Development of a Fuzzy Logic Wall Following & obstacle avoiding Mobile Robots

(Group07–explicit robot)

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Abstract *(HEADING 1)*

Abstract- The design of a fuzzy logic controller for a mobile robot that follows walls, behavior according to the given instructions, and avoids obstacles is described in this work. Maintaining a safe distance between the mobile robot and the wall is a fundamental behavior that all wall following robots should possess. This work provides an embedded fuzzy logic controller to allow a mobile robot to follow a wall smoothly and steadily. The fuzzy controller was created in MATLAB and simulated in Proteus 8.9 Professional. A differential robot is implemented with Arduino UNO to verify our technique as well as simulated using PIC16F877A. The simulated experiment and test results methods were presented to demonstrate the validity of the proposed method.

Keywords- mobile robot; wall following navigation, fuzz logic controller

Introduction *(HEADING 2)*

Mechanical device that performs given tasks and instructions called robot, either automatically or by remote control is called robot. Robotics is the engineering discipline dealing with the design, construction, and operation of robots. Mainly, these robots can be controlled by hydraulic ways, pneumatically ways or electronica ways. Robots can classified into non-adaptive robots, adaptive robots, mobile robots, stationary robot. Mobile Robots are robots with a mobile base which makes the robot move freely in the environment.

A mobile robot that can follow walls even that has interior and exterior bents, under the introduction to controls and robotics module, as well as this, can avoid obstacles if any of them are on the way. and the main and special part is this robot can have the ability to follow the wall using a fuzzy implement system which is a concept of Artificial Intelligence. Three Ultrasonic sensors are giving sight to the robot. IR sensors can be used to identify and avoid obstacles as well as can be used a buzzer to indicate the obstacles. used 3.7x2 batteries for the power and used l293d motor shield as motor controller and Arduino UNO as the microcontroller.

There been my research about this wall following with fuzzy logic, some of are In, the automated design of a fuzzy. Controller using genetic algorithms for the implementation of. the wall-following behavior in a mobile robot is described. The use of machine learning techniques. or artificial neural networks allows to automate the design of these controllers. [1]. Evolutionary algorithms adapt a wall following behavior implemented by means of fuzzy control rules. A messy coding scheme for fuzzy rules reduces the size and complexity of the rule base, with the result, that the fuzzy control design remains tractable for the genetic algorithm. An evolution strategy tunes the scaling factors for the controller's input and output and optimizes the adjustment of the sensors on the robot [2]. A fluffy regulator then, at that point, utilizes the data given by the idea of general insight to direct the robot along dividers of discretionary shape and around obstructions which are treated as a feature of a divider, except if the distance among impediment and divider permits a protected section. This paper initially presents the idea of general insight and afterward clarifies the fluffy regulator exhaustively. All enrollment capacities and the total standard base are given. The idea of general discernment along with the fluffy regulator were tried on a genuine robot performing divider following and hindrance aversion missions and a portion of the resulting trial results [3]

Methodology *(HEADING 3)*

Mobile Robot Architecture

The experimental prototype is a build on the harbored chassis made by hand, and it shown in the figure 1. Four dc motors independently control two wheels on a two axis. three ultrasonic sensors named as front sensor (FS), left sensor (LS) and right sensor (RS) comprise the sensory system of the robot. All these sensors are mounted on left and right side or front of the robot of robot to follow the left wall or right wall or avoided the obstacle.

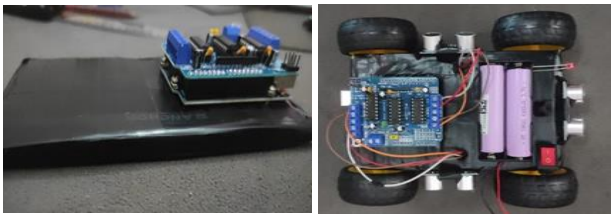

Figure 02 robot design

Circuit Design and Program

Circuits were designed for both PIC16F877A and Arduino Uno. After testing multiple times with various possible conditions, actual circuit was implemented by using Arduino UNO .

Proteus 8 Professional

This is the main simulation software that used to design the circuit. Proteus Design Suite combines ease of use with a powerful feature set to enable the rapid design, test, and layout of professional printed circuit boards. Other than designing the circuit, this simulation software was used to test robot in various conditions. These tests were done to ensure that the robot works with longer duration without losing any rated performances.

