Position Control System On Autonomous Vehicle Movement Using Fuzzy Logic Methods

By Suci Dwijayanti

Position Control System On Autonomous Vehicle Movement Using Fuzzy Logic Methods

Bhakti Yudho Suprapto, Diah Rahmah Dini, Muhammad Naufal Ghiffari Iskandar, Patrick Kusuma Wijaya, Rendyansyah, Suci Dwijayanti
dept. of electrical engineering
Faculty of engineering
Palembang, Indonesia
bhakti@ft.unsri.ac.id, diahrahmahdini13@gmail.com, nagihifari@gmail., patrick_cluvert@yahoo.com, rendyansyah.ilkom@gmail.com, sucidwijayanti@ft.unsri.ac.id

***Abstract*— An autonomous vehicle is designed to be driven automatically without a crew controlling it. The autonomous vehicle can ease the people in driving. Thus, a control system is important to ensure the autonomous electric vehicle run properly. Various control systems can be implemented on the autonomous vehicle. However, the previous studies have shown that the inaccuracy and inconsistency may still occur. Thus, this study presents the combination of compass and fuzzy logic to control the position of the autonomous vehicle. The Sugeno fuzzy logic method is used to control the position of the movement of autonomous vehicle by considering several inputs, such as the direction to the destination, the position of the destination, and the distance to the intended target. Meanwhile, the rotational speed of the motor becomes the output. In this study, the autonomous vehicle was run in Universitas Sriwijaya located in two locations, namely at Palembang Campus, and Indralaya Campus. The results show that the autonomous vehicle was able to reach the destination position with the motor speed output on the autonomous electric vehicle which was read according to the fuzzy. This study shows that fuzzy rule for 5 memberships function has the lowest heading error of 6.8 degrees compared to 3 memberships function. Nevertheless, 3 memberships function has the shortest time to reach the destination. The results of this study indicate that the control system using the fuzzy logic method works well.**

***Keywords*—MPU6050, ublox neo M8N, position control, autonomous electric vehicle, fuzzy logic**

I. Introduction

Technology has developed very rapidly, including autonomous vehicles. Such a vehicle is helpful because the accident rate is getting higher due to the driver's negligence or conditions that make him impossible to drive, such as drowsiness and unfocused driving. Those reasons become the trigger in the development of autonomous vehicles in Indonesia.

Autonomous electric vehicle is an unmanned vehicle designed in such a way to ease the drivers to travel to various areas safely and comfortably. In addition, autonomous electric vehicles are also widely used by elderly and people with disabilities whose circumstances do not allow them to drive a vehicle [1]. This autonomous electric vehicle runs automatically without any intervention from the driver and can minimize traffic accidents because this autonomous vehicle has various sensors that can detect and avoid objects around the vehicle. In addition, the autonomous vehicles are equipped with a system to find the coordinates and direction of the vehicle.

The autonomous electric vehicle is self-driving that can run automatically and move along a predetermined route or path so the passengers can get security and comfortability to reduce the rate of traffic accidents. The autonomous electric vehicles require a position control system to move according to a predetermined route or path to perform self-driving.

Some previous studies have discussed the position control for autonomous vehicles using various sensors, such as Light Detection and Ranging (LiDAR)[2], Global Positioning System (GPS)[3], ultrasonic sensors[4], [5], and compass sensors[3], [5], [6]. The results obtained by the LiDAR sensor have the best results compared to GPS, ultrasonic sensors, and compass sensors. However, LiDAR is the most expensive compared to GPS, ultrasonic sensor, and compass. In terms of use, GPS is easier to use to determine coordinates, but GPS has several weaknesses, one of which is the inaccurate information provided by the Google Maps API [7]. Ultrasonic sensor is also easy to use. However, it is less effective because the maximum distance to be able to be read is only 4 meters.

Apart from sensors, another factor to consider in position control is the method used. Several studies of autonomous control use the Proportional Integral Derivative (PID) method[4], artificial neural network (ANN)[8], and fuzzy logic[9]. PID control is a fine conventional control with a mathematical form that change the error to zero. However, PID is less stable if the input data is too much, and the overshoot depends on the proportional, integral, and differential parameters[10]. On the other hand, the ANN can get a low value of error output. However, ANN requires quite a lot of training data so that the results obtained are optimal.

