Autonomous Self-Navigating Robot With 2D Mapping- A Survey

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Abstract*—Autonomous indoor navigation and environment mapping play a significant role in robotic application used in warehouses, industrial automation, service robotics, and search-and-rescue operations. Recent advancements in Simultaneous Localization and Mapping (SLAM), Deep Reinforcement Learning (DRL), sensor fusion, and 2D LiDAR have significantly improved mapping, localization, path planning, and obstacle avoidance in unknown environments. Techniques such as Hector SLAM, Graph-SLAM, Active SLAM, LiDAR-IMU-Vision fusion, and map less navigation enhance navigation accuracy, exploration efficiency, and real-time decision-making. These technologies enable robots to generate accurate 2D maps, estimate their position, detect obstacles, and navigate safely without human intervention. Despite the dependable performance of these approaches, method challenges including substantial computational cost, increased hardware complexity, long training time, and reduced performance in highly dynamic environments still exist. Overall, integrating SLAM, artificial intelligence, LiDAR, and multi-sensor technologies provide an effective, scalable, and cost-efficient solution for developing intelligent and reliable autonomous mobile robots for future indoor navigation applications.

Index Terms*—Robot Operating System (ROS), Simultaneous Localization and Mapping (SLAM), 2D LiDAR, Indoor Navigation, Real-Time Mapping, Localization, Path Planning, Obstacle Detection, Obstacle Avoidance, Mobile Robotics, Autonomous Exploration, Sensor-Based Navigation, and Navigation Stack

I. INTRODUCTION

Autonomous mobile robots have become an important area of research due to their wide range of applications in industries, hospitals, warehouses, smart buildings, and service robotics. These robots are capable of navigating through unknown environments without human intervention by sensing their surroundings, identifying their position, and planning safe paths to reach a desired target location. The advancement of sensing technology, along using the ROS framework, has significantly improved the accuracy and efficiency of autonomous navigation systems.

SLAM is a core technology that enables a mobile robot to create a map of an unfamiliar environment while also estimating its own position within that environment. Among various SLAM techniques, Hector SLAM is widely used for indoor navigation because it generates accurate maps using only 2D LiDAR data without relying on wheel odometry. Combined with ROS, SLAM provides a flexible framework for integrating mapping, localization, path planning, and the avoidance of obstacles into a complete autonomous navigation system.

Recent research has advanced traditional navigation systems by integrating AI techniques, including Deep Reinforcement Learning (DRL), sensor fusion, and multi-sensor SLAM. These methods improve the robot's ability to navigate dynamic and crowded environments by enabling adaptive decision-making and efficient obstacle avoidance. However, many of these methods demand substantial computing resources, expensive hardware, or extensive training, making them difficult to implement in low-cost mobile robots.

The proposed project focuses on developing an indoor robot capable of autonomous navigation using a 2D LiDAR sensor, ROS, and Hector SLAM for real-time mapping and localization. The robot is designed to generate an accurate map of an unknown indoor environment, localize itself within the generated map, and navigate safely while avoiding obstacles. The system utilizes the ROS Navigation Stack to support

autonomous path planning and motion control, providing reliable navigation in structured indoor environments.

The primary aim of this projects is to develop a cost-effective, reliable, and efficient self-directed navigation a system that can operate in indoor environments with minimal human intervention. The proposed system can be applied in warehouse automation, hospital assistance, educational robotics, office navigation, and smart indoor transportation, demonstrating the practical significance of autonomous mobile robot technology.

II. LITERATURE REVIEW

Kiran B. et al. [1] Developed an autonomous indoor navigation system by integrating the Robot Operating System (ROS) with the GMapping SLAM algorithm and a 2D RPLIDAR sensor. The system enables a mobile robot to perform simultaneous Localization and Mapping (SLAM) while navigating through unknown indoor environments without requiring prior knowledge of the surroundings. The ROS Navigation Stack is utilized for global path planning, local path planning, and obstacle avoidance, allowing the robot to move safely toward the target location. Experimental results demonstrated that the robot successfully generated accurate occupancy grid maps and achieved reliable localization in indoor environments. The implementation also highlighted the advantages of using open-source ROS packages, making the system cost-effective, flexible, and suitable for research and educational applications. However, navigation performance may degrade in highly dynamic environments where moving obstacles frequently alter the surroundings, affecting mapping accuracy and localization. Overall, the study demonstrates that combining ROS with the GMapping SLAM algorithm provides an efficient and practical solution for autonomous indoor mobile robot navigation.