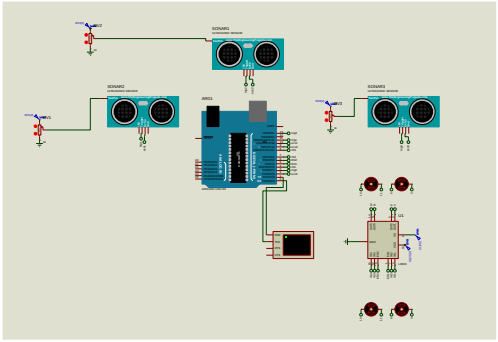

Figure 01 Proteus simulation

Implementing Fuzzy mamadani Control System Architectures

Fuzzy logic uses to increase the smoothness and accuracy of the robot. Analog sensor readings were noted before implementing code using fuzzy logic Mamdani fuzzy inference was first introduced as a method to create a control system by synthesizing a set of linguistic control rules obtained from experienced human operators [1]. In a Mamdani system, the output of each rule is a fuzzy set. Following steps were followed. Since Mamdani systems have more intuitive and easier to understand rule bases, they are well-suited to expert system applications where the rules are created from human expert knowledge

1. Sensor inputs
2. Fuzzification
3. Build up rule base (inference engine)
4. Membership functions
5. Defuzzification

	error			
Delta error		**Negative**	**Zero**	**Positive**
	Negative	NB	NS	X
	Zero	NS	X	PS
	Positive	X	PS	PB

Table 01 (input and outputs)

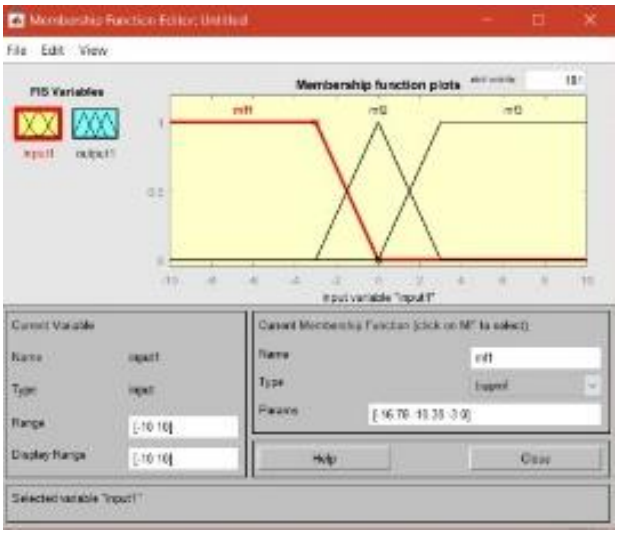

Figure 03 matlab fuzzy implementation input

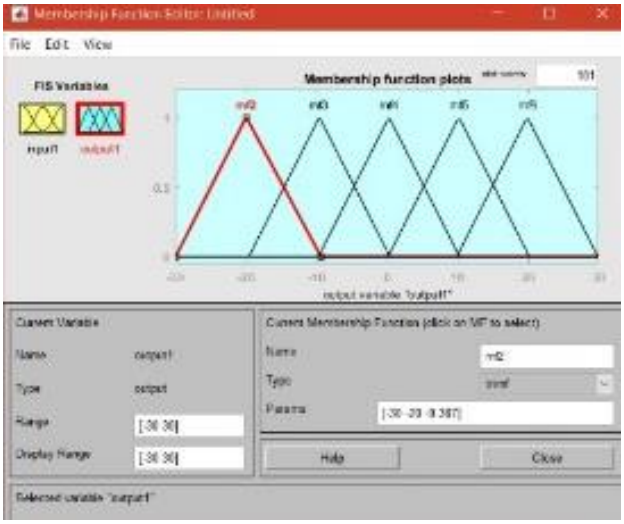

Figure 03 matlab fuzzy implementation output

Code error checking.

Before finalizing the robot, all equipment is checked using preferred methods. Some of the checking were motors, ultrasonic sensors, ultrasonic and motors poling, sensor corrupt check, motor shield as a motor driver.

After the above-mentioned tests started the final demonstration step by step. move forward turning left and right, Interior 90 degree turn, exterior 90-degree turn, obstacle avoiding, and the stop. then after that connected all functions together.

Results and Observations *(HEADING 4)*

when configuring the ultrasonic sensors, they worked as expected but when using the front sensor, it always shows the first values as zero, so included a condition to avoid that observation and wrong value.

