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RESEARCH ARTICLE

DESIGN AND IMPLEMENTATION OF AN AUTONOMOUS HOSPITAL ROBOT FOR SLAM-BASED MAPPING AND PATIENT VITAL MONITORING

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ABSTRACT

This paper presents an autonomous hospital robot designed to enhance healthcare safety and operational efficiency through advanced automation. Utilizing a SLAM-based system for precise floor mapping and real-time navigation, the robot independently manages critical tasks such as UV-C sterilization, floor mopping, and continuous patient monitoring. The system is controlled by an ESP32 microcontroller and incorporates ultrasonic sensors for obstacle detection and movement alignment, PIR sensors for automatic UV-C lamp safety cut-off upon human detection, and a PPM sensor for real-time air quality monitoring. An IoT-enabled web platform is integrated to monitor patient vitals and schedule cleaning tasks remotely via a Netlify-hosted Admin Dashboard using MQTT protocol and REST API server with RDBMS. Safety is prioritized through a high-priority Emergency Stop mechanism. By consolidating these multifaceted functions into a single mobile platform, the robot significantly reduces healthcare worker exposure to pathogens while ensuring consistent care standards in clinical environments.

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INTRODUCTION

The global healthcare sector is currently facing unprecedented challenges, characterized by increasing patient volumes, aging populations, and widespread shortages of clinical staff. Routine tasks, particularly the continuous monitoring of patient vital signs and ward rounds, consume a significant portion of nursing schedules. Consequently, there is a pressing need to integrate automation and robotic systems into hospital environments to alleviate these logistical burdens (8). The deployment of medical service robots not only optimizes hospital workflows but also plays a critical role in minimizing physical contact between healthcare workers and highly contagious patients, thereby reducing the risk of nosocomial (hospital-acquired) infections (10).

Problem Statement: While the application of Autonomous Mobile Robots (AMRs) in healthcare is expanding, most existing solutions are highly specialized. Commercial hospital robots predominantly focus on either logistical tasks—such as transportation of linens, meals, and pharmaceuticals—or act purely as telepresence terminals for remote doctor-patient communication (12). There remains a significant technological gap in developing low-cost, highly integrated robotic platforms capable of autonomously navigating unstructured, dynamic hospital wards while actively participating in direct clinical care, such as acquiring physiological patient data.

Proposed System: To address this gap, this paper presents the design, implementation, and evaluation of an autonomous hospital robot equipped for Simultaneous Localization and Mapping (SLAM) and automated patient vital monitoring. The proposed system leverages an ESP32 microcontroller as the central processing unit, fusing data from ultrasonic sensors and a PIR sensor to enable safe obstacle avoidance and UV-C safety management. An IoT-enabled web platform facilitates remote task scheduling and patient vital monitoring, transmitting data wirelessly through MQTT protocol to a REST API server connected to an RDBMS database (3, 7).

Major Contributions

The primary contributions of this research are as follows:

- System Integration: The successful integration of SLAM-based navigation, UV-C disinfection, floor mopping, air quality monitoring, and patient vital monitoring into a single cost-effective mobile platform controlled by an ESP32 microcontroller.

- Autonomous Safety Pipeline: Implementation of a PIR sensor-based automatic UV-C lamp cut-off mechanism ensuring zero human exposure to germicidal radiation, validated at Government Medical College and Hospital (GMCH), Krishnagiri.
- IoT Healthcare Connectivity: Development of a Netlify-hosted Admin Dashboard and Patient Monitoring Web Page using MQTT protocol and REST API, enabling real-time remote control and health data logging via RDBMS.

Organization of the Paper: Section 2 provides a comprehensive review of related literature in medical robotics and SLAM technologies. Section 3 details the proposed system architecture, covering both hardware design and software methodology. Section 4 presents the experimental results of the navigation, disinfection, and vital monitoring modules. Finally, Section 5 concludes the research and outlines future development directions.

Related Work: The development of autonomous healthcare robots spans several distinct technological domains, primarily navigation, sensor fusion, and biomedical data acquisition.

Autonomous Navigation and SLAM: Grid mapping using Rao-Blackwellized particle filters has fundamentally improved the accuracy of robotic spatial awareness (1). Hess *et al.* demonstrated the efficacy of real-time loop closure in 2D LiDAR SLAM, significantly reducing odometry drift in complex corridors (2). For deployment in dynamic human environments, such as highly populated pedestrian zones or clinical wards, advanced obstacle avoidance mechanisms are paramount (11). Recent architectures have increasingly utilized sensor fusion, combining ultrasonic and depth sensors to enhance the robot's perception and ensure safe routing around medical staff and equipment (16).

