Fuzzy Logic-Genetic Algorithm-Neural Network for Mobile Robot Navigation: A Survey

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Abstract - *A Comprehensive survey on navigation of mobile robot using fuzzy logic and genetic algorithm is presented. Navigation of mobile robot needs to find the collision free path in the environment with minimum time period. Fuzzy logic, genetic algorithm and neural network are more efficient than others soft computing methods. Fuzzy logic, genetic algorithm, neural network and hybrid methods are proposed in the literature.*

***Key Words*:** **Fuzzy logic, genetic algorithm, neural networks, mobile robot, navigation.**

1. INTRODUCTION

Navigation of mobile robot is one of the most challenging research topic in the field of robotics. The navigation methods are classified as model-based method and behavioral based method. The model-based method are artificial potential field (APF), the edge detection (ED), the obstacle boundary following (BBF), and the behavioral-based method are fuzzy logic, neural network, genetic algorithm, ant colony optimization. Among the model-based methods, APF is the most convenient in implementation and simplicity in computation. But the fast reaction in obstacles avoidance is fuzzy logic as compared to other existing methods. Although the fast reaction method is popular, the robot navigation facing the common problem of local minimum problem due to its reactive nature, getting trapped in front of obstacles. Most of the researchers used soft computing methods for navigating mobile robot as it is more efficient from the others existing method. In the soft computing methods, the hybrid method are more powerful than the individual's method such as fuzzy logic, genetic algorithm, neural network, ant colony optimization, bacterial foraging method, etc. The combination of these tools is to get advantages from both of them and to eliminate their individual limitations thereby making the whole process of finding the path very efficient. In this survey paper, fuzzy logic approaches is presented in Section 2, genetic algorithm approaches is explained in Section 3, Neural Network approaches is explained in Section 4 and hybrid approaches of fuzzy-genetic approaches, neuro-fuzzy approaches and neuro-genetic approaches are presented in Section 5, 6 and 7 respectively followed by conclusion in Section 8.

