DAFTAR PUSTAKA

A. Khanna and S. Kaur. Evolution of Internet of Things (IoT) and its significant impact in the field of Precision Agriculture, Computers and Electronics in Agriculture, 157: 218–231, 2019.

Andi Irfan. Rancang Bangun Alat Penyiram Tanaman Otomatis Berbasis Microcontroller, Jurnal Ilmiah Sistem Informasi dan Teknik Informatika, 1(2): 1-8, 2018.

Chiragkumar A., Chinmay S., Ajay M., Mayur L. Adaptive Irrigation System Based On Fuzzy Logic, International Journal of Scientific & Technology Research, 9(3): 6732-6740, 2020.

D. Tantowi and Y. Kurnia. Simulasi Sistem Keamanan Kendaraan Roda Dua Dengan Smartphone dan GPS Menggunakan Arduino, Algor, 1(2): 9–15, 2020.

Deddy P., Amelia Y., dan Andi W. P. Rancang Bangun Alat Pengontrol Penyiram Tanaman Otomatis Menggunakan Sensor Kelembaban Tanah Di Area Pertanian, Jurnal Rekayasa Sistem dan Teknologi Informasi, 2(3): 807 – 812, 2018.

Hakim, L. Penerapan Metode Sugeno Menentukan Tingkat Loyalitas Pelanggan Berdasarkan Kualitas Produk dan Kepuasan Pelanggan (Studi Kasus di Sabana Fried Chicken Cabang Malang, 2016.

Kadir, Abdul. Pemograman Arduino Dan Processing, Jakarta : PT. Elex Media Komputindo.

M. Hafiz dan O. Candra. Perancangan Sistem Pendeteksi Kebakaran Berbasis Mikrokontroler dan Aplikasi Map dengan Menggunakan IoT, Jurnal Teknologi Elektro dan Vokasional, 7(1): 53–63, 2021.

Meimaharani, R., dan Listyorini, T. Analisis Sistem Inference Fuzzy Sugeno dalam Menentukan Harga Penjualan Tanah untuk Pembangunan Minimarket, Jurnal SIMETRIS, 5(1): 89-96, 2014.

P. Giashinta. Alat Pengatur Suhu Kelembaban dan Monitoring Masa Panen pada Budidaya Jamur Tiram Berbasis Arduino Uno, 2018.

Pengukuran Suhu dan Kelembaban Antara Sensor DHT11 dan DHT22 Studi Komparatif pada Platform ATMEL AVR dan Arduino, Jurnal Informatika, Telekomunikasi dan Elektronika, 6(2): 49–55, 2019.

Prayama, D., Yolanda, A. and Pratama, A.W. Rancang Bangun Alat Pengontrol Penyiram Tanaman Otomatis Menggunakan Sensor Kelembaban Tanah Di Area Pertanian, Jurnal RESTI (Rekayasa Sistem dan Teknologi Informasi), 2(3): 807-812, 2018.

Putri, A. D., dan Effendi. Fuzzy Logic Untuk Menentukan Lokasi Kios Terbaik Di Kepri Mall Dengan Menggunakan Metode Sugeno Kecerdasan Buatan (Artificial Intelligence), Jurnal Edik Informatika Penelitian Bidang Komputer Sains Dan Pendidikan Informatika, 3: 49-59, 2019.

R. S. Krishnan et al. Fuzzy Logic based Smart Irrigation System using Internet of Things, Journal of Cleaner Production, 252: 119902, 2020.

Saputra, T. R. Muhammad, Syaryadhi, Mohd, And Dawood, Rahmad. Penerapan Wireless Sensor Network Berbasis Internet of Things Pada Kandang Ayam Untuk Memantau dan Mengendalikan Operasional Peternakan Ayam, Seminar Nasional dan Expo Teknik Elektro: 2017 (https://www.researchgate.net/publication/320518805, diakses 23 November 2022).

Sri Kusumadewi dan Hari Purnomo. 2019, Aplikasi Logika Fuzzy untuk Pendukung Keputusan. Yogyakarta: Graha Ilmu.

Suardika, K. W., Gandhiadi. G. K., dan Harini, L. P. I. Perbandingan Metode Tsukamoto, Metode Mamdani, dan Metode Sugeno untuk Menentukan

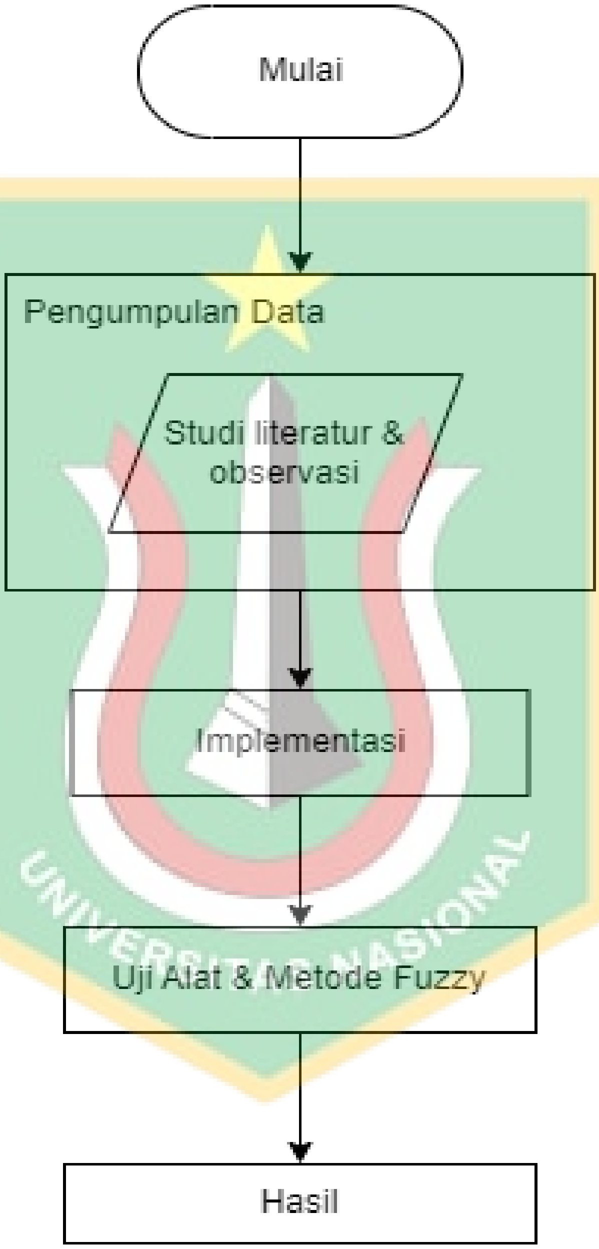
Produksi Dupa (Studi Kasus : CV. Dewi Bulan), E-Jurnal Matematika, 7(2): 180, 2018.

Umaritawan dan Nurul, C. Rancang Bangun Alat Penyiraman Tanaman Otomatis Berbasis Arduino dan Berbasis Web, Prosiding Seminar Nasional Inovasi Teknologi, 2021.

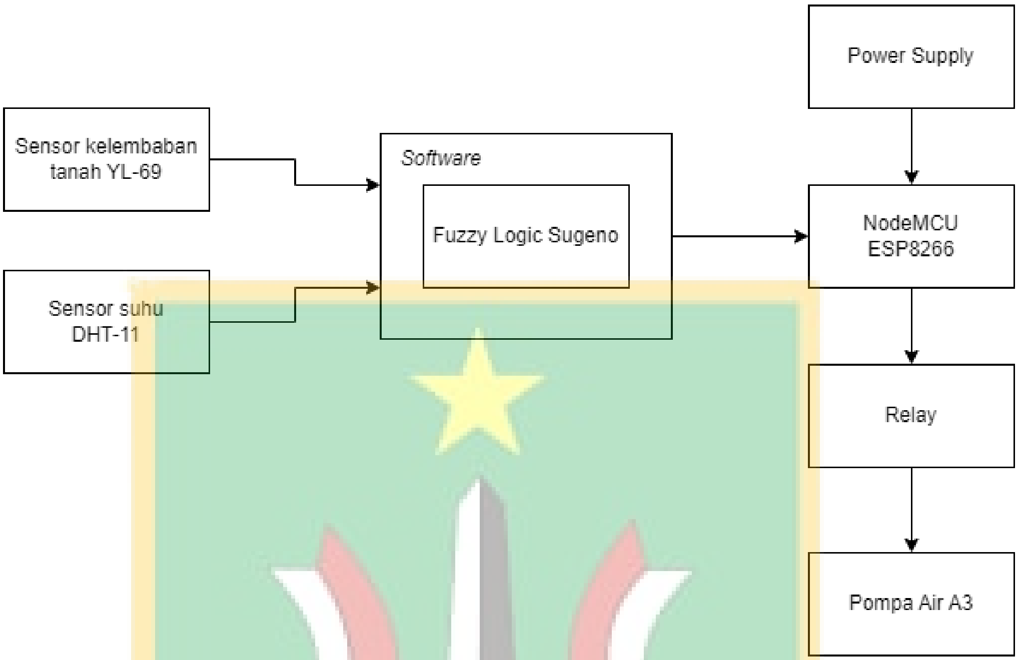
Wilda, R. N., Joko, S., dan Andrio, P. Otomatisasi Penyiraman Tanaman Jambu Madu berdasarkan Waktu dan Kelembaban Tanah Berbasis Arduino, Jurnal Informatika Kaputama, 5(2): 417-423, 2021.

