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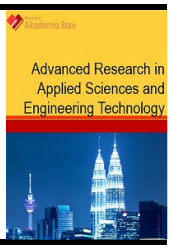

Obstacle Avoidance Autonomous Robot: An Implementation of Fuzzy Inference System

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ABSTRACT

Designing of autonomous navigation is very complex and challenging. The main motive of the proposed research was to construct an autonomous robot which has a proficiency to move in unpredictable and dynamic environments, and for that reason the robot has to sense the environment and lug out the required tasks irrespective of any hindrances in its working area. Applications of autonomous mobile robots can include espionage, underground mining, military operations, driverless transportation, identification of intrusion and protect missions, etc. Several various approaches have been critiqued to perform such operability of robot but results proved that the Fuzzy logic found to be the best for this kind of robotics operations because it has the capability to respond meritoriously to the complex inputs. To refrain and bypass the obstacles accurately and to attain the destination under various contour of obstruction in surroundings, a fuzzy logic approach has been studied and carried out to advance the motion of robot vigorously with less false alarm rate using 'If-Then' basic principle fuzzy inference norms and defuzzification procedure for the accurate and precise path planning and navigation of autonomous robot. The unmanned robot was furnished with sensors (ultrasonic HC-SR04) which has the aptitude to detect the scope of hindrances on the premise of how close or far the impediment is. To achieve this a solitary board PC was utilized, to be specific Raspberry-Pi 2 model b which takes the inputs from the sensors and maintain a strategic distance from the snags set in their way lastly proceeds onward. Results proved that our designed robot is a cost-effective solution performed better than the other techniques.

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1. Introduction

Unmanned vehicles and robotics has always been a part of research and as far as mobile robots are concerned, it is an important part of research around the globe. The utilization of mobile robots is increasing gradually in number as it is used in many applications. Recently Robotics has made its most outstanding progress to date in the realm of modern assembling. Robots have exigency in the present time and can understand a wide range of errands without the human mediation. Conversely with this, a self-governing robot would have the capacity to go in the controlled element condition and can bring choices without anyone else with the assistance of sensors. In our proposed research a fuzzy logic technique has been designed to resolve the path planning planning issue concerned to mobile robot due to the different contour of static and dynamic obstacles for the prevention of collision [1]. The application of various combined soft computing approaches like vector field histogram (VFH), artificial potential field (APF), neural network (NN), fuzzy logic with ant colony, genetic algorithm (GA) and behavioural-based techniques have been applied by many researchers to resolve this collision issue [1]. Fuzzy set theory and fuzzy logic can be considered as the most important and the simplest tool for handling uncertain, inaccurate, or unmodeled data in computational intelligence. A fuzzy logic based control architecture in robotics has the dominance that it permits the instinctive behaviour of collision-free exploration to be simply modelled by utilizing the semantic terminology. Due to the relative computational simplicity the intelligent decisions can be done in real-time by applying the fuzzy rule-based systems in order to avoid all the collisions. The robotic behaviours can be classified into two types: global (path planning and pursue targeted destination) and local (hindrances prevention and track navigation). A network of camera can be used in global robotic behaviour. In local behaviour navigation is based on sensors and transducers outputs. The robotic navigation in ambiguous surroundings utilizing fuzzy logic control architecture comprised of (turning angle) between a robot and the desired target and the distance estimation of the mobile robot and the obstacles to left, front and right locations. In 1984 Landsberger analysed cable driven parallel robots and estimated the motion [2].

2. Problem Statement

In practical, path planning and building navigation of the robots can be considered as the most complex task and a bit challenging for the researchers as interpretation of all the methods is needed that permit a robot to survey anonymous surroundings without leaving the correct path. Numerous various solutions have been developed to overcome the collision problem. The typical solutions are EPF (E1ectrostatic Potential Field) [3-5], VG (Vomoi Graph) [4] and Cell decomposition [4].To resolve this challenging task, we have proposed an obstacle avoidance robot using fuzzy inference system.

3. Methodology

Authors' proposed autonomous Robot based on fuzzy inference system is an immediate point of concentration that utilizes know-how from combination of mechanics, electronics, gadgets, and portable PC building, for the mot. One of the essential requesting circumstances of the independent route for self- ruling robots is the Apply autonomy is an imperative place of concentrates that utilizations know-how all through a few teaches together with mechanics, gadgets, and portable PC building, to move a self-sufficient automated in characterized surroundings with a couple of certificate of independence. One of the essential requesting circumstances of the independent

route for self-ruling robots is the identification and limits evasion amid the robot route task [6]. This issue can be fathomed by method for alluding to one of a kind strategies or calculations to have the capacity to procure brilliant impacts.