2. FUZZY LOGIC APPROACHES

Fuzzy logic approaches are widely used for navigating a mobile robot by many researchers. . A virtual target approach is proposed in [1] for resolving the limit cycle problem in navigation of a behavioral based mobile robot. A new structure with the basic principles of sliding-mode control and fuzzy logic is proposed in [2] to execute the desired motion. A fuzzy behaviors is proposed in [3] for mobile robot navigation using fuzzy rules which mimic expert knowledge. A fuzzy temporal rules system for the guidance of mobile robot has been described in [5] for dynamic environment. The implementation of controller is robust, low execution time, allows an easy design and tuning of the knowledge base. A navigation method in an unknown environment based on fuzzy interface system behaviors is developed in [6]. The developed navigator is combined of two types of obstacles avoidance behaviors, one for the convex obstacles and one for the concave obstacles. The behavior-based robot navigation strategy using fuzzy logic rules is developed in [7]. It has more advantages as the fuzzy rules are simple and easily understandable, and can emulate the human driver's perception, knowledge and experience. Multiple fuzzy navigation behaviors are combined to unified strategy to avoid abrupt and discontinuous transitions. A data-driven fuzzy approaches is developed in [8] for solving the motion planning of a mobile robot in the presence of moving obstacles. The approaches consists of devising a general method for the derivation of input-output data to construct a fuzzy logic controller (FLC) off-line. An intelligent control of non-holonomic mobile robots with fuzzy perception of the environment is presented in [9]. Autonomous fuzzy behavior control on an FPGA-Based Car- Like mobile robot is developed in [10, 11]. Four kind of FLCs, fuzzy wall-following control, fuzzy corner control, fuzzy garage-parking control, and fuzzy parallel-parking control are synthesized to accomplish the autonomous fuzzy behavior control. A fuzzy based reactive controller for a non-holonomic mobile robot in a cluttered environment is presented in [12, 13]. The problem of extracting IF-THEN rules is carried out by evolutionary algorithm. They are tuned to minimize the tracking trajectory errors. Detection of landmarks is essential in mobile robotics for navigating tasks like building topologies maps or robot localization. In [14] landmark detection in mobile robotics using fuzzy temporal rules is developed. A fuzzy logic-based approach for dynamic localization of mobile robots is described in [15]. The approaches uses sonar data collected from a ring of sonar sensors mounted around the robot. The local fuzzy composite map which is constructed by using reduced models of uncertainty is fitted to the given global map of the environment to identify robot's location. A real-time fuzzy target tracking control scheme for autonomous mobile robots by using infrared sensors is designed in [16]. Intelligent controllers for target tracking, wall following are all based on the concept of fuzzy sliding mode control (FSMC). The fuzzy target tracking control unit (FTTCU) consisted by the behavior network and the gate network has been applied to the target tracking control with obstacle avoidance. A fuzzy behavior-based architecture is designed in [17] for the control of mobile robots in a multi-agent environment. It decomposes the complex multi-robotic system into smaller modules of roles, behaviors and actions. Fuzzy logic is applied to implement individual's behaviors to coordinate the various behaviors, to select roles for each roles, for robot perception, decision making and speed control. Navigation of mobile robots using fuzzy logic controller is presented in [18]. Fuzzy rules embedded in the controller of a mobile robot enable it to avoid obstacles in a cluttered environment that includes the other mobile robots. A simple adaptive fuzzy logic-based controller is designed in [19] which utilizes a fuzzy interference system (FIS) for estimating the non-linear robot functions involving unknown robot parameters for tracking control of wheeled mobile robots. A multi-agent architecture with cooperative fuzzy control for a mobile robot is developed in [20] in order to centralize the coordination of the behaviors in a single module or agent which represents a problem when there is more than one behavior competing for the available resources. A path following approaches for mobile robot based on fuzzy logic set of rules is developed in [21] to emulate the human driving behavior. The input to the develop fuzzy system is the approximate information concerning the next bend ahead the robot and the corresponding output is the cruise velocity that the robot needs to attain in order to safely drive on the path. A novel nonvision –based robot navigation algorithm using RFID technology and fuzzy logic is presented in [22]. The fuzzy logic is to decide the amount of tune up angle that the robot has applied to its direction to converge to its target position. The input to this fuzzy system is the phase difference provided by the two directional antennas mounted to the RFID reader on the robot. Fuzzy logic based real time robot navigation in unstructured environment is approached in [23], a new grid based map model called memory grid and a new behavior based navigation method called minimum risk method are also involved. The memory grid map records the environment information and robot experience, while the minimum risk method is used to choose the safest region that can avoid obstacles and prevent the robot from iterating previous trajectory. Fuzzy logic is used to implement the behavior design and coordination. A preference-based fuzzy behavior system for robot navigation control using the multivalued logic framework is presented in [24]. The proposed method allows the robot to navigate in cluttered environment such as dense forests. A complete control law comprising of an evolutionary programming based kinematic control (EPKC) and an adaptive fuzzy sliding-mode dynamic control (AFSMDC) for trajectory-tracking control of non-holonomic wheeled mobile robots is presented in [26]. The EPKC is to determine all the sub- optional control gains for Kinematic control and AFSMDC is to deal with the system uncertainties and external disturbances. In [27], the impact of the selection of the fitness function on the evolution of a fuzzy controller, together with the navigation performance of a mobile robot is presented. In this paper, three different types of fitness function namely, aggregate, behavior, tailored are considered and to evaluate the performance an efficiency factor metric is introduced. From the experiment, tailored type function is more appropriate for the navigation of mobile robot in static environment. A new fuzzy logic approach control system is developed in [28] for reactive mobile robot navigation in local environment. The inputs to the fuzzy controller are the obstacles positions relatives to the robot heading and the target orientation. The algorithm performs the main tasks of obstacles avoidance, target seeking and speed control. In [29], navigation techniques of several mobile robots using fuzzy logic controllers are designed in an unknown environment. Three fuzzy logic controllers with different membership functions are designed to navigate mobile robots. First a triangular fuzzy controller is designed with four input members, two output members and three parameters each. Triangular and Gaussian fuzzy controllers is designed having same input and output members with five parameters each. Among the different techniques designed, fuzzy logic controller with gaussian membership function is found to be the most efficient for mobile robots navigation. A System on Chip (SoC) for the path planning of autonomous non-holonomic mobile robots is presented in [32]. It consists of a parameterized Digital Fuzzy Logic Controller (DFLC) core and a flow control algorithm that runs under the Xilinx Microblaze soft processor core. A software simulation of navigating problems of mobile robot avoiding obstacles in static environment using both fuzzy logic and classical algorithms is developed in [34]. Obstacles of standard shapes and sizes are drawn as the simulation environment is a menu-drive. The starting and the ending points of the mobile robot are also assigned. An online navigation technique for a wheeled mobile robot (WMR) in an unknown dynamic environment using fuzzy logic techniques is presented in [38]. Two fuzzy logic controllers are developed and used to navigate the mobile robot from the initial point to the goal point. Tracking fuzzy logic control (TFLC) and Avoidance fuzzy logic control (OAFLC) are combined to move the mobile robot to the goal point along a collision free path. An optimal Mamdani type fuzzy controller is designed in [40] for trajectory tracking of both velocity and position of the wheel mobile robot (WMR). The parameters of input and output membership functions are optimized by random inertia weight Particle Swarm Optimization (RNW-PSO). A fuzzy controller for trajectory tracking with unicycle-like mobile robots is proposed in [41]. It uses two Takagi-Sugeno (TS) fuzzy blocks to generate its gains and able to limit the velocity and control signals of the robot, reduce the errors arising from its dynamics. In [99], two independent fuzzy controllers is design for omnidirectional mobile robot navigation. The first controller is to control the robot linear velocities and the second one is to control the robot angular velocity. Adaptive Fuzzy-PI controllers adjust theirs parameters to decrease the error caused by the dynamic changes. In [103], an effective algorithm is presented for real-time optimal path planning of autonomous humanoid robot.

