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OPTIMUM PATH FINDING FROM MULTI - PATHS BASED ON FUZZY LOGIC SYSTEM

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Abstract- This paper introduced the fuzzy logic technique to find the optimum path from multi-paths. The fuzzy logic system used six input as: distance (front, left obstacle, right obstacle, angle goal, turn and distance goal) that have been membership function for each input, as well as output direction, the success of the fuzzy logic algorithm and ensure the optimum path obtained from six paths, these paths takes at different rules of fuzzy logic system . Fuzzy logic technique is not an optimization technique as the particle swarm technique and the genetic algorithm are considered optimization, but in this research get several paths after changing the rules and then the optimal path is obtained from these paths in terms of short length and minimum time of implementation. This technique give the best result as well as the sixth red path is best path which is characterized by its short length and lowest processing time, This technique applied of mobile robots and use in engineering, medical, military and industrial application.

Keywords- path finding, fuzzy logic, mobile robot, obstacles

I. INTRODUCTION

The robot is necessary element in society today's. Many frequently jobs, and without used human facility. The word of robots are utilize in wide range for mechanical mobility machine [1] [2]. Path planning of mobile robot, located in environment with obstacles, is define to find path robot to reach from source to destination without hitting of obstacle [3], topics as shortness of path and simple are criteria of optimality to select path. Determining path from completeness is divided two types of constraint satisfaction and accurate. The first type is find optimal path or prove there is no path and in term is time consuming of time complexity, [2], So the second type find appropriate path in short time [3]. Many researchers study a mobile robot as: **Weria Khaksar et.al (2015)** [4] present a review motion path of mobile robot planning in unknown environments because robotics are achieved enormous in recent years for high demand in factories and carry high-precision jobs. **Mihai Duguleana et.al (2016)** [5] propose Q-learning and artificial neural network for path planning in static and dynamic obstacles. The algorithms presented effective in navigation scenario that information global. Result illustrate that algorithms give good rate conversion computed at speed satisfying. **Akram Adib et. al (2017)** [6] in this paper proposed Autonomously navigation mobile robots in unknown environments. By design fuzzy logic to make the easier navigation and use initial knowledge of reinforcement learning for coordinating behavior that caused robot to select the best action in any situation. The result show fuzzy logic and learning automata of navigation robot is give better performance in convergence and learning speed relatively of fuzzy logic and Q-algorithm. **Fiorato Nicola et.al (2018)** [7] propose neural network Long Short-Term Memory (LSTM) online path planning of mobile robots in unknown environment , structure LSTM is analyzed . Then compared the result between LSTM with A* algorithm LSTM is give good performance. **H. Bharadwaja et.al (2018)** [8] present Neural Networks of mobile robot to path planning, parameters take for training time, performance of network, forecasted distance is considered after iterating for achieve optimal dataset using Probabilistic Roadmap (PRM) algorithm. Improvement 36% in forecasted distance achieve use neural network and then compared with traditional PRM algorithm

II. PATH FINDING

Since 1980, Many research employment to solve issues of mobile robots path planning. By applied two ways as: Firstly using global scenario, obstacle information and characteristics of robot. Second way collect local information during sensor and explain path traversing problem. Developing effective trajectory planning employ optimization technique to strike trade-off between reactive to environmental event and. [9]. Finding a path to a robot is a common problem in portable robots. the robot should be able to

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move itself from the start Location to the target location without colliding with obstacles. So an important research topic in this area is navigation of autonomous portable robots, which are to find universally optimized. The path from starting point to target in particular environment. At the same time avoid collisions. That's where the path is optimized. Means that the path must meet certain criteria such as length. The path is shorter, or the power consumption of the robot is the lowest or the time required to reach the goal is minimal etc. Many artificial intelligence techniques and algorithms have been used to find path as (Fuzzy, ANN, ANFIS, ACO, PSO, Bee colony, Genetic).

