International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 4 Issue 1, December 2019 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Motion Control of Mobile Robots using Fuzzy Controller

Halil Çetin[1], Akif Durdu[2]

[1,2]Department of Electrical and Electronics Engineering,
[1]Konya Technical University, Konya, Türkiye
[2]Ohio State University, Columbus, USA

ABSTRACT

In this study, a motion control based on fuzzy logic is designed so that mobile robots can make the turns they make when moving in an unknown environment more flexibly and smoothly. Fuzzy logic control is suitable for controlling mobile robots because the results can be obtained under uncertainty. Fuzzy logic control is implemented through a set of rules created using expert knowledge. The fuzzy rules created in this paper are designed to allow mobile robots to escape from obstacles, to avoid contact with walls, and to make soft turns without harming their structure. According to the obtained simulation results, the mobile robot has been shown to have successful results in fuzzy logic based motion control.

KEYWORDS: *fuzzy logic; fuzzy logic controller; mobile robot; simulation; motion control*

How to cite this paper: Halil Çetin | Akif Durdu "Motion Control of Mobile Robots using Fuzzy Controller" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-4 | Issue-1, December 2019, pp.637-641, URL: www.ijtsrd.com/papers/ijtsrd29626.pdf

IJTSRD29626

I. INRODUCTION

Mobile robots are mechanical devices that are capable of moving autonomously in a given environment. The autonomous movement of the robots is achieved by taking the information in the environment by using the distance sensors or imaging methods. The most common sensors are the distance sensors (ultrasonic, laser, etc.) that have the ability to measure distances to obstacles in the paths that robots follow. Advanced autonomous robots have to be equipped with abilities when they are left in a certain environment, moving along the corridor, following the walls, turning round the corners and entering the open spaces of the rooms [1]. The autonomous moving robots that have existed since the 1950s have been used primarily for the storage of factories and cargoes in mining. Today, the development of technology and especially the development of signal processing technology, the use of mobile robots has become widespread. Especially in the defense industry, it has had an important place in search and rescue operations and space exploration. Generally, to be able to act autonomously of wheeled mobile robot is based on a computer or sensors help the processor and the engine driven by perceptions around him [2].

Many researchers used fuzzy logic approach for mobile robot movements. Raguraman et al. [3] simulated motion of the mobile robot which has sensors by using fuzzy logic. They stated that the mobile robot can avoid obstacles and follow a trajectory. Sang et al. [1] used fuzzy logic to control movement of a sensor-based wheeled robot along a predefined path. Gaonkar et al. [4] used fuzzy logic to develop intelligent autonomous mobile robots using sensors to counter unexpected changes in the environment and to avoid obstacles.

Mobile robots are used in many applications; they move in dynamic environment having unknown obstacles instead of moving on a predetermined route. Considering this situation, robots, which can detect the obstacles that are not affected by the changes that may occur in the environment and reach their targets without hitting them and damaging their mechanical parts, should be designed. In this study, a robot that can be operated in a dynamic environment is realized in a fuzzy logic based motion control simulation environment. The inputs of the fuzzy logic controller are the values of the front, right and left ultrasonic sensors of the robot and the angle of the target direction, and the output of the controller is the rotation angle of the mobile robot. A control model was created in accordance with the data given from the sensors. A series of fuzzy logic rules have been developed based on expert knowledge under various circumstances.

In the following sections of this paper, the applied fuzzy logic control method first will be mentioned, and then the simulation and the results obtained will be given and the future work plan will be explained.

II. FUZZY LOGIC CONTROL

Zadeh [5] suggested a method of modeling human logic using fuzzy arrays. Some features that may be mentioned for fuzzy logic; i) uses certain information in a systematic way, ii) it can be considered as Boolean logic because of allowing the processing relative accuracy values between completely right and completely wrong, iii) it is an ideal approach to model complex systems where there is an uncertain model. With fuzzy logic control, the uncertain and suspicious knowledge of a robot is evaluated and an appropriate output is produced.

There are three stages in the fuzzy logic control; fuzzification, fuzzy inference and defuzzification [6-8]. If these are briefly mentioned:

1. **Fuzzification:** No information is lost in the fuzzification process and it is simply transformed from a real value to a degree of membership functions. Membership functions defined on input variables are used to determine the accuracy of the actual values. Each input value must be converted into a form within the applicable rules.

2. **Fuzzy Inference:** All entries received by the system are evaluated by using the IF-THEN rules to determine the truth values. A part of the input data is used to assign values to a given invariance. All the fuzzy results obtained from the result mechanism are summed to a specific result. Different techniques are used to find the most appropriate results. Examples are Mamdani model, Takagi Sugeno model and Tskamoto model.