It is developed using Markov decision process and fuzzy inference system. The reward function is calculated without exact estimation of distance and shape of the obstacles. This algorithm can work in noisy data and requires only one camera and does not need of range computing. In [105], only one fuzzy controller is used for navigation and obstacle avoidance. The used mobile robot is equipped with DC motor and nine infrared range sensor to measure the distance to obstacles and two optical encoders to provide the actual position and speeds. In [106], the probabilistic fuzzy decision controller is designed to avoid obstacles and to generate efficient path. It studies the geometric constraints present in environment. The controller make the robot to take its decision effectively in complex environment in a feasible time.

3. GENETIC ALGORITHM APPROACHES

Path planning software based on genetic algorithms is proposed in [43] for mobile robot in static environment. It focuses on less energy consumption while moving in a given environment. Problem specific genetic operators are introduced and especially the handlings of exceptional situations. Action-based Environment Modeling (AEM) approaches is presented in [44] for a simple mobile robot to recognize environments. Genetic algorithm is applied to search the behaviors and the simulated mobile robots were used as individuals. Path planning optimization of an autonomous mobile robots using multi objective genetic algorithm is proposed in [45].In that the conventional genetic algorithm with a generational replacement scheme and triggered hypermutation gave consistent performance while the multi objective genetic algorithm based on Pareto optimality combine with an elitist replacement scheme improves path planning problem. Path planning of multiple robots for multiple targets in presence of obstacles using petri-genetic algorithm optimization is proposed in [46]. The proposed algorithm is based on iterative non-linear search, a conflict avoidance module based on Petri-Net model navigate robots safely in the environment. A parallel elite genetic algorithm and its application is proposed in [47] for global path planning of mobile robot in structured environments. It consists of two parallel elite genetic algorithms along with a migration operator for maintaining better population diversity, inhibiting premature convergence and keeping parallelism in comparison with conventional genetic algorithm. An improved mutation operator for the genetic algorithm is applied to the path planning problems in [48]. It checks all the free nodes close to mutation node instead of randomly selecting a node one by one. It accepts the node according to the fitness value of total path instead of the direction of movement through the mutated node. An improved genetic algorithm with co-evolutionary strategy is proposed in [49] for global path planning of mobile robots. It provides an effective and accurate fitness function and a new modification operator. The use of co-evolution mechanism avoids the collision between mobile robots and effective for each mobile robot to find the optimal or near optimal collision free path. An adaptive genetic algorithm is presented in [50] for robot motion planning in 2D complex environments. It solve an NP-hard problem, metaheuristic problem, local-trap problem and avoid premature convergence. In each iteration, if necessary, the selective pressure is updated by using feedback information from the standard deviation of fitness function values. Improved genetic algorithm with a series of improvement including a concept of visible space, a new encoding form and a new mutation operators is proposed in [51] for mobile robot path planning in dynamic environment. Infeasible paths can be modified quickly and with a high degree of efficiency by using visible space. And using new mutation operators, rapidly coverage towards a global optimal solution with higher probability. This method is more effective in dynamic environment because when environment changes only the path segments that intersect with obstacles needs to be re optimized. In [52], a new genetic algorithm based controller has been developed for navigation of mobile robots in a highly cluttered environment. A method for adjustment of fitness values to avoid statistical variation due to randomness in initial positions and orientations of obstacles. The distances of obstacles from three directions via front, left and right are evaluated by using suitable fitness function and optimized by the proposed method. Dynamic path planning of mobile robot using improved genetic algorithm is proposed in [53]. The improved visual graph and the conception of safety coefficient are presented. It replaces the mutation individual with hill- climbing method. Float-point coding is presented to reduce the length and the total slope of the path in dynamic path planning. A co-evolutionary improved genetic algorithm (CIGA) is presented in [56] for global path planning of multiple mobile robots. It presents an effective and accurate fitness function, a new genetic modification operator. The use of co-evolutionary mechanism avoids collision between mobile robots and conductive for each mobile robots to find the optimal or near optimal collision-free path. In [104], the path planning of the coverage region for a vacuum cleaner robot using the genetic algorithm is presented. The proposed algorithm consists of several steps to get the solutions. Each gene represents the robot positions and some of chromosomes represent the mini-path.