Many research literary works utilized delicate PC calculations to oversee independent robots in scholastic territory and also inside the designing zone. Fuzzy logic decision making ability is utilized inside the format of suitable responses to complete adjacent route, overall route, course arranging [7]. Especially, autonomous can be regarded as a crucial issue due to the underwater accidents that is uncertain and perilous [8, 9]. The controller that has been used in our errand is Raspberry PI 2 B has many features of interest and adaptability. It's execution and processing are more speedy than other controllers. Robot auto was designed in such a way that enables you to work without the human intercession and may bring choices with which it will probably be modified. By this rationale robot can take decisions to maintain a strategic distance from confinements happening to their course and can stream forward, left, right or turn around inside the surroundings fuzzy rationale may be done the utilization of a python dialect. Many researches used the technique of fuzzy logic controller as it is simple and easy to implement for the planning of autonomous robot [10]. Advancing velocity has been regulated for the rigor tracking by the authors [11].

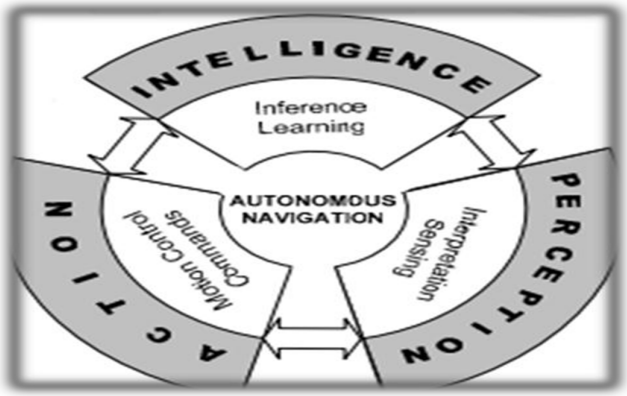

Fig. 1. Phases

The roposed research can be classified into three phases:

- Intelligence
- Perception
- Action

3.1 Intelligence

To overcome the ambiguity in path planning intelligently, fuzzy logic can be an optimum solution. In fact, for the highway autonomous driving fuzzy is preferred and authors have used fuzzy to steer the vehicles at highway [12]. Avoid limitations which had been located in its route by utilizing its intelligence and revel in positive things then getting know-how approximately the barriers that where and in which role the obstacle be positioned in the course after then practice sure logic in step with avoid it by using the usage of fuzzy logic technique.

3.2 Perception

At this stage sensors which are deployed with robot go about as data sources takes pursuing from the encompassing about the obstructions that how far close left right be set in the way. Measure the separation from robot to the snag after then takes the deliberate perusing to the raspberry pi. Raspberry pi coordinates that perusing and takes choice as indicated by it and the sends the signs to robot. Robot according to its insight percept that choice and afterward pushes ahead, switch right and left in an element environment.

3.3 Action

Here, at this level the intelligence and perception both phases make up the activation section. With the assist of intelligence, sensing measurement and commands ship through the raspberry pi controls the entire robot automobile. Robot is ready to move on the course b itself without the human steering and remote devices. Now, the robotic is capable of heading off boundaries with the convenience of sensors and the fuzzy logic algorithms.

These three above stages whilst working collectively making up the autonomous navigation system and with assist of those our robot car navigate in the dynamic surroundings and may keep away from the impediment coming in its course.