Based on the shortcomings in previous studies that have described the sensors and methods used for autonomous position control, there are still inaccuracies and inconsistencies. So, this study uses a compass as a position control system for the movement of autonomous vehicles using a fuzzy logic control system as the algorithm. The fuzzy logic method can help reduce errors that occur in the reading of routes and directions by the sensors. In addition, the advantage of the fuzzy logic control system is that the system design concept in this method is complex and easier to be implemented. Thus, a fuzzy logic control system is implemented as a position control system for the movement of the autonomous vehicle using a compass sensor to obtain accurate and stable results. The alignment of movement on the autonomous vehicle can be achieved when there is a change in position from the initial location to the destination location automatically and accurately.

978-1-6654-5512-1/22/$31.00 ©2022 IEEE

The paper is organized as follows: Section 2 gives an overview of the Fuzzy Logic. Section 3 shows the method performed in this study. The results and discussions are presented in Section 4. Finally, the paper is concluded in Section 5.

II. METHOD

Hardware Design

In this study, several devices are used to support the implementation of an autonomous vehicle, such as: Ublox Neo M8N, MPU6050, Arduino Mega 2560, DC Motor, and ESP8266 Module.

The position of the components used in this study is designed as can be seen in Fig.1.

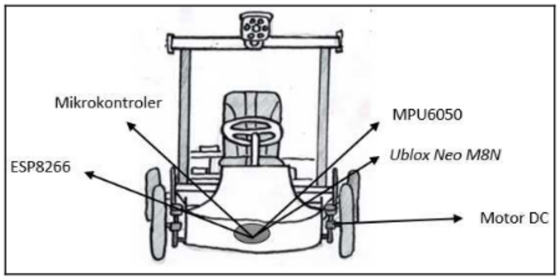


Fig. 1. Design of component placement on autonomous electric vehicles

Position Control System Design

The design of the position control system for the movement of autonomous electric vehicle can be seen in Fig. 2. The process of fuzzy logic can be seen in Fig. 3.

In this study, the inputs are in the form of the direction of the vehicle and the route to reach the destination coordinate point. Table I is the membership function of the direction towards the autonomous electric vehicle, Table II is the membership function of the target distance, and Table III is the membership function of the motor speed output.

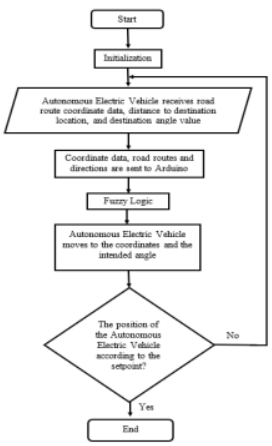


Fig. 2. System Flowchart

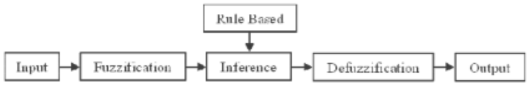


Fig. 3. Block diagram of Fuzzy Logic [10]

TABLE I. MEMBERSHIP FUNCTIONS FOR VEHICLE DIRECTIONS

Direction (°)			Variable	Variable Description
3 Members	*5 Members*	*7 Members*		
(-125) – (-10)	(-125) – (-55)	(-125) – (-83)	Left Broken	LB
–	–	(-85) – (-43)	Left	L
–	(-75) – (-5)	(-45) – (-3)	Slanted Left	SL
(-15) – 15	(-10) – 10	(-5) – 5	Straight	S
–	5 – 75	3 – 45	Slanted Right	SR
–	–	43 – 85	Right	R
10 – 125	55 – 125	83 – 125	Right Broken	RB

TABLE II. MEMBERSHIP FUNCTION DISTANCE DESTINATION

Distance (meters)			Variable	Variable Description
3 Members	*5 Members*	*7 Members*		
–	–	6 – 47	Very Close	VC
–	6 – 76	37 – 83	Quite Close	QC
6 – 100	56 – 126	73 – 119	Close	C
90 – 174	106 – 158	109 – 155	Medium	M
164 – 200	138 – 208	145 – 191	Far	F
–	188 – 258	181 – 227	Quite Far	QF
–	–	217 - 258	Very Far	VF