LAMPIRAN

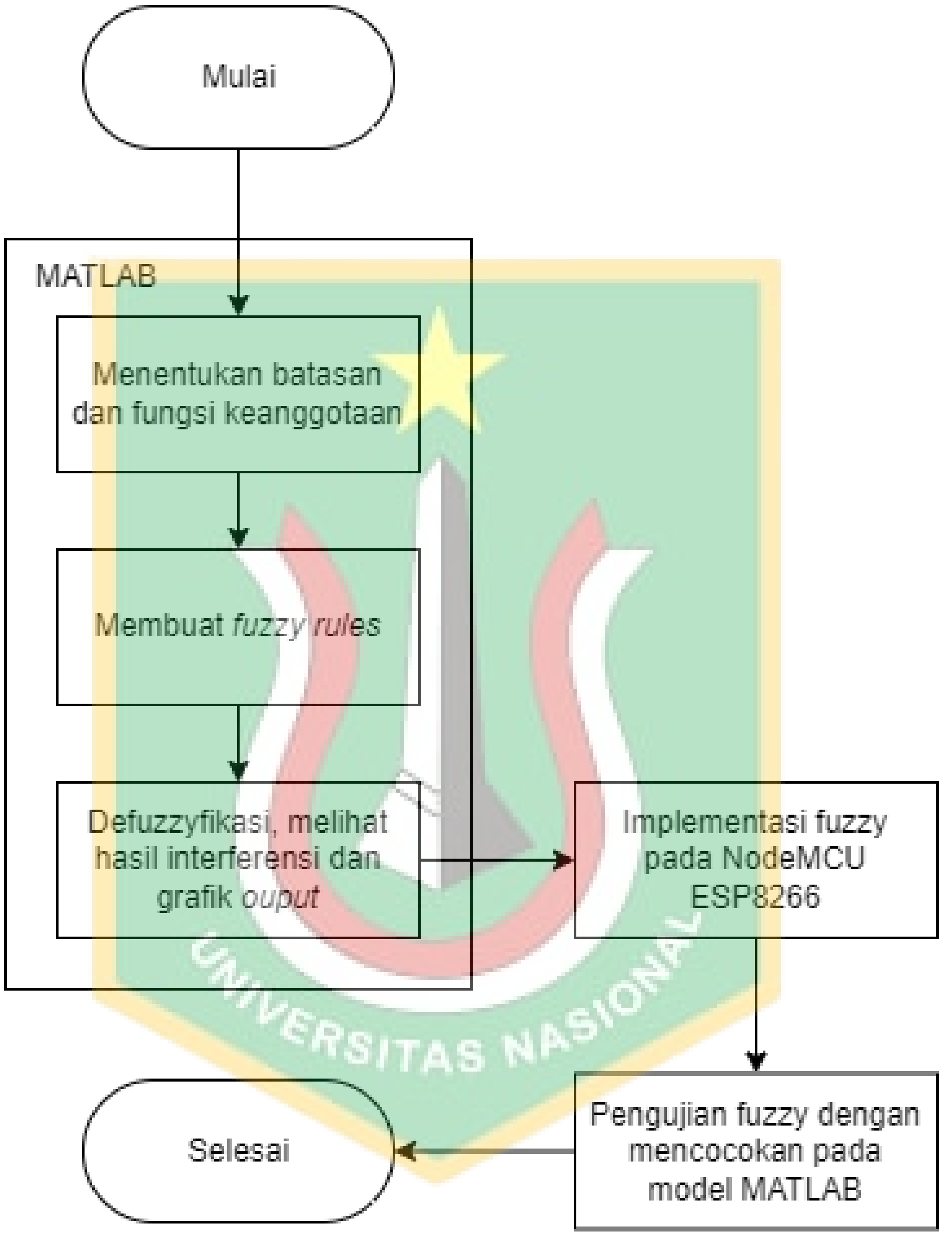
Lampiran 1. Kerangka Berpikir



Lampiran 2. Blok Diagram Implementasi Fuzzy pada Alat

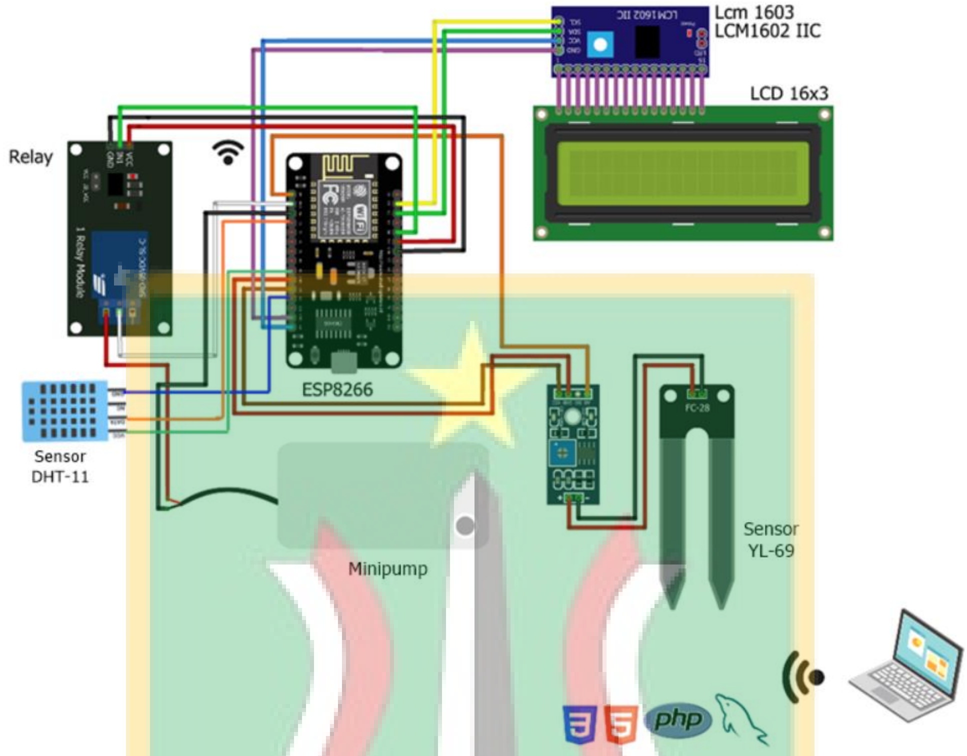


Lampiran 3. Alur Kontruksi Fuzzy Logic



Lampiran 4. Kebun Bayem House

Lampiran 5. Usulan Keseluruahn Rangkaian Penyiraman Otomatis



Lampiran 6. Tabel Analisis Kebutuhan Hardware

No	Perangkat	Kegunaan
1	NodeMCU ESP8266 LUA WiFi v3 4MB 32MBITS CH530	Mikrokontroler sebagai pemrosesan alat utama, pusat pengumpulan data inputan, dan dilakukanya pemerosesan logika fuzzy.
2	NodeMCU v3 BaseBoard Base Plate	Sebagai penghubung dari kabel-kabel sebelum terhubung ke NodeMCU8266 dan sensor-sensor.
3	Sensor YL-69 Soil Mouisture Hygrometer	Sebagai inputan untuk mengetahui perkiraan kelembaban tanah suatu tanaman.
4	Sensor DHT-11	Sebagai inputan yang mampu mengetahui suhu di sekitar.
5	Mini Pump Motor Submersible Horizontal DC 3v-5v	Sebagai keran untuk menyiram tanaman.
6	LCD 1602 Char Blue Backlight with I2C Serial Interface Module	Sebagai output tulisan pada menyiram tanaman menggunakan layar.
7	Relay Module Single Channel 1ch 10A 250VAC 30VDC Modul DC-AC Arduino	Sebagai saklar arus listrik yang terhubung ke arus mini pump.
8	Kabel Jumper Female-Female	Sebagai kabel penghubung antara perangkat.
9	Selang Air Benang Serat 5/16 inch	Sebagai penyalur air dari mini pump
10	Kabel Data Micro USB 2A	Sebagai penghubung pasokan daya
11	Box Elektronik X6 Arduino	Sebagai tempat untuk alat penyiraman otomatis

