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Convolutional Neural Network-Based Robot Path Planning and Equipment Obstacle Intelligent Recognition System

Wusong Sun[1,a*] **and Hua Lin**[2,b]

[1] *School of Automotive and Mechanical & Electrical Engineering, Lu'an Vocational Technical College, Lu'an 237158, Anhui, China*
[2] *School of Mechanical and Automation Engineering, West AnHui University, Lu'an 237012, Anhui, China*

Robots need quick and efficient handling to take the minimum possible path. A robot and autonomous vehicle require path planning to establish the fastest and most efficient path from a start point to the final destination. A mapping of the surrounding area is needed for path planning and knowledge of the current and future environmental conditions. Robot planning challenges include working with other robots and people, managing high levels of freedom of movement with substantial awareness of the situational limits of motion, combining perception with planning, and real-time performance. Most convolutional neural networks and the analysis revealed that the robot responds quicker in dynamic environments with obstacles to the communication system. An innovative strategy for path planning for robotic systems is using the fuzzy analytical hierarchy process (FAHP) to handle a decision-making issue with multiple objectives efficiently. Robot identification using a reinforcement learning (RL)-based obstacle avoidance path planner that shortens routes and uses fewer path servers can increase the robot's efficiency. Hence, FAHP-RL has improved robot path planning, which is critical for guaranteeing robot precision and avoiding collisions. Robot path planning for industrial robots is a crucial component of the automation system of a robot capable of performing automated handling activities. The robot can perform autonomous tracking, grabbing, and transportation functions. Efficient robotic systems are essential for the future sustainability of the planet. Moreover, safer and more effective operations are possible under harsher environmental conditions because of advancements in visual sonar-based localization, mapping, and learning control.

Keywords: reinforcement learning, fuzzy analytic hierarchy process, robot path planning, equipment obstacle intelligent recognition system.

1. OVERVIEW OF ROBOT PATH PLANNING

Path planning is the most critical aspect of vehicle navigation as it determines the geometrical route from a vehicle's present position to a destination point while avoiding obstacles [1]. Robots are intelligent machines able to detect obstacles in their path and autonomously change course to avoid them. It is necessary to design a robot with the capability to navigate an uncharted area while avoiding collisions [2]. Robot path planning is essentially either local or global, depending on the level of environmental cognition in an optimal system and the reactive intelligent evaluation engine [3]. Obstacle mapping is essential for safe path planning for intelligent robots operating in unfamiliar environments. The location of an obstacle must be determined quickly enough for the robot control to engage and execute appropriate movements [4]. Because maximizing productivity is challenging, motion planning is crucial to developing mobile robots that can travel freely from one location to another despite static and dynamic

*Address for correspondence: Wusong Sun, School of Automotive and Mechanical & Electrical Engineering, Lu'an Vocational Technical College, Lu'an 237158, Anhui, China, Email: wu88866621@163.com. [a]Email: wu88866621@163.com, [b]Email: linhua5704@163.com

barriers requiring human intervention [5]. Robotic path planning aims to establish the best path from the beginning, free of obstacles. A planned path ensures lengths among the established response interaction and intermediate region [6]. Employing a unique prediction process, a convolutional neural network (CNN) facilitates the development of entire paths with multiple offshoots. The strategy can create optimal and near-optimal routes in more environments for single-path predictions [7]. Multi-objective path planning has been extensively explored, and CNN can consider numerous factors at various times, such as path distance, collision avoidance, and speed. The multi-objective optimizer can be adapted to the path's length and the effort required to navigate it [8].

FAHP can be used for inter-decision-making in autonomous robots. With the proposed FAHP, triangulation fuzzy statistic extent investigates the determinants robust feature vector using different perspectives [9]. FAHP analytically chooses a sub-goal on a mobile robot's sensing boundary based on the distance covered, the likelihood of contact with obstacles, and the robot's ability to turn to face its destination [10]. RL prepares machine learning models to help a robot achieve its goals in a complex and unpredictable environment by establishing a set of actions that the robot can learn. [11]. A learning-based method that uses environmental spatiotemporal knowledge for the robot planning path is applied, offering a globally-directed RL that is different from previous machine learning approaches and includes a unique reward structure that adapts to unfamiliar environments [12]. Intelligence must be integrated into its design for the robot to execute a task better. In response to this need, several research issues related to robotic applications have emerged, including planning, work distribution issues, navigation, and tracking [13]. The disadvantage of the proposed method is that the shortest path is determined without regard for safety. However, ensuring safe path navigation requires more time and resources as a robot controller needs to be efficient and effective, requiring a more complex and computationally intensive solution [14]. Therefore, there is a need for robot path planning strategies that can be applied to a range of robots and handle disruptions. These strategies incorporate real-time, autonomous, high-risk area identification and risk management [15]. The approach achieves high levels of effectiveness by establishing an efficient fuzzification of the continuous environment and then quickly solves the resulting separate planning issue. Due to this analytical strategy, speed and supported robot density are significantly improved by many units of magnitude [16]. Path planning issues are a single target, whereas all groups of robots have been employed for multiple independent targets. Several simulated ecosystems of various sizes have tested proposed approaches. Experimental results demonstrate that domain knowledge-based operators improve traditional reproduction systems [17].