Luis Andrade et al. [2] Accurate localization and mapping are important for autonomous mobile robots operating in industrial environments, where sensor noise and repetitive structures can affect navigation performance. The paper "Lidar-Inertial and Downward Vision Based Mobile Robot SLAM in Digital Workshops" presents a multi-sensor SLAM framework that combines LiDAR, an Inertial Measurement Unit (IMU), and a downward vision camera to improve localization accuracy and mapping reliability. Sensor fusion is performed using an Enhanced Iterative Closest Point (ICP) algorithm together with an Extended Kalman Filter (EKF), enabling the robot to minimize cumulative localization errors during long-distance navigation. Experimental results demonstrate that the integration of multiple sensors provides more accurate positioning and produces consistent maps compared with LiDAR-only approaches. The framework also exhibits greater robustness against environmental disturbances and sensor noise, making it is suitable for digital workshop applications. However, the use of multiple sensors increases hardware complexity, computational requirements, need for precise sensor calibration before deployment.

Luis Andrade, Miguel Torres, et.al [3] Mobile Autonomous Robot Vehicle for Investigation and Navigation," Luis Andrade et al. presented a low-cost autonomous mobile robot designed for indoor investigation, mapping, and navigation The proposed robot uses a 2D LiDAR sensor and the Hector SLAM algorithm to generate real-time maps and perform simultaneous Localization and Mapping (SLAM) without relying on wheel encoders. The system is capable of generating real-time maps while navigating autonomously through unknown indoor environments. The authors integrated autonomous navigation functions such as path planning, obstacle detection, and obstacle avoidance to improve the robot's operational efficiency. Experimental results demonstrated that the robot could accurately map indoor environments and navigate safely with satisfactory localization performance. The study also highlighted the affordability, modular design, and ease of implementation of the proposed platform, making it suitable for research, educational, and inspection applications. However, the system's mapping accuracy may decrease during rapid robot movements, and communication latency in the ROS framework can affect navigation performance in complex environments.

Jinzhou Wang and Ran Huang [4]. A Mapless Navigation Method Based on Deep Reinforcement Learning and Path Planning," Jinzhou Wang et al.

proposed an intelligent navigation framework that enables a mobile robot to navigate in unknown environments without relying on a pre-built map. The proposed approach combines Deep Reinforcement Learning (DRL) with path planning to improve the robot's decision-making ability during navigation. The robot uses 2D LiDAR data and target position information as input to learn an optimal navigation policy through continuous interaction with the environment. The trained model is capable of avoiding static and dynamic obstacles while generating smooth and efficient navigation paths toward the target location. Experimental results indicated that the proposed method achieved a higher success rate, reduced travel distance, and improved obstacle avoidance compared with conventional map-based navigation methods. The authors concluded that integrating DRL with path planning significantly enhances navigation in complex indoor environments. However, the proposed model requires extensive training and considerable computational resources, which may limit its deployment on low-cost robotic platforms.

Jinyang Lai, Zejie Jiang, Yunlong Liu, et al. [5] Spatiotemporal Dynamic Augmented LiDAR Encoder for Obstacle Detection and Avoidance in Crowded Environments," Jinyang Lai et al. proposed a deep reinforcement learning-based navigation framework that enables mobile robots to safely navigate through crowded and dynamic enviroments using only a 2D LiDAR sensor. The authors introduced the Dynamic Augmented LiDAR Encoder (DARE), which extracts both spatial and temporal features from consecutive LiDAR scans to improve the robot's understanding of moving obstacles. In contrast to conventional approaches that rely on multiple sensors or explicit motion prediction models, this method enables robots to understand obstacle dynamics and generate safer navigation policies. Experimental evaluations in both simulation and real-world environments demonstrated that the DARE framework achieved a higher navigation success rate, smoother trajectories, and fewer collisions compared with existing reinforcement learning-based methods. The proposed system also demonstrated improved generalization in complex environments with dense pedestrian traffic. However, the framework requires extensive training and considerable computational resources for model optimization. which may limit its deployment on low-cost robotic platforms.

