IMPLEMENTATION AND SIMULATION OF ROBOT FOR COLLISION AVOIDANCE USING FUZZY LOGIC

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OBJECTIVE

We present a collision avoidance system that can control and safely navigate robot motion in a static environment presented with any number of objects. The success of the mobile robot navigation control depends mostly on the accuracy of absolute measurements of its position, hurdle distances, goal distance, velocity and orientation. This is achieved by simulating the robot to traverse in landscapes created on VREP and by fuzzy logic controller implemented in MatLab.

PROBLEM DESCRIPTION

An autonomous robot in a real-world setting should be capable of sensing its environment, understanding the sensed information and deciphering the knowledge of its location and surrounding environment. Hence, planning how the robot can freely move with hurdle avoidance becomes an important part of designing autonomous robot navigation. We study and analyse this by implementing simulations of a robot navigating in an environment filled with objects that pose as hurdles. Further, Fuzzy Logic is used in the system to perform local navigation and speed control of a mobile robot.

LITERATURE REVIEW

A significant publication by Anish Pandey et al uses an array of ultrasonic range finder sensors and sharp infrared range sensors to read the front, left and right obstacle distances. The cascade neural network is used to train the robot to reach the goal. The inputs are the different obstacle distance received from the sensors. The output of the neural network is a turning angle between the robot and goal. This model is able to achieve its goal successfully with only a marginal error rate of 5%.

Another work in this domain approached the task with two varied methods. The initial method by Divya Davis et al applied a defuzzification procedure to both the left and right velocity wheels and the results are compared with the defuzzified values obtained from sugeno-weighted average method. The second approach ignores the four inputs and follows the same fuzzy technique. A comparison of the two approaches indicates that the first method is more precise.

Anmin Zhu et al has proposed a learning algorithm which is developed to suppress redundant rules in the designed rule base. A state memory strategy is proposed for resolving the “dead cycle” problem. Under the control of the proposed model, a mobile robot can adequately sense the environment around, autonomously avoid static and moving obstacles, and generate reasonable trajectories toward the target in various situations without suffering from the “dead cycle” problems. Further a notable paper by S.Parasuraman et al designed a controller which maps the sensors input to the motor output through Fuzzy Logic Inference System and formulated the decision-making processes by using Fuzzy Associative Memory (FAM) using simulation. The above method and techniques are applied for Active Media Pioneer Robot and tested through Simulation.

THEORY

FUZZY LOGIC

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 theory of fuzzy logic is based on the notion of relative graded membership, as inspired by the processes of human perception and cognition, and membership functions relate to the degree or extent of belongingness.

FUZZY LOGIC CONTROLLER

Fuzzy logic controller is a control system based on fuzzy logic or fuzzy sets which analyses the analog input values in terms of logical variables that take on continuous values between 0 and 1. Therefore, boundaries of fuzzy sets can be vague and not precise, making them useful for approximation models.

The conventional controller consists of four steps namely fuzzification, knowledge base, fuzzy reasoning and defuzzification. The first step in the fuzzy controller is to define the input and output variables of the fuzzy controller. FLC controllers use a very flexible set of if-then rules and the controller rules are usually formulated in linguistic terms. Thus, the use of linguistic variables and fuzzy sets implies the fuzzification procedure, that is, the mapping of the input variables into suitable linguistics values. The final step is defuzzification which converts fuzzy based linguistic terms to scalar output values.

MAMDANI AND SUGENO MODEL

The most commonly used fuzzy inference technique is the Mamdani fuzzy method which was proposed, by Mamdani and Assilian. It was proposed as a first attempt to control a steam engine and boiler combination by a set of linguistic control rules obtained from experienced human operators. The task of the standard Mamdani fuzzy logic controller is to find a crisp control action from the fuzzy rule base and a set of crisp inputs.

The Sugeno Fuzzy model was proposed by Takagi, Sugeno, and Kang in an effort to develop a systematic approach to generating fuzzy rules from a given input-output dataset. A typical fuzzy rule in a Sugeno fuzzy model has the form,

$$if\ x\ is\ A\ and\ y\ is\ B\ then\ z = f(x,y)$$

where A and B are fuzzy sets in the antecedent, while z=f(x,y) is a crisp function. The major difference between Mamdani and sugeno is in the outputs. Mamdani outputs are fuzzy sets while that of Sugeno is in the form of a function.