The main contributions of this study

- Path planning is conducted to locate the quickest, least-obstructed route to a robot or autonomous vehicle's optimal state (destination). The route has several types and destinations. Path planning includes the beginning, objective (destination), and environment mapping.
- Obstacle-avoiding robot FAHP-RL path planning uses intelligent machines to recognize and avoid obstacles in front of the robot and change its direction to avoid collision. An autonomous robot can manage an unfamiliar environment and limit vibrations.
- This paper extends the research on the outcomes of underlying robotics and automation ideas. This study evaluates physics, electrical engineering, and statistical strategies. Modelling, kinematics, control, optimization, and probabilistic inference are also considered.

  Section 2 describes the methodology adopted for this study; section 3 examines the FAHP-RL approach; section 4 presents the experimental analysis; and section 5 concludes the paper.

2. LITERATURE REVIEW

Kang et al. (2021) explained the Rapidly-Exploring Random Tree (RERT) approach that is based on random statistical analysis; however, ensuring optimality is challenging [18]. Using extrapolation, the proposed strategy creates a path near the ideal path and alleviates the sharp path issue to a specific measure. The suggested approach in this research uses the RERT algorithm to reduce planning time and boost optimization efficiency. In addition, the study provides post-triangulation processing of the midpoint interpolation approach to minimize the path length of the parameter estimation algorithm, thus reducing the time required for robot path planning.

Wang et al. (2021) explored the notion of robot path planning and proposed a novel parallel communication approach to implement the Adaptive Parallel Arithmetic Optimization Algorithm (APAOA) to evaluate an optimal path for pedestrians in an environment with obstacles [19]. First, using established benchmarks, the researchers compared the results of their approach with those of several commonly used implementations. APAOA was then utilized to complete the robot route planning, and experimental results show that the new algorithm works better in terms of solution and prediction accuracy.

Chen et al. (2022) applied the Interval Multi-Objective Particle Swarm Optimization (IMOPSO) technique to examine the shortest path length and lowest risk of encountering obstacles [20]. This path design method sought to identify robot paths that avoid obstacles while minimizing travel time and risk. Furthermore, to increase population diversity, the IMOPSO technique offers a clever interval update that considers the crowding distance of each risk degree interval to determine the optimal global and local positions. Results reveal that the proposed method outperforms three popular multi-objective evolutionary algorithms to locate optimal paths via parameter estimation.

Yang et al. (2022) examined the Fusion Multi-strategy Marine Predator Algorithm (FMMPA) that was developed to address the issues mentioned earlier and determine the mobile robot's global best path [21]. The traditional route can solve the difficult challenge of mobile robotics path planning; planning algorithms need to avoid becoming caught

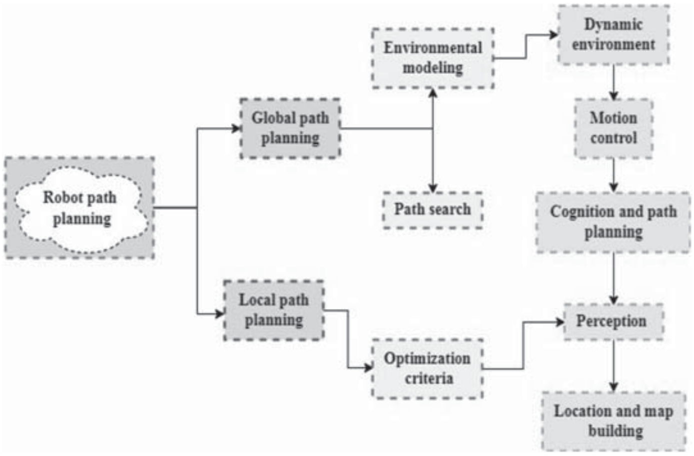

Figure 1 The architecture of robot path planning.

in local minima and having to traverse complex search spaces. For this real-time tracking of prey and predator populations, a nonlinear convex decreasing weighting scheme was used to find a happy medium between the algorithm's global exploration propensity and its capacity for local exploration. Finally, the tests on the mobile robot route planning design confirmed the feasibility of using FMMPA to address real-world optimization problems.

Salama et al. (2021) applied a method known as Radial Cell Decomposition (RCD) to achieve more compact and speedier networks [22]. Many autonomous mobile robots are commonly deployed in various sectors, including manufacturing, health and agriculture, to name just a few, making it imperative that their optimal path be determined. Many methods for path planning have been developed to find the optimal route quickly. Simulation results indicate that the RCD method reduces route length and processing time well.

Ajeil et al. (2020) suggested a unique central regulator and optimization of aging-based ant colony optimization (ABACO) for robot path planning [23]. However, finding an ideal route for a mobile robot is challenging since it must be the most direct and least hazardous path from a robot's starting point to its destination. Therefore, Ajeil et al.'s (2020) research is concerned with developing swarm intelligence optimization-based methods for planning a mobile robot's movement using static and dynamic information.