Wenjie Na, Zhihao Liu, Mengqi He, Chao Li et.al [6] "Goal Decision-making in Active SLAM Using 2D LiDAR Based on DRL Driven by Intrinsic Rewards" focuses on improving exploration efficiency during Active SLAM by integrating Deep Reinforcement Learning with an intrinsic reward mechanism. Unlike conventional frontier-based exploration methods, the robot determines its next exploration target by evaluating the uncertainty of the surrounding environment using Shannon entropy. A 2D LiDAR sensor continuously collects environmental information, while the DRL model learns to select goal location that maximize information gain and accelerate map construction. Experimental results showed that the robot explored its surroundings more quickly, achieved better map completeness, and improved localization accuracy compared with traditional Active SLAM techniques. The learning-based decision-making strategy also reduces unnecessary robot movements, thereby improving navigation efficiency. Although the method performs well in unknown environments, its training process is computationally demanding and requires careful tuning of the reward function to achieve stable learning.

Ahmad Abeideh, Abdul Rahman Zamrik, et.al [7] Indoor mapping plays a vital role in enabling autonomous mobile robots to navigate safely in unfamiliar environments. "Autonomous Driving Robot for Indoor 2D Mapping," Ahmad Abeideh et al. developed a mobile robot capable of creating accurate two-dimensional maps while moving autonomously inside buildings. The system integrates a 2D LiDAR sensor with the Hector SLAM algorithm running on the Robot Operating System (ROS) to perform simultaneous localization and mapping in real time. Hardware components such as a Raspberry Pi, Arduino, ultrasonic sensors, and wireless communication modules were incorporated to achieve a compact and cost-effective robotic platform. The generated maps can be visualized and monitored through a mobile application, allowing users to track the robot remotely. Experimental evaluation confirmed that the robot was able to navigate efficiently and generate reliable indoor maps, making

it suitable for applications such as warehouse inspection, office navigation, and educational research. Despite these advantages, the performance of the system depends on the accuracy of the LiDAR sensor and stable wireless communication, while complex indoor layouts and moving obstacles may reduce mapping accuracy.

Jae-Do Park et.al [8] Reliable navigation in structured indoor environments, such as corridors, laboratories, and office buildings, remains an important challenge for autonomous mobile robots. In the paper "An Autonomous Navigation Method Using 2D LiDAR for Structured Indoor Environments," Jesus Canales et al. presented a navigation strategy that relies on a 2D LiDAR sensor to detect walls and obstacles while maintaining the robot's position within the center of a corridor. The navigation algorithm continuously processes LiDAR scan data to estimate the robot's surroundings and generate appropriate steering commands for safe movement. The study demonstrated that the robot could travel through indoor environments smoothly without requiring expensive sensing equipment or complex vision-based systems.
Experimental results showed stable navigation performance, accurate obstacle avoidance, and reliable operation under different indoor conditions. The simplicity of this approach also makes it suitable for real-time implementation on low-cost mobile robots used in educational and industrial applicationas. However, the navigation accuracy decreases in cluttered or highly unstructured environments where irregular obstacle arrangements and complex layouts can affect LiDAR-based perception and decision-making.