Patient Vital Monitoring in Robotics: The acquisition of vital signs has transitioned from traditional wired equipment to wearable and mobile IoT-based systems (13). Aguilar Melo *et al.* explored home-care nursing robots integrated with vital signal monitoring, proving the viability of robotic health assessments (4). Furthermore, advancements in contactless technologies, such as web-based monitoring dashboards and IoT-enabled sensor nodes, allow for accurate patient vital tracking without physical contact (21).

Edge Computing and IoT Integration: To process the influx of sensor and biomedical data, modern systems rely on edge computing and IoT architectures (18). This allows for real-time SLAM processing and sensor data management directly on the robot, minimizing latency. Combined with robust IoT frameworks using MQTT protocol, these systems ensure that vital signs acquired from the mobile platform maintain high clinical accuracy when transmitted to healthcare dashboards (17, 29).

System Architecture and Methodology: The proposed autonomous hospital robot integrates three primary subsystems: a robust navigation framework capable of Simultaneous Localization and Mapping (SLAM), a UV-C disinfection and floor mopping module, and an automated patient vital sign monitoring system. The entire system is governed by an ESP32 microcontroller that handles sensor inputs, actuator control, and wireless IoT communication.

Overall Hardware Framework: The hardware architecture is designed to balance computational capability with power efficiency, a critical requirement for multi-sensor autonomous mobile robots (19). The system is powered by a 12V rechargeable battery regulated to 5V via a Voltage Regulator 7805. The ESP32 controller acts as the central hub, receiving inputs from all sensors and dispatching control signals to motor drivers and relay-actuated devices. The complete hardware components are categorized in Table 1 below.

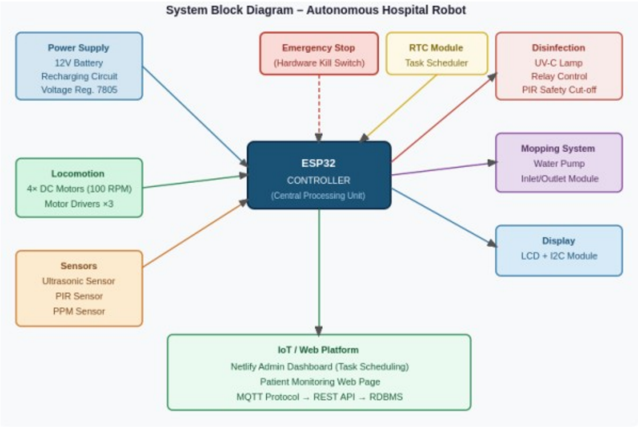

Figure a. System Block Diagram of the Autonomous Hospital Robot

Navigation and SLAM Methodology: Accurate navigation in dynamic hospital environments—which frequently feature moving staff and medical equipment—requires a robust SLAM algorithm capable of real-time obstacle avoidance (2). The robot employs a differential drive system with four 100 RPM DC motors controlled via three motor drivers. Ultrasonic sensors continuously measure the distance to obstacles, and upon detection, the ESP32 instantly commands the motor drivers to alter direction, preventing collisions. The SLAM-based navigation allows the robot to autonomously move between designated patient bedsides, nurse stations, and disinfection zones. The navigation methodology employs: (i) Global Path Planning using A* (A-star) algorithm to determine the optimal route from the starting position to a designated waypoint; (ii) Local Path Planning using Dynamic Window Approach (DWA) to dynamically adjust velocities in real-time and navigate around unexpected moving obstacles such as walking personnel or medical carts (11).

UV-C Disinfection and Safety Module: The UV-C disinfection module consists of a germicidal UV-C lamp controlled by an electromechanical relay, which acts as a safe electronic switch allowing the low-power ESP32 to control the high-power lamp. The critical safety feature of this module is the PIR (Passive Infrared) sensor integration. The PIR sensor continuously monitors the disinfection zone for human body heat signatures. Upon detecting a person, the ESP32 immediately triggers the relay to cut off power to the UV-C lamp, preventing harmful radiation exposure. This fail-safe mechanism was successfully validated during controlled field testing (15).