Hao et al. (2021) explored the issue of robot path planning. To rectify flaws in the original genetic algorithm, they proposed an Adaptive Genetic Algorithm based on Collision Detection (AGACD), including low convergence path quality, the need for multiple extensions to access convergence, and the ease with the optimal local solution can be obtained [24]. The relative importance of route length and path safety can be determined via early analysis. A collision-detection approach is offered to determine whether the desired path collides with the barrier minimization process. The conventional crossover operator is an enhanced solution considering population diversity and algorithm iterations.

In their investigation, Nair et al. (2020) found that the Recurrent Neural Network (RNN) method is generally considered appropriate for robot path planning [25]. This is because RNN uses past inputs for present output, making it applicable for temporal data. The increasing use of artificial systems has made this research area vital to path planning. Several classifiers and learning systems have been developed and evaluated for the path planning objective. This is effective for temporal data since RNN relies on historical inputs to predict future results.

A few drawbacks of robot path planning and obstacle recognition using convolutional neural networks are a lack of issues in the modern day. One difficulty in avoiding a moving obstacle is that the robot pauses before an impediment for better measurement. The disadvantages of RERT, APAOA, IMOPSO, and FMMPA are that they are less accurate in robot movement and position control; hence, this study suggests the proposed FAHP-RL method.

3. INTELLIGENT RECOGNITION SYSTEM FOR THE ROBOT EQUIPMENT AND OBSTACLES USED IN PATH PLANNING

The intelligence recognition systems in robotics include path planning, a major focus of intelligent robot design. Path safety and distance are two specific goals the suggested method can help achieve. Furthermore, the sliding control technique, a robust control rule, is implemented to regulate the steadiness of an autonomous mobile robot following a predetermined path. Finally, the simulation results demonstrate the effectiveness of the control rule for stable mobile robot tracking, demonstrating that the established approach is feasible for establishing an acceptable route.

Figure 1 shows that collision avoidance and path planning are essential to ensure the robot's safety and precision. The efficiency of automation systems relies heavily on path planning for robots. This is essential for achieving reliable, secure, and effective path planning. The component of the proposed architecture is frequently divided into sub-sections: the global planner, which utilizes a normative knowledge of the environment to choose the best technically possible and ethically sound path, and the local planner, which recalculates the previous plan to account for any previously

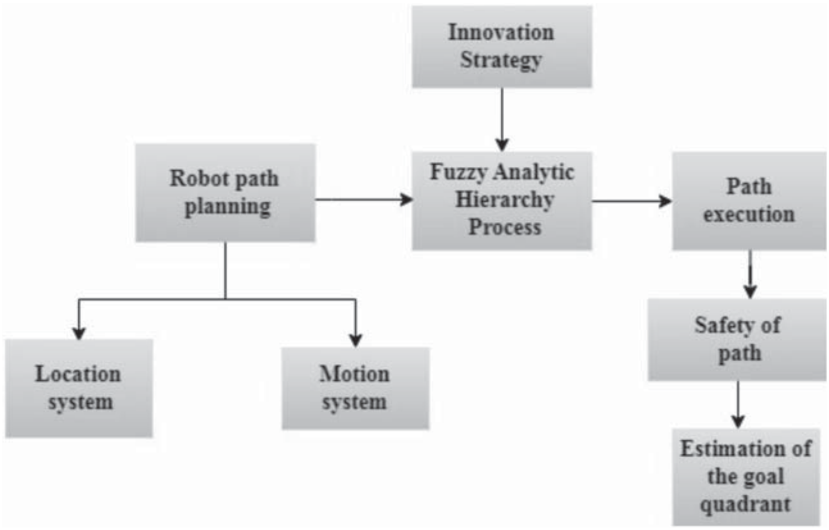

Figure 2 Robot path planning and equipment obstacle intelligent recognition system.

dynamic obstacles. This proposed technique makes finding a way in real-time and adjusting to changing impediments possible. Developing and using mathematical models of the natural world is known as environmental modelling. Modelling the environment may be done for various reasons, including essential scientific inquiry, a deeper understanding of ecological systems, and delivering an interdisciplinary analysis to inform decision-making and policy. Instead of removing or adding material to build an item, as was the case with toolpath planning, robotic path planning seeks to address the issue of an object moving across an area, including known or unknown obstacles, while minimizing collisions. Using automatic robots can help businesses become more efficient and reduce costs. They need to be nimble in their responses to market changes and the development of new ideas, goods, and services if businesses are to remain competitive in a dynamic economic climate.

The term 'motion control' refers to the method by which machines are moved employing rotary and linear actuators. A linear actuator, electric motor, hydraulic pump, or servo motor are all motion control devices that can regulate a machine's position and velocity. A cognitive-based path planning algorithm finds a path using cognitive science and adaptive-based approaches when they have access to supplementary information. To a robot, perception is a mechanism that enables it to take in sensory data, process it, and draw conclusions regarding the surroundings. In addition to utilizing self, the robot uses a map, a three-dimensional depiction of the agents detected by its onboard sensors. Creating a map is crucial when trying to convey details about a location. Grids with filled and empty cells and continuous maps with obstacle coordinates are used to depict maps. The frontier method allows the robot to traverse a grid map and assess the likelihood that each square is occupied or available.

