Fuzzy approaches for mobile robotics in dynamic environment

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Abstract

The next generation autonomous robot is required to navigate in unknown and dynamic environments. Over the last two decades, there was an open problem in mobile robot navigation. To design an autonomous system, robots must have input data, decoding that input and respond to a changing world. The robot design is based on sensor-actuator control techniques often. Autonomous mobile robots play a major role in military, industry, space and transportation. Mobile robot must support both static and dynamic environment. For navigation of mobile robot, several techniques have been adopted by various researchers. This article mentions the mobile robot navigation using fuzzy intelligent techniques.

Keywords: mobile robot, sensor, actuator, navigation, fuzzy

I. INTRODUCTION

Obstacle avoidance and navigation are one of the major problems in mobile robotics. Celestial navigation is avital task in mobile robotics. The previous knowledge of the environment should be available for navigation. The robots are completely equipped with sensors such as UV, IR, Proximity, Vision. These sensors will provide input data to the robots. Then the robot will decide or control its motion and navigate in the environment. Here, the main objective is to avoid collision and travel in static and dynamic environments. This similar work has been carried out by many researches and attracted for intelligent navigation. In this paper, we describe the navigation and behavioural control of the robot using fuzzy logic.

II. RELATED WORK

Anish Pandey et al., [1] suggests that mobile robot is an autonomous agent capable of navigating intelligently anywhere using sensor-actuator control techniques. The applications of the autonomous mobile robot in many fields such as industry, space, defence and transportation, and other social sectors are growing day by day. The mobile robot performs many tasks such as rescue operation, patrolling, disaster relief, planetary exploration, and material handling, etc. Therefore, an intelligent mobile robot is required that could travel autonomously in various static and dynamic environments. Several techniques have been applied by the various researchers for mobile robot navigation and obstacle avoidance. The present article focuses on the study of the intelligent navigation techniques, which are capable of navigating a mobile robot autonomously in static as well as dynamic environments.

Pangiotis G. Zavlanga et al., [2]describes an intelligent motion planning and navigation system for omnidirectional mobile robots based on fuzzy logic.The robot receives a continuous flow of information about occurring events and generates new commands in response to the incoming events, while previously planned motions are being executed. The fuzzy-rule-base of the proposed system combines the repelling influence, which is related to the distance and the angle between the robot and nearby obstacles, with the attracting influence produced by the distance and the angular difference between the actual direction and position of the robot and the final configuration, to generate actuating commands for the mobile platform. It can be considered as an on-line local navigation method for omnidirectional mobile robots for the generation of instantaneous collision-free motions. This reactive system is especially suitable for real-time applications. The use of fuzzy logic leads to a transparent system which can be tuned by hand or by a set of learning rules. Furthermore, this approach allows obstacle avoidance and navigation in dynamic environments. The functioning of the fuzzy motion planner with respect to omnidirectional mobile robots and results of simulated experiments are presented.

Mohammed Faisal et al. [3] presents mobile robot navigation has remained an open problem over the last two decades. Mobile robots are required to navigate in unknown and dynamic environments, and in recent years the use of mobile robots in material handling has considerably increased. Usually workers push carts around warehouses and manually handle orders which is not very cost-effective. To this end, a potential method to control a swarm of mobile robots in a warehouse with static and dynamic obstacles is to use the wireless control approach. Further, to be able to control different types of mobile robots in the warehouse, the fuzzy logic control approach has been chosen. Therefore, in this paper, an on-line navigation technique for a wheeled mobile robot (WMR) in an unknown dynamic environment using fuzzy logic techniques is investigated.

III. FUZZY APPROACHES

Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based. The idea of fuzzy logic was first advanced by Dr. Lotfi Zadeh of the University of California at Berkeley in the 1960s. Dr. Zadeh was working on the problem of computer understanding of natural language. Natural language (like most other activities in life and indeed the universe) is not easilytranslated into the absolute terms of 0 and 1.

Fuzzy logic includes 0 and 1 as extreme cases of truth (or "the state of matters" or "fact") but also includes the various states of truth in between so that, for example, the result of a comparison between two things could be not "tall" or "short" but ".38 of tallness. "Fuzzy logic seems closer to the way our brains work.