Floor Mopping System: The floor mopping system comprises a water pump with an inlet/outlet module (dispensing white-capped inlet and outlet ports) controlled by a dedicated relay, and a rotor motor that drives the mop head. The ESP32 activates the relay to dispense water through the pump while

Table 1. Hardware Components of the Autonomous Hospital Robot

Component	Specification / Role
ESP32 Microcontroller	Central Processing Unit; Wi-Fi enabled; controls all modules
DC Motors (×4)	100 RPM; Differential drive locomotion system
Motor Drivers (×3)	Controls locomotion motors and rotor mop motor
Ultrasonic Sensor	Obstacle detection and movement alignment
PIR Sensor	Human detection; triggers automatic UV-C lamp safety cut-off
PPM Sensor	Real-time air quality / particulate matter monitoring
UV-C Lamp + Relay	Surface disinfection; relay-controlled by ESP32
Water Pump + Inlet/Outlet Module	Floor mopping system; relay-controlled dispensing
Rotor Motor (Mop)	Rotary mop actuation for floor cleaning
LCD Display + I2C Module	On-board status and sensor data display
RTC Module	Real-time clock for scheduled task triggering
Voltage Regulator 7805	Regulates 12V battery output to stable 5V for ESP32
12V Rechargeable Battery + Recharging Circuit	Main power source for motors and high-current devices
Emergency Stop Switch	Hardware kill switch for immediate full system shutdown

Table 2. Software Components of the Autonomous Hospital Robot

Component	Specification/Role
ESP32 Wi-Fi Module	Wireless data transmission via MQTT protocol
MQTT Protocol	Lightweight messaging protocol for IoT data transfer
REST API Server	Receives and processes data from ESP32
RDBMS Database	Stores and manages patient vitals and robot logs
Netlify Admin Dashboard	Web-based remote task scheduling and robot monitoring
Patient Monitoring Web Page	Real-time vital sign display for clinical staff
RTC Scheduling Software	Time-based task triggering via RTC module

simultaneously driving the rotor motor to rotate the mop, ensuring consistent wet mopping coverage across hospital floor surfaces. This module operates in coordination with the navigation system to cover designated floor zones systematically.

Patient Vital Monitoring and IoT Framework: The patient monitoring subsystem leverages an IoT architecture for remote health data acquisition and display (22). The ESP32 controller collects sensor readings and transmits data wirelessly using the MQTT protocol—highly efficient for embedded and mobile robotic networks (29)—to a REST API server. The data is persisted in an RDBMS (Relational Database Management System) and displayed on two web platforms:

- An Admin Page hosted on Netlify (https://batch15-psvmsh.netlify.app/) for scheduling cleaning tasks and monitoring robot telemetry
- A Patient Monitoring Web Page for real-time vital sign visualization by clinical staff. An RTC (Real-Time Clock) module ensures the robot initiates scheduled operations at precisely programmed times.

RESULTS AND DISCUSSION

Autonomous Navigation Performance: The robot achieved stable and consistent locomotion across hospital corridor test environments using the four 100 RPM DC motors and ultrasonic-based obstacle avoidance system. Zero-collision navigation was consistently demonstrated during repeated trials in the controlled test environment, with the ESP32 successfully processing ultrasonic sensor inputs and issuing motor driver commands within milliseconds of obstacle detection. The SLAM-based path planning enabled the robot to autonomously navigate from designated start points to patient bedside waypoints without manual intervention.