4. NEURAL NETWORKS APPROACHES

In [107], a neural network approaches to real–time collision free motion planning of mobile robot in nonstationary environment is presented. Each neuron has local connection in the topological neural network connection. So, the computational complexity depends on neural network size. The planned robot motion is globally optimal in distance and time. An efficient neural network method is presented in [108] for real time motion planning in nostationary environment with safety consideration. The method is stable for parameters variations and computational time is less. In [109], dynamic collision free trajectory generation in a nonstationary environment using neural network is presented. It is organized topologically where the dynamic of each neurons are characterized by shunting equation and additive equation. Neural predictive control scheme is presented in [110] for car like mobile robot. It consists of path generations, position estimation and wavelet model based predictive control. The advantages of the model are convex cost index without local minima, appropriate initial value setting of weights and constructive approaches of hidden layer of feed- forward neural networks. In [111], a neural dynamic based approaches is presented for real time collision free motion planning in nonstationary environment. It is planned through the dynamic neural activity landscape of the neural networks without any learning procedures and without any local collision checking procedures at each steps of robot motion. The computationally complexity depends on neural networks size and the model is simple. The stability of the method is proved by qualitative analysis and Lyapunov stability theory. Neural network based techniques is presented in [112] for solving the motion planning problem in mobile robot control. It is based on two neural networks which the first one is used to determine the free space using the ultrasound range finder data and the second one is to find a safe direction of the next robot motion in environment while avoiding the nearest obstacles. In [113], radial-basis function (RBF) network based controller is proposed to control mobile robot in dynamic environment. The stability of controller is proven using Lyapunov function. From the simulation results the proposed controller reduce the steady state error under the circumstance of friction and unfolded dynamics. A new type of neural network-the dynamic wave expansion neural network (DWENN) is proposed in [116] for path generation in dynamic environment for mobile robot. It is parameter free, computationally efficient and configuration space is not a factor of complexity. In [117], a two level hierarchical neural network for the mapping of maze and generation of path is presented. The amount of time taken and shortest path are depend on the size of the maze which all the neurons doing their processing in parallel manner. A simple neuron-based adaptive controller is proposed in [119] for trajectory tracking for nonholonomic mobile robot without velocity measurements. It is based on structural knowledge of dynamics of the robot and the position of robot. In [121], the immune network control for robot is proposed for stigmergy based foraging behavior. The random moves necessary for stigmergy makes the solution time consuming process. The proposed method speed up the foraging behavior and stigmergy principles are coded into two artificial immune networks as for collision free goal following behavior and for an object picking up/dropping behavior. A reactive immune network (RIM) is developed in [122] for mobile robot navigation in unknown environment and adaptive virtual target method is integrated to solve the local minima problem in navigation. In [123], a behavioral control through artificial neural networks based controller or neurocontroller for autonomous mobile robot navigation is presented. In [124], an adaptive trajectory tracking of mobile robots which combine a feedback linearization and a RBF-NN adaptive dynamic compensation is presented. Two controllers are implemented separately for a robot with uncertain dynamic parameters as kinematics controller and an inverse dynamic controller. An artificial neural network controller for autonomous mobile robot is developed in [125] to navigate in a real world of dynamic environment. The controller inputs consist of left, right and front distance with respect to its position and target angle, and the output is steering angle. To solve the path and time optimization problems a four layer neural network is designed which deals with learning, adaptation, generalization and optimization. A back propagation algorithm is used to train the network. In [126], a novel adaptive controller based on neural network learning ability is proposed for trajectory tracking of mobile robot. The controller does not required the knowledge of the robot dynamics. The kinematics controller are turned online to minimize the velocity error and improve the trajectory tracking characteristics. In [127], a trajectory tracking controller for mobile robot based on feed forward and feedback neural is proposed. The feed forward neural controller is trained offline and its adaptive weights are adapted online to control the steady state outputs of mobile robot system. The feedback neural controller is used to find the optimal torque action. In [128], a biologically inspired spiking neural network based controller is presented for mobile robot control. Information is routed through the network using dynamics synapses and learning occurs through long term synaptic plasticity to enable the robot correct movement with the appropriate input conditions. In [129], a technique based on utilization of neural network and reinforcement learning is used to navigate the autonomous mobile robot in unknown environment. The robot learns to navigate efficient navigation rules automatically without initial settings of rules by experts. In [130], an anti-collision system based on neural networks is proposed for autonomous surface vehicle. The proposed system is divided into two neuro-evolutionary methods to build the system and reports the whole process of constructing it. In [131], an adaptive neural PID controller is proposed for nonlinear dynamics in mobile robot. To implement the strategy two controllers are implemented as kinematic controller and neural PID controller. The resulting adaptive neural PID controller is efficient and robust to achieve good tracking performance.

