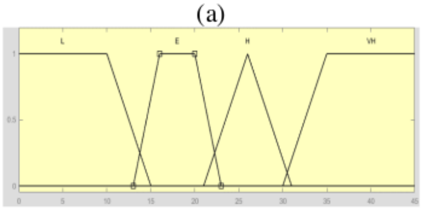
2.8 Fuzzy Logic Mamdani

Table 1. Membership function Input.

Input	Category	Range (PPM)			
		a	b	c	d
TDS	VL	100	100	300	400
	L	370	465	465	560
	E	530	588	780	830
	H	800	900	1200	1200
Range (L)					
Water Volume	L	0	0	10	15
	E	13	16	20	23
	H	21	26	26	31
	VH	30	35	45	45



(a)



(b)

Fig. 4 Membership function Input (a) TDS value and (b) Water Volume

Table 2. Membership function Output.

Output	Category	Range (s)		
		a	b	c
Nutrition pump	ZO	-0,5	0	0.5
	S	0,5	1,25	2
	M	2	2,75	3,5
	LG	3,5	4,25	5
	VLG	5	8	8
Solenoid Valve	ZO	-5	0	5
	S	5	12,5	20
	M	20	27,5	35
	LG	35	42,5	50
	VLG	50	65	65
Drain Pump	ZO	-10	0	10
	S	10	35	60
	M	60	85	110
	LG	110	135	160
	VLG	160	210	210

In this system, fuzzy logic processes two inputs and produces 3 outputs. On the input, each has four variables, namely VL (Very Low), L (Low), E (Enough), H (High), and VH (Very High). At the output, each output has five variables, namely ZO (Zero), S (Short), M (Medium), LG (Large), and VLG (Very Large).

In designing fuzzy logic for this system used sixteen rules. The fuzzy logic rules shown in Table 3.

Table 3. Rule Base.

Rule	Input		Output		
	TDS	Water Volume	Nutrition Pump	Solenoid Valve	Drain Pump
R1	VL	L	VLG	M	ZO
R2	VL	E	VLG	ZO	ZO
R3	VL	H	M	ZO	M
R4	VL	VH	S	ZO	VLG
R5	L	L	LG	LG	ZO
R6	L	E	M	ZO	ZO
R7	L	H	S	ZO	LG
R8	L	VH	S	ZO	VLG
R9	E	L	ZO	M	ZO
R10	E	E	ZO	ZO	ZO
R11	E	H	ZO	ZO	M
R12	E	VH	ZO	ZO	LG
R13	H	L	S	M	ZO
R14	H	E	ZO	S	S
R15	H	H	ZO	M	VLG
R16	H	VH	ZO	VLG	VLG

3 RESULT AND DISCUSSION

Three-inch PVC pipe is used for the hydroponic gutter and a ½" PVC pipe is used for the hydroponic water pipe. The electronic circuit is placed above the reservoir in a basket. An ultrasonic sensor is placed under the electronic basket to measure the volume of the reservoir. To measure the volume in the nutrient AB Mix container, an ultrasonic sensor was placed under the lid of the box. The electric socket is placed in a box to avoid rainwater. The hydroponic system can be seen in Figure 5.

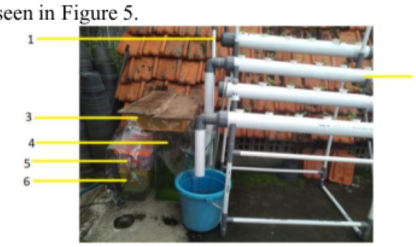


Fig. 5 Physical form of the system.

1. Hydroponic water pipe
2. Hydroponic Gutter
3. Electronic circuit basket
4. Water reservoir
5. Electric socket box
6. Nutrient Container

Table 4. System Control Data

Data	initial value		Time	Final Value	
	TDS (ppm)	Water Volume (L)		TDS (ppm)	Water Volume (L)
First	885	14,1	11 minute 9 second	616	15,1
Second	898	13,9	11 minute 36 second	780	16,5
Third	822	10,8	13 minute 34 second	647	18,0
Fourth	171	17,6	14 minute 23 second	772	17,2
Fifth	277	29,5	18 minute 23 second	721	16,9
Sixth	761	11	6 minute 40 second	797	17,5
Control time			6 – 19 minutes		

Control time is based on how long the actuator is on and the time it takes the system to connect to Wi-Fi and Blynk. The system will reconnect to Wi-Fi and Blynk every time the control has been completed due to a system delay that is too long causing the system to disconnect from the Blynk server. The system requires control that is carried out repeatedly to achieve the desired condition because the incoming water discharge is unstable.

Table 5. Fuzzy Test Data

Out-put	No	TDS (PPM)	Water Volume (L)	Result of Fuzzy Logic		Accuracy (%)
				Sys-tem	Mat-lab	
Nutrition pump	1	823	10, 8	0,48	0,358	65,92
	2	171	17,6	8	7,03	86,20
	3	278	29,5	2,75	2,75	100
Solenoid Valve	1	823	10,8	95	95	100
	2	829	18,4	33,33	34,7	96,05
	3	974	16,2	35	35	100
in p	1	278	29,5	85	85	100
	2	829	18,4	34,7	34,7	100
	3	974	16,2	35	35	100
Average						94,24%

The accuracy of fuzzy results is obtained by comparing the results of fuzzy systems with MATLAB simulations. The difference in the use of decimal values causes differences in the results of the fuzzy system with the MATLAB simulation.

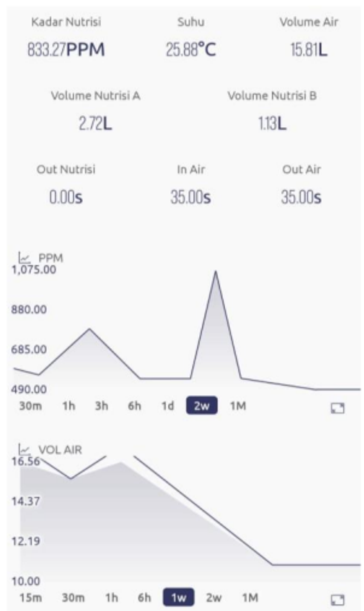


Fig 6. Blynk Interface

On the Blynk display as in Figure 6, we can see the results of the TDS sensor readings, the temperature sensor on the reservoir, and the volume in the reservoir and the volume in the nutrition containers A and B. The results of fuzzy logic in the form of the duration of the actuator being on can also be monitored.

4 Conclusions

The system work well and has a fairly accurate sensor reading accuracy. There are differences in the results of fuzzy logic systems with MATLAB simulations due to differences in the use of decimals. The fuzzy method used can produce the desired nutritional value and volume of water by performing repeated controls due to unstable water discharge.

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