As shown in Figure 2, the template-matching filters used for detecting obstacles are merged with the evolutionary artificial potential field methodology applied when planning routes to provide a system for self-navigating mobile robots.

Approximate coordinates of the target: The mobile robot's identification system uses a digital camera to take visual data from its surroundings. A network of space-variant filters is applied to the collected picture to identify obstacles and determine whether the robot can navigate the region.

Path planner: Evolutionary artificial potential fields are used in the path planner to construct the most significant possible field functions via evolutionary virtualization. The robot itself serves as the reference point in the robot's coordinate system.

Mission planning: Mission planning is a task that often requires the cooperation of several different organizations. This assists dispersed planning since the space department is one of many groups responsible for various aspects of mission operations planning.

Motion planning: In robotics, motion planning is done by dividing a complex task into smaller, more manageable chunks, each of which satisfies the constraints imposed by the overall mission and may even be optimized.

The robot moves through the selected grid: Consider a mobile robot moving inside a building to a distant waypoint, the act of snatching something, unlocking a door, packing an order into a box, or folding a garment. In every case, tasks need robots that can intelligently plan and control the movements of their hands and arms.

Effectors: An end effector is a device or tool attached to the end of a robot arm where the hand would be. The end effector is the portion of the robot that interacts with its surroundings. Once the infrared and passive infrared sensors detect a signal, the built robot can travel a specific route while avoiding obstacles.

Obstacles intelligence recognition system: The robot can accomplish required activities without constant human direction in unstructured conditions, snatching something, unlocking a door, packing an order into a box, or folding a garment in every case. Robotic systems move via the use of locomotion and steering, whereas robotic arms move through the use of rotating and sliding joints. However, robots use their tools to do their duties.

Manipulator: Manipulative tasks include those involving a gripper, and sensory tasks include those concerning camera placement. Robots perform various functions in various

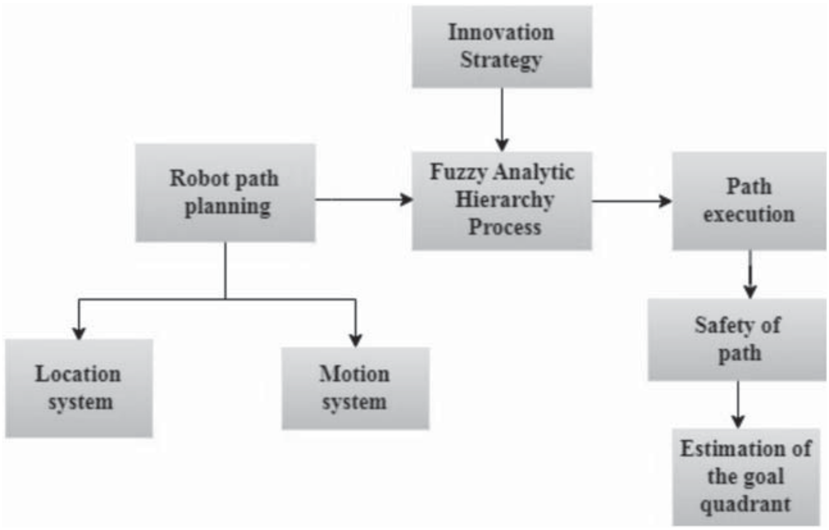

Figure 3 Robot path planning in Fuzzy Analytic Hierarchy Process.

industries, including construction; industries such as mining, transportation, earth and space exploration, medicine, combat, research, safety, and mass manufacturing of consumer and industrial items have benefited greatly from developing scientific methods and tools applied to robotics.

The robot reaches the goal: The robot's positive index value points forward, while the positive black line points perpendicularly to the left. Planning a route is the most crucial part of driving anywhere. This establishes a geometric obstacle-free path from where the plane is to where it needs to be. Robot path planning using the fuzzy analytical hierarchy process is illustrated in Figure 3.

Innovative strategy: A creative approach directs allocating an industry's resources to achieve its innovation goals, provide customer value, and increase its competitive advantage. Evaluating the technical and competitive landscape is necessary for every business's strategy—considering external threats and potential benefits.

Fuzzy Analytic Hierarchy Process: The qualitative and quantitative processes are integrated. FAHP differs primarily in dividing assessment criteria into three distinct categories: goal, measure, and factor.

Path execution: A program's execution route consists of several different ways the program might be run. During symbolic execution, the mapping from variables to symbolic expressions is kept and updated for each execution route. The application can branch into several directions whenever a control flow statement like 'if' is used.

Safety of path: A program's execution route is the set of all feasible ways the program might execute. During symbolic execution, a mapping from variables to symbolic expressions is maintained and updated for each possible execution path—statements of control flow such as 'if because the current execution route is split in half.

Motion system: In robotics, motion planning decomposes a desired assigned movement into individual movements that adhere to the movement restrictions and, perhaps, maximize some movement component.

Location system: Imagine a mobile robot attempting to navigate to a distant waypoint within a skyscraper. Path execution involves guiding a mobile robot to a predetermined location while meeting specific performance requirements.