Mamdani is more well-suited to human input and has a widespread acceptance. Also, it has a more interpretable rule base. On the other hand, Sugeno is computationally efficient and works well with linear techniques, such as PID control. It also is efficient with optimization and adaptive techniques and guarantees output surface continuity It is well-suited to mathematical analysis

METHODOLOGY

An environment for the navigation of the robot is created in the VREP, a robot simulator and tester software, for the simulation and performance of the robot in an object filled environment. The robot used for this purpose is Pioneer 3dx, a small lightweight two-wheel two-motor differential drive robot ideal for indoor laboratory or classroom use. Further, three ultrasonic sensors are attached at the left, right and front parts of the robot to detect objects.

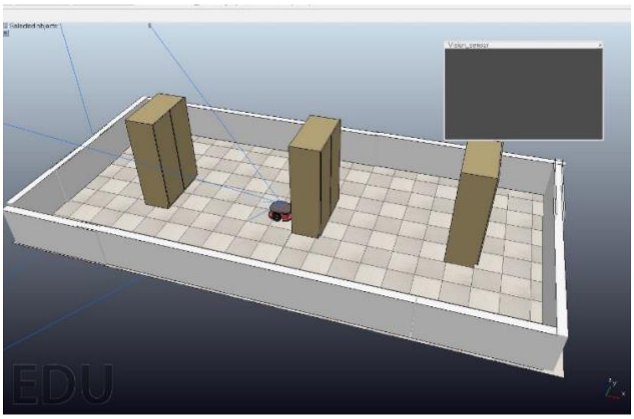

Fig 1: Vrep simulated environment for robot navigation

The various fuzzy stages like suitable identification of input and output parameters along with linking them to the fuzzy based variables is carried out in the fuzzy logic controller and is implemented in Matlab using the fuzzy command. A Mamdani based controller with three inputs and two outputs is obtained with the inputs being the left, right and the front ultrasonic sensor and the outputs correspond to the velocity of the left and right motor. The membership function and the ranges for the input and output variables were assigned after various trials to get the accurate result. Further the rulebase for the relation between the input, output and fuzzy variables is framed by using fuzzy rules and is created in the controller. The matlab file is linked with VREP scene by code and is thus executed and the result is noted.