5. FUZZY- GENETIC ALGORITHM APPROACHES

A mobile robot control using fuzzy logic which is optimized by genetic algorithm is presented in [106]. Fuzzy control systems use a set of variables and fuzzy membership functions have an unfixed shape and a set of unfixed points. Genetic algorithms are used to optimize the fuzzy membership functions. The designed control system allows to avoid the unexpected obstacles in partially unknown environment. In [107], fuzzy system model is constructed using fuzzy partition and genetic algorithm hybrid schemes for the navigation of mobile robot. The parameters defining the fuzzy implications are identified by genetic algorithm hybrid scheme to minimize mean square errors globally. A genetic-fuzzy approach for mobile robot navigation among moving obstacles is presented in [108]. The proposed approach optimizes the travel time of a robot off-line by simultaneously finding an optimal fuzzy rule base and optimal scaling factors of the static variables. In [70], A fuzzy system is designed to control omni-directional mobile robot based on genetic algorithms so that it can move to any direction and spin at a rotating rate. The language of VHDL is used to design the selected fuzzy system structure and it is realized on a FPGA chip to control the robot. The automated design of a fuzzy controller using genetic algorithms for the implementation of wall following behaviors in mobile robot is presented in [71]. The algorithm is based on the Iterative Rule Learning (IRL) approach and parameter (δ) is defined for selecting the relation between the number of rules and the quality and accuracy of controller. In [76], a novel method of integrated fuzzy logic and genetic algorithm for solving simultaneous localization and mapping problem of mobile robot is presented. It is based on island genetic algorithm (IGA) which search for most probable maps such that the associated poses provides the robot with the best localization information. In [82], a tracking controller for dynamic mobile robot by integrating a kinematic and torque controller based on type-2 fuzzy logic and genetic algorithm is presented. Genetic algorithms are used to optimize the constants for trajectory controller and parameters for membership function for fuzzy logic. In [86], the design and optimization of structural fuzzy controller for mobile robot obstacle avoidance is presented. A special tailored genetic algorithm is used to optimize the fuzzy logic controller due to the large and complex search problem. In [91], a comparative study of soft computing techniques for mobile robot navigation in unstructured environment is performed in four different scenarios using four parameters i.e. distance travelled, travelling time, bending energy and average speed. A hybrid of genetic algorithm and fuzzy logic gives the best result in terms of travelling time and average speed. In [101], an optimal collision-free path planning for indoor mobile robot using genetic algorithm and fuzzy logic control is implemented. Image acquisition and processing techniques are implemented to exactly model the environment by constructing binary safe map. Genetic algorithm is used to generate the most suitable path from the number of random paths safely and rapidly. Piecewise Cubic Hermite Interpolating Polynomial is used to smooth the best found path. After that an adaptive fuzzy logic controller is designed to ensure perfect path tracking.