4. Block Diagram and Flow Chart

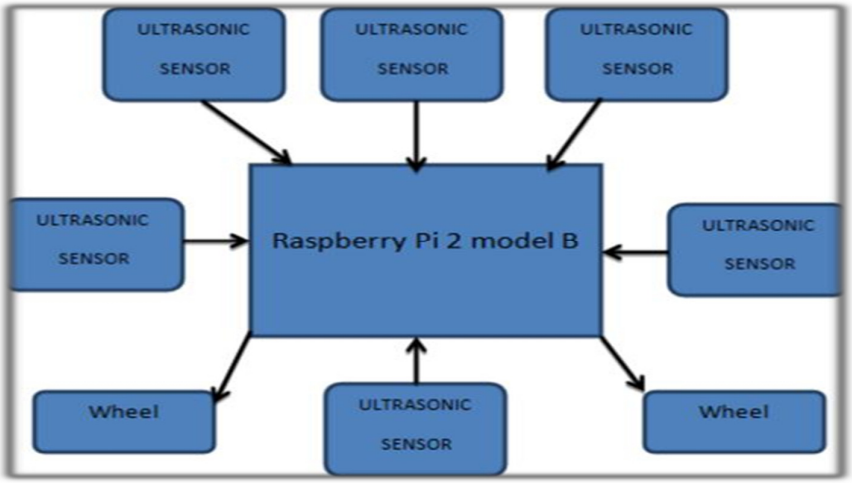

Fig. 2. Block Diagram of the autonomous robot hardware architecture

Fig. 2 elaborates that there are six ultrasonic sensors directly related to the left, r i g h t , top and base of the robot auto and it also comprised of a downsized PC alluded to as raspberry pi. It involved wheels at the robot edges, to run the wheels there is IC L298 which go about as a controller for the motors.

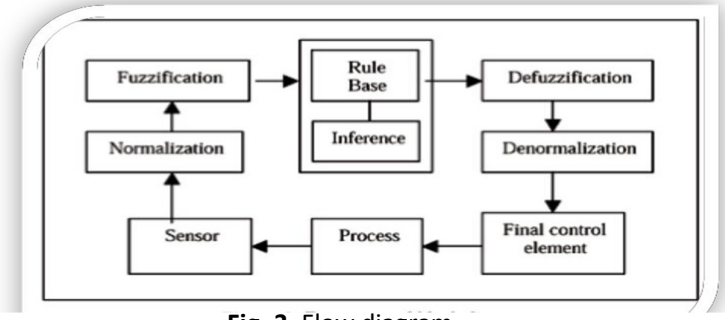

Fig. 3. Flow diagram

Figure 3 illustrates the main flow diagram of the proposed research. Initially, the robot will start to move straight in transit a brief timeframe later it gets the signals from the raspberry pi whether to push ahead, pivot, right or left. Raspberry pi receives the signals from the sensors then the sensors as demonstrated by their extent of identifying detachment take decision and check is there any blockage? At what separation distance? In which course it is be set? Sensors are accountable for measuring the partition viably and then sends the ponder readings to the raspberry pi. There are 24 GPIO sticks in raspberry pi from which 4 pins are related with the auto robot. When obstruction is perceived on its course then instantly it must keep up a vital separation from the robot automatically and it should be moved in an opposite direction heading without touching the obstacle and thereafter ensuing to go for quite a while straight and stops.

5. Fuzzt Logic

5.1 Fuzzy Logic Controller

To handle the heap adjusting issue, ordinary control hypothesis can be connected to re-establish framework harmony. Fuzzy logic control endeavours to catch instinct in the shape of IF-THEN principles, and conclusions are drawn from these tenets. In view of both natural and master information, framework parameters can be displayed as semantic factors also, their relating participation capacities can be outlined. Accordingly, nonlinear framework with incredible many-sided quality and vulnerability can be controlled successfully in light of fuzzy principles without managing mind boggling, dubious, and mistake inclined numerical models. Figure 4 explains the input to output flow diagram of the fuzzy knowledge base controller.

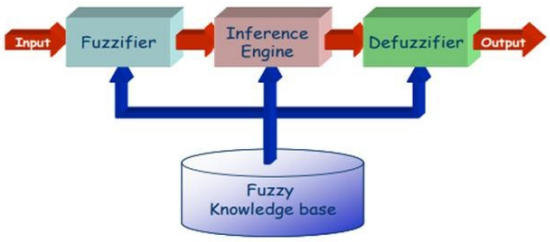

Fig. 4. Flow diagram of Fuzzy knowledge base Controller

5.1 Fuzzy Inference System

The way toward making a mapping amongst info and yield utilizing fuzzy logic is known as fuzzy inference [13]. The mapping is the base from which preferences can be made or recognized. Two sorts of fuzzy inference frameworks can be actualized in the tool kit: Mamdani-sort and Sugeno-sort. The portrayal of these two strategies is given in. The most widely used strategy is the Mamdani's fuzzy derivation framework. This was one of the main control structure manufactured using fuzzy set theory recommended by Ebrahim Mamdani in 1975. It was designed to regulate a steam motor, heater blend by combining a pattern of phonetic control rules achieved from professional and competent supervisors. Lotfi Zadeh's 1973 paper on fuzzy estimation for complicated design and choice procedures was the main impetus behind this work of Mamdani. After the collection procedure, we got a fuzzy set for each yield variable which is defuzzified to get the fresh esteems [15]. Figure 5 demonstrates the proposed mathematical model for the fuzzy inference system which have been applied to our autonomous robot.