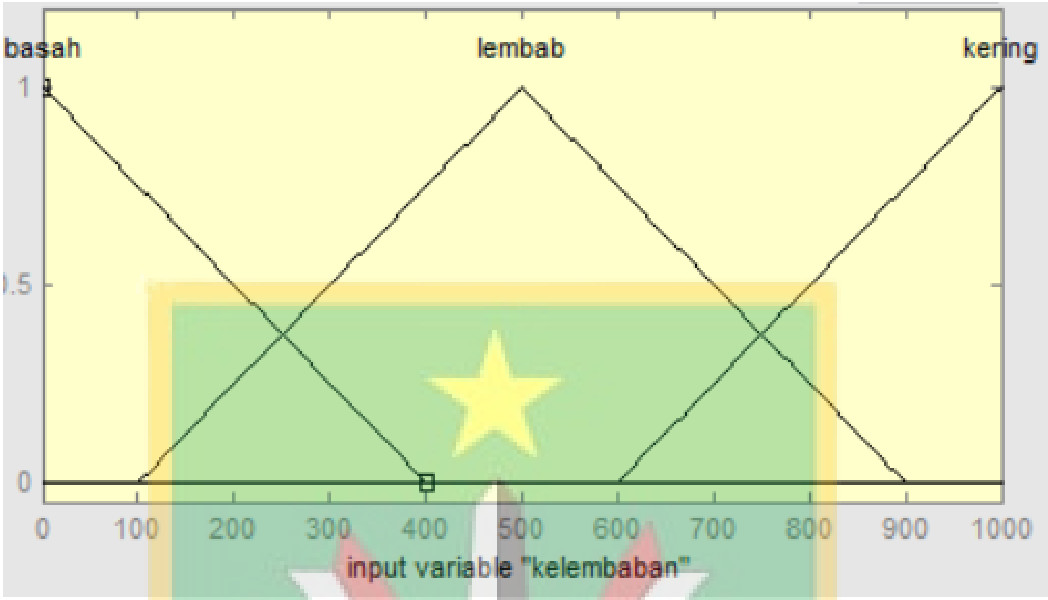
Lampiran 7. Tabel Analisis Kebutuhan Software

No	Nama Software	Kegunaan
1	Arduino IDE	Aplikasi untuk menulis kode program yang ditulis menggunakan Bahasa C pada alat penyiraman otomatis
2	XAMPP	Berfungsi sebagai *database local*
3	Visual Studio Code	Aplikasi untuk membuat sistem *monitoring* yang akan terhubung dengan *database*
4	Matlab	Digunakan untuk memvisualisasikan hasil fuzzy yang telah dibuat.
5	Diagrams net	Digunakan untuk membuat blok diagram pada penelitian.

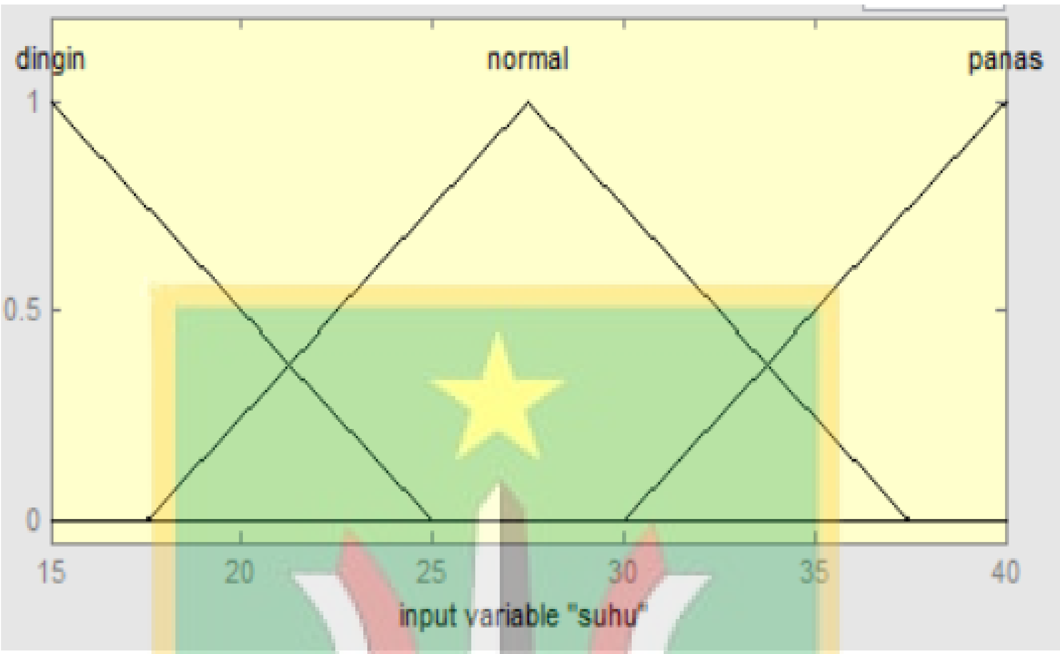
Lampiran 8. Tabel Himpunan Fuzzy

Fungsi	Variabel	Himpunan Fuzzy	Semesta Pembicara	Domain
Input	Tanah	Basah	[0, 1024]	[0, 400]
		Lembab		[200, 800]
		Kering		[600, 1024]
	Suhu	Dingin	[15, 40]	[15, 25]
		Normal		[20, 35]
		Panas		[30, 40]
Output	Pompa Air	Tidak Siram	[0, 1]	[0, 0.5]
		Siram		[0.5, 1]

Lampiran 9. Fungsi Keanggotaan Sensor Kelembaban Tanah



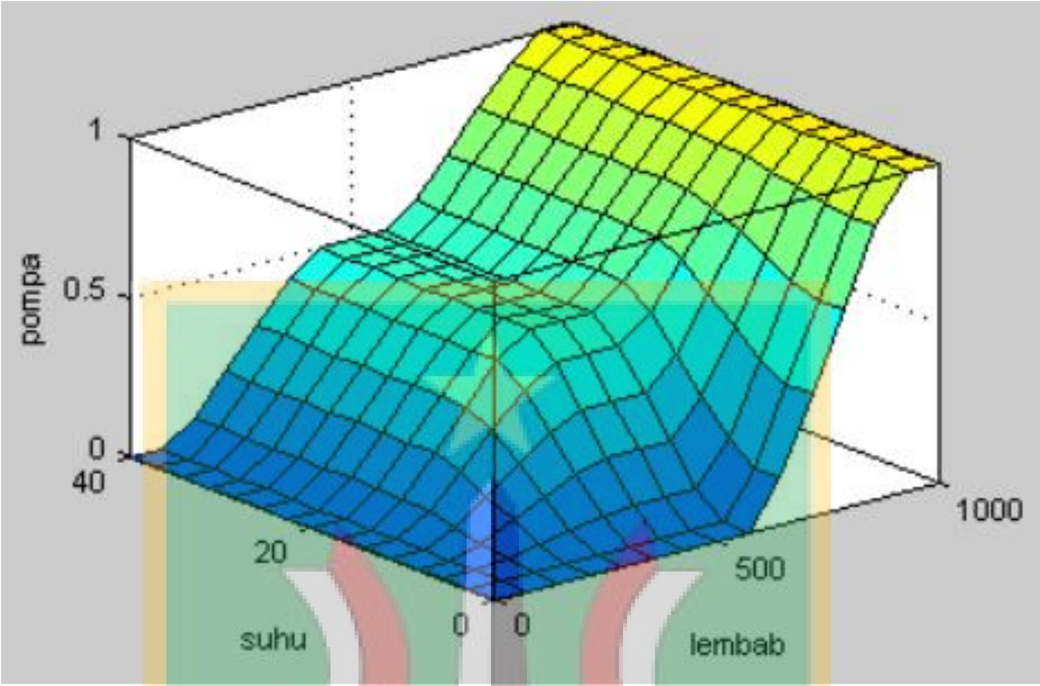
Lampiran 10. Fungsi Keanggotaan Sensor Suhu



Lampiran 11. Tabel Komposisi Fuzzy Rules

Rule		Tanah		Suhu		Output
R1	IF	Basah	AND	Dingin	THEN	Tidak Siram
R2	IF	Basah	AND	Normal	THEN	Tidak Siram
R3	IF	Basah	AND	Panas	THEN	Tidak Siram
R4	IF	Lembab	AND	Dingin	THEN	Tidak Siram
R5	IF	Lembab	AND	Normal	THEN	Tidak Siram
R6	IF	Lembab	AND	Panas	THEN	Tidak Siram
R7	IF	Kering	AND	Dingin	THEN	Siram
R8	IF	Kering	AND	Normal	THEN	Siram
R9	IF	Kering	AND	Panas	THEN	Siram

Lampiran 12. Grafik Hasil Fuzzy Sensor Suhu dan Sensor Kelembaban Tanah



Lampiran 13. Tabel Interferensi Fuzzy Sugeno dari Sistem Penyiraman Tanaman

No	Lembab Tanah (RH)	Suhu (ºC)	Output Fuzzy
1	127	30	0
2	231	30	0
3	352	30	0
4	409	31	0
5	531	31	0
6	644	30	0.248
7	802	32	0.615
8	954	31	0.92
9	1012	32	1

Lampiran 14. Implementasi Alat Penyiraman Otomatis

Lampiran 15. Tampilan Website Monitoring

Tanggal : **20-Dec-2022** | Pukul : **20:53:33** , **Selamat Malam**

Sistem Pemantauan Kebun Bayem House

Selamat datang, berikut adalah data pemantauan penyiraman tanaman anda.