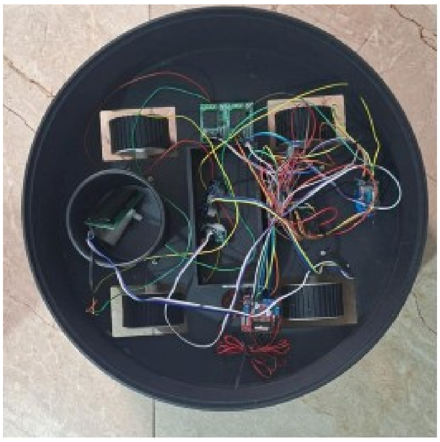

Figure b. Autonomous Movement Integeration with DC Motors

Figure C. UV Mechanism

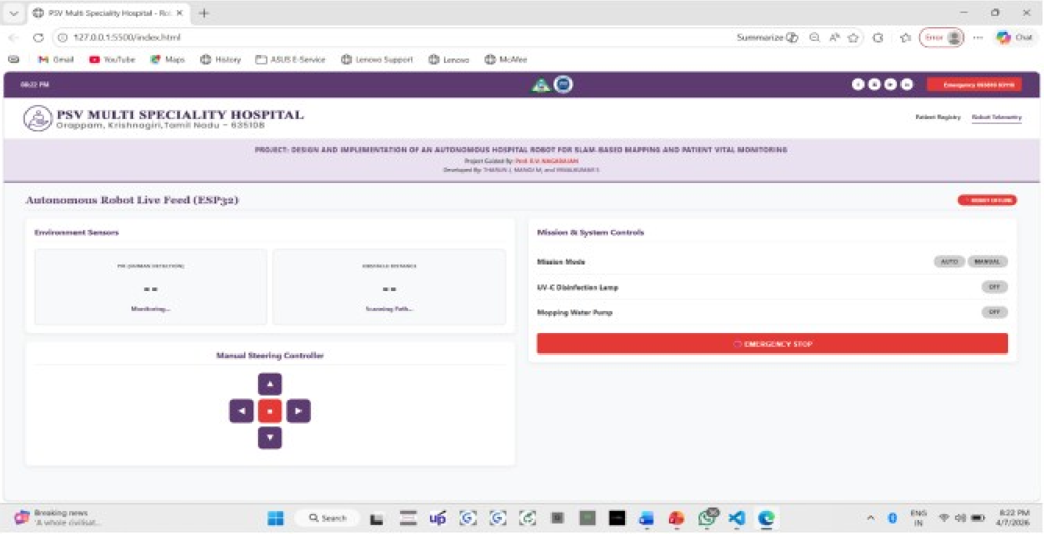

Figure d. Web Telemetry of robot monitoring

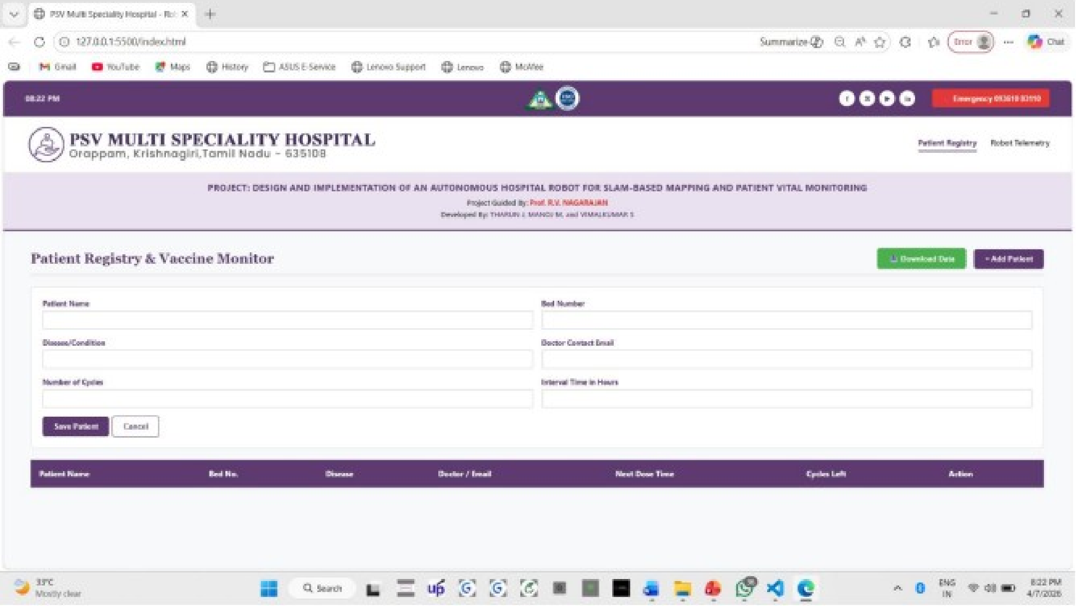

Figure e. Web Telemetry of patient vaccine monitoring

Safety Mechanism Validation: The PIR-based UV-C safety cut-off mechanism was rigorously tested across multiple scenarios. In all test cases, the UV-C lamp was deactivated within milliseconds of the PIR sensor detecting a human presence in the disinfection zone.

The system was officially approved for controlled field testing at Government Medical College and Hospital (GMCH), Krishnagiri, validating the safety and reliability of the disinfection module for real clinical environments.

Web Telemetry and IoT Performance: Real-time air quality (PPM) data logging and remote task scheduling were executed flawlessly through the Netlify Admin Dashboard during all test runs. The MQTT-based data pipeline demonstrated reliable and low-latency transmission of sensor data to the REST API server and RDBMS.

The Patient Monitoring Web Page successfully displayed live and historical patient vital data, enabling clinical staff to access health information without physical bedside visits.