TABLE III. MOTOR MOVEMENT OUTPUT MEMBERSHIP FUNCTION

PWM				Variable	Variable Description
Motor1	*Motor2*	*Motor3*	*Motor4*		
-65	135	-85	135	Left Broken	-2
-20	120	-40	120	Slanted Left	-1
75	75	95	75	Straight	0
120	-20	140	-20	Slanted Right	1
135	-65	155	-65	Right Broken	2

System Evaluation

After designing the hardware and software, the next step is data collection and evaluation. Data retrieval and evaluation are carried out on the designed system to determine the ability of the system to achieve the desired goals. Data collection and evaluation are carried out at Universitas Sriwijaya which has two campuses, Palembang campus as first test location and Indralaya campus as second test location. The map for both locations can be seen in Fig. 3 and 4, respectively. The purpose of evaluation is to determine the performance and the error rate on the designed system.

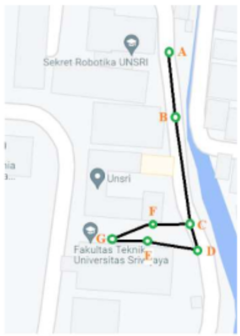


Fig. 4. First test location map

Fig. 5. Second test location map

III. Result and Discussion

This section discusses the results of position control of autonomous vehicle using the fuzzy method to produce alignment and accuracy of the movement of the autonomous vehicle in moving positions.

A. Results of Autonomous Electric Vehicle Design

The resulting design of this tool is carried out before testing the system, namely by providing various components needed by the prototype autonomous electric vehicle, such as sensors and microcontrollers. The design of this autonomous vehicle prototype consists of mechanical design and wiring design for the components used. The components used in this prototype are Ublox Neo M8N, MPU6050 and four 12 V DC motors which are controlled using the Arduino Mega microcontroller. The results of the design of this tool can be seen in Fig. 6.

Fig. 6. Prototype of an autonomous electric vehicle

B. Data Coordinates and Routes

The road routes are evaluated in two locations, namely at Universitas Sriwijaya, Palembang campus for the first test route and Indralaya campus for the second test route. This test route was taken from latitude and longitude readings on the Ublox Neo M8N GPS for the first route and from Google Maps readings for the second route. The first test route consists of 7 coordinates, which are represented by letters starting from A to G which can be seen in Table IV. There are five routes taken within the Faculty of Engineering, Palembang campus for the first test to be carried out which can be seen in Table V.

The second test route consists of 23 coordinate points, which are represented by the letters A to W. The coordinates of the second test route can be seen in Table VI and the test route in Table VII.

The coordinate points that have been created is then used as targets to be traversed by the autonomous electric vehicle. The coordinate point data is inputted into a website that can be accessed to select the desired travel route. The website address for selecting the route is siapbot1.com/pathfind/. Then, the route selected sent to the microcontroller using the ESP8266 module with an intermediary program on the Arduino.

TABLE IV. Coordinates Of First Test Route

No.	Location	Latitude	Longitude
1	Waypoint A	-2.984024	104.734252
2	Waypoint B	-2.984283	104.734275
3	Waypoint C	-2.984644	104.734352
4	Waypoint D	-2.984724	104.734359
5	Waypoint E	-2.984707	104.734268
6	Waypoint F	-2.984658	104.734252
7	Waypoint G	-2.984705	104.734169

TABLE V. First Test Route

No.	Test Route	Representation on the map	Distance (meters)
1	A>B>C>D>E		89.2
2	B>C>F>G		62.94
3	G>F		10.6
4	D>C>F		20.14
5	E>G		11