Tong Jia et al [9] "A Deep Reinforcement Learning-Based Robot Navigation Method Using Sensor Information Fusion," investigated how the integrating of data from multiple sensors can improve the navigation performance of autonomous mobile robots. Instead of relying solely on LiDAR data, the study integrates LiDAR and camera information through a sensor fusion framework, enabling the robot to perceive its surroundings more accurately. A self-attention network is incorporated into the deep reinforcement learning model to extract important environmental features and enhance decision-making during navigation. The experimental results demonstrated that the proposed approach achieved higher navigation success rates, smoother path planning, and more reliable obstacle avoidance than conventional DRL-based methods. The fusion of visual and LiDAR information also improved the robot's ability to operate in complex and dynamic indoor environments. Despite these advantages, the model requires considerable computational power and a large amount of training data, making real-time implementation challenging on low-cost robotic platforms.

Zhangfan Lu et al. [10] developed a deep reinforcement learning framework to enable autonomous mobile robots to navigate safely in uncertain and dynamic environments. Their approach combines the Deep Deterministic Policy Gradient (DDPG) algorithm with a long Shirt-Term Memory (LSTM) network. Allowing robots to develop navigation strategies from sequential 2D LiDAR sensor measurements. The learning model generates motion commands without relying on a pre-built map, enabling the robot to react effectively to moving obstacles and continuously changing surroundings. Experimental evaluation demonstrated that the framework achieved smoother path planning, improved obstacle avoidance, and a higher navigation success rate than conventional reinforcement learning methods. The incorporation of LSTM further enhanced the robot's ability to capture temporal information, resulting in more stable and reliable navigation decisions. Although the approach offers significant improvements in dynamic environments, it requires extensive training, high computational resources, and large datasets before deployment in real-world applications.

Han Beomsoo et al. [11] presented a framework for indoor mobile robot navigation that is based on Deep Reinforcement Learning (DRL) using the Proximal Policy Optimizatin(PPO) algorithm. The navigation system learns optimal movement strategies directly from 2D LiDAR sensor data through ongoing interaction with its surrounding environment, eliminating the need for manually designed control rules. By maximizing cumulative rewards, the robot gradually acquires the ability to avoid obstacles and reach target locations through safe and efficient paths.

Experimental evaluation showed that the PPO-based model converged faster and achieved higher navigation success rates than several conventional reinforcement learning algorithms. The study also demonstrated improved adaptability in unfamiliar indoor environments, allowing the robot to respond effectively to changes in obstacle configurations. Although the learning-based approach enhances autonomous decision-making, its training process involves numerous episodes significant computational resources, and careful parameter tuning to obtain stable performance.

Istighfar Chetti, Mohamed Amine Bouchareb et al. [12] Enhanced Graph-SLAM with Pose Graph Optimization for Accurate 2D Indoor Mapping, proposed by Istigh for Chettih et al. [12], presents an enhanced Graph-SLAM approach for improving the accuracy of 2D indoor maps using Pose Graph Optimization (PGO) and loop closure detection. The system utilizes LiDAR data with the ROS GMapping package to generate consistent occupancy grid maps while minimizing localization drift during long-distance navigation. It also employs map-based navigation to optimize the robot's trajectory, reducing data collection time and improving mapping efficiency. Experimental results demonstrated improved map accuracy, reliable localization, and better trajectory estimation compared to conventional Graph-SLAM techniques. However, the approach depends on accurate loop closure detection and requires additional computational resources for pose graph optimization.

Table: Comparative Study of Existing Literature on Autonomous Mobile Robot Navigation