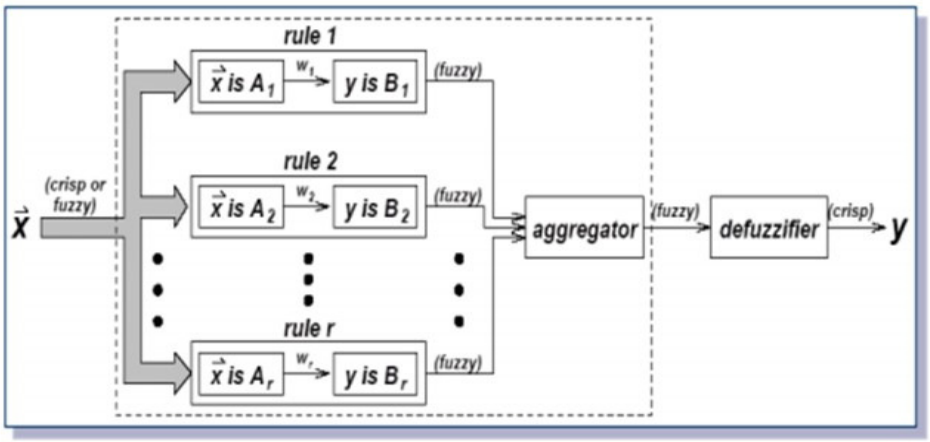

Fig. 5. Mathematical model of FIS

6. Validation of Experimental Analysis

6.1 Testing Sensors

First set the raspberry pi board to work

- Install the OS in raspberry pi
- Build a circuit on board using ultrasonic sensor interfacing it with raspberry pi The ECHO output yields 5v. The input pin of Raspberry Pi GPIO is evaluated at 3.3v. So 5v can't be straight forwardly given to the unprotected 3.3v at the input pin. In this manner we utilize a voltage divider circuit utilizing suitable resistors to cut down the voltage to 3.3V.

6.2 Testing Fuzzy Rules

The input variables from the sensors are normally mapped in a fuzzy control system through membership functions namely "fuzzy sets". We have set three rules far, near and very near based on the distance sensors getting from the obstacles through which the decision is made that in which direction the robot will move. Following are the test results for the fuzzy rules.