No	Lembab Tanah	Definisi	Suhu	Penyiraman	Waktu
1	474	Tanah Lembab	28.50	Sudah disiram	2022-12-08 22:43:53
2	473	Tanah Lembab	28.50	Sudah disiram	2022-12-08 22:43:49
3	473	Tanah Lembab	28.50	Sudah disiram	2022-12-08 22:43:42
4	472	Tanah Lembab	28.50	Sudah disiram	2022-12-08 22:43:38
5	474	Tanah Lembab	28.50	Sudah disiram	2022-12-08 22:43:30
6	474	Tanah Lembab	28.50	Sudah disiram	2022-12-08 22:43:23
7	474	Tanah Lembab	28.50	Sudah disiram	2022-12-08 22:43:20
8	474	Tanah Lembab	28.50	Sudah disiram	2022-12-08 22:43:12
9	475	Tanah Lembab	28.50	Sudah disiram	2022-12-08 22:43:04
10	474	Tanah Lembab	28.50	Sudah disiram	2022-12-08 22:43:01

Lampiran 16. Tabel Analisa Pengujian Blackbox

No	Subjek	Nama Pengujian
1	Alat Penyiraman Otomatis	• Pengujian tingkat error sensor kelembaban tanah YL-69 dengan perbandingan alat 3 Way Soil Meter • Pengujian tingkat error sensor suhu DHT-11 dengan perbandingan alat HTC-1
2	*Fuzzy Logic*	• Kecocokan penggunaan *Fuzzy Logic* Metode Sugeno pada Alat Penyiraman Otomatis ESP8266 dengan Matlab
3	Database	• Koneksi dengan Website • Koneksi dengan NodeMCU ESP8266 • Database menerima nilai sensor kelembaban dan sensor suhu
4	Web Monitoring	• Website mengambil data terakhir dari *database* • Website menampilkan waktu terikini • Website menampilkan waktu nilai kelembaban dan nilai suhu

Lampiran 17. Tabel Pengujian Sensor YL-69

Uji	Sensor YL-69	Alat Way Soil Meter	Selisih	
	Lembab Tanah (RH)	Lembab Tanah (RH)	Nilai (RH)	Persen (%)
1	1024	1000	24	2.4 %
2	920	900	20	2.222222222 %
3	719	700	19	2.714285714 %
4	831	900	69	7.666666667 %
5	690	700	10	1.428571429 %
6	459	500	41	8.2 %
7	367	400	27	6.75 %
8	390	400	10	2.5 %
9	799	800	1	0.125 %
10	585	600	15	2.5 %
11	663	700	37	5.285714286 %
12	797	800	3	0.375 %
13	512	600	88	14.66666667 %
14	428	500	72	14.4 %
15	403	500	97	19.4 %
16	378	400	22	5.5 %
17	346	400	54	13.5 %
18	460	500	40	8 %
19	473	500	27	5.4 %
20	468	500	32	6.4 %
21	428	500	72	14.4 %
22	403	500	97	19.4 %
23	586	600	14	2.333333333 %
24	512	600	88	14.66666667 %
25	663	700	37	5.285714286 %
26	797	800	3	0.375 %
27	418	500	82	16.4 %
28	836	900	64	7.111111111 %
29	341	400	59	14.75 %
30	362	400	38	9.5 %
	Rata-rata		42.066	7.788531746 %

Lampiran 18. Tabel Pengujian Sensor DHT-11

Uji	DHT-11	Alat HTC-1	Selisih	
	Suhu (ºC)	Suhu (ºC)	Suhu (ºC)	Persen (%)
1	29.8	30.1	0.3	0.75 %
2	28.5	29	0.5	1.25 %
3	30.2	30.5	0.3	0.75 %
4	31.2	30.9	0.3	0.75 %
5	29.8	29.6	0.2	0.5 %
6	30.8	30.7	0.1	0.25 %
7	32.3	31.7	0.6	1.5 %
8	31.3	31.1	0.2	0.5 %
9	29.3	29.4	0.1	0.25 %
10	28.5	28.7	0.2	0.5 %
11	31.9	32.3	0.4	1 %
12	28.9	29	0.1	0.25 %
13	27.1	27.5	0.4	1 %
14	33	33.4	0.4	1 %
15	29.9	30.3	0.4	1 %
16	30.4	30.6	0.2	0.5 %
17	31.2	31.3	0.1	0.25 %
18	32.2	32.3	0.1	0.25 %
19	32.5	32.9	0.4	1 %
20	31.7	31.8	0.1	0.25 %
21	29.8	30.1	0.3	0.75 %
22	30.2	30.4	0.2	0.5 %
23	31.3	31	0.3	0.75 %
24	31.2	31.2	0	0 %
25	29.3	29.4	0.1	0.25 %
26	28.5	28.6	0.1	0.25 %
27	28.1	28.3	0.2	0.5 %
28	29.3	29.5	0.2	0.5 %
29	29.6	29.3	0.3	0.75 %
30	29.8	30.5	0.7	1.75 %
Rata-rata			0.26 ºC	0.65 %

Lampiran 19. Tabel Pengujian Fuzzy Logic

Uji	Data Uji		Fuzzy Logic (Manual)	Fuzzy Logic (Matlab)	Selisih
	Lembab Tanah (RH)	Suhu (ºC)			
1	1024	29.8	1	1	0
2	920	28.5	1	1	0
3	719	30.2	0.759902913	0.75	0.009902913
4	831	31.2	1	1	0
5	690	29.8	0.623996764	0.679	0.055003236
6	459	30.8	0.485833333	0.5	0.014166667
7	367	32.3	0.463125	0.433	0.030125
8	390	31.3	0.47375	0.48	0.00625
9	799	29.3	0.448980583	0.5	0.051019417
10	585	28.5	0.402777778	0.5	0.097222222
11	663	31.9	0.578446602	0.619	0.040553398
12	797	28.9	0.878565264	0.989	0.110434736
13	512	27.1	0.442222222	0.5	0.057777778
14	428	33	0.515	0.5	0.015
15	403	29.9	0.443888889	0.5	0.056111111
16	378	30.4	0.49625	0.456	0.04025
17	346	31.2	0.330833333	0.388	0.057166667
18	460	32.2	0.521666667	0.5	0.021666667
19	473	32.5	0.54	0.5	0.04
20	293	31.7	0.2621875	0.264	0.0261875
21	343	29.8	0.229479167	0.381	0.110479167
22	403	30.2	0.506875	0.5	0.006875
23	630	31.3	0.54342233	0.554	0.01057767
24	717	31.2	0.791618123	0.745	0.046618123
25	663	29.3	0.590946602	0.619	0.028053398
26	797	28.5	0.860787487	0.989	0.128212514
27	323	28.1	0.314583333	0.336	0.021416667
28	836	29.3	1	1	0
29	341	29.6	0.355416667	0.377	0.021583333
30	362	29.8	0.44708333	0.423	0.024083333
			Rata-rata		0.03755788385

Lampiran 20. Tabel Implementasi Fuzzy Logic

Uji	Data Uji		Fuzzy Logic	Kondisi Pompa	Keterangan
	Lembab Tanah (RH)	Suhu (°C)			
1	29.8	1024	1	Hidup	Butuh siram
2	28.5	920	1	Hidup	Butuh siram
3	30.2	719	0.75	Hidup	Butuh siram
4	31.2	831	1	Hidup	Butuh siram
5	29.8	690	0.679	Hidup	Butuh siram
6	30.8	459	0.5	Mati	Tersiram
7	32.3	367	0.433	Mati	Tersiram
8	31.3	390	0.48	Mati	Tersiram
9	29.3	799	0.5	Hidup	Butuh siram
10	28.5	585	0.5	Mati	Tersiram
11	31.9	663	0.619	Hidup	Butuh siram
12	28.9	797	0.989	Hidup	Butuh siram
13	27.1	512	0.5	Mati	Tersiram
14	33	428	0.5	Mati	Tersiram
15	29.9	403	0.5	Mati	Tersiram
16	30.4	378	0.456	Mati	Tersiram
17	31.2	346	0.388	Mati	Tersiram
18	32.2	460	0.5	Mati	Tersiram
19	32.5	473	0.5	Mati	Tersiram
20	31.7	293	0.264	Mati	Tersiram
21	29.8	343	0.381	Mati	Tersiram
22	30.2	403	0.5	Mati	Tersiram
23	31.3	630	0.554	Mati	Tersiram
24	31.2	717	0.745	Hidup	Butuh siram
25	29.3	663	0.619	Hidup	Butuh siram
26	28.5	797	0.989	Hidup	Butuh siram
27	28.1	323	0.336	Mati	Tersiram
28	29.3	836	1	Hidup	Butuh siram
29	29.6	341	0.377	Mati	Tersiram
30	29.8	362	0.423	Mati	Tersiram