Sl. No	Authors	Year	Methods Used	Merits	Demerits
1.	Kiran B., G. V. Naveen Kumar, M. V. Raghavendra, and H. S. Guruprasad	2020	ROS, GMapping SLAM, RPLiDAR, Navigation Stack	Low-cost implementation with low power consumption. Provides reliable communication between robot and PC through ROS and generates accurate indoor maps suitable for educational and research applications.	Mapping accuracy decreases in dynamic environments and communication performance depends on network stability
2.	Yanchao Zhang, Hao Geng, Bin Liu, Yinlong Zhang, Xudong Yuan, and Sichao Zhang	2024	LiDAR-IMU-Vision Fusion, ICP, EKF	Achieves excellent mapping accuracy with minimal localization drift. Fast sensor communication and real-time processing make it suitable for industrial applications.	High hardware cost, increased power consumption, and complex multi-sensor calibration
3.	Luis Andrade, Miguel Torres, Carlos Paredes, and Juan C. Rojas	2020	Hector SLAM, ROS, 2D LiDAR	Low-cost and energy-efficient solution with fast map generation and accurate localization without wheel encoders. Suitable for real-time indoor mapping.	Mapping quality reduces during rapid robot movement and communication performance depends on ROS network latency.
4.	Jinzhou Wang and Ran Huang	2022	Requires extensive DRL training, large datasets, and powerful computing hardware before real-world deployment.	Provides intelligent mapless navigation with smooth trajectory planning and efficient obstacle avoidance. Produces accurate navigation decisions in unknown environments.	High computational cost, increased power consumption, and long DRL training time before deployment.

5.	Jinyang Lai, Zejie Jiang, Yunlong Liu, Xiaohui Zhang, and Yibin Li	2026	DARE Framework, DRL, Spatiotemporal LiDAR Encoder	Excellent obstacle detection with very fast response in crowded environments. Provides highly accurate navigation and mapping using advanced LiDAR encoding	Expensive hardware requirements, high power consumption, and extensive training data are required.
6.	Wenjie Na, Zhihao Liu, Mengqi He, Chao Li, Chengju Liu, and Qijun Chen	2024	Active SLAM, DRL, Shannon Entropy Reward	Intelligent exploration significantly improves mapping coverage and navigation efficiency while selecting optimal exploration goals.	High computational complexity increases power consumption and exploration time during training
7.	Ahmad Abeideh, Abdul Rahman Zamrik, and Wisam Elmasry	2024	Hector SLAM, ROS, LiDAR	Cost-effective indoor mapping with reliable robot-PC communication over Wi-Fi. Generates accurate 2D maps and autonomous navigation for indoor environments.	Communication depends on Wi-Fi quality and reflective surfaces reduce mapping accuracy.
8.	Jesus Canales and Jae-Do Park	2025	2D LiDAR Steering Control Algorithm	Very low-cost implementation with low power consumption and fast navigation in structured indoor	Mapping capability is limited and performance decreases in cluttered or
9.	Tong Jia, Yao Wang, Yifan Chen, Minghao Li, and Jian Sun	2025	DRL, Sensor Fusion, Self-Attention Network	Sensor fusion improves mapping accuracy, localization, and obstacle detection. Provides robust navigation with efficient communication between sensing modules.	High implementation cost, increased power consumption, and computationally intensive AI processing.
10.	Zhangfan Lu and Ran Huang	2020	DDPG, LSTM, Deep Reinforcement Learning	Smooth autonomous navigation with effective dynamic obstacle avoidance and accurate path planning in unknown environments.	Long training time, high computational cost, and increased energy consumption
11.	Han Beomsoo, Kim Seongmin, Lee Jisoo, and Park Hyunwoo	2020	PPO, Stochastic Deep Reinforcement Learning, 2D LiDAR	Provides stable navigation with faster learning convergence and accurate path planning while maintaining moderate power consumption.	Requires large training datasets and real-world deployment is time-consuming.
12.	Istighfar Chetti, Mohamed Amine Bouchareb, and Abdelhamid Mellouk	2024	Graph-SLAM, Pose Graph Optimization (PGO), Loop Closure Detection	Produces highly accurate and consistent environment maps with reduced localization drift. Efficient for large indoor areas and long-duration mapping.	Pose graph optimization increases computational complexity and processing time, leading to higher power consumption.