Robot path plan: The robot needs strategies to finish executing and tracking the created path. Path planning execution guides a mobile robot to a predetermined location while meeting performance requirements. In this case, the robot needs methods to carry out the execution and tracking of the created route.

Estimation of the goal quadrant: Estimating the state of an airborne robotic vehicle, typically its location, velocity, orientation, and angular velocity, but in more complex scenarios, also predicting higher-level conditions like altitude and heading presents the difficulty of state estimation.

Figure 4 shows that the highest intermediate levels comprise the FAHP framework for determining the best possible setting. Analytically, it chooses a sub-goal from a set of places on the mobile robot's sensing boundary that best balances its rotational speed, distance from the target, and the risk of colliding with obstacles. The relative relevance of the goals is quantified and then used to rank the alternatives. The ultimate objective of RL in robotics is to provide robots with the capacity to learn, develop, adapt, and duplicate tasks based on exploration and autonomous learning, all while dealing with restrictions subject to constant and unpredictable change. Convolutional neural networks are being developed to manage a robot that checks in on people's homes. The neural network can be diagnosed and enhanced by securely connecting the robot to a graphical user interface on a mobile. The neural network on a robot has been developed via supervised training.

This study introduces a fuzzy logic controller that can mimic natural behaviours like obstacle avoidance and track to make a robot act more like a real human. The proposed architectural design of the robot includes several ultrasonic sensors for gathering real-time information from the environment and a fuzzy logic controller that can help a robot mimic natural (human) behaviour like obstacle avoidance. The model may contain semantic and physically-based information, planning system models, and a query method for retrieving the required data. Its automated planning system can provide human-like results in real time. The fields of robotics and automation rely

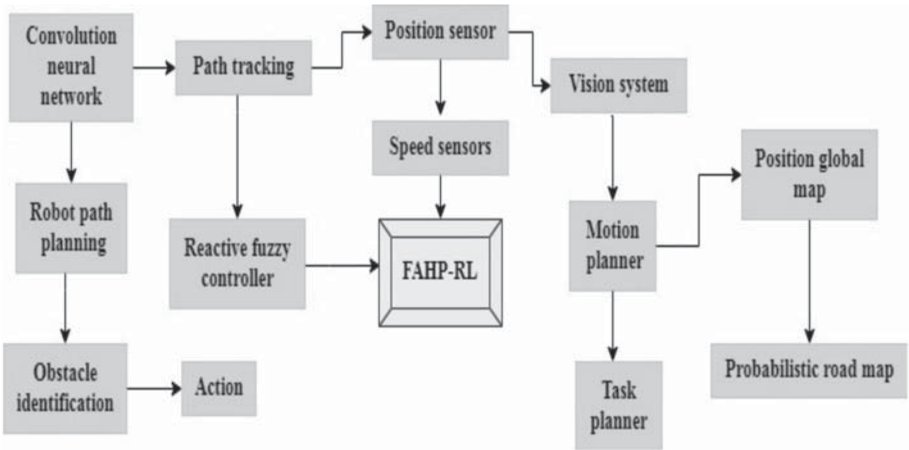

Figure 4 Overview of FAHP-RL.

heavily on position sensors. Accurate movement and position control rely on these encoders inside the robot. Cameras attached to a computer make up a robotic vision system. The computer is loaded with processing software that provides the robot with visual context.

'Robotic vision' is one of the newest developments in robotics and automation. Robotic vision, in its most basic definition, is an advanced technology that helps a robot perform tasks such as object recognition, navigation, localization, inspection, and manipulation. Because robots cannot achieve objectives that would be unattainable with ad hoc activities, task planning algorithms are required. Designers of intelligent robots may utilize off-the-shelf tools to tackle various challenges. For example, a probabilistic road map is a directed acyclic graph depicting the multiple routes one could take through a specific map, considering the locations of both available and taken-up areas. According to the parameters of the probabilistic roadmap algorithm, the mobile robot object randomly generates nodes.

Step 1: The path planning system proposed in this paper is based on FAHP according to the option provider's preferences or objectives, which may be adapted to various dynamic operating environments.

Step 2: RL has a lot of untapped potential for robotic systems and production systems in general, particularly for processes that exhibit some uncertainty, hence the need for a comprehensive and robust strategy for process automation.

Step 3: In the proposed strategy, optimum robustness can be achieved utilizing the FAHP. The robustness of the solution to changes in impartial coefficients can be handled.

Step 4: The FAHP-RL can obtain the shortest route, average path length, longest path, and worst path for each test environment, as well as the standard deviation of actual test implementation. An autonomous vehicle follows a predetermined course in offline mode, the autonomous navigation through the environment.