TABLE VI. Coordinates of Second Test Route

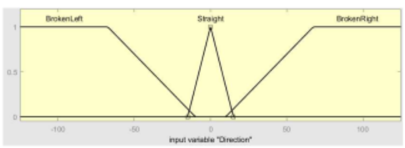
No.	Location	Latitude	Longitude
1	Waypoint A	-3.217456	104.646508
2	Waipoint B	-3.216977	104.646513
3	Waypoint C	-3.216721	104.646551
4	Waypoint D	-3.216112	104.647109
5	Waypoint E	-3.215489	104.647742
6	Waypoint F	-3.215500	104.648622
7	Waypoint G	-3.214244	104.647729
8	Waypoint H	-3.213909	104.647735
9	Waypoint I	-3.213851	104.648532
10	Waypoint J	-3.213951	104.650844
11	Waypoint K	-3.215532	104.650835
12	Waypoint L	-3.216698	104.650866
13	Waypoint M	-3.216704	104.651128
14	Waypoint N	-3.216689	104.650618
15	Waypoint O	-3.216036	104.650439
16	Waypoint P	-3.216669	104.649535
17	Waypoint Q	-3.215775	104.650308
18	Waypoint R	-3.215501	104.649569
19	Waypoint S	-3.216258	104.649535
20	Waypoint T	-3.216682	104.648646
21	Waypoint U	-3.216681	104.647740
22	Waypoint V	-3.216287	104.647742
23	Waypoint W	-3.216681	104.647264

C. System Testing Using Fuzzy

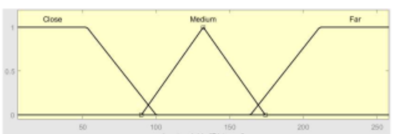
In this study, the testing uses 2 input variables, namely, the direction of the vehicle and the distance to the target coordinates. The test inputs for the direction facing the vehicle are, broken left, tilted left, straight, tilted right and broken right. Meanwhile, the target distance input is also in the form of very far, far, medium, close, and very close. The fuzzy curves for the input facing direction and the target distance input can be seen in Figs. 7, 8, and 9. The rules can be seen in Tables VIII, IX, and X.

TABLE VII. SECOND TEST ROUTE

No.	Test Route	Representation on the map	Distance (meters)
1	A>B>C>W		161.5
2	A>B>C>W>U>V		258.2
3	A>B>C>D>E>G>H>I		537.5
4	A>B>C>D>E>F>R		476.1
5	A>B>C>W>U>T>P>S		459.8



(a)



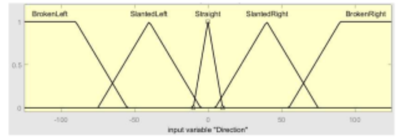
(b)

Fig. 7. Fuzzy curve input 3 Members (a). Forward Direction. (b). Target Distance.

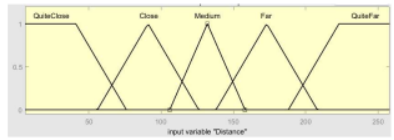
The last step in the fuzzy system is defuzzification, which aims to convert the results of the inference engine and is displayed in the form of fuzzy sets to real numbers. The defuzzification process in this study uses Sugeno's fuzzy rules for Order Zero with the weight average method, where the value taken is the average value using the membership function. The equation of the weight average method can be seen in the following equation:

$$WA = \frac{\alpha 1z1+\alpha 2z2+\alpha 3z3+\cdots+\alpha nzn}{\alpha 1+\alpha 2+\alpha 3+\cdots+\alpha n} \quad (1)$$

Testing location in Palembang campus (first location) uses 3 test routes and Indralaya campus (second location) uses 2 test routes to collect data. Tables XI, XII, and XIII are a sample of the tests carried out at the first location:

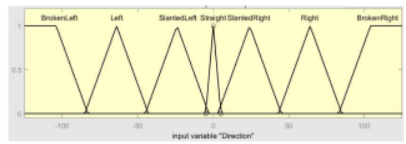


(a)

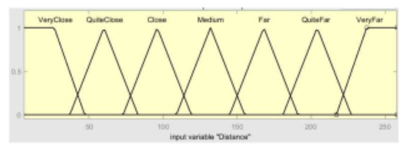


(b)

Fig. 8. Fuzzy curve input 5 Members (a). Forward Direction. (b). Target Distance.



(a)



(b)

Fig. 9. Fuzzy curve input 7 Members (a). Forward Direction. (b). Target Distance.

TABLE VIII. FUZZY RULES 3 MEMBERS

Rules Number	Input		Output
	Direction	*Distance*	*Motor Movement*
0	LB	F	-2
1	LB	M	-2
2	LB	C	-1
3	S	F	0
4	S	M	0
5	S	C	0
6	RB	F	2
7	RB	M	2
8	RB	C	1

After testing the system using fuzzy, the latitude and longitude data obtained are plotted into a graph to see if the route traversed by the autonomous electric vehicle is following the test route. Then, the current heading of each system test route is compared with the target heading against time to see the magnitude of the heading error.