III. ARTIFICIAL INTELLIGENCE TECHNIQUES

Artificial Intelligence (AI) has seen tremendous progress in recent years. It is a thriving research area with an increasing number of important research and basic technology areas for an increasing number of application areas. In addition to algorithmic innovations. Artificial intelligence is being utilized to enhance sciences and technologies due to its amazing capability of dealing with big data, complexity, high accuracy, and speedy processing. Artificial Neural Network (ANN), Fuzzy Logic, Neuro - Fuzzy Interference System (ANFIS), Genetic algorithm (GA), Particle Swarm Optimization (PSO), etc. are the familiar tools of Artificial Intelligence , AI has been employed in various areas such as engineering , science, medicine , computing , finance , economics and so on.

IV. FUZZY LOGIC SYSTEM

First proposed of fuzzy logic by Zadeh in 1965 and it's based on fuzzy sets concept. Theory of Fuzzy sets are provides mean of representing uncertainty, theory of probability is primary tool of analyzing uncertainty, and suppose that uncertainty is random process. Though, uncertainty not all is random [10], The basic problem in the robot path is the need to deal with it. With a huge amount of possibilities. The advantage fuzzy logic is its ability to use common sense to describe complex systems. Very responsive. The system is complicated in a simple way described by creating a set of input and output set Variables and generate a simple rule based matrix Using fuzzy logic. The fuzzy system is composed of the following four elements [10-13]: a rule base (a set of If – Then rules), that contain quantification fuzzy logic of expert's linguistic explanation for good performance.

An interface fuzzification, that convert input into data that mechanism inference can apply to apply rules.

An interface defuzzification, that convert conclusion of mechanism inference to actual input of process

Fig1: Proposed fuzzy logic system

The path using fuzzy logic is runs of number of nodes along path. flow char of mobile robot using fuzzy logic system show in Fig (2) .In this paper, fuzzy has been utilized six input to determine the path illustrated in Fig(3) one of inputs represents distance front and has three membership function (Mfs) (low, medium and large), left obstacle has two membership function (small, medium), right obstacle has two membership function (small, medium), angle goal has five membership function (negative, no, positive, more negative ,more positive), turn has two membership function (left, right), distance goal has three membership function (low, medium , and high) as well as output variable direction has five membership function (left , right, no ,more left, more right) described in Fig (4).

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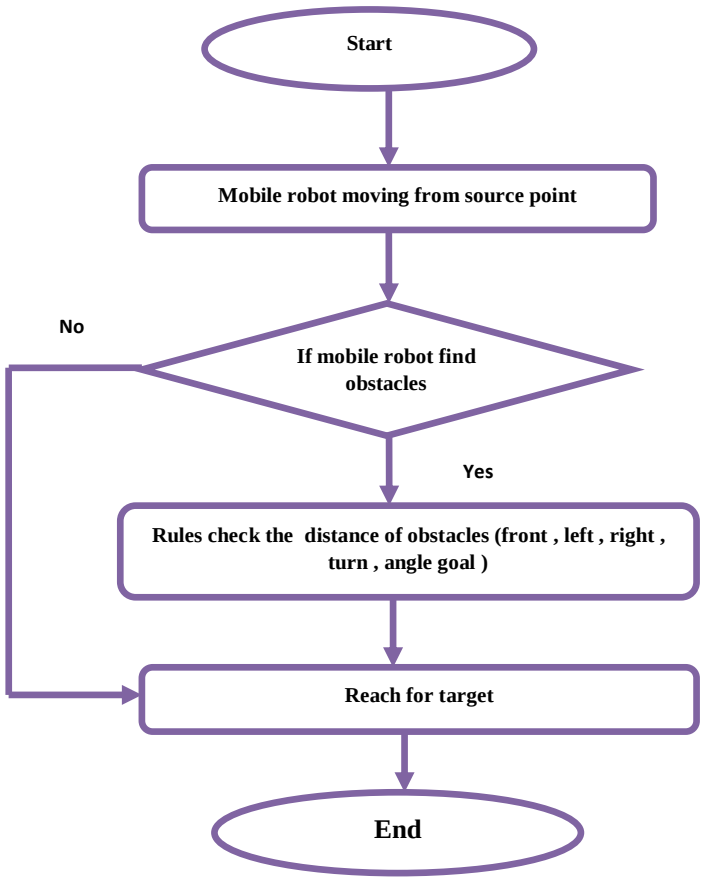