The robot provided it is in a condition that varies with probability s, selects one of a limited number of behaviour patterns at each time interval, and P travelling through a restricted, discrete environment.

$$\boldsymbol{P} = \boldsymbol{t} + \boldsymbol{s}^r\boldsymbol{s} + \boldsymbol{R}_{st} \tag{1}$$

The equation (1) where t is a robot, provided it is in a condition that varies with probability s^r, selects one of the limited patterns of R_{st} behaviour at each time interval and travelling through s a restricted, discrete environment. The configuration space has a collection of passable regions denoted by Z_{fre}, which can be derived using equation (2). Furthermore, the value of Z can fluctuate in real time because the Z_{obs} is a dynamic obstacle,

$$\mathbf{Z}_{\boldsymbol{fre}} = \mathbf{Z}/\mathbf{Z}_{\boldsymbol{obs}} \tag{2}$$

The strategy addresses the challenge of real-time route planning for mobile robots in uncertain environments. Once a sensor has acquired data from an environmental map, the data must be processed. This study utilizes a combination of map files—some produced from a prepared simulation map and others obtained after the sensor has gathered and analyzed information from the natural environment.

4. RESULTS AND DISCUSSION

Robot path planning research recommendations are at a mature stage. Mobile robot route planning is based on the particle swarm process, and single robot path planning relies on the genetic algorithm. Both global and local path planning are used to determine the best possible routes. There is international route planning, in which the environment of obstacles is fully understood, and local path planning, where the sensors detect the barriers locally. Single-robot path planning is obstacle-based global path planning. There are various ways to represent the environment for international path planning. These include using a grid, a can view, topological hair, and free space. The grid approach is the most thorough in reflecting the distribution of obstacles and is the unique kind that provides access to the spatial distribution, making robot movement precision more achievable. To demonstrate environments with obstacles, this research utilized a system strategy.

Dataset Description: Eight randomly chosen robots were used for computer simulation for path planning and simultaneous localization and mapping (SLAM) of an autonomous

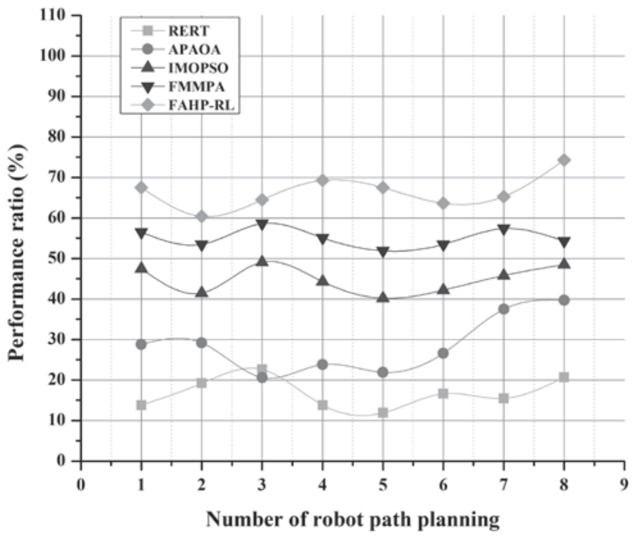

Figure 5 Performance of robot path planning in FAHP-RL.

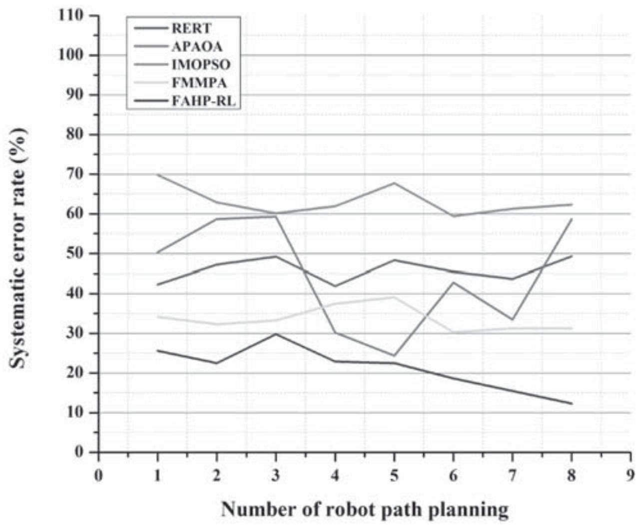

Figure 6 System error rate in FAPH-RL.

indoor mobile robot vehicle. Firstly, parametric and non-parametric Bayesian filtering SLAM solutions are obtained. Comparative simulations demonstrate each method's merits and shortcomings and the capability of robot path planning with fuzzy logic integration. In the second stage, path planning and a proportional controller enable SLAM robots to follow planned pathways to their destination without colliding. Thirdly, the robot decides where to go by studying the data input and exploring reduced travelling costs. Finally, feature-based and occupancy grid maps are considered in environmental reasoning. Using these methods, an indoor autonomous mobile robot framework is developed, and its performance is tested [26]. Among robotic applications are automotive manufacturing, packaging, electronics, telerobots, space probes, automated fruit-picking equipment, and domestic environments [27–28].

Figure 5 shows that the input taken for the robot path planning seeks to locate a safe route for the moving vehicle. Also, the path has to be the best possible option. A variety of studies have addressed the path-planning issue in the proposed approach. This research evaluates the route design strategies, comparing their computational times and path lengths. This research examined various path-planning techniques; findings indicate significant differences in computational time and route length. To strengthen the validity of the results, the simulation was run in three different environments: one with mild clutter, one with moderate clutter, and one with a great deal of clutter. It was discovered that the default path is produced using the visibility graph, while the node image generates the longest path. Most optimization in robot navigation path planning is done by analyzing path length and quality. The navigation of mobile robots is segmented into global, local, and individual navigation focused on path planning. Therefore, the most efficient route for robots results in longer battery life and lower overall energy consumption. Path planning performance in robot value using the proposed method is 72.4% compared to other existing methods.

