Fuzzy Logic Controller for the Navigation of an Autonomous Mobile Robot

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Abstract— *This work deals with the problems of the navigation of an autonomous mobile robot in an unknown or partially known environment. This is achieved by means of fuzzy logic controller (FLC). The work involves the design of a controller having functions like obstacle avoidance by providing a heading angle to autonomous robot. Autonomous mobile robots are machines which navigate around their environment extracting sensory information from environment and performing actions dependent on this sensory data. The fuzzy logic controller developed is simples and efficient. Fuzzy logic control is characterized by the use of linguistic rules to manipulate and implement human knowledge in control systems so as to handle the uncertainty present in the environment.*

Keywords— Obstacles, Autonomous mobile robot, Fuzzy logic

I. INTRODUCTION

Mobile robot navigation in an unknown environment has two main problems: localization and path planning. The other problem is the path planning in which the mobile robot needs to find a collision free path from its starting point to its destination point. In order to be able to find that path, the robot needs to run a suitable path planning algorithm, to calculate the path between any two points [1]. Navigation is a major requirement for an autonomous mobile robot trying to fulfill its mission. The sensors used for localization determine the types of localization method that can be applied to mobile robot navigation problems [2]. To perform complex navigation tasks and to coordinate its movement with other agents in indoor environments, autonomous mobile robot

Needs knowledge about the world in which it is moving. A lot of successful works on self-localization in indoor or bounded environments with laser range finders are very accurate, sharp and robust [3]. There are numerous difficulties for the attainment of this objective. This is principally due to the fact that real environments are generally uncertain, unknown and dynamic; thus, the knowledge which is available a priori on these environments may be non-existent, incomplete , uncertain or imprecise, or the environments may undergo modifications over time, which render them more complex and unpredictable, all these inconveniences are compounded due to the sensorial limitations of mobile robot[4].The application of mixed soft computing techniques like neural network, fuzzy logic and genetic algorithm are apply in various researchers that are commonly present in real-world problems. The membership functions and rule set of fuzzy logic controller (FLC) which a robot uses to navigate among moving obstacle. The objective of this paper is to navigate an autonomous mobile robot using a fuzzy logic controller. In the area of robotics, one of the main areas of research is to construct autonomous intelligent mobile robots, which can plan own motion during navigation through two-dimensional or three dimensional terrains [5]. Motlagh et al. described a control technique for reactive navigation of mobile robots. The problems of large number of rules, and inefficient definition of contributing factors, e.g., robot wheel slippage, are resolved. Causal inference mechanism of the fuzzy cognitive map (FCM) is hired for deriving the required control values from the FCM's motion concepts and their causal interactions. The results and comparisons with the related works are given using Active Media simulation and a developed FCM simulation tool. [6]. Muthu et al. present the performance of a low cost, fuzzy logic based controller for autonomous navigation in which the controller makes the system move through obstacles without human intervention in an efficient manner. Further, in this correspondence, we present the way we developed the fuzzy logic controller along with liquid crystal display (LCD) controller, universal asynchronous receiver transmitter (UART) [7]. Foudil et al. defined Autonomous mobile robotics is providing robots with some level of intelligence and ability to perform desired tasks without continuous human guidance. Fuzzy logic has become a mean of receiving human knowledge and experience and dealing with uncertainties in the control process difficulties. Now, fuzzy logic is becoming a very popular topic in control engineering fields [8].

II. PROBLEM IDENTIFICATION

The path planning process asks for a direct path to goal but if intersections with obstacles exist, path finding is constrained by the shortest distance between initial and destination points. In case of obstacles in the way possible intermediate goals are evaluated taking into account the global distance in each possible path among obstacles, and the shortest one is chosen.

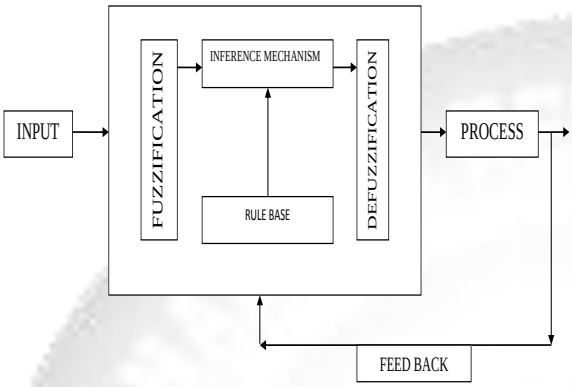
For this purpose a robot requires surrounding data to find its path in crowded area. The data required is the goal point distance, the distance between obstacles and robot. To navigate robot from the crowded area fuzzy logic technique is imparted to reach the goal safely. Path of robot can be decided by changing the heading angle. This heading angle can be achieved with the help of the fuzzy logic controller (FLC). FLC enables mobile robot to move robot through obstacles without human intervention in an efficient manner.