We aggregate data and form a number of partial truths which we aggregate further into higher truths which in turn, when certain thresholds are exceeded, cause certain further results such as motor reaction. A similar kind of process is used in neural networks, expert systems and other artificial intelligence applications. Fuzzy logic is essential to the development of human-like capabilities for AI, sometimes referred to as artificial general intelligence: the representation of generalized human cognitive abilities in software so that, faced with an unfamiliar task, the AI system could find a solution.

IV. DESIGN OF FUZZY LOGIC CONTROLLER

Fuzzy logic controller (FLC) consists of fuzzification, inference and defuzzification. FLC focusses on obstacle avoidance and navigation of robot.

Mobile robotics for fuzzy logic consists of fuzzy logic controller which has two inputs: Distance, angle and two outputs: Turn, Velocity. The fuzzy inference system is Mamdani Rules.

Mobile robotic for obstacle avoidance

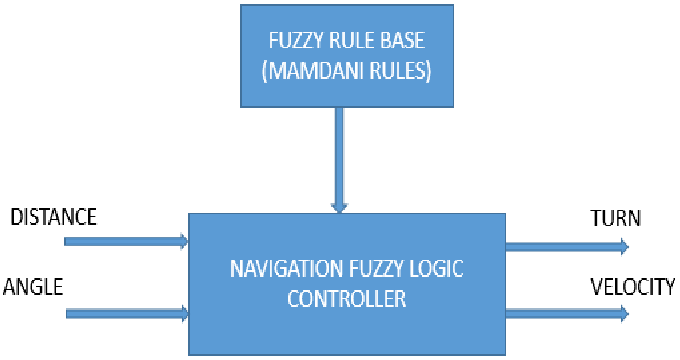

Fig 1: FLC for obstacle avoidance robot

The first step to realize a fuzzy controller is fuzzification which transforms each real value's inputs and outputs into grades of membership for fuzzy control terms. Fuzzification is the process of transformation of crisp set into a fuzzy set. For example, if one person is told that the temperature is 9^{o} C, the person is translates the crisp set input value into linguistic variable such as cold or warm according to one's knowledge and then makes a decision about the need to wear jacket or not. There are many methods of fuzzification, In this paper, we focus on Intuition- Based upon the human intelligence.

Fuzzy input set considered here is Distance and Angle for Mobile Robot obstacle avoidance robot. The distance and angle from the start point to obstacle is calculated. The sensor provides input to the FLC and based on the rules framed. The navigation of robot is done through output fuzzy set, Velocity and Turn.

DISTANCE

Range [0 300] Near [-15 0 50] Far[50 150 200] Very Far[200 250 300]

ANGLE

Range[0 90] Small[-90 0 20] Medium[20 45 60] Large[60 75 90]