3. **Defuzzification:** After the rules are processed, an internal refinement mechanism is implemented in which the proposed action is transformed into real values. This step is necessary because the control of physical systems requires discrete signals.

III. SIMULATION AND APPLICATION RESULTS

A. System design

As previously mentioned, the fuzzy logic systems are used for modeling experience from experts in any situation. The test simulation environment of the fuzzy logic based control system was shown in the following Figure 1.

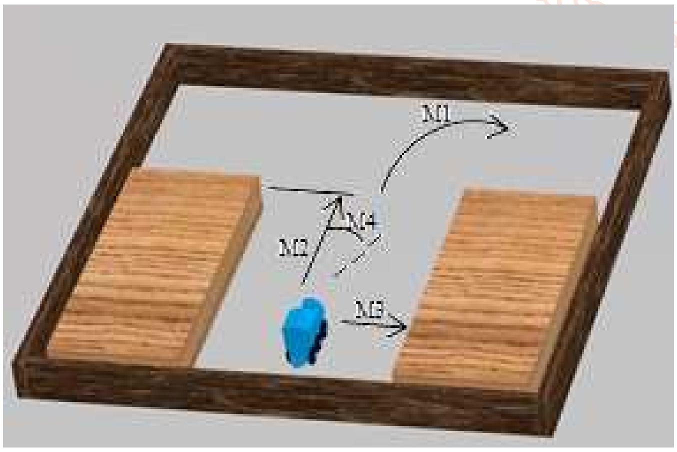

Figure1. Test environment

In the rule base of the fuzzy logic control system, four input variables M1, M2, M3 and M4 and one output variable Y are identified. M1-variable is direction to rotate relative to the mobile robot plan, M2-variable is the vertex distance to the end of the obstacle, M3-variable is the distance to the right wall, M4-variable refers to the angle with respect to the path of the mobile robot and Y-output variable mobile robot is intended to allow orientation of the front wheel assembly of a motor of the wheel angle. In this study, design was made considering that the wheel speeds are constant. The state of these variables and their relation to the mobile robot are shown in Figure 1.

In the fuzzy logic design of the study, two membership functions for M1, two for M2, three for M3, three for M4 and three for Y were determined. As mentioned before, membership functions and shapes for fuzzy logic input and output are given in the following Figure 2. The rule table for the design of the fuzzy logic system is given in Table 1.