III. DESIGN OF FUZZY BEHAVIORS

The set of behaviors that are being implemented can include, for example, the following of walls, corridors or the avoidance of obstacles. There is not however an established way of designing the rule bases of these behaviors. A lot of approaches use expert knowledge to decide on the response of the behavior according to its objective but without defining that objective explicitly. On the other hand, we think that the robot must use several abstraction levels on the information that it has collected from the environment which it can use to control its own motion.

Fuzzy decision making controller is made up of 3 steps:

- Fuzzification: Converts controller inputs into information that the inference mechanism can be easily use to activate and apply rules.
- Rule: It contains a set of fuzzy rules.
- Defuzzification: This converts the conclusions of the interface mechanism into actual inputs for the process.

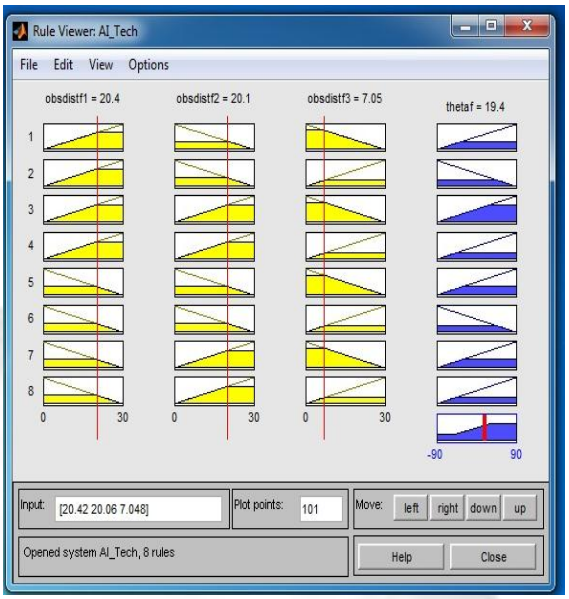


IV. FUZZY CONTROL RULES FOR OBSTACLE AVOIDANCE USING TWO MEMBERSHIP FUNCTION

Fuzzy rule no.	Obstacle distance 1	Obstacle distance 2	Obstacle distance 3	Thetaf
1	Away	Close	Close	Positive
2	Away	Close	Away	Negative
3	Away	Away	Close	Positive
4	Away	Away	Away	Positive
5	Close	Close	Close	Positive
6	Close	Close	Away	Negative
7	Close	Away	Close	Positive
8	Close	Away	Away	Positive

These fuzzy logic rules show that the robot mainly adjusts its motion direction and quickly moves to the target if there are no obstacles around the robot. In general, the weights of the behaviors, obstacle avoidance and target steer, depend largely on the distances between the robot and the obstacles to the left, front, and right locations.

Rule viewer of fuzzy interface system (FIS) as shown in figure on applying this rules in MATLAB software for simulation process. It shows how membership function of thetaf changes according to membership function of obstacle distance 1, 2 and 3 respectively for a particular obstacle distance. According to eight rules it provides eight different membership function value of thetaf, and on the basis of that it provides final heading angle to mobile robot for safe navigation.



V. SIMULATION RESULTS AND DISCUSSION

The simulation experiment shows that the proposed fuzzy controller, using MATLAB, can perform robot navigation in known or partially known environments. The trajectory of mobile robot navigation in an unknown environment with three obstacles as shown in Figures, The simulation program offers an excellent alternative based on navigation methods with a fraction of the processing requirements result a fast responding reliable application.

This thesis concludes and presents a new mobile robot navigation strategy based on the fuzzy logic approach avoiding the obstacle and drives the mobile robot to target with the given initial position. The simulated robot provides collision free path when moving from number of obstacles at different location in an unknown environment. When the robot is near to obstacle, it changes its heading angle to avoid collision.

The Fig. shows a robot is controlled by fuzzy controller to changing its heading angle and moves from a starting point (0, 0) to the goal (250, 250) and avoids three obstacles placed in (50, 50), (100, 100) and(180, 180). In this simulation obstacle are placed along the way to target.

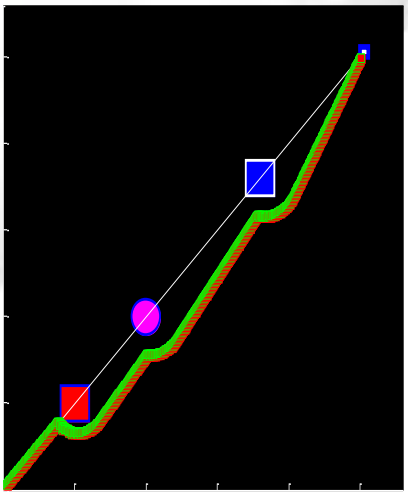


Fig: Simulation of Three Obstacles along Path using Fuzzy controller

Table of input data of obstacle and target for simulation

	X	**Y**
Obstacle 1	50	50
Obstacle 2	100	100
Obstacle 3	180	180
Target	250	250

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