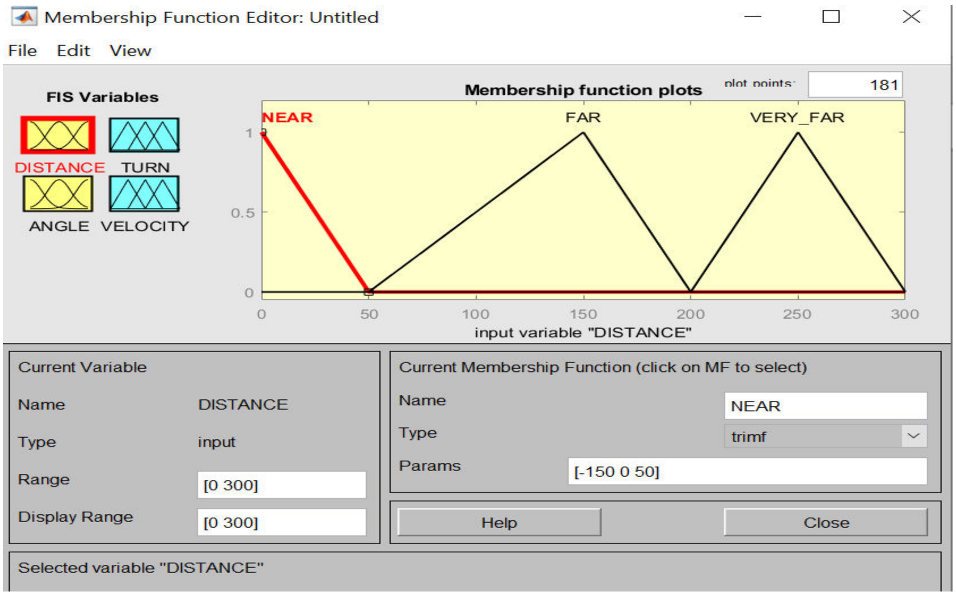

Fig 2: Membership function of input set- Distance

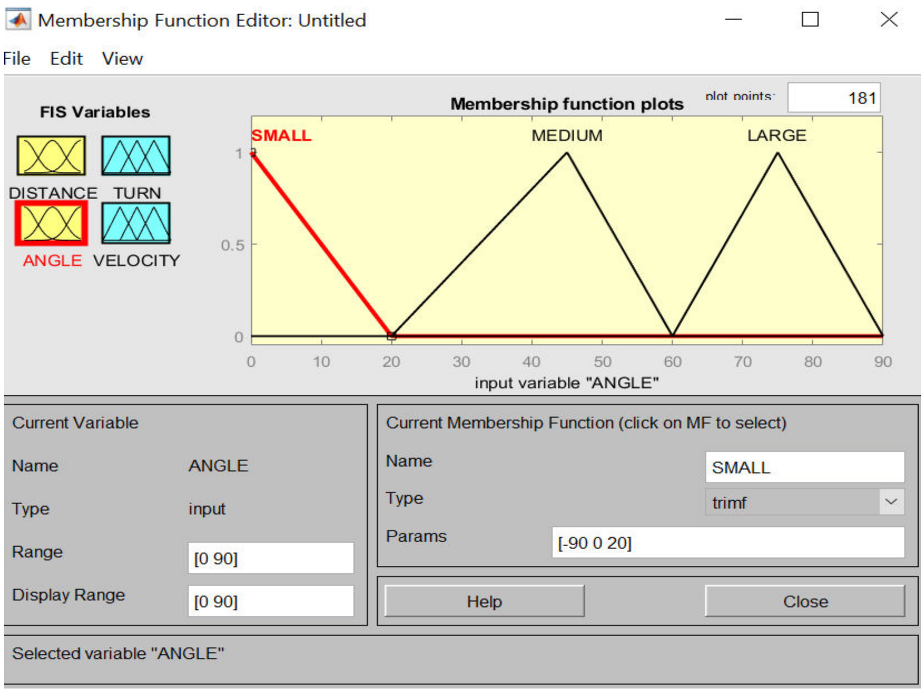

Fig 3: Membership function of input set- Angle

Fuzzy output set considered here is Velocity and Turn in FLC.

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TURN

Range[0 90] Very sharp[0 0 90] Sharp Turn[0 0 80] Medium Turn[0 0 60]
Mild Turn[0 0 45] Zero Turn[-90 0 0]

VELOCITY

Range[0 300] Very Slow[0 0 10] Slow Speed[0 20 50] Fast Speed[200 220 270]
Very Fast[100 150 200] Fast Fast[60 80 100] Top Speed[250 280 300]