1) System Testing on D→C→F 3 Members

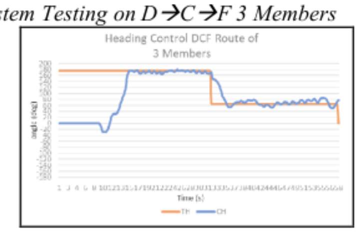


Fig. 10. Graph of Heading Control Results on D→C→F 3 Members Routes

TABLE IX. FUZZY RULES 5 MEMBERS

Rules Number	Input		Output
	Direction	*Distance*	*Motor Movement*
0	LB	QF	-2
1	LB	F	-2
2	LB	M	-2
3	LB	C	-1
4	LB	QC	-1
5	SL	QF	-1
6	SL	F	-1
7	SL	M	-1
8	SL	C	-1
9	SL	QC	-1
10	S	QF	0
11	S	F	0
12	S	M	0
13	S	C	0
14	S	QC	0
15	SR	QF	1
16	SR	F	1
17	SR	M	1
18	SR	C	1
19	SR	QC	1
20	RB	QF	2
21	RB	F	2
22	RB	M	2
23	RB	C	1
24	RB	QC	1

TABLE X. FUZZY RULES 7 MEMBERS

Rules Number	*Input*		*Output*
	Direction	*Distance*	*Motor Movement*
0	LB	VF	-2
1	LB	QF	-2
2	LB	F	-2
3	LB	M	-2
4	LB	C	-2
5	LB	QC	-1
6	LB	VC	-1
7	L	VF	-2
8	L	QF	-2
9	L	F	-2
10	L	M	-2
11	L	C	-1
12	L	QC	-1
13	L	VC	-1
14	SL	VF	-2
15	SL	QF	-2
16	SL	F	-1
17	SL	M	-1
18	SL	C	-1
19	SL	QC	-1
20	SL	VC	-1
21	S	VF	0
22	S	QF	0
23	S	F	0
24	S	M	0
25	S	C	0
26	S	QC	0
27	S	VC	0
28	SR	VF	2
29	SR	QF	2
30	SR	F	1
31	SR	M	1
32	SR	C	1
33	SR	QC	1
34	SR	VC	1
35	R	VF	2
36	R	QF	2
37	R	F	2
38	R	M	2
39	R	C	1
40	R	QC	1
41	R	VC	1
42	RB	VF	2
43	RB	QF	2
44	RB	F	2
45	RB	M	2
46	RB	C	2
47	RB	QC	1
48	RB	VC	1

TABLE XI. SYSTEM TESTING ON D→C→F 3 MEMBERS ROUTE

Start → Target	DT (meters)	CT (degree)	TH (degree)	HE (degree)	MMO
D → C	11	0	174	174	SR
D → C	11	0	174	174	SR
D → C	11	0	174	174	SR
D → C	11	0	174	174	SR
D → C	11	0	174	174	SR
D → C	11	0	174	174	SR
D → C	11	0	174	174	SR
D → C	11	0	174	174	SR
D → C	11	0	174	174	SR
D → C	11	-1	174	175	SR
C → F	9	65	76	-11	S
C → F	9	65	68	-3	S
C → F	9	65	57	8	S
C → F	9	65	52	13	S
C → F	9	65	50	15	S
C → F	9	65	51	14	S
C → F	9	65	57	8	S
C → F	9	65	63	2	S
C → F	9	65	73	-8	S
C → F	2	65	77	-12	S

Note: DT: distance target; CH: current heading; TH: target heading, and HE: heading error; MMO: motor movement output

TABLE XII. SYSTEM TESTING ON D→C→F 5 MEMBERS ROUTE

Start → Target	DT (meters)	CT (degree)	TH (degree)	HE (degree)	MMO
D → C	10	4	174	170	SR
D → C	10	5	174	169	SR
D → C	10	7	174	167	SR
D → C	10	8	174	166	SR
D → C	10	9	174	165	SR
D → C	10	9	174	165	SR
D → C	10	7	174	167	SR
D → C	10	5	174	169	SR
D → C	10	4	174	170	SR
D → C	10	11	174	163	SR
C → F	4	65	37	28	SR
C → F	4	65	46	19	SR
C → F	4	65	58	7	S
C → F	4	65	67	-2	S
C → F	4	65	70	-5	S
C → F	4	65	71	-6	S
C → F	4	65	75	-10	S
C → F	4	65	75	-10	S
C → F	4	65	74	-9	S
C → F	2	65	63	2	S