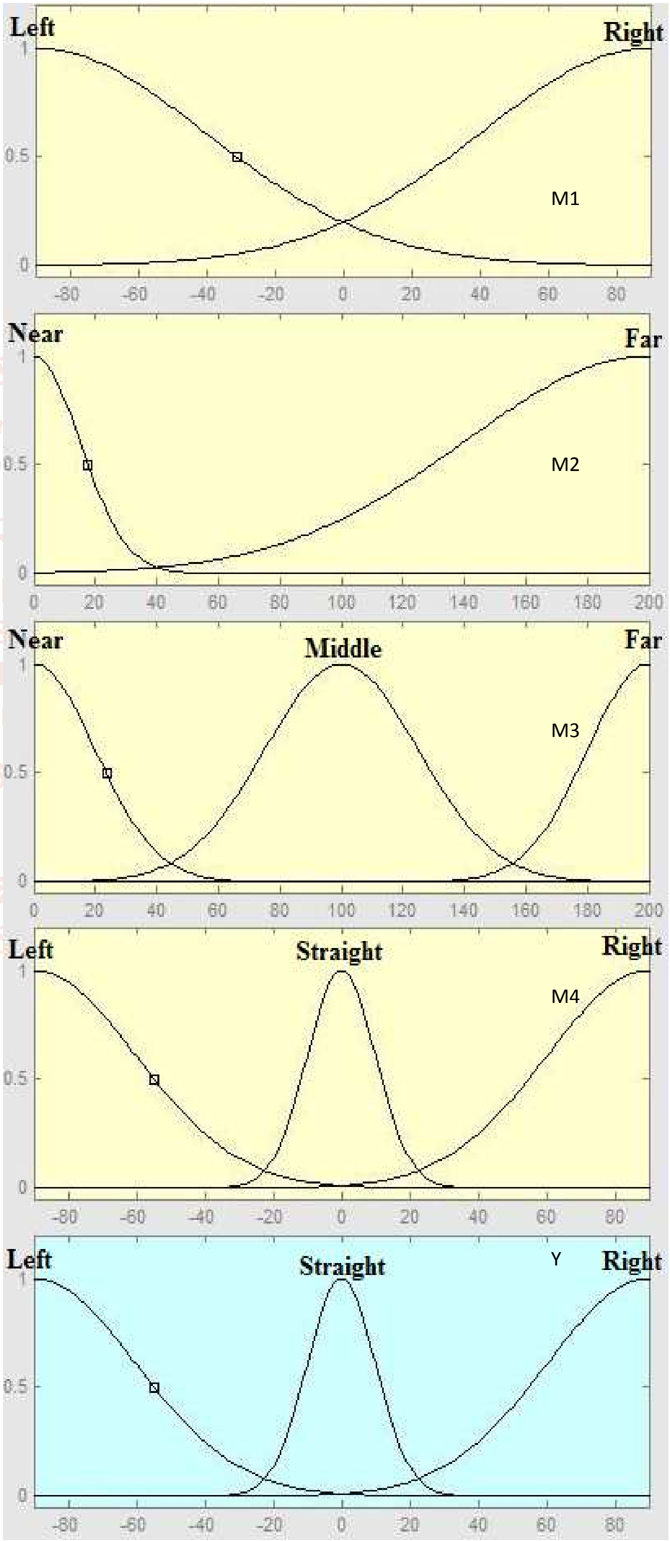

Figure 2. The membership functions for the M1, M2, M3, M4 inputs and Y output of the fuzzy logic system from top to bottom respectively

	Input				Output
	Direction to be Returned M1	Distance to Corner M2	Distance to Right M3	Vehicle Angle M4	Wheel Angle Y
1	Left	Near	Near	Left	Straight
2	Left	Near	Near	Straight	Left
3	Left	Near	Near	Right	Left
4	Left	Near	Middle	Left	Straight
5	Left	Near	Middle	Straight	Left
6	Left	Near	Middle	Right	Left
7	Left	Near	Far	Left	Right
8	Left	Near	Far	Straight	Right
9	Left	Near	Far	Right	Straight
10	Left	Far	Near	Left	Straight
11	Left	Far	Near	Straight	Left
12	Left	Far	Near	Right	Left
13	Left	Far	Middle	Left	Right
14	Left	Far	Middle	Straight	Straight
15	Left	Far	Middle	Right	Left
16	Left	Far	Far	Left	Right
17	Left	Far	Far	Straight	Right
18	Left	Far	Far	Right	Straight
19	Right	Near	Near	Left	Straight
20	Right	Near	Near	Straight	Left
21	Right	Near	Near	Right	Left
22	Right	Near	Middle	Left	Right
23	Right	Near	Middle	Straight	Right
24	Right	Near	Middle	Right	Straight
25	Right	Near	Far	Left	Right
26	Right	Near	Far	Straight	Right
27	Right	Near	Far	Right	Straight
28	Right	Far	Near	Left	Straight
29	Right	Far	Near	Straight	Left
30	Right	Far	Near	Right	Left
31	Right	Far	Middle	Left	Right
32	Right	Far	Middle	Straight	Straight
33	Right	Far	Middle	Right	Left
34	Right	Far	Far	Left	Right
35	Right	Far	Far	Straight	Right
36	Right	Far	Far	Right	Straight

Table1. The rule table of the designed fuzzy logic system

B. Testing of the designed system

In the design section above, a trial example is made to test the designed fuzzy logic motion control on mobile robots, within the membership functions and rule table specified in the design section above. The road routes of the simulation applications, the positions of the mobile robots and the paths followed are as shown in Figure 3. The numerical outputs obtained are given in Table 2.