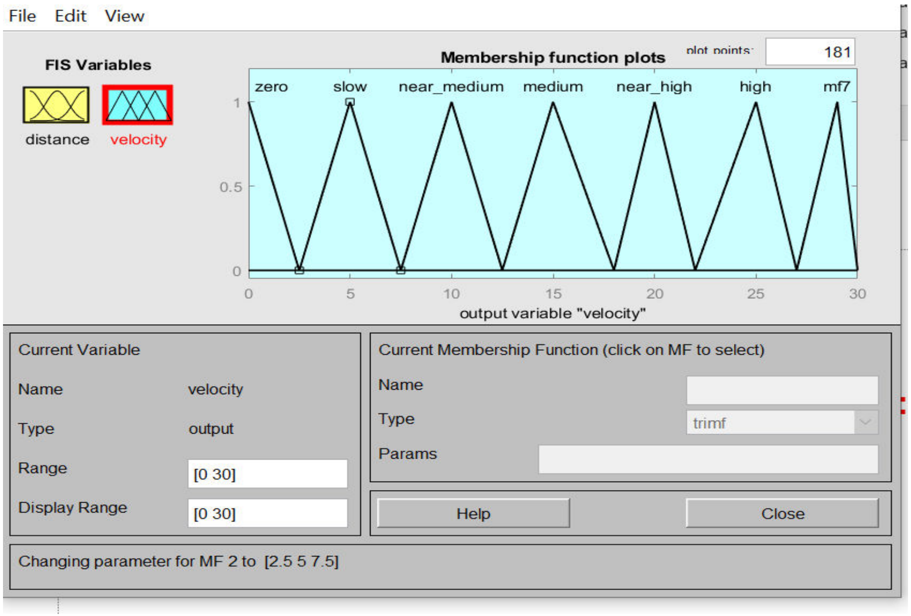

Fig 4: Membership function of output set- Velocity

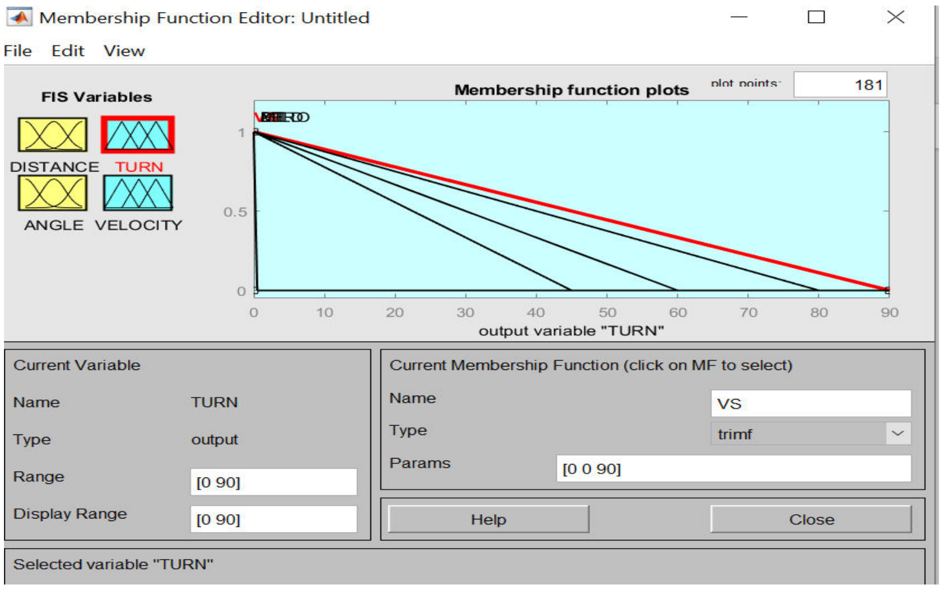

Fig 5: Membership function of output set- Turn

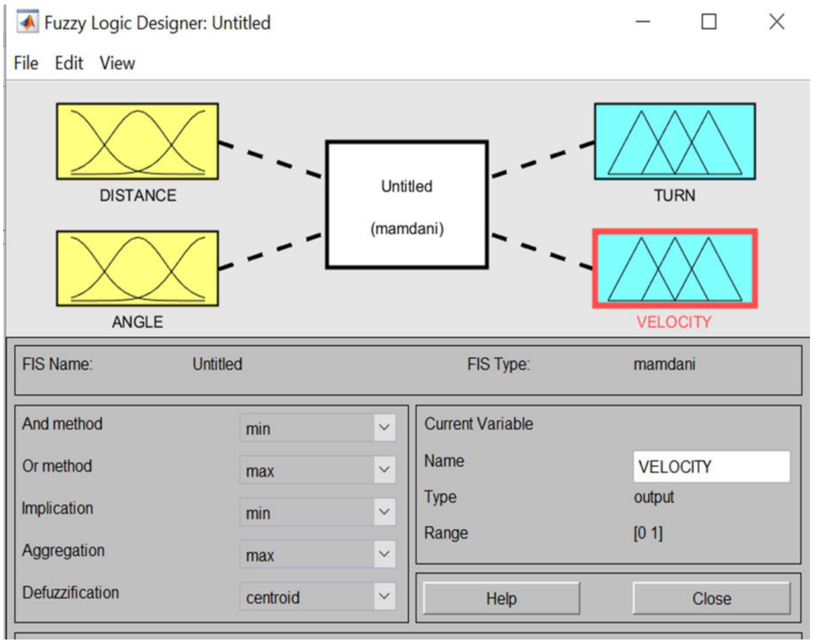

Fig 6: Fuzzy Inference Controller

The second part is fuzzy inference which combines the facts acquired from the fuzzification of the rule base and conducts the fuzzy reasoning process. There are some methods of fuzzy inference depending on the uses and the form of the membership function. When the input and the output variables and membership function are defined, the fuzzy rule is presented as the following form: IF THEN rules.