2) System Testing on D→C→F 5 Members

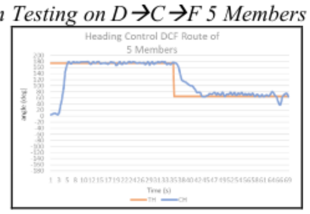


Fig. 11. Graph of Heading Control Results on D→C→F 5 Members Routes.

TABLE XIII. SYSTEM TESTING ON D→C→F 7 MEMBERS ROUTE

Start → Target	DT (meters)	CT (degree)	TH (degree)	HE (degree)	MMO
D → C	11	166	174	8	SR
D → C	11	170	174	4	S
D → C	11	175	174	-1	S
D → C	11	176	174	-2	S
D → C	11	176	174	-2	S
D → C	11	177	174	-3	S
D → C	11	177	174	-3	S
D → C	11	178	174	-4	S
D → C	11	179	174	-5	SL
D → C	11	176	174	-2	S
C → F	3	65	65	0	S
C → F	3	66	65	-1	S
C → F	3	67	65	-2	S
C → F	3	67	65	-2	S
C → F	3	68	65	-3	S
C → F	3	68	65	-3	S
C → F	3	69	65	-4	S
C → F	3	69	65	-4	S
C → F	3	70	65	-5	SL
C → F	2	67	65	-67	SL

3) System Testing on D→C→F 7 Members

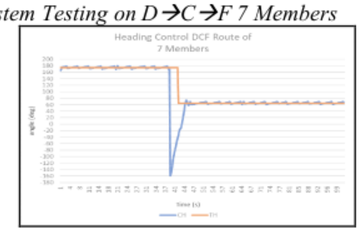


Fig. 12. Graph of Heading Control Results on D→C→F 7 Members Routes

Fig. 10 shows a graph of controlling headings on the D→C→F 3 members route against time, Fig. 11 shows the results of controlling headings on the D→C→F 5 members route against time, and Fig. 12 shows the results of controlling headings on the D→C→F 7 members route against time. CH is the current heading represented in blue, and TH is the target heading represented in orange. The target heading from point D to point C is 174 degrees, and from the point D to point F is65 degrees. The time needed to reach the destination point with 3 members is 58 seconds, namely from point D to point F with a distance of 20.14 meters, and an average heading error of 47 degrees. Furthermore, the time needed to reach the destination point from point D to point F with 5 members is 69 seconds, with an average heading error of 18.5 degrees. Then, the time needed to reach the destination point, namely from point D to point F with 7 members is 99 seconds, with an average heading error of 11.4 degrees. In addition to the sample data and test chart for the D→C→F route that has been attached above; other routes have been tested. Overall, test routes have been carried out in 5 test routes for the first test location, and 2 test routes for the second test location.

Based on the system testing that has been done, the travel time required to reach the destination coordinates using fuzzy of 3 members is faster than fuzzy of 5 members and 7 members. This is caused by the number of fuzzy members, where the fewer the number of fuzzy members, the less time it will take to get to the destination coordinates. Meanwhile, the results of heading control using fuzzy 7 Member are more stable than using fuzzy 3 Member and fuzzy 5 Member. This is also caused by the number of fuzzy members, where the greater the number of fuzzy members, the smaller the heading error value when moving positions on an autonomous electric vehicle. This test using fuzzy 7 members is carried out to prove the assumption that the fewer the number of fuzzy members, the less time it will take to get to the destination coordinates, and the fuzzier members, the smaller the heading error value when moving positions on the autonomous vehicle is correct.