Figure 6 shows that input is taken for the telerobot's increased heating; inaccurate sensing in serious conditions and insufficient visibility are adverse environmental variables

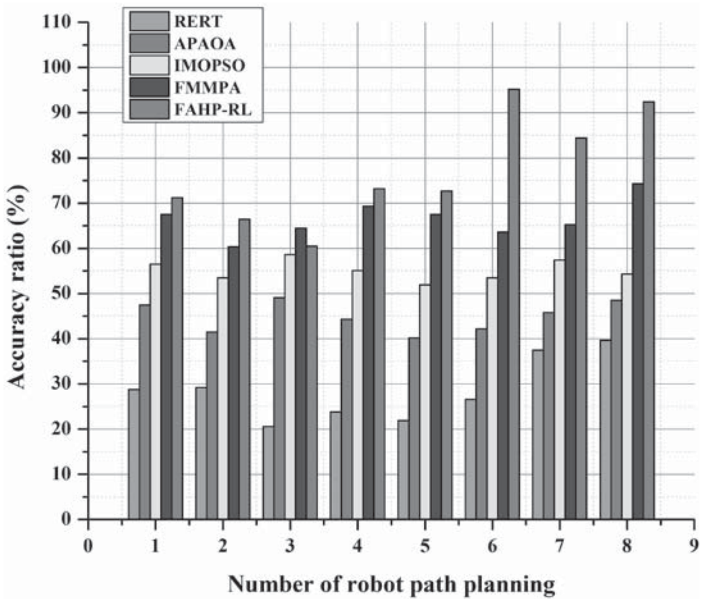

Figure 7 Accuracy of robot path planning and equipment obstacle intelligent recognition system.

that may cause the robot to behave erroneously. Basic posture estimation for wheeled mobile robots may be obtained from odometry. However, odometrical inaccuracy grows proportionally with robotic distance travelled. An error can be minimized by calibrating the system—standardized approaches to wheeled mobile robots require high-precision calibration. The proposed strategy considers the interaction among the most common sources of systematic errors. Experiments indicate that the proposed system can potentially improve the location accuracy of mobile robots. Engine encoder odometry offers essential posture estimation for wheeled mobile robots. However, the main problem with odometry is that errors are compounded the further the robot travels. The error rate obtained by the proposed system is 12.3% compared to other systems.

Figure 7 shows the accuracy of robot path planning and equipment obstacle intelligent recognition system. The robot industry is developing an approach for efficient calibration and implementation of take and move locations. The robot's accuracy can be defined as the margin of error between the target value and the actual value reached by the robot. Accuracy and repeatability go hand-in-hand. The repeatability of a robot's performance is defined as the consistency with which it reaches a targeted destination. The accuracy of a robot is defined as the margin of error between the value of the point where the robot is instructed to go and the point it reaches. The ability of a robot to return to a previously established location is referred to as the robot's repeatability. High robot accuracy during production guarantees consistent, reliable outcomes regardless of the changes in the manufacturing process. Most robotic applications, such as welding and material removal, prioritize precision. Robots must be reliable and consistent in fields such as medical surgery. The proposed method for robot planning achieves an accuracy of 93.6% compared with other methods.

Figure 8 shows the input for a space probe, where route planning is crucial for autonomous robotic systems. Over several decades, several strategies have been proposed. However, things have become more difficult for robots in the real world due to the complexity of their surroundings. This study tested several scenarios to determine the most efficient route planning techniques. It was found that the autonomous driving robot's driving distance and time were improved by streamlining the route. However, there was still a collision issue between the microrobot and the obstacle. This study aimed to close the gap between trajectory planning and route length minimization, solving the problems related to mobile robot collisions with immobile and moving obstacles in dynamic environments. This study used particle swarm optimization to develop an intelligent strategy and user-friendly module for guiding a mobile robot across an unpredictable environment. The efficiency of the proposed method is 78.1% compared to other existing methods.

Figure 9 shows several obstacles that make mechanical precision assembly challenging regarding the input. With a fast-expanding population and dwindling labour resources in rural areas, the development of precision in intelligent robots for fruit picking has been a priority in recent decades. The need for high accuracy, assembly tolerance limits in the precision domain, difficulty integrating sensors, and surface force effects all contribute to creating a stressful environment. High crop yields and throughputs can be achieved only with well-designed and tested control and planning during automated micro-assembly operations. In contrast to more common macroscale applications, there is a strong relationship between the choice of a precision robotic manipulator and the design of a route for a micro-assembly. Industrial automatic polishing has the potential to become a more cost-effective and intelligent technology than traditional polishing equipment in ultra-precision production. However, the problem with robotic polishing is poor control precision, significantly impacting the quality. This study offers an adaptive route planning approach that considers the individual form error in each location. In every instance,