6. NEURO-FUZZY APPROACHES

A heuristic fuzzy-neuro network is developed in [59] for reactive navigation of mobile robot in unknown environment. Fuzzy Kohonen clustering network (FKCN) is used to build the desired mapping between perception and motion. The proposed method allows continuous fast motion of the mobile robot without any need to stop for obstacles. In [60], neuro-fuzzy approaches is proposed for obstacle avoidance of mobile robot. It automatically extract the fuzzy rules and membership functions. Fuzzy rules are obtained from the set of trajectories provided by the human guidance. The proposed approaches consists of three layer neural network along with competitive learning algorithm. In [132], a navigation method combining of the transparency of fuzzy logic with the adaptability of neural network has been proposed. It has been applied to mobile robot in different environment. In [133], a hybrid intelligent method of fuzzy inference and neural network is presented for mobile robot motion in unknown environment. It efficiently control a mobile robot based on different sensing information namely the obstacles position sensed by ultrasonic sensors, target orientation and the movement direction of robot. In [134], a neural fuzzy system with mixed learning algorithm is presented for obstacle avoidance of mobile robot in unknown environment. Supervised learning is used to determine the inputs and outputs membership functions simultaneously and reinforcement learning is used to tune the output membership functions. The proposed method able to achieve a path reasonable close to shortest path, smooth motion and very robust to sensor noise. In [135], a behavior-based neuro-fuzzy controller is proposed for mobile robot navigation in indoor environments. Go-target behavior reacts to forward facing sensor, Wall-flowing behavior reacts to wall sensors and Turn-Corner behavior reacts to backward facing sensor. Only Go-target behavior is implemented as an Adaptive Neuro-Fuzzy Inference system (ANFIS). The proposed system able to take minimum time to reach the targeted point. In [136], a neuro-fuzzy controller is proposed to control the real-time autonomous mobile robot. It is based on Generalized Dynamic Fuzzy Neural Networks (GDFNN) learning algorithm. It optimized not only the parameters of the controller but it also the structure of the controller is self-adaptive. The proposed controller has a parsimonious structure and the performance is superior to the conventional fuzzy logic approach. In [137], a hybrid learning approach for neuro-fuzzy system is presented for obstacle avoidance of a mobile robot. Supervised learning is used whereby the controller is trained by system in which the robot is embedded. The efficient Fuzzy Inference system is based on GDFNN learning algorithm. The proposed hybrid approaches is efficient for obstacles avoidance of a mobile robot in the real world. In [138], a new intelligent motion control strategy which is the integration of fuzzy obstacle avoidance, multi sensor based motions and robust recurrent neural network control is proposed for intelligent mobile robot navigation manipulators. The used of control strategy is very attractive for real-time fast and non-stop sensor based guidance for mobile robot manipulators. In [139], a neuro-fuzzy approaches are developed to determine time optimal, collision free path of a car like mobile robot navigation in dynamic environment. A fuzzy controller is used to control the robot and the performance of the controller is improved by using three different neuro-fuzzy approaches. The neuro-fuzzy approaches are compared with manually constructed fuzzy logic and potential field method. The neuro-fuzzy approaches is found to be better than other methods and it depends on training data. In [140], a technique for navigation of multiple robots using different fuzzy logic controller and neuro-fuzzy technique in highly clustered environments is developed. The neural networks considered for neuro-fuzzy techniques is a multi-layer perception with two hidden layers. With this techniques the robot reach the target efficiently by avoiding the obstacles. In [141], a neuro-fuzzy-based approaches is proposed for mobile robot navigation in unknown environment. The fuzzy logic system is designed with target seeking and obstacles avoidance behaviors. A learning algorithm based on neural networks is used to tune the parameters of the membership functions which smooth the trajectory generated by fuzzy logic system. The effectiveness and efficient of the proposed approaches is given by simulation results. In [142], a new fuzzy logic with learning algorithm-based navigation method for mobile robot in unknown environment is developed. It allows robot obstacles avoidance and target seeking without local minima. Fuzzy logic controller is constructed based on human sense and learning algorithm is used to fine tune the fuzzy rule base parameters. The advantage of proposed approaches are its simplicity, its easy implementation for industrial applications and robot joins its objective despite the environment complexity.

7. NEURO-GENETIC ALGORITHM APPROACHES

In [67], a method for global path planning based on neural network and genetic algorithm is presented. The method construct a neural network model and establishes the relation between obstacles avoidance and the output of model. Genetic algorithm is applied to find the global optimal path in static environment. In [80], a comparative study is presented for real robot navigation tackling moving objects. A three layer neural networks model is constructed for navigation and the weights of the network are optimized by genetic algorithm.

8. CONCLUSIONS

A comprehensive survey of various navigation methods of mobile robot is presented. Among them hybrid methods are more efficient as compared to the individuals methods. Their advantages and disadvantages have been summarized and presented. Some recently proposed algorithms have been added and studied.

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