Fig 2: Flow chart for path finding of mobile robot using fuzzy logic system

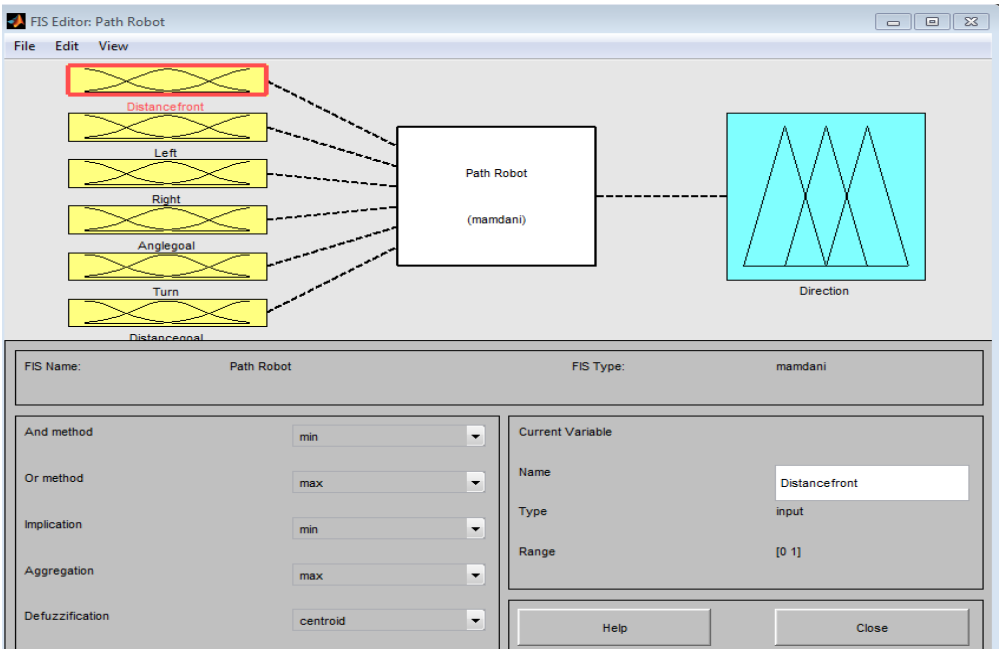

Fig (3) Inputs and output fuzzy logic system

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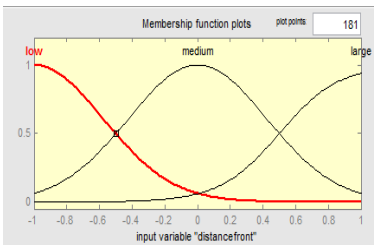
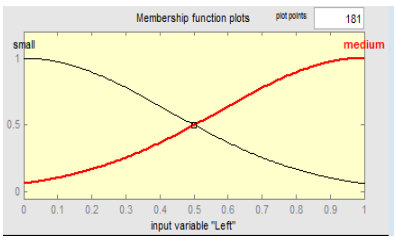
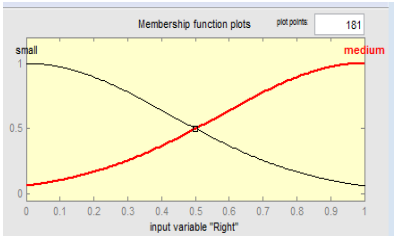