IV. CONCLUSION

This study has shown that the fuzzy logic control system can be used as a position control system for the movement of autonomous electric vehicles, where the prototype of the autonomous vehicle provides an appropriate response, is quite stable, and is accurate based on the given rules. 2. The ability of the autonomous vehicle to move positions using a fuzzy with 5 members is more stable than using a fuzzy of 3 members, it can be seen from the average heading error of system testing of 6.8 degrees for a fuzzy of 5 members, and 12.2 degrees for a fuzzy of 3 members. However, the time required to reach the destination point using a fuzzy of 5 members is longer than using a fuzzy of 3 members, which is evidenced by the average time needed to reach the coordinates of the destination test for the first location and the second location with a fuzzy of 5 members, namely during 440.5 seconds, and with 3 members fuzzy for 319.2 seconds.

REFERENCES

[1] J. Hecht, "Lidar for Self-Driving Cars," *Opt. Photonics News January 2018*, pp. 28–33, 2018.

[2] M. Aldibaja, N. Suganuma, and K. Yoneda, "LIDAR-Data Accumulation Strategy To Generate High Definition Maps For Autonomous Vehicles," *2017 IEEE Int. Conf. Multisens. Fusion Integr. Intell. Syst. (MFI 2017)*, pp. 422–428, 2017.

[3] A. A. Othman and M. M. H. Mahjoub, "Self Navigated Robot using GPS and Compass," University of Science and Technology, 2017.

[4] S. Surendharan and J. Jennifer Ranjani, "Environment conscious automated vehicle navigation system using PID controller," *Indian J. Sci. Technol.*, vol. 9, no. 48, 2016, doi: 10.17485/ijst/2016/v9i48/108017.

[5] A. M. Fathan, A. N. Jati, and R. E. Saputra, "Mapping algorithm using ultrasonic and compass sensor on autonomous mobile robot," *ICCEREC 2016 - Int. Conf. Control. Electron. Renew. Energy, Commun. 2016, Conf. Proc.*, pp. 86–90, 2017, doi: 10.1109/ICCEREC.2016.7814986.

[6] T. Van-Tang PHAM, Dinh-Chinh NGUYEN, Quang-Huy TRAN, Duc-Trinh CHU and Duc-Tan, "Thermal Stability of Magnetic Compass Sensor for High Accuracy Positioning Applications," *Sensors & Transducers*, vol. 195, no. 12, pp. 1–8, 2015.

[7] N. Xia, L. Cheng, S. Chen, X. Wei, W. Zong, and M. Li, "Accessibility based on Gravity-Radiation model and Google Maps API: A case study in Australia," *J. Transp. Geogr.*, vol. 72, no. April, pp. 178–190, 2018, doi: 10.1016/j.jtrangeo.2018.09.009.

[8] E. N. Budisusila, B. Arifin, S. A. D. Prasetyowati, B. Y. Suprapto, and Z. Nawawi, "Artificial neural network algorithm for autonomous vehicle ultrasonic multi-sensor system," *EECCIS 2020 - 2020 10th Electr. Power, Electron. Commun. Control. Informatics Semin.*, pp. 128–131, 2020, doi: 10.1109/EECCIS49483.2020.9263459.

[9] H. Omrane, M. S. Masmoudi, and M. Masmoudi, "Fuzzy Logic Based Control for Autonomous Mobile Robot Navigation," *Comput. Intell. Neurosci.*, vol. 2016, 2016, doi: 10.1155/2016/9548482.

[10] Gaurav and A. Kaur, "Comparison between Conventional PID and Fuzzy Logic Controller for Liquid Flow Control: Performance Evaluation of Fuzzy Logic and PID Controller by Using MATLAB/Simulink," *Ijitee*, vol. 1, no. 1, pp. 84–88, 2012.

Position Control System On Autonomous Vehicle Movement Using Fuzzy Logic Methods

ORIGINALITY REPORT

8%
SIMILARITY INDEX

MATCH ALL SOURCES (ONLY SELECTED SOURCE PRINTED)

★Markus Hermawan, Zaenal Husin, Hera Hikmarika, Suci Dwijayanti, Bhakti Yudho Suprapto. "Road Identification using Convolutional Neural Network on Autonomous Electric Vehicle", 2021 8th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI), 2021 — 3%
Crossref

EXCLUDE QUOTES	ON	EXCLUDE SOURCES	OFF
EXCLUDE BIBLIOGRAPHY	ON	EXCLUDE MATCHES	OFF