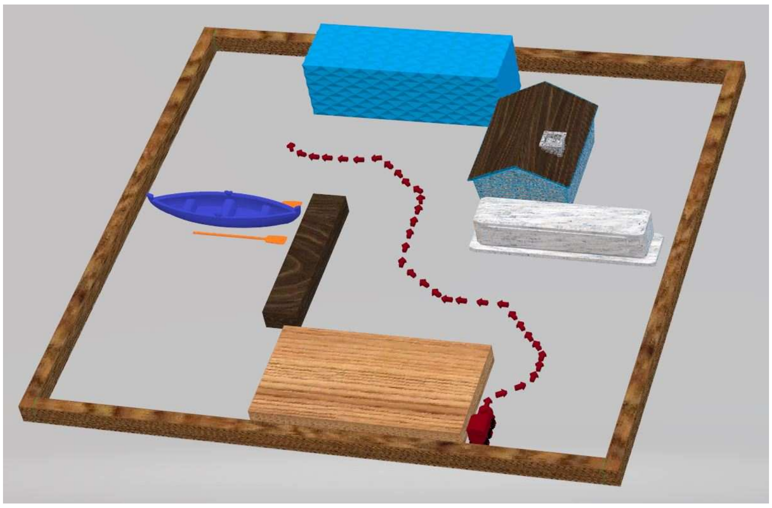

Figure3. The map used to test the designed system and the obtained route

	Input				Output
	Direction to be Returned M1	Distance to Corner M2	Distance to Right M3	Vehicle Angle M4	Wheel Angle Y
1	-90	130	192,5	0	60,95
2	-90	110	175	60,95	-2,899
3	-90	90	145	58,051	-51,86
4	-90	70	122,5	6,191	-8,217
5	-90	50	120	-2,026	4,363
6	-90	30	120	2,337	-44,89
7	-90	10	140	-42,553	3,205
8	90	190	190	50,652	-0,3223
9	90	170	170	50,3297	-5,059
10	90	155	150	45,2707	-45,13
11	90	130	130	0,1407	-0,0613
12	90	90	130	0,0794	-0,06699
13	90	55	130	0,01241	-0,01915
14	90	35	130	-0,00674	32,28
15	90	10	120	32,27326	-0,5245
16	-90	200	25	-58,25124	2,285
17	-90	180	52,5	-55,96624	49,25
18	-90	160	70	-6,71624	3,047
19	-90	130	75	-3,66924	1,581
20	-90	90	75	-2,08824	1,752
21	-90	60	75	-0,33624	0,5746
22	-90	40	75	0,23836	-16,21
23	-90	20	85	-15,97164	-48,57
24	90	245	195	25,45836	18,99
25	90	225	180	44,44836	-1,588
26	90	210	165	42,86036	-10,75
27	90	180	145	32,11036	-47,29
28	90	158	130	-15,17964	10,09
29	90	123	140	-5,08964	3,274
30	90	95	140	-1,81564	1,377
31	90	70	140	-0,43864	0,5821
32	90	40	140	0,14346	15,73
33	90	15	135	15,87346	49,63

Table2: The results obtained by the test of the designed system

When the mobile robot, the rotation angle information of the examined test results that route, i.e. according to the information given in Table 2, it is seen that the designed control system operating correctly and efficiently.

Conlusıons

The intelligent controls that can be used in mobile robots, which are used in many applications in the field, can be even more involved in our lives in the near future. In this study, a fuzzy logic based control system is designed for a mobile robot moving in an unknown environment and its accuracy is tested by simulation study. According to the simulation results obtained, the fuzzy logic based motion control of the mobile robot gives successful results. On the other hand, it can be seen that a real-time application of the control of the movement of an autonomous mobile robot can be made via the designed fuzzy logic based control system. A real-time mobile robot motion control can be performed using several ultrasonic distance sensors, several DC motors, a micro controller with a fast processor, and signal processing techniques. In addition, the fact that one of the system's input parameters specifies the direction to be turned next creates the ground that will allow the system to integrate with the path planner another system.

REFERENCES

[1] Sang. S., Wu. H., Zhao J. and An Q. ''Fuzzy Logic Control for Wheeled Mobile Robots'' , *Sixth International Conference on Fuzzy Systems and Knowledge Discovery*, 2009

[2] Siba M. S., Waladin K. S.and Farah S. K , A Rule-Based System for Trajectory Planning of an Indoor Mobile Robot,*7th International Multi-Conference on Systems, Signals and Devices,* 2010

[3] Raguraman S. M., Tamilselvi D. And Shivakumar N. , ''Mobile Robot Navigation Using Fuzzy Logic Controller'' , *İnternational Conference On Control Automation Communication And Energy Conservation*, 2009

[4] Gaonkar P. K., DelSorba A and Rattan K. S, ''An İntelligent Robot System using Fuzzy Logic'',*48th Midwest Symposium* ,2005

[5] Zadeh L. A, ''Fuzzy Sets'', *İnformation and Control, vol 8 pp 338-353,* 1965

[6] Dupre M. And Yang S. X. ''Two-Stage Fuzzy Logic-Based Controller for Mobile Robot Navigation'', *İnternational Conference on Mechatronics and Automation,* 2006

[7] Ü.İlbay Bozkurt, Akif Durdu, "Modeling A Distributed Control System With Fuzzy Logic In Wireless Sensor Network Based Industrial Environments", IV. International Electric and Electronic Engineering and Technologies Conference (ELECTROTECH'16), September 29-30, 2016, Istanbul, Turkiye.

[8] Akif Durdu, Nuri Orhan, Sedat Çalışır, "Detection Of Vortex At The Deep Well Submersible Pumps By Using Fuzzy Logic Controller And Impacts On Pump Operating Characteristics", International Human and Nature Sciences: Problems and Solution Seeking Congress (IHANAS 2016), October 7-9, 2016, Sarajevo, Bosnia and Herzegovina.