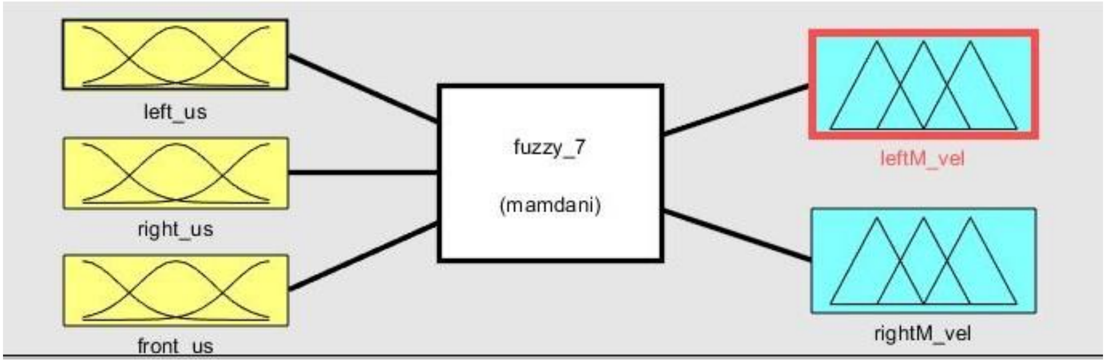

Fig 2: Mamdani Fuzzy Logic Controller Implemented on MatLab

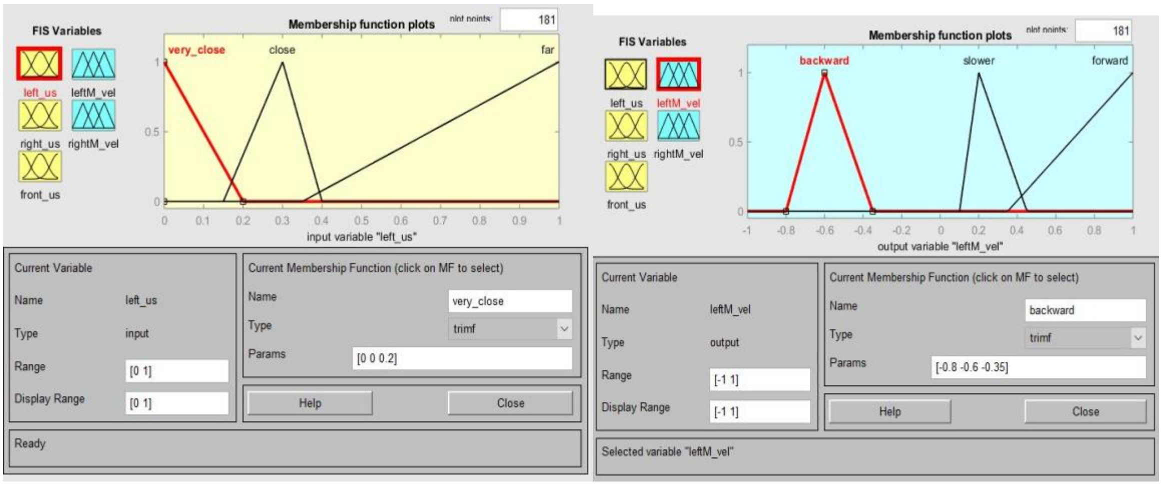

Fig 3: Input and Output membership function

LEFT_US	RIGHT_US	FRONT US	LEFTM_VEL	RIGHTM_VEL
Close	Far	Far	Backward	Forward
Close	Far	Close	Forward	Backward
Close	Far	Very Close	Backward	Forward
Close	Close	Far	Forward	Forward
Close	Close	Close	Forward	Backward
Close	Close	Very Close	Forward	Backward
Close	Very Close	Far	Slower	Forward
Close	Very Close	Close	Backward	Forward
Close	Very Close	Very Close	Backward	Forward
Very Close	Far	Far	Forward	Slower
Very Close	Far	Close	Forward	Backward
Very Close	Far	Very Close	Forward	Backward
Very Close	Close	Far	Forward	Slower
Very Close	Close	Close	Forward	Backward
Very Close	Close	Very Close	Forward	Backward
Very Close	Very Close	Far	Backward	Forward
Very Close	Very Close	Close	Forward	Backward
Very Close	Very Close	Very Close	Forward	Backward
Far	Far	Far	Forward	Forward
Far	Far	Close	Slower	Forward
Far	Far	Very Close	Backward	Forward
Far	Close	Far	Backward	Forward
Far	Close	Close	Backward	Forward
Far	Close	Very Close	Backward	Forward
Far	Very Close	Far	Backward	Forward
Far	Very Close	Close	Backward	Forward
Far	Very Close	Very Close	Backward	Forward

Fig 4: Rulebase for the Fuzzy Logic Controller

RESULT AND DISCUSSION

The created VREP scene with the robot was executed and it is observed that the robot could successfully avoid objects in its vicinity. Thus, the aim was achieved and the collision avoiding robot was simulated on software. This design allows the robot to navigate in an unknown environment by avoiding collisions, which is a primary requirement for any autonomous mobile robot.

CONCLUSION

In this paper, we have performed an implementation of fuzzy logic controlled mobile robot for the task of navigating through a course of objects and thus avoiding collisions. The robot with the known target and obstacle is articulated using mamdani fuzzy based methods. The entire route framework has been tried in a simulation domain with fulfilling results. A fuzzy logic controller with 3 input variables has been used for the implementation of the same. This procedure produces reasonable control of the self-governing vehicle which is utilized by the robot to stay away from any crash in jumbled condition. This holds a scope for further research of collision avoidance and robot navigation across the numerous domains that utilize and encompass autonomous robots.

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MATLAB CODE