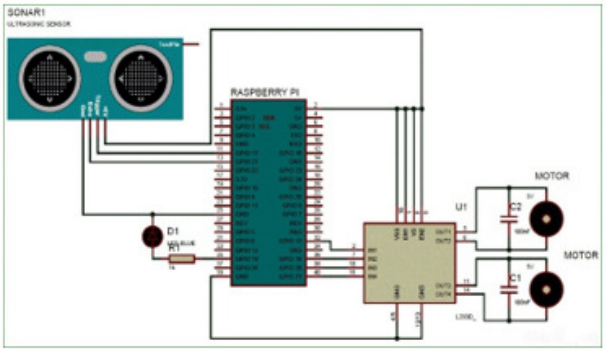

Fig. 6. Schematic diagram

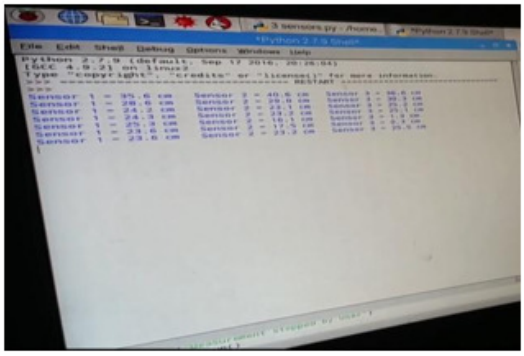

Fig. 7. Analysis of 3 sensors readings

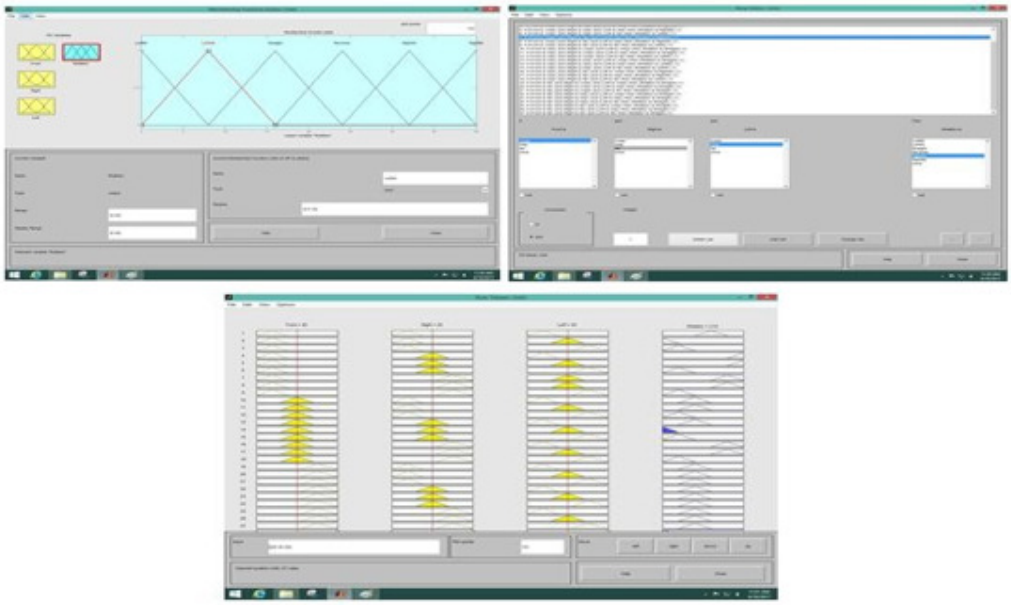

Fig. 8. Membership functions for fuzzification

7. Conclusion and Future Enhancement

Results proved the benefits of fuzzy logic that has brought to the performance of Autonomous mobile robot; this research showed the possible logic strategy for the complex motion systems. The collision avoidance mobile robots have become a major area of research in robotics that involves various degrees of uncertainty. The developed fuzzy logic let the Autonomous mobile robot to have an ability to avoid the static obstacles coming in its path without the involvement of any human being. Fuzzy logic approach has been proved to be a simple and an easier technique for such kind of robots. The Fuzzy logic control approach has proved to be a satisfactory control approach for the mobile robot to avoid the collision problem. It behaves intelligently in real time in order to prevent the robot to hit with any obstacle in the environment.

Overall, this proposed research will serve as groundwork for the detailed investigation and development of smarter intelligent robots. This research can be further enhanced and can be used

for the surveillance system by adding image processing techniques as well. Furthermore, Multi-layer perceptron (MLP) can be applied to reduce the false alarm rate briskly. Our proposed approach can be used for implementing the idea of a driverless car. By modifying this robot, this design can be used as a vacuum cleaner robot and an unmanned firefighter robot. Espionage using this robot can also be performed.

References

[1] Pandey, Anish, Rakesh Kumar Sonkar, Krishna Kant Pandey, and D. R. Parhi. "Path planning navigation of mobile robot with obstacles avoidance using fuzzy logic controller." In Intelligent Systems and Control (ISCO), 2014 IEEE 8th International Conference on, pp. 39-41. IEEE, 2014.

[2] Landsberger, Samuel Ernest. "Design and construction of a cable-controlled, parallel link manipulator." PhD diss., Massachusetts Institute of Technology, 1984.

[3] Hwang, Yong K., and Narendra Ahuja. "A potential field approach to path planning." *IEEE Transactions on Robotics and Automation* 8, no. 1 (1992): 23-32.

[4] Tsourveloudis, Nikos C., Kimon P. Valavanis, and Timothy Hebert. "Autonomous vehicle navigation utilizing electrostatic potential fields and fuzzy logic." *IEEE transactions on robotics and automation* 17, no. 4 (2001): 490-497.