TABLE 1:STEERING ADJUSTMENT

DISTANCE / ANGLE	NEAR	FAR	VERY FAR
SMALL	VERY SHARP	SHARP TURN	MEDIUM TURN
MEDIUM	SHARP TURN	MEDIUM TURN	MILD TURN
LARGE	MEDIUM TURN	MILD TURN	ZERP TURN

Illustration:

IF DISTANCE FROM THE OBSTACLE IS NEAR AND ANGLE FROM THE OBSTACLE IS SMALL THEN TURN VERY SHARPLY

Based on the input fuzzy set (distance, angle), fuzzy rules are framed for the above table. The robot navigation is controlled by the actuator connected. Navigation (Turn) of the robot is based on the sensor-actuator control.

TABLE 2: SPEED ADJUSTMENT

DISTANCE / ANGLE	NEAR	FAR	VERY FAR
SMALL	VERY SLOW	SLOW SPEED	FAST SPEED
MEDIUM	SLOW SPEED	FAST SPEED	VERY FAST
LARGE	FAST SPEED	VERY FAST	TOP SPEED

Illustration:

IF DISTANCE FROM THE OBSTACLE IS NEAR AND ANGLE FROM THE OBSTACLE IS SMALL THEN VELOCITY IS VERY SLOW

Based on the input fuzzy set (distance, angle), fuzzy rules are framed for the above table. The robot navigation is controlled by the actuator connected. Movement(Velocity) of the robot is based on the sensor-actuator control.

The third part of fuzzy logic is defuzzification block. The objective of this part is to transform the subsets of the outputs which are calculated by the inference engine.

Mapping process from a space of fuzzy control actions defined over an output universe of discourse into a space of crisp control actions specify set analysis. One of the defuzzification method is Max-Membership function.

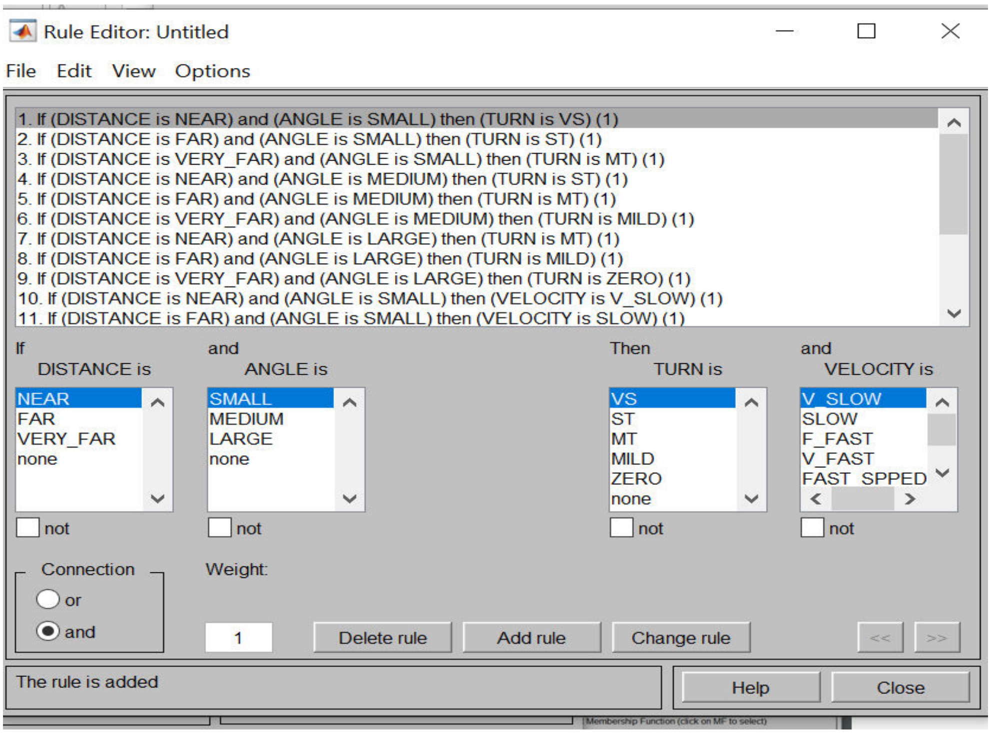

Fig 7: FLC based on Inference Rules

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V. RESULTS AND DISCUSSION:

In this part, we will present the results of our simulation system using MATLAB simulator.

The robot takes the input sets, distance and Angle from the starting point and the obstacle. According to the fuzzy inference rules framed, the robot reach its target position based on its velocity and steering adjustment.

Several tests, for different configurations of the desired positions, have been carried out.

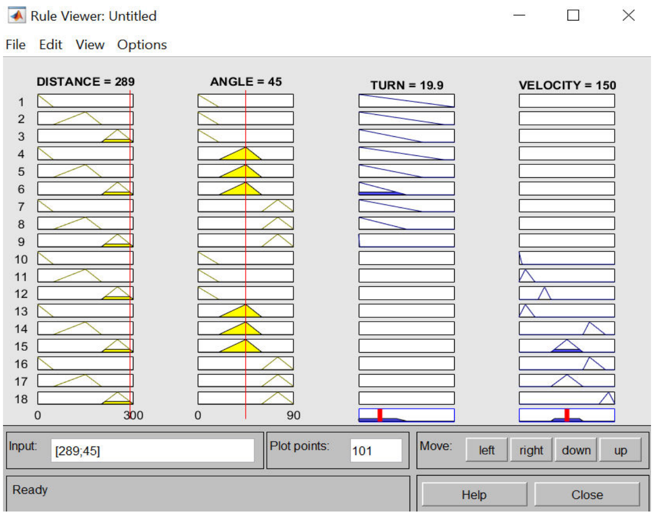

Fig 8: Simulation result – FLC with obstacle avoidance robot

Figures 9indicate the variation of angle orientation and distance at various simulation times. When the mobile robot oriented towards its target point, FLC compute left and right robot wheel speeds to reach the goal.