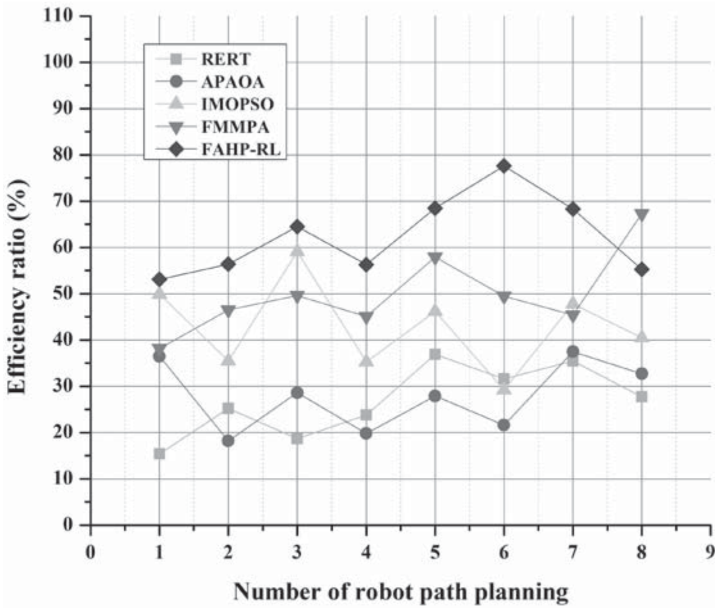

Figure 8 Efficiency of robot path planning in FAHP-RL/

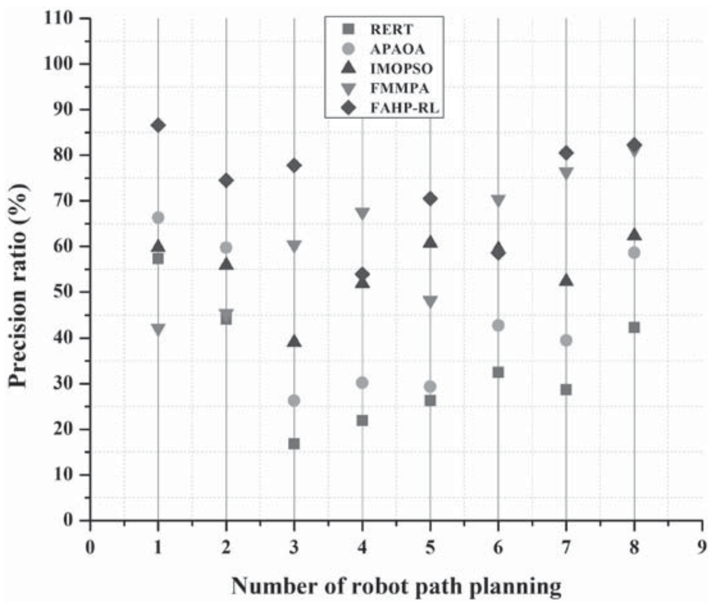

Figure 9 Precision of robot path planning FAHP-RL.

the areas with a significant enough form error are polished, maximizing consistency and productivity. The proposed method contributes to the precision of robot path planning, which is 85.9%.

5. CONCLUSION

Path planning for intelligent machines has several strengths and shortcomings. This study explored robot navigation, the relationships between mapping, path planning, and moving systems, and the issues associated with equipment and established processes. Path planning for autonomous vehicles is based on algorithms that create the best route for a robot in a given environment. The systems can initially attempt to locate accessible paths for the robot in the area, avoiding collision with obstacles and barriers and reading the environment map or storage space to execute the navigation tasks. This strategy aims to develop a convolutional neural network trajectory tracking controller and use the best path to manage the robot's movement. The FAHP-RL method was applied to evaluate the improvement in navigational performances, including path distance, collision avoidance, and fast rotation. Simulation was used to assess the effectiveness of the proposed approach for route planning. This study focused on a route planning strategy using a mobile robot in different operational environments. The results obtained from this research can be applied to various transportable robot systems utilized in dynamic operating environments that require multiple paths depending on the user's requirements, such as path length, collision avoidance, and protection of sensitive industrial equipment. Although machines are sometimes safer than humans, they are more expensive to acquire, train, and control. Several issues present real difficulties for the production sector and need to be addressed with forethought and innovative solutions. The shortcoming of edge-based obstacle avoidance is that when a robot meets an obstacle, it must pause before giving a more precise estimation. Due to improved sensor equipment, in the future, the robots' path planning can continue to evolve from mechanical robots to collaborators with cognitive functions.

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Wusong Sun was born in Anqing, Anhui, P.R. China, in 1983. He received the master degree from Shandong University of Science and Technology, P.R. China. Now, he works at the School of Automotive and Mechanical & Electrical Engineering, Lu'an Vocational Technical College. His research interests include automation, mechatronics and robotics.
E-mail: wu88866621@163.com

Hua Lin was born in DongZhi, Anhui, P.R. China, in 1984. He received the doctoral degree from Hefei University of Technology, P.R. China. Now, he works at the School of Mechanical and Automotive, West Anhui University. His research interests include automation, mechatronics and intelligent manufacturing.
E-mail: linhua5704@163.com