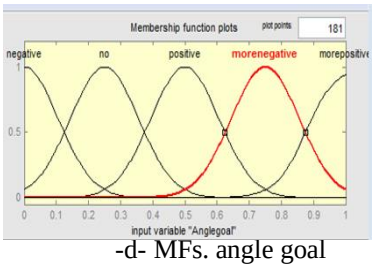
-a- MFs. distance front



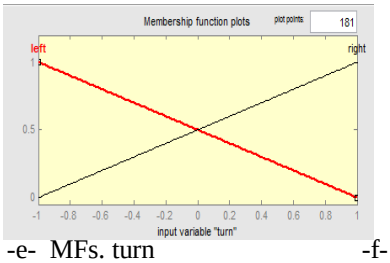
-b- MFs. distance left



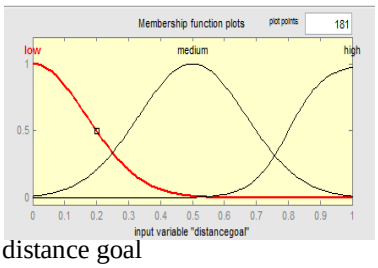
-c- MFs. distance right



-d- MFs. angle goal



-e- MFs. turn



-f- MFs. distance goal

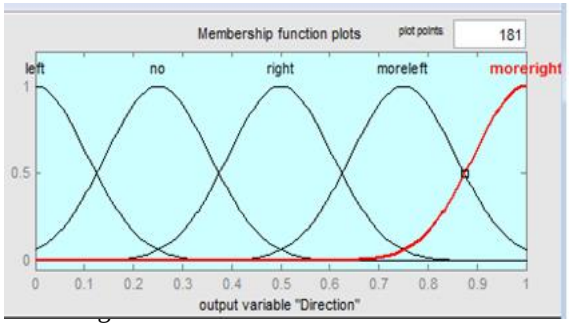


Fig (4) Membership function of inputs and outputs fuzzy logic system

V. THE SIMULATED RESULTS

Fuzzy logic system for path finding by using Matlab (2014a), Toolbox (Fuzzy logic system) and algorithm to inter six input as: distance (front, left, right, angle goal, turn and distance goal) that have been membership function for each input, as well as output direction, then the rules that illustrate in Table (I) applied. These save as file in Matlab with name (path robot.fis) and then call it in algorithm that built using m-file for path finding of mobile robot. Algorithm is a function for calculating distances from obstacles, selecting source position in Y, X format, goal position in Y, X format, initial heading direction and safety distance S =10. When mobile robot moves, it continuously measures the distance from different directions. There is a comparison made between the distance and a threshold value which is equal to 30 cm. Figs (5), (6), (7) and (8) shows the rule base editor, rule viewer, surface viewer and paths resulting from the algorithm (multiple paths in one form) where optimum path obtained from six paths, these paths takes at different rules of fuzzy logic system show in Table (II). These paths can be applied to find a path for a mobile robot.

Table (I) The fuzzy rules

Number of rules	Distance front	Left	Right	Angle goal	Turn	Distance goal	Direction
1.	Low	None	None	None	Left	None	More left

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2.	Medium	None	None	None	Left	None	Left
3.	Large	None	None	None	Left	None	Left
4.	Low	None	None	None	Right	None	More right
5.	Medium	None	None	None	Right	None	Right
6.	Large	None	None	None	Right	None	Right
7.	None	Small	None	None	None	None	More right
8.	None	Medium	None	None	None	None	Right
9.	None	None	Small	None	None	None	More right
10.	None	None	Medium	None	None	None	Left
11.	None	None	None	Negative	None	Low	More left
12.	None	None	None	More negative	None	Low	More left
13.	None	None	None	No	None	Low	No
14.	None	None	None	Positive	None	Low	More right
15.	None	None	None	More positive	None	Low	More right
16.	None	None	None	Negative	None	Medium	Left
17.	None	None	None	No	None	Medium	No
18.	None	None	None	Positive	None	Medium	Right
19.	None	None	None	More positive	None	Medium	More right
20.	None	None	None	More negative	None	High	Left
21.	None	None	None	Negative	None	High	Left
22.	None	None	None	No	None	High	No
23.	None	None	None	Positive	None	High	Right
24.	None	None	None	More positive	None	High	Right
25.	None	None	None	More negative	None	Medium	More left