III. CONCLUSION

The reviewed literature demonstrates that LiDAR, SLAM, Deep Reinforcement Learning (DRL), and sensor fusion play a significant role in enabling autonomous mobile robot navigation in indoor environments. SLAM-based approaches such as GMapping, Hector SLAM, and Graph-SLAM provide

accurate mapping and localization, while LiDAR-IMU-Vision fusion improves positioning accuracy and reduces localization drift. DRL-based navigation methods enhance autonomous decision-making, obstacle avoidance, and mapless navigation, allowing robots to operate effectively in dynamic and unknown environments. Advanced techniques such as Active SLAM, sensor fusion, and spatiotemporal LiDAR encoding further improve exploration efficiency, dynamic obstacle detection, and navigation reliability. However, practical implementation still faces challenges such as high computational requirements, extensive training time, sensor dependency, increased hardware cost, and reduced performance in highly dynamic or unstructured environments. Overall, these studies demonstrate that integrating SLAM, artificial intelligence, and multi-sensor technologies provides a robust foundation for developing intelligent, accurate, and reliable autonomous mobile robots for future indoor navigation applications.

REFERENCES

[1] K. B. Kiran, K. N. Manjunatha, S. Karthikeyan, S. Manoj Kumar, M. A. Suhel Pasha, and S. V. Moras, "Design and development of autonomous mobile robot for mapping and navigation system," in Proc. 2023 Int. Conf. on Electronics, Computing and Communication Technologies (CONECCT), 2023, pp. 1–5.

[2] Y. Zhang, H. Geng, B. Liu, Y. Zhang, X. Yuan, and S. Zhang, "Lidar-inertial and downward vision based mobile robot SLAM in digital workshops," in Proc. 2024 IEEE 13th Data Driven Control and Learning Systems Conference (DDCLS), 2024, pp. 428–433.

[3] L. Andrade, M. Fajardo, C. Tutiven, E. Valarezo, A. Recalde, R. Cajo, and F. Yumbla, "MARVIN: Mobile autonomous robot vehicle for investigation and navigation," in Proc. IEEE Int. Conf. on Automation Science and Engineering (CASE), 2020.

[4] J. Wang and R. Huang, "A mapless navigation method based on deep reinforcement learning and path planning," in Proc. 2022 IEEE Int. Conf. on Robotics and Biomimetics (ROBIO), 2022, pp. 1781–1786.

[5] J. Lai, Z. Jiang, and Y. Liu, "DARE to navigate: Spatiotemporal dynamic augmented LiDAR encoder for obstacle detection and avoidance in crowded environments," IEEE Robotics and Automation Letters, vol. 11, no. 2, pp. 1930–1937, 2026.

[6] W. Na, Z. Liu, M. He, C. Li, C. Liu, and Q. Chen, "Goal decision-making in active SLAM using 2D LiDAR based on DRL driven by intrinsic rewards," in Proc. 2024 Photonics and Electromagnetics Research Symposium (PIERS), 2024, pp. 1–10.

[7] A. Abeideh, A. R. Zamrik, and W. Elmasry, "Autonomous driving robot for indoor 2D mapping," in Proc. 2024 Innovations in Intelligent Systems and Applications Conference (ASYU), 2024.

[8] J. Canales and J.-D. Park, "An autonomous navigation method using 2D LiDAR for structured indoor environments," in Proc. Int. Conf. on Artificial Intelligence, Computer, Data Sciences and Applications (ACDSA), 2025.

[9] T. Jia, H. Deng, J. Zhan, and L. Zhang, "A deep reinforcement learning-based robot navigation method using sensor information fusion," in Proc. 2025 40th Youth Academic Annual Conference of Chinese Association of Automation (YAC), 2025, pp. 559–564.

[10] Z. Lu and R. Huang, "Autonomous mobile robot navigation in uncertain dynamic environments based on deep reinforcement learning," in Proc. IEEE Int. Conf. on Robotics and Automation, 2020, pp. 1–6.

[11] B. Han, A. A. Ravankar, and T. Emaru, "Mobile robot navigation based on deep reinforcement learning with 2D-LiDAR sensor using stochastic approach," in Proc. IEEE Int. Conf. on Robotics and Automation, 2020.

[12] I. Chettih, F. Chouireb, S. Achour, and K. Mokhtari, "Enhancing Graph-SLAM 2D maps accuracy and data efficiency via loop closure through PGO and map-based navigation," in Proc. IEEE Int. Conf. on *Robotics and Automation*, 2024.