When trying to drive the motors using the motor shield there were complex schematic designs in the circuit design and had to use libraries to get expected outputs but used PIC with motor driver to practice.

after identifying the pins which use by the motor shield then used polling to drive the motors in order to sensor inputs and it worked as expected.

Exterior and interior bends were obtained after some calculations. and it cold smooth using fuzzy logic. The wall following of the robot could be obtained after some motor balances it also could smooth using the fuzzy logic. With mentioned functions, it could be possible to obtain a complete wall following design.

The obstacle-avoiding part is also possible to do with previous functions. And when it identifies three walls surround the robot it will identify the destination and stop.

with all the above-mentioned functions together, a perfect wall follower obtained.

When coming through the path to the final demonstration there were uncountable numbers of unexpected observations. robot started rotating around itself hit on walls, move without using given conditions were some of them.

Discussion *(HEADING 5)*

There were problems right from the beginning. Through this pandemic time, we were unable to find pic micro-control and had to use an Arduino. Right components were also not on the online market to buy. But manage to avoid those problems and overcome them with alternative solutions.

when creating 3d design from the thinker cad the ultrasonic sensor has to create by hand. the battery size has gotten wrong and have to reorganize the chassis and basic design.

After arriving real batteries struggled to find motor shield pins, not enough pins used motor shield so we used only one l293d motor drive when testing the sensors there was a mistake in the sensors giving output as zeros. Batteries not charged and then buy some extra when buying happened a lot of funny and critical moments.

Already coded a perfect code and then it didn't work as expected and then re-programmed the current code.

The Left sensor was configured mistakenly wrong and struggled to find the error.

To implement the correct 90-degree turn, needed to adjust the ultrasonic sensors accurately.

The switch consumed much power and slow down the robot and then it had to replace by another switch.

The front ultrasonic sensor first wave becomes so close small value as unexpected and needed another function to avoid that.

After testing one time before the final evaluation, the robot didn't work at the first attempt of the evaluation, one ultrasonic sensor didn't power up. The cause for that was the faulty jumper wires miss placed.

When coding the fuzzy logic. To evaluate the performance of the proposed controller, the mobile robot is tested in the real-world environment containing walls that have different trajectories including straight and turns. Although the robot does fulfill the requirements and follows a certain wall, the robot sensors can only be used to detect a small distance. So it couldn't follow a wall if the robot was in the middle of the room. the robot is not quite capable of taking turns of 90 degrees or greater so the robot will slow down a bit in such instances. A rechargeable battery of 9V was used for this robot. Therefore, after a certain amount of time, the battery will have to be recharged again to get the robot working.

Conclusion *(HEADING 6)*

The robot was made by following a series of steps. The first step that was taken in building the robot was obtaining the basic components necessary for the robot.

The components needed for the mechanical aspect of the robot were the wheels, robot base, motors, etc. The robot base was designed by the members of the group. As for the electrical components, based on our initial knowledge and through trial and error, the perfect components needed for the robot were obtained.

As for the coding and programming part of the robot, this was programmed using a normal way instead of fuzzy logic.

This project has opened several pathways to many innovative ideas as well as new concepts leading to more advanced products by realizing the concepts learned in the course so far. Therefore, by considering all the data and information stated above, it can be concluded that the robotics project of simple line following robot was performed successfully achieving all the intended objectives with lots of positives to the engineering career of all the group members.

For the future development of the wall following with fuzzy logic robot, we like to improve the robot fuzzy logic code and make it smoother, make the robot identify the wall color and decide it, add a sound when the is an obstacle in ahead. Using motors with encoder to increase the precision another enhancement we are planning is to build a cover for the robot. This will cover the robot's interior and make the robot look much better. This will also give better protection to the interior circuit.

And the robot can be upgraded to find the closest wall in the room and move towards the wall and follow the wall.

Acknowledgement *(HEADING 7)*

This simple written acknowledgement will not be sufficient, for the support and encouragement of many people and organizations. However, we take this opportunity to add a few words of appreciation for all those who have been a part of this project right from its inception. We hereby grant our gratitude to miss Subhashini, the lecturer of "Introduction to Control and Robotics" module, for giving the instructions, guidance in doing this project and helping to make it a successful one. Without the peer-to-peer relationships in between the team members this project would be unsuccessful, therefore the second thanks go for them. Finally, our parents and the instructors for giving their support.

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