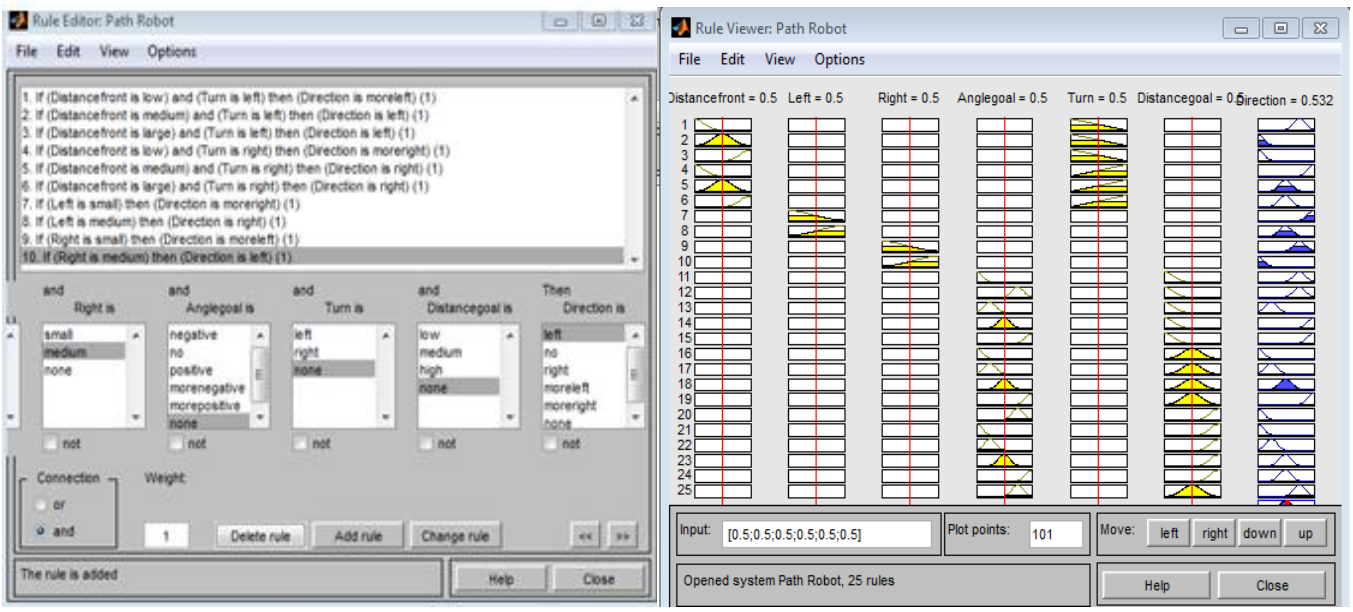

Fig 5: The rule base editor

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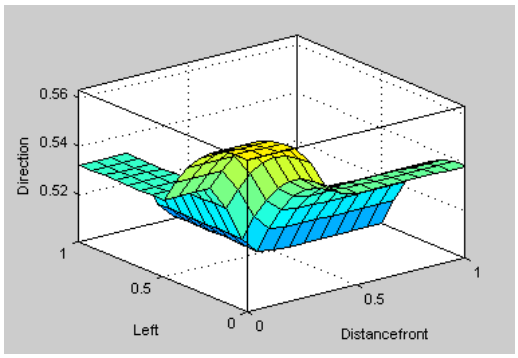
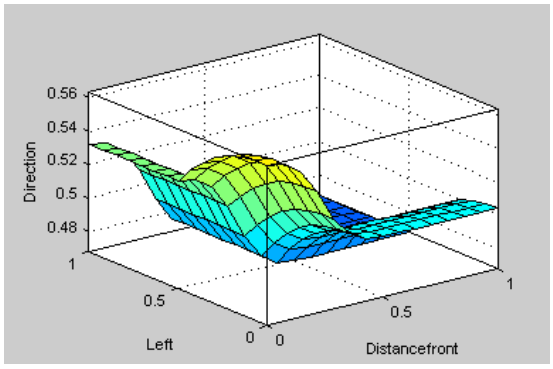
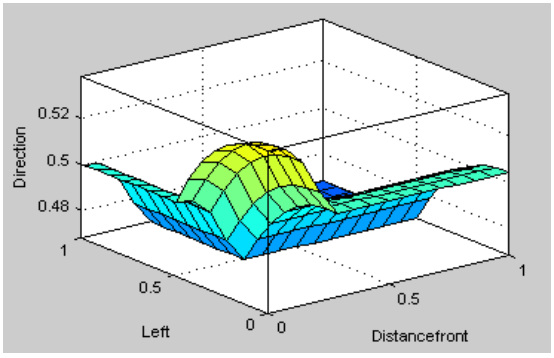