[5] Howie C., llhan K. and Joel B., "Mobilc Robot Navigation: Issue in lmplcmentating the Generalized Vomai Graph in the Plane", Proceedings of the 1996 lEEE/SlCE/RSJ Internotionol Conference on Mullisemor Furion and lnlegrolion for lntelligenr Systems. pp. 241- 248, Dec. 1996.

[6] Pradhan, Saroj Kumar, Dayal Ramakrushna Parhi, and Anup Kumar Panda. "Fuzzy logic techniques for navigation of several mobile robots." *Applied soft computing* 9, no. 1 (2009): 290-304.

[7] Dong, Tao, X. H. Liao, Ran Zhang, Zhao Sun, and Y. D. Song. "Path tracking and obstacles avoidance of uavs-fuzzy logic approach." In Fuzzy Systems, 2005. FUZZ'05. The 14th IEEE International Conference on, pp. 43-48. IEEE, 2005.

[8] Sayyaadi, H., T. Ura, and T. Fujii. "Collision avoidance controller for AUV systems using stochastic real value reinforcement learning method." In SICE 2000. Proceedings of the 39th SICE Annual Conference. International Session Papers, pp. 165-170. IEEE, 2000.

[9] Liu, Xuemin, Liang Peng, Jiawei Li, and Yuru Xu. "Obstacle avoidance using fuzzy neural networks." In Underwater Technology, 1998. Proceedings of the 1998 International Symposium on, pp. 282-286. IEEE, 1998.

[10] Lee, T. H., H. K. Lam, Frank HF Leung, and Peter KS Tam. "A practical fuzzy logic controller for the path tracking of wheeled mobile robots." *IEEE control systems* 23, no. 2 (2003): 60-65.

[11] Antonelli, Gianluca, Stefano Chiaverini, and Giuseppe Fusco. "A fuzzy-logic-based approach for mobile robot path tracking." *IEEE Transactions on Fuzzy Systems* 15, no. 2 (2007): 211-221.

[12] Guo, Jinghua, Ping Hu, Linhui Li, and Rongben Wang. "Design of automatic steering controller for trajectory tracking of unmanned vehicles using genetic algorithms." *IEEE Transactions on Vehicular Technology* 61, no. 7 (2012): 2913-2924.

[13] Kimiaghalam, Bahram, Abdollah Homaifar, Bodin Suttikulvet, and Bijan Sayyarrodsari. "A multi-layered multi fuzzy inference systems for autonomous robot navigation and obstacle avoidance." In Fuzzy Systems, 2001. The 10th IEEE International Conference on, vol. 1, pp. 340-343. IEEE, 2001.

[14] Beom, Hee Rak, and Hyung Suck Cho. "A sensor-based navigation for a mobile robot using fuzzy logic and reinforcement learning." *IEEE transactions on Systems, Man, and Cybernetics* 25, no. 3 (1995): 464-477.

[15] Handayani, Ade Silvia, Nyayu Latifah Husni, Siti Nurmaini, and Irsyadi Yani. "Formation control design for real swarm robot using fuzzy logic." In Electrical Engineering and Computer Science (ICECOS), 2017 International Conference on, pp. 77-82. IEEE, 2017.

[16] Scicluna, Neil, Edward Gatt, Owen Casha, Ivan Grech, and Joseph Micallef. "Fpga-based autonomous parking of a car-like robot using fuzzy logic control." In Electronics, Circuits and Systems (ICECS), 2012 19th IEEE International Conference on, pp. 229-232. IEEE, 2012.

[17] Lee, Seung-Hwan, Tae-Seok Lee, and Beom-Hee Lee. "A sensor fusion system using enhanced extended Kalman filter with double fuzzy logics for autonomous robot guidance." In System Integration (SII), 2011 IEEE/SICE International Symposium on, pp. 579-584. IEEE, 2011.

[18] Martinez-Marroquin, Ricardo, Oscar Castillo, and Jose Soria. "Parameter tuning of membership functions of a fuzzy logic controller for an autonomous wheeled mobile robot using ant colony optimization." In Fuzzy Systems, 2009. FUZZ-IEEE 2009. IEEE International Conference on, pp. 2007-2012. IEEE, 2009.

[19] Gaonkar, Priti K., Anthony DelSorbo, and Kuldip S. Rattan. "Fuzzy navigation for an autonomous mobile robot." In Fuzzy Information Processing Society, 2005. NAFIPS 2005. Annual Meeting of the North American, pp. 412-417. IEEE, 2005.