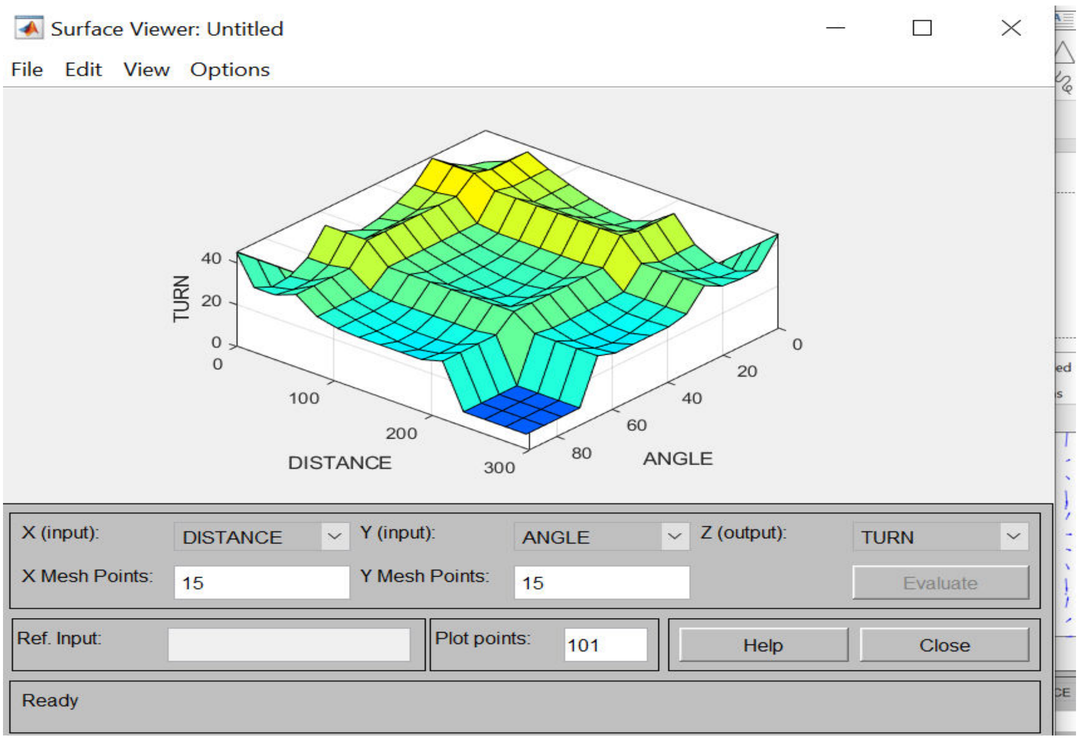

Fig 9: Simulation results based on angle orientation and distance at various simulation times

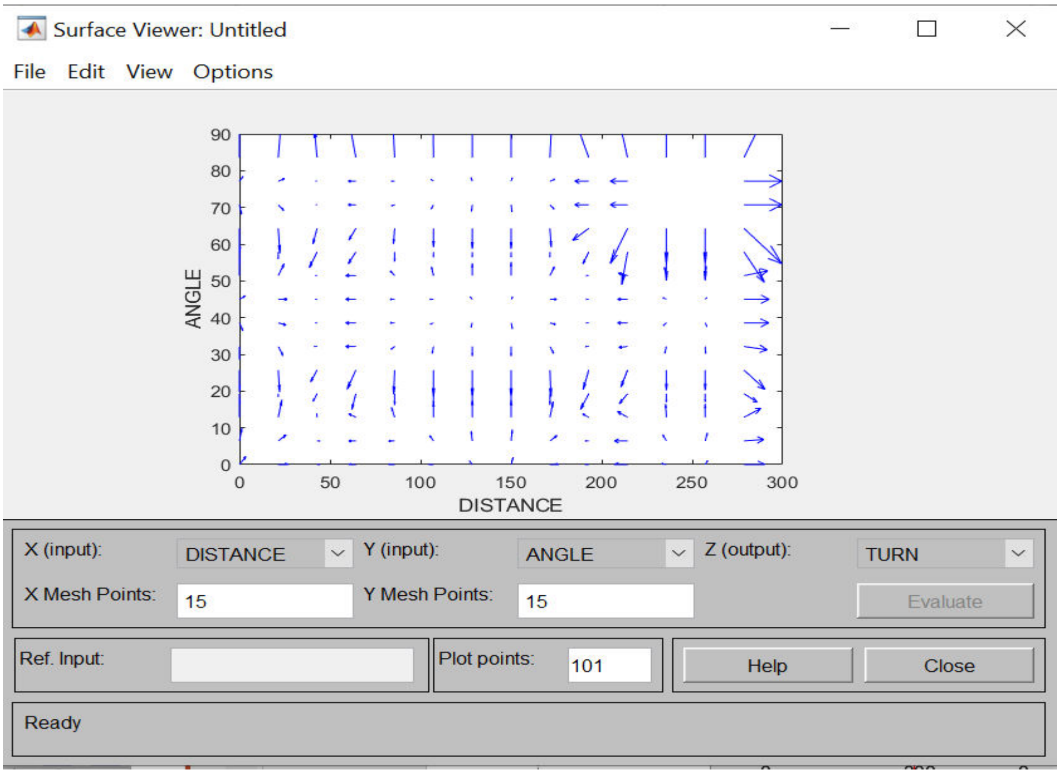

Fig 10: Navigation of Obstacle avoidance robot

In this section, the mobile robots have to navigate in environment with obstacles. We notice that if the infrared range sensors detect an obstacle, the robot is forced to make an adequate turn to avoid collision with the object. Once the robot detects another obstacle, it makes changes based on the proposed deign of fuzzy logic controller.

VI. CONCLUSION

The paper presents the design and simulation of mobile robot along with obstacle avoidance system. We designed fuzzy controller which computed the navigation of robot on collision with obstacle. The simulation results is obtained from MATLAB. The simulation results, using MATLAB and SIMIAM simulation platform, have shown the effectiveness of the designed FLC giving good navigation performances. Simulation results provided a clear performance improvement of the navigation systems.

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