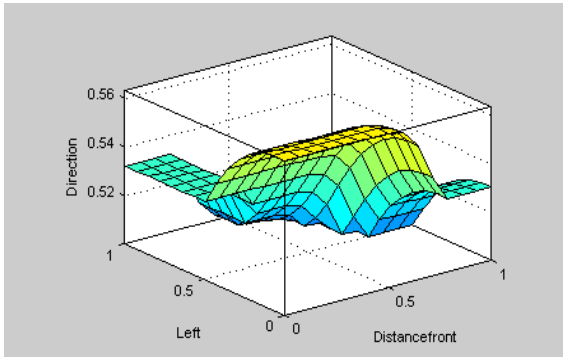
a-path 1



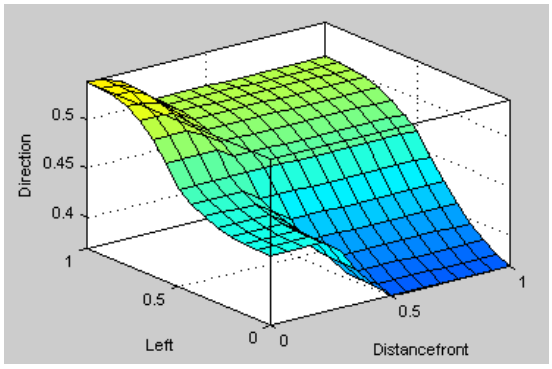
b- path 2



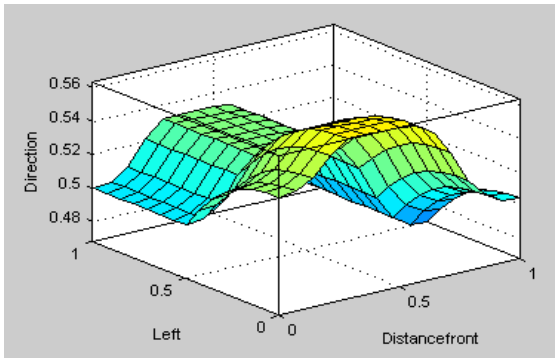
c-path 3



d- path 4

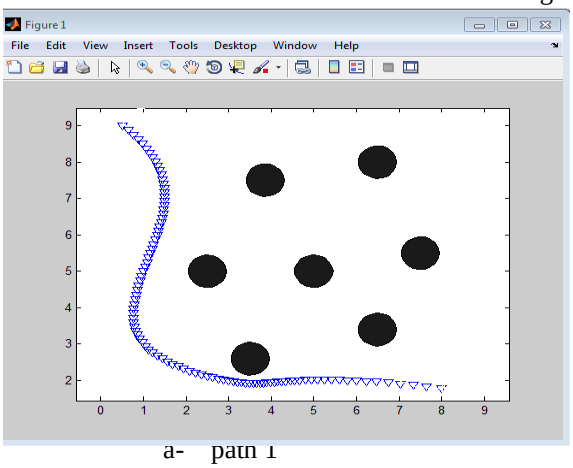


e- path 5

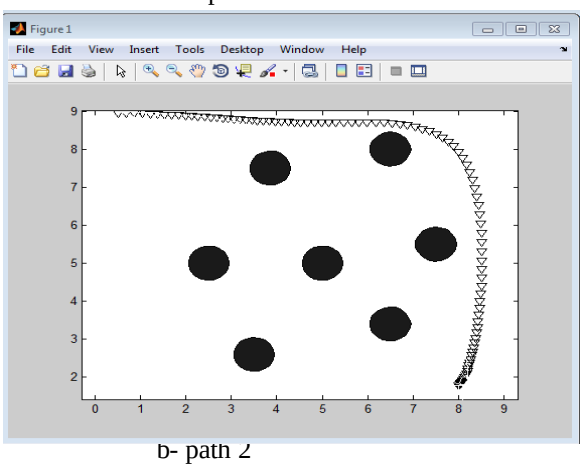