Lampiran 21. Tabel Pengujian Database

No	Nama Pengujian	Hasil yang diharapkan	Hasil
1	Koneksi website	Database terkoneksi dengan website monitoring	Berhasil
2	Koneksi hardware	Database terkoneksi pada alat penyiraman dengan *GET Method API*	Berhasil
3	Nilai sensor kelembaban tanah dan suhu	Database dapat mengambil data dari alat penyiraman	Berhasil

Lampiran 22. Tabel Pengujian Request Web Sistem Pemantauan

Nama Pengujian	**Hasil yang diharapkan**	**Uji**	**Hasil *(ms)***		**Selisih *(ms)***
			Chrome	Edge	
Website request data	Website melakukan *request* untuk pengambilan *database* dari webserver	1	16	15	1
		2	17	15	2
		3	19	11	8
		4	15	19	4
		5	22	16	6
		6	17	16	1
		7	16	14	2
		8	29	17	12
		9	15	15	0
		10	20	15	5
		11	7	12	5
		12	16	15	1
		13	13	17	4
		14	26	15	11
		15	14	14	0
	Rata-rata		17.46 *ms*	15.06 *ms*	4.13 *ms*

Lampiran 23. Tabel Pengujian Response Web Sistem Pemantauan

Nama Pengujian	Hasil yang diharapkan	Uji	Hasil *(ms)*		Selisih (ms)
			Chrome	Edge	
Website response time	Website melakukan *response* untuk pengambilan *database* dari webserver	1	46	25	21
		2	45	39	6
		3	35	25	10
		4	38	39	1
		5	26	34	8
		6	56	44	12
		7	81	38	43
		8	57	38	19
		9	41	37	4
		10	50	33	17
		11	21	23	2
		12	42	34	8
		13	25	33	8
		14	21	43	22
		15	27	37	10
Rata-rata			40.73 ms	34.8 ms	12.73 ms

Lampiran 24. Tabel Pengujian Load Page Web Sistem Pemantauan

Nama Pengujian	Hasil yang diharapkan	Uji	Hasil (ms)		Selisih (ms)
			Chrome	Edge	
Website Load Page	Website melakukan *load page* untuk menampilkan data dari webserver	1	1972	1154	818
		2	1750	1290	460
		3	1736	1117	619
		4	1683	1116	567
		5	2354	1352	1002
		6	1911	1070	841
		7	1648	1190	458
		8	2006	1248	758
		9	1721	1154	567
		10	2016	1230	786
		11	846	647	199
		12	726	832	106
		13	683	720	37
		14	742	688	54
		15	855	598	257
Rata-rata			1509.93 ms	1027.07 ms	501.93 ms

Skripsi Ganjil 22/23

by Satrio Bagus Wicaksono

Submission date: 21-Feb-2023 02:03AM (UTC-0500)
Submission ID: 1977224948
File name: Satrio_Bagus_Wicaksono_-_183112706450230_-_Informatika_1.docx (1.99M)
Word count: 7865
Character count: 45466

Skripsi Ganjil 22/23

ORIGINALITY REPORT

20%	19%	7%	9%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	123dok.com Internet Source	2%
2	etheses.uin-malang.ac.id Internet Source	1%
3	media.neliti.com Internet Source	1%
4	text-id.123dok.com Internet Source	1%
5	ejurnal.seminar-id.com Internet Source	1%
6	repository.uin-suska.ac.id Internet Source	1%
7	www.mdpi.com Internet Source	1%
8	www.semanticscholar.org Internet Source	1%
9	ejurnal.stmik-budidarma.ac.id Internet Source	1%

Journal Knowledge Computers and Information (Journal of Computer Science and Information)
15/1 (2022), xx-xx. DOI: http: // dx . doi . org / 10 . 21609 / jiki . v15i1 . xxx

Automatic Plant Watering Based on Internet of Things Using Fuzzy Sugeno Method and ESP8266 Microcontroller

Satrio Bagus Wicaksono[1] , Septi Andryana[2]

[1,2,3] Informatics Department, Faculty of ICT, National University, Jakarta, 12520, Indonesia

E-mail: [1]satriobaguswicaksono2018@student.unas.ac.id, [2]septi.andryana@civitas.unas.ac.id ,

Abstract

Watering is an activity that needs attention in the process of plant care. One important factor in the process of developing a plant is knowing when to water it. This study aims to test automatic plant sprinklers using fuzzy logic with the Fuzzy Sugeno Method. The tool created is a prototype with the help of ESP8266 microcontroller hardware and Arduino IDE software. Spinach plants are used as subjects in this study. The watering process is carried out periodically 2 times a day during the nursery period and 1 time a day after the seedling growth period. The study used a soil analyzer for testing soil moisture and htc-1 for testing room temperature as a comparison. From the results of the Matlab application analysis, fuzzy inference graphs are obtained for temperature sensors with a range of 10 to 40 degrees Celsius and soil moisture with a value range of 1 to 1024 RH.

Keywords: *Spinach Plants, Watering, Fuzzy Sugeno, ESP8266 Microcontroller*

1. Introduction

During plant care, watering is an important activity that needs attention. One important aspect of the development process of a plant is knowing when to water it. The need for water in plants must be considered. This is because plant growth can be optimal if the provision of water is sufficient in the right amount and time [1].

Plants need water for their growth and development just like humans. Water plays an important role as the main component during the process of photosynthesis and transpiration. In addition, water also acts as a source of energy for plants [2]. Lack of water in plants will make the plants unhealthy and look wilted. As a result, the need for minerals for plants to be reduced. This is because water can help channel minerals from the soil to the top of the plant.

As the times progress, most plant owners still use the conventional method as a plant watering technique, namely by watering the plants manually. This method is considered to have drawbacks, namely plant owners sometimes forget or there is no time to provide the water needs of the plants they own. In addition, humidity is also a factor that plays an important role in the growth and development of a plant.

Based on previous research conducted by R. Santhana Krishnan (2020), this research proposes a smart irrigation system that helps farmers water their agricultural land using the GSM Module. This system provides notification messages regarding the status of work being carried out such as soil moisture levels and ambient temperature [3].

Another study entitled Adaptive Irrigation System Based on Fuzzy Logic by Chiragkumar Aboti (2018) also discusses the automation of automatic plant watering. using an irrigation system based on the Internet of Things (IoT) and the proposed system based on a Wireless Sensors Network (WSN) installed in a greenhouse. This watering device sends data from the plant environment such as soil moisture and temperature to the server (Raspberry pi) by means of radio frequency (RF) communication, the Fuzzy Logic Controller (FLC) process to make smart and optimal decisions [4].

Based on the background previously described, as an effort to help the owner of the Bayem House garden, this watering tool is made using a microcontroller named ESP8266 which has the main control function of this automatic watering device. This tool is equipped with an output indicator, namely the LCD screen. Besides looking directly at the LCD screen, this tool also uses the website as a monitoring system with a local webserver with the PhpMyAdmin database.

In practice, this tool uses NodeMCU which can be connected to the internet so that it is more optimal in terms of monitoring systems and uses a fuzzy logic method to determine decisions from several variables and rules in terms of automatic watering. Fuzzy logic is a methodology on a system that can help control sensors. For example, it plays a role in air humidity and soil moisture [5, 6].

Based on this, researchers are interested in testing more deeply and conducting research entitled "Automatic Plant Watering with the IoT-Based Fuzzy Logic Method using the ESP8266 Microcontroller". The fuzzy logic method is proposed as the method applied in this research. This has the goal of determining when the system will send a signal to the IoT device so that it can implement the process of automating plant watering and knowing soil moisture conditions and using the website as a monitoring system for sensors based on temperature and soil moisture which will later be stored in a database to view automatic watering activities. .

2. Research methods

2.1 Fuzzy Logic

Prof. LA Zadeh in 1965 is known as originator idea fuzzy logic . Expansion the crisp set is one principles on fuzzy sets . A crisp set is a usual set _ used for group one individual Becomes a number of category among them i.e. member and not member .

When reviewed from crisp set , only there is two possibility score membership , that is zero or one . In use , value membership in this fuzzy set own range value 0 to with 1. As for example , if x has score fuzzy membership $\mu A[x] = 0$, p this show that x doesn't belong to in set A. Also valid for $\mu A [x] = 1$, p this means that x belongs to in set A as member full [7].

set conventional normal used as operation fuzzy set . There is a number of operations that have a specific meaning with purpose i.e. combine and transform fuzzy set. A α- predicate is frequent terms _ known because own score membership results from operation two set . Some basic operators results Zadeh 's works include AND operators, OR operators, and NOT operators.

Function implication is rules that exist on the line of vague and possessing knowledge connection with fuzzy relationship . Following this is ratio general from function implication .