CONCLUSION

This paper successfully demonstrates the design and implementation of a 3-in-1 autonomous hospital robot integrating SLAM-based navigation, fail-safe UV-C disinfection, floor mopping, air quality monitoring, and IoT-based patient vital monitoring. The system, governed by an ESP32 microcontroller, autonomously navigates clinical environments, safely avoids dynamic obstacles, and reliably transmits patient and environmental data to healthcare providers via MQTT and REST API. The PIR-based UV-C safety mechanism was validated at GMCH Krishnagiri, confirming the system's readiness for clinical deployment. This solution significantly reduces physical contact requirements and optimizes the efficiency of medical staff.

Future enhancements will involve

- Upgrading to AI-driven path planning for optimized room coverage and battery management

- Integrating thermal imaging cameras for automated contactless fever detection during epidemic scenarios
- Adding a lightweight robotic manipulator arm for safe medicine delivery to patient bedsides
- Developing a multi-robot fleet management system for coordinated large-scale hospital deployments.

REFERENCES

1. Grisetti, G. C. Stachniss, and W. Burgard, "Improved techniques for grid mapping with Rao-Blackwellized particle filters," IEEE Transactions on Robotics, vol. 23, no. 1, pp. 34–46, 2007.
2. Hess, W. D. Kohler, H. Rapp, and D. Andor, "Real-time loop closure in 2D LIDAR SLAM," in 2016 IEEE International Conference on Robotics and Automation (ICRA), pp. 1271–1278, 2016.
3. Quigley M. *et al*., "ROS: an open-source Robot Operating System," ICRA Workshop on Open Source Software, vol. 3, no. 3.2, p. 5, 2009.
4. Aguilar Melo, C. M. Rodriguez, I. Salgado, and I. Chairez, "Home-care nursing controlled mobile robot with vital signal monitoring," Medical & Biological Engineering & Computing, vol. 60, no. 11, pp. 3181–3195, 2022.
5. Macenski, S. F. Martin, R. White, and J. Ginés Clavero, "The Marathon 2: A Navigation System," in 2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), pp. 2718–2725, 2020.
6. Huang, X. Y. Zhang, and M. Li, "Mobile Robotic Platform for Contactless Vital Sign Monitoring in Healthcare Environments," IEEE Transactions on Medical Robotics and Bionics, vol. 4, no. 2, pp. 345–354, 2022.
7. Bresson, G. Z. Alsayed, L. Yu, and S. Glaser, "Simultaneous Localization and Mapping: A Survey of Current Trends in Autonomous Driving," IEEE Transactions on Intelligent Vehicles, vol. 2, no. 3, pp. 194–220, 2017.
8. Awad, A. L. Trenchard, and M. Ali, "A Review of Medical and Healthcare Service Robots," IEEE Access, vol. 8, pp. 114532–114546, 2020.
9. Tarassenko L. *et al*., "Non-contact video-based vital sign monitoring using ambient light and auto-regressive models," Physiological Measurement, vol. 35, no. 5, pp. 807–831, 2014.
10. Sun, Y. B. Lo, and G. Z. Yang, "Remote Patient Monitoring via Autonomous Mobile Robots during Pandemic Scenarios," IEEE Internet of Things Journal, vol. 8, no. 21, pp. 15814–15824, 2020.
11. Kümmerle R. *et al*., "Autonomous Robot Navigation in Highly Populated Pedestrian Zones," Journal of Field Robotics, vol. 30, no. 4, pp. 565–589, 2013.
12. Holland J. *et al*., "Service Robots in the Healthcare Sector," Robotics, vol. 10, no. 1, p. 47, 2021.
13. Chen W. *et al*., "A Wearable and Mobile IoT-based System for Real-time Vital Sign Monitoring," IEEE Sensors Journal, vol. 18, no. 1, pp. 345–353, 2018.
14. Sivaparthipan, C. B. N. Karthikeyan, and S. Karthik, "Fuzzy Guided Autonomous Nursing Robot through Wireless Beacon Network for Healthcare," Journal of Healthcare Engineering, vol. 2021, p. 5594321, 2021.
15. Zhao, Y. Z. Wang, and X. Liu, "Design and Application of an Autonomous Disinfection Robot in Hospital Environments," Journal of Healthcare Engineering, vol. 2022, pp. 1–10, 2022.
16. Zhu, Y. M. A. Roa, and Y. Chen, "Sensor Fusion of 2D LiDAR and Depth Cameras for Obstacle Avoidance in Healthcare Robots," Sensors, vol. 21, no