f- path 6

Fig 6: Surface viewer of all paths



a- path 1



b- path 2

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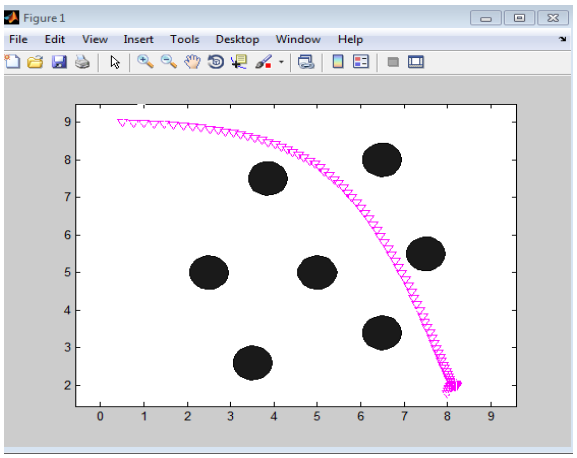
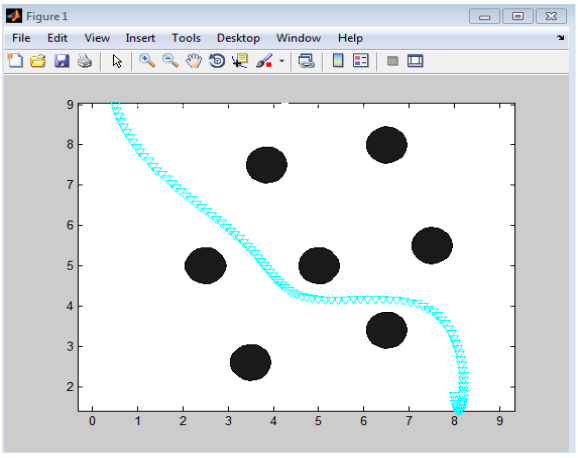
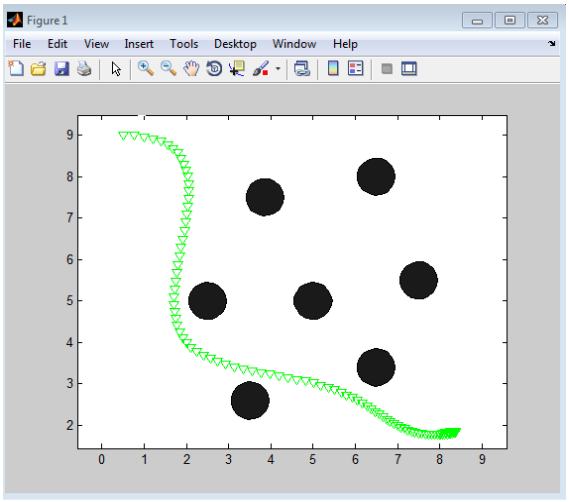