IF x is A THEN y is B (1)

Antecedents is usual terms _ used and symbolized relationship following IF . Whereas consequently is usual terms _ worn for symbolize relationship following THEN . Proposition it can be developed use fuzzy operators like :

IF (x1 is A1) • (x2 is A2) • (x3 is A3) • .... • (xN is AN) • THEN y is B (2)

2.2 Fuzzy Sugeno Method

Method Sugeno including in one _ Fuzzy Logic Method . Method this introduced in 1985 by Takagi - Sugeno Kang. Weakness pure fuzzy system can be overcome with exists Fuzzy Sugeno system with add calculus mathematics simple as part from THEN. Change this produce weighing fuzzy system average value in parts fuzzy IF-THEN rules . Weakness sugeno fuzzy system located in the THEN section. For example , existence calculation math can provide framework experience for presentation knowledge real human [8] .

reasoning method sugeno own difference with reasoning Mandani. Mamdani's reasoning has a system (consequent) output in the form of fuzzy set , whereas reasoning Method Sugeno the output form constant or linear equation . Method this introduced in 1985 by Takagi – Sugeno Kang, so method this often known _ with TSK method [9].

Fuzzy logic uses method sugeno this implemented with a number of stage . There are 4 stages used i.e. as following :

2.2.1 Establishment Fuzzy Set

Study this use two variable that is humidity soil and temperature sensors . Each set blurry own incoming domain value to in range universe talk . this _ allowed for operate on a set run away . Table universe talks fuzzy sets are in Table 1

Table 1. Fuzzy Set

Function	Variable	Fuzzy Set	Speaker Universe	Domain
Inputs	Land	Wet	0 – 1024	0 – 400
		Moist	0 – 1024	200 – 800
		Dry	0 – 1024	600 – 1024
	Temperature	Cold	15 – 40	15 – 25
		Normal	15 – 40	20 – 35
		Hot	15 – 40	30 – 40
output	Water pump	No Flush	0 – 1	0 – 0.5
		flush	0 – 1	0.5 – 1

Function membership made after formation fuzzy set . In fuzzy sets , functions membership this conducted mapping input data to in degree / value membership . intervals used for value / degree membership i.e. 0 to 1. On research this approach _ function obtained from function membership . On research this use function representation trapezoid . Function humidity sensor membership land shown in Figure 1 and function temperature sensor membership shown in Figure 2.

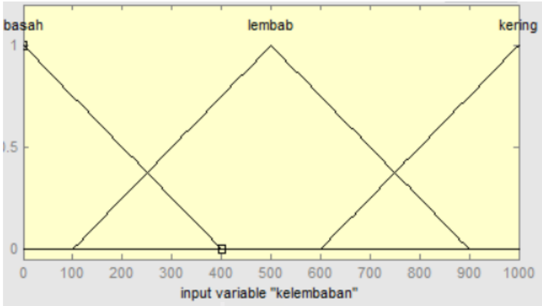


Figure 1 . curve variable humidity land

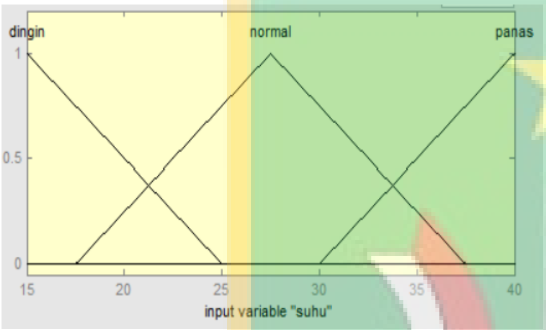


Figure 2 . curve variable temperature

Based on Table 1 can be seen that there is humidity sensor variable divided land _ into 3 fuzzy sets , namely wet , moist , and dry . Whereas for temperature sensors shared into 3 fuzzy sets , namely cold , normal, and hot . Then variables dry represented in shape curve in the form of the left shoulder on the humidity sensor ground .

Whereas curve right shoulder shape represented for variable wet . For variable land , the input values shown on the x- axis have unit form percentage . For score level membership from input value is indicated with symbol μ(x).

temperature sensor , used curve left shoulder _ for variable cold , curves trapezoid for normal variable , and right shoulder curve for variable hot . Axis x°C is input value with unit level Celsius for variable temperature , while μ (x°C) is score level membership from temperature sensor input value .

2.2.2 Functions Implications

Application function implication use the MIN function is in the function Step inference , calculation function implication is as following

$$ai = \mu Ai\,(x) \cap \mu Bi\,(x) = \min\,(\mu Ai\,(x), \mu Bi\,(x)) \quad (3)$$

Description :

ai : Minimum rule value to-i on fuzzy sets A and B

μAi(x) : fuzzy set A with level membership x rules i-th

μBi(x) : fuzzy set B with level membership x rules i-th

2.2.3 Composition of Rules

Fuzzy rules are created at this stage. In making fuzzy rules, it is necessary to determine the output based on the variables used in the research, namely soil moisture and temperature variables. The method used is the Sugeno Method. The purpose of making this rule is to be able to state the relationship between input and output which will later be made into 9 combination rules. Here is a table of composition rules for the output .

Table 2. Fuzzy Rules

Code	Rule
R1	Damp IF land Wet AND temperature Cold water pump THEN No flush
R2	Damp IF land Wet AND Normal temperature THEN water pump No flush
R3	Damp IF land Wet AND temperature Heat THEN water pump No flush
R4	Damp IF land Humidity AND temperature Cold water pump THEN No flush
R5	Damp IF land Humid AND Normal temperature THEN water pump No flush
R6	Damp IF land Humidity AND temperature Heat THEN water pump No flush
R7	Damp IF land Dry AND temperature Cold water pump THEN Flush
R8	Damp IF land Dry AND Normal temperature THEN Water pump Flush
R9	Damp IF land Dry AND temperature THEN heat pump Flush water

2.2.4 Defuzzification

The input generated from the defuzzification process is a fuzzy number obtained from the composition of fuzzy rules. While the output obtained is in the form of numbers in the set of fuzzy domains. If the fuzzy set is given in a certain range, it must be able to take a certain sharp value as output. Defuzzification can be done by finding the weighted average value in the Sugeno Method as follows.

$$WA = \frac{\sum_{n}^{9} = 1\ \alpha nzn}{\sum_{n}^{9} = 1\ \alpha nzn} \quad (4)$$

Information:

WA : Weighted average value

ai : a-predicate to-i

xi : i-th consequence

2.3 System Requirements

In building the system hardware or hardware is needed, the following hardware is selected after considering the functional requirements of the system and the literature studies that have been carried out, the hardware needed is as follows:

1. NodeMCU ESP8266 LUA WiFi v3 4MB 32MBITS CH530
2. NodeMCU v3 BaseBoard Base Plate
3. YL-69 Soil Mouisture Sensor
4. DHT-11 Temperature Sensors
5. Mini Pump Motor Submersible Horizontal DC 3v-5v
6. LCD 1602 Char Blue Backlight with I2C Serial Interface Module
7. Relay Module Single Channel 1ch 10A 250VAC 30VDC Arduino DC-AC Module
8. Female-Female Jumper Cable
9. Fiber Thread Water Hose 5/16 inch
10. 2A Micro USB Data Cable
11. Arduino X6 Electronic Box

Software software is also needed in building the system. The selected software has been considered according to research needs and has referred to the study literature used. The software used includes:

1. Arduino IDE
2. XAMPP
3. Visual Studio Code
4. Matlab
5. Net diagrams

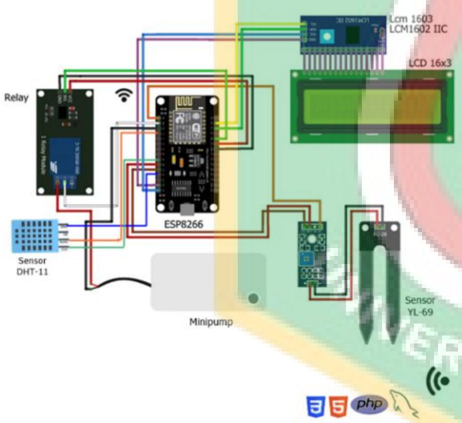


Figure 3. Suite need system

2.4 Block Diagrams

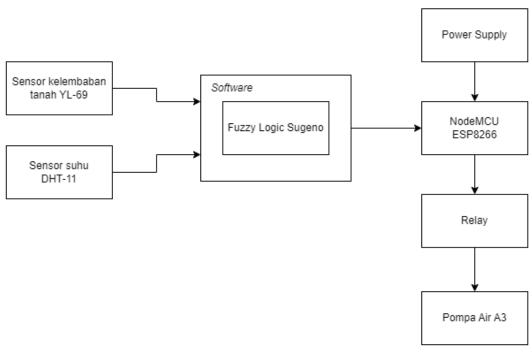


Figure 4. Watering block diagram

From Figure 4 it is known that the purpose of making this block diagram is to design the required components. Another goal is to explain the correlation between components in a system. The sensors in the system, namely the soil moisture sensor and temperature sensor, will later be connected to the NodeMCU ESP8266 directly and the computation will be carried out on the machine. The computational results that have been read are used to determine whether the condition of the water pump is on or not on. The current originating from the NodeMCU ESP8266 cannot be used for the current contained in the water pump. Therefore, it requires another current source. In order to turn on and off the current can be controlled, in this case using a relay as an assistant.

2.5 Fuzzy Construction Flow

In making fuzzy, the first step is to determine the boundaries of the fuzzy input set. This limit can be taken from the sensor input limit. To determine the graph or membership function, it can be done by communicating with the garden owner. Apart from this method, it can also be used by checking sensor results with real conditions in the garden.

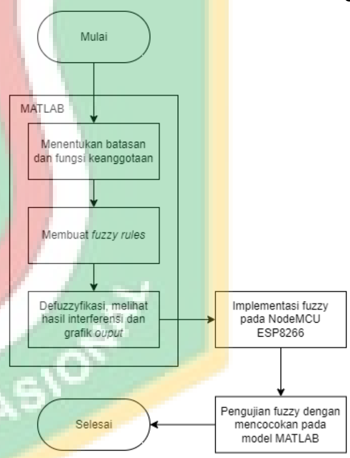


Figure 5. Fuzzy Logic construction flow

Next is to determine the rules of fuzzy inference, the method used in determining these rules is watering is done when the soil conditions are dry and the temperature is moderate or the soil conditions are dry and the temperature is hot. Conditions other than that watering is not done. The last is defuzzification using the Sugeno Method and using the weighted average formula. The results of the fuzzy can then be seen in Matlab, and are ready to be implemented into code form in the NodeMCU ESP8266.

3. Results and Discussion

Determination of Soil Moisture Range

set condition wet

$$\mu\text{Basah}(x) = \begin{cases} 0 \quad , & x > 400 \\ \dfrac{400 - x}{400 - 0}, & 0 < x < 400 \\ 1 \quad , & x < 400 \end{cases}$$

set condition moist

$$\mu\text{Lembab}(x) = \begin{cases} 0 \quad , & x < 200 \text{ or } x > 800 \\ \dfrac{x - 200}{400 - 200}, & 200 < x < 400 \\ \dfrac{800 - x}{800 - 600}, & 600 < x < 800 \end{cases}$$

set condition dry

$$\mu\text{Kering}(x) = \begin{cases} 0 \quad , & x < 600 \\ \dfrac{x - 600}{1024 - 600}, & 600 < x < 1024 \\ 1 \quad , & x > 1024 \end{cases}$$

Determination of the Temperature Range

set condition cold

$$\mu\text{Dingin}(x) = \begin{cases} 0 \quad , & x > 25 \\ \dfrac{25 - x}{25 - 15}, & 15 < x < 25 \\ 1 \quad , & x < 25 \end{cases}$$

set normal conditions

$$\mu\text{Normal}(x) = \begin{cases} 0 \quad , & x < 25 \text{ or } x > 35 \\ \dfrac{x - 20}{25 - 20}, & 20 < x < 35 \\ \dfrac{35 - x}{35 - 30}, & 30 < x < 35 \end{cases}$$

set condition hot

$$\mu\text{Panas}(x) = \begin{cases} 0 \quad , & x < 30 \\ \dfrac{x - 30}{4 - 30}, & 30 < x < 40 \\ 1 \quad , & x > 40 \end{cases}$$

Sugeno's Fuzzy Calculations

For example, if the soil moisture data is 362 and the temperature is 29.8, it is included in the 3rd rule and can be calculated like this:

[R3] IF the soil is moist and the temperature is hot THEN the water pump does not flush

Soil Moist

$$Min = \frac{362 - 0}{800 - 0} = \frac{362}{800} = 0.4525$$

Temperature

$$Min = \frac{29.8 - 20}{35 - 20} = \frac{9.8}{15} = 0.6533$$

Defuzzification

$$WA = \frac{0.4525 + 0.6533}{2} = 0.447083333$$

Implementation of Automatic Watering Tool

Testing the tool on plants was carried out on 1 plant, namely green spinach in the Bayem House garden, the tool is located next to a pot containing plants that will be watered when soil moisture conditions have been determined on the microcontroller system.

Figure 6. Tool Implementation

Display Website Monitoring

Website monitoring testing is carried out to see the results of sensor readings that have been stored in the database by showing the value of humidity, definition of soil moisture, temperature, safe monitoring status and when the sensor readings work.

Tanggal : 20-Dec-2022 | Pukul : 20:53:33 , Selamat Malam

Sistem Pemantauan Kebun Bayem House

Selamat datang, berikut adalah data pemantauan penyiraman tanaman anda.

No	Lembab Tanah	Definisi	Suhu	Penyiraman	Waktu
1	474	Tanah Lembab	28.50	Sudah disiram	2022-12-08 22:43:53
2	473	Tanah Lembab	28.50	Sudah disiram	2022-12-08 22:43:49
3	473	Tanah Lembab	28.50	Sudah disiram	2022-12-08 22:43:42
4	472	Tanah Lembab	28.50	Sudah disiram	2022-12-08 22:43:38
5	474	Tanah Lembab	28.50	Sudah disiram	2022-12-08 22:43:30

Figure 7. Monitoring website display

Black box testing

Blackbox testing has a goal with the main focus on a system that has been designed to meet the requirements stated in the specifications or not. This research runs or executes the unit and then makes observations regarding the results of the unit being tested regarding suitability with the design process.

Table 3. Black box testing

No	subject	Test Name
1	Watering Tool Automatic	Testing humidity sensor error rate ground YL-69 with ratio 3 Way Soil Meter tool Testing DHT-11 temperature

		sensor error rate with ratio HTC-1 tool
2	Fuzzy Logic	Compatibility use of Fuzzy Logic Method Sugeno on the Watering Tool ESP8266 auto with Matlab
3	Databases	Connection with Websites Connection with NodeMCU ESP8266 Database accepts humidity sensor and temperature sensor values
4	Web Monitoring	The website fetches the last data from databases Website displays time latest Website displays time score humidity and value temperature

YL-69 Sensor Accuracy Testing

Table 4. YL-69 sensor testing

No	YL-69 sensors	Way Soil Meter Tool	Difference	
	Soil Moist (RH)	Soil Moist (RH)	Score (RH)	Percent (%)
1	1024	1000	24	2.4
2	920	900	20	2,222
3	719	700	19	2,714
4	831	900	69	7.666
5	690	700	10	1.428
6	459	500	41	8.2
7	367	400	27	6.75
8	390	400	10	2.5
9	799	800	1	0.125
10	585	600	15	2.5
11	663	700	37	5.285
12	797	800	3	0.375
13	512	600	88	14.666
14	428	500	72	14.4
15	403	500	97	19.4
16	378	400	22	5.5
17	346	400	54	13.5
18	460	500	40	8
19	473	500	27	5.4
20	468	500	32	6.4
21	428	500	72	14.4
22	403	500	97	19.4
23	586	600	14	2.3333
24	512	600	88	14.666
25	663	700	37	5.2857
26	797	800	3	0.375
27	418	500	82	16.4
28	836	900	64	7.11111
29	341	400	59	14.75
30	362	400	38	9.5
	Average		42,066	7.78853

Based on the test results, thirty test results have been carried out, there is a comparison between the YL-69 soil moisture sensor and the way soil meter tool. This shows that the difference between the sensor and the temperature gauge is not too far off with an average of 42,066 in RH units and in percent units of only 7.78853%

Accurate Testing of DHT-11 Sensors

Table 5. DHT-11 sensor testing

No	DHT-11 sensors	HTC-1 Tool	Difference	
	Temperature (ºC)	Temperature (ºC)	Temperature (ºC)	Percent (%)
1	29.8	30.1	0.3	0.75
2	28.5	29	0.5	1.25
3	30.2	30.5	0.3	0.75
4	31.2	30.9	0.3	0.75
5	29.8	29.6	0.2	0.5 %
6	30.8	30.7	0.1	0.25
7	32.3	31.7	0.6	1.5
8	31.3	31.1	0.2	0.5
9	29.3	29.4	0.1	0.25
10	28.5	28.7	0.2	0.5
11	31.9	32.3	0.4	1
12	28.9	29	0.1	0.25
13	27.1	27.5	0.4	1
14	33	33.4	0.4	1
15	29.9	30.3	0.4	1
16	30.4	30.6	0.2	0.5
17	31.2	31.3	0.1	0.25
18	32.2	32.3	0.1	0.25
19	32.5	32.9	0.4	1
20	31.7	31.8	0.1	0.25
21	29.8	30.1	0.3	0.75
22	30.2	30.4	0.2	0.5
23	31.3	31	0.3	0.75
24	31.2	31.2	0	0
25	29.3	29.4	0.1	0.25
26	28.5	28.6	0.1	0.25
27	28.1	28.3	0.2	0.5
28	29.3	29.5	0.2	0.5
29	29.6	29.3	0.3	0.75
30	29.8	30.5	0.7	1.75
	Average		0.26 ºC	0.65

Based on the test results, thirty test results have been carried out, there is a comparison between the DHT-11 temperature sensor and the HTC-1 device. This shows that the difference between the sensor and the temperature gauge is not too far off with an average of 0.26 in units of ºC and only 0.65 % in percent units.