c- Path 3



d- path



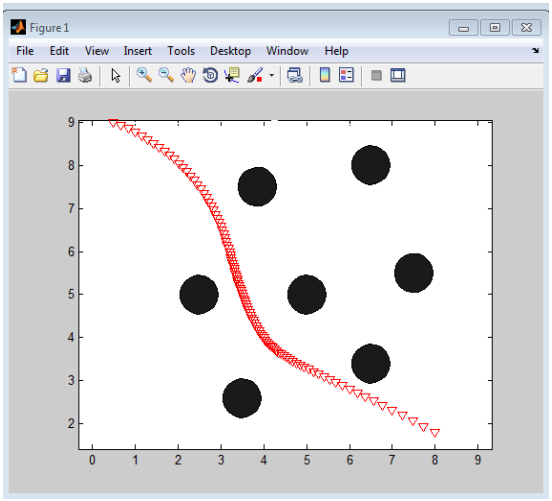


Fig 7 (a, b, c, d, e, f): Path Finding for mobile robot

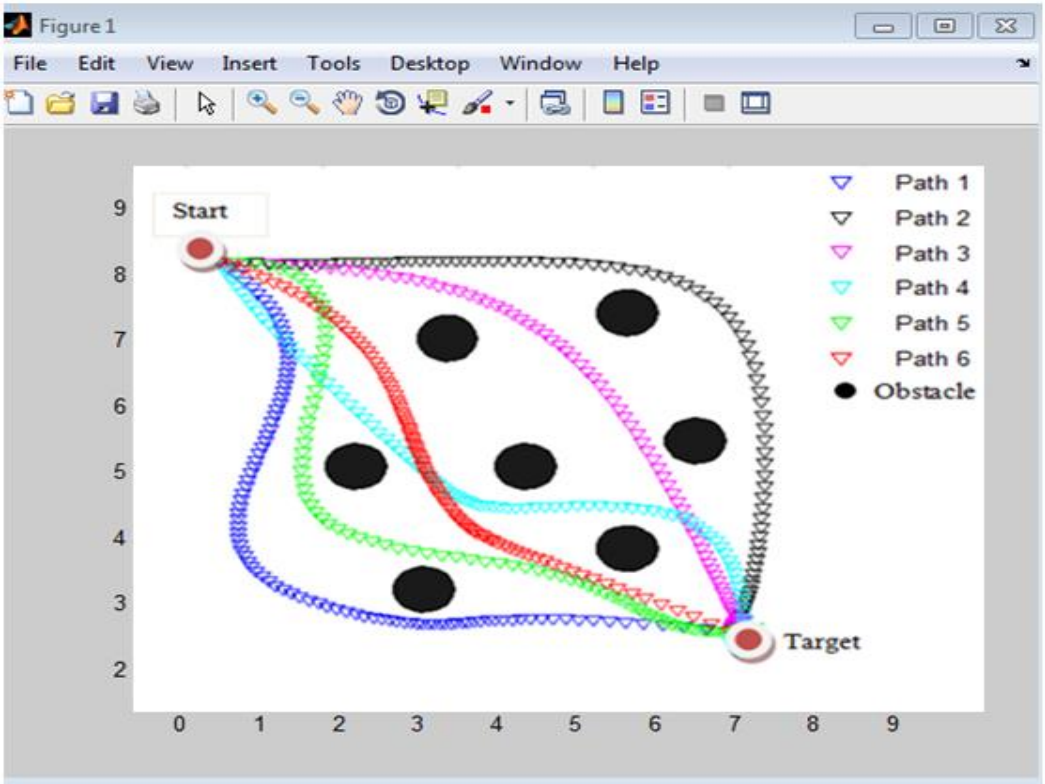


Fig 8: Multiple paths and best path (the red)

Table (II) Lengths of the paths and their implementation time

No. of Paths	Length Path(cm)	Time Processing (sec.)
Path 1	89.21	14.432
Path 2	88.27	13.211
Path 3	85.99	11.528
Path 4	86.38	11.788
Path 5	87.25	13.97
Path 6	85.01	11.31

VI. CONCLUSION

The paper discussed fuzzy logic system technology of the path and avoid the robots obstacles using image as a map. fuzzy logic is used to perform path behavior and avoidance obstacles to find the optimum path the mobile robot can access target this illustrates the success of the fuzzy logic algorithm for robots and ensure the optimum path for mobile robots which optimum path obtained from six paths, these paths takes at different rules of fuzzy logic system. which the sixth red path is best path which is characterized by its short length and the lowest processing time. Fuzzy logic technique is not an optimization technique as the particle swarm technique and the genetic algorithm are considered optimization, but in this research get several paths after changing the rules and then the optimal path is obtained from these paths in terms of short length and minimum time of implementation. This technique give the best result. As well as the sixth red path is best path which is characterized by its short length and lowest processing time, This technique applied of mobile robots

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