Fuzzy Logic Testing

Table 6. Sugeno's Fuzzy Logic Test

No	Soil Moist (RH)	Temperature (ºC)	Fuzzy Logic Manual	Matlab Fuzzy Logic	Difference
1	1024	29.8	1	1	0
2	920	28.5	1	1	0

3	719	30.2	0.7599	0.75	0.0099
4	831	31.2	1	1	0
5	690	29.8	0.6239	0.679	0.0550
6	459	30.8	0.4858	0.5	0.0141
7	367	32.3	0.4631	0.433	0.0301
8	390	31.3	0.4737	0.48	0.00625
9	799	29.3	0.4489	0.5	0.05101
10	585	28.5	0.4027	0.5	0.09722
11	663	31.9	0.5784	0.619	0.04055
12	797	28.9	0.8785	0989	0.11043
13	512	27.1	0.4422	0.5	0.05777
14	428	33	0.515	0.5	0.015
15	403	29.9	0.4438	0.5	0.0561
16	378	30.4	0.4962	0.456	0.04025
17	346	31.2	0.3308	0.388	0.0571
18	460	32.2	0.5216	0.5	0.0216
19	473	32.5	0.54	0.5	0.04
20	293	31.7	0.2621	0.264	0.0261
21	343	29.8	0.2294	0.381	0.1104
22	403	30.2	0.5068	0.5	0.0068
23	630	31.3	0.5434	0.554	0.0105
24	717	31.2	0.7916	0.745	0.0466
25	663	29.3	0.5909	0.619	0.0280
26	797	28.5	0.8607	0989	0.1282
27	323	28.1	0.3145	0.336	0.0214
28	836	29.3	1	1	0
29	341	29.6	0.3554	0.377	0.0215
30	362	29.8	0.4470	0.423	0.0240
			Average		0.0375

Based on the test results of Sugeno's Fuzzy Logic method, the thirty expected test results have the same value as those produced by calculations by Matlab. This shows that the fuzzy logic with the Sugeno Method which is on the ESP8266 only has an error of 0.037529

Watering Equipment Testing

Table 7. Testing tool sprinkling

No	Soil Moist (RH)	Temperature (°C)	Fuzzy Logic	Pump Condition
1	1024	29.8	1	Life
2	920	28.5	1	Life
3	719	30.2	0.75	Life
4	831	31.2	1	Life
5	690	29.8	0.679	Life
6	459	30.8	0.5	Dead
7	367	32.3	0.433	Dead
8	390	31.3	0.48	Dead
9	799	29.3	0.5	Life
10	585	28.5	0.5	Dead
11	663	31.9	0.619	Life
12	797	28.9	0989	Life
13	512	27.1	0.5	Dead
14	428	33	0.5	Dead
15	403	29.9	0.5	Dead
16	378	30.4	0.456	Dead
17	346	31.2	0.388	Dead
18	460	32.2	0.5	Dead
19	473	32.5	0.5	Dead
20	293	31.7	0.264	Dead
21	343	29.8	0.381	Dead
22	403	30.2	0.5	Dead
23	630	31.3	0.554	Dead
24	717	31.2	0.745	Life
25	663	29.3	0.619	Life
26	797	28.5	0989	Life
27	323	28.1	0.336	Dead
28	836	29.3	1	Life
29	341	29.6	0.377	Dead
30	362	29.8	0.423	Dead

Based on the implementation results, the expected thirty test results have the same value as those generated by calculations by ESP8266. This indicates that the watering tool is running as expected.

Database Testing

Table 8. Database testing

No	Test Name	Expected results	Results
1	Website connection	Connected databases with monitoring websites	Succeed
2	Hardware connection	The database is connected to the device sprinkling with *GET Method API*	Succeed
3	Humidity sensor value soil and temperature	Databases can retrieve data from tool sprinkling	Succeed

Based on the test results on the database, it is as expected by testing the connection to the website, connecting to the watering device and retrieving data from the automatic plant watering device.

Monitoring Website Testing

Table 9. Testing request data

Test Name	No	Result (*ms*)		difference (*ms*)
		chrome	edge	
Website requests data	1	16	15	1
	2	17	15	2
	3	19	11	8
	4	15	19	4
	5	22	16	6
	6	17	16	1
	7	16	14	2
	8	29	17	12
	9	15	15	0
	10	20	15	5
	11	7	12	5
	12	16	15	1
	13	13	17	4
	14	26	15	11
	15	14	14	0
Average		17.46	15.06	4.13

Based on the test results on the monitoring website, it is as expected by testing using the page load time extension to calculate the time for requesting data for automatic plant watering tools that have been stored on the web server using the Google Chrome and Microsoft Edge browsers which are tested using millisecond units (milliseconds) with an average - an average of 17.46 ms using Google Chrome and 15.06 ms using Microsoft Edge as well as an average time comparison of 4.13 ms.

Table 10. Response time testing

Test Name	No	Result (*ms*)		difference (*ms*)
		chrome	edge	
Website response time	1	46	25	21
	2	45	39	6
	3	35	25	10
	4	38	39	1
	5	26	34	8
	6	56	44	12
	7	81	38	43
	8	57	38	19
	9	41	37	4
	10	50	33	17
	11	21	23	2
	12	42	34	8
	13	25	33	8
	14	21	43	22
	15	27	37	10
Average		40.73	34.8	12.73

Based on the test results on the monitoring website, it is as expected by testing using the page load time extension to calculate the time for retrieving data from an automatic plant watering tool that has been stored on the web server using the Google Chrome and Microsoft Edge browsers which are tested using millisecond units (milliseconds) with an average -an average of 40.73 ms using Gooogle Chrome and 34.8 ms using Microsoft Edge as well as an average time comparison of 12.73 ms.

Table 11. Page load testing

Test Name	No	Result (*ms*)		difference (*ms*)
		chrome	edge	
Website load page	1	1972	1154	818
	2	1750	1290	460
	3	1736	1117	619
	4	1683	1116	567
	5	2354	1352	1002
	6	1911	1070	841
	7	1648	1190	458
	8	2006	1248	758
	9	1721	1154	567
	10	2016	1230	786
	11	846	647	199
	12	726	832	106
	13	683	720	37
	14	742	688	54
	15	855	598	257
Average		1509.93	1027.07	501.93

Based on the test results on the monitoring website, it is as expected by testing using the page load time extension to calculate the overall time of the automatic plant watering monitoring website that has been stored on the web server using the Google Chrome and Microsoft Edge browsers which are tested using millisecond units (milliseconds) with an average -an average of 1509.93 ms using Gooogle Chrome and 1027.07 ms using Microsoft Edge as well as an average time comparison of 501.93 ms.

4. Conclusion

Based on the results and discussion, it can be concluded as follows:

- Automatic plant sprinklers are made using the Sugeno method to implement fuzzy logic on automatic watering devices with an error rate of 0.0375 .
- The existence of a soil moisture sensor and temperature sensor can easily turn on and off the water pump when the conditions are met and the sensor results will be sent to the monitoring website which has a database as a log whether watering has been done or not.
- This tool is in accordance with what is required based on the results of black box testing.

References

[1] Wilda, RN, Joko, S., and Andrio, P. Watering Automation of Guava Plants based on Time and Soil Moisture Based on Arduino, Journal of Informatics Kaputama, 5(2): 417-423, 2021.

[2] Umaritawan and Nurul, C. Design and Build of Arduino-Based and Web-Based Automatic Plant Watering Equipment, Proceedings of the National Technology Innovation Seminar, 2021.

[3] Andy Irfan. Design of a Microcontroller-Based Automatic Plant Sprinkler, Scientific Journal of Information Systems and Informatics Engineering, 1(2): 1-8, 2018.

[4] Chiragkumar A., Chinmay S., Ajay M., Mayur L. Adaptive Irrigation System Based On Fuzzy Logic, International Journal of Scientific & Technology Research, 9(3): 6732-6740, 2020.

[5] A. Khanna and S. Kaur. Evolution of the Internet of Things (IoT) and its significant impact in the field of Precision Agriculture, Computers and Electronics in Agriculture, 157: 218–231, 2019.

[6] Krishnan, R. S., Julie, E. G., Robinson, Y. H., Raja, S., Kumar, R., & Thong, P. H. Fuzzy logic based smart irrigation system using internet of things. *Journal of Cleaner Production*, *252*, 2020.

[7] Sri Kusumadewi and Hari Purnomo. 2019, Fuzzy Logic Applications for Decision Support. Yogyakarta: Science Graha.

[8] Meimaharani, R., and Listyorini, T. Analysis of Sugeno's Fuzzy Inference System in Determining Land Sales Prices

for Minimarket Development, SIMETRIS Journal, 5(1): 89-96, 2014

[9] Putri, AD, and Effendi. Fuzzy Logic To Determine The Best Kiosk Locations In Kepri Mall Using The Artificial Intelligence Sugeno Method, Journal of Edik Informatics Research in the Field of Computer Science and Informatics Education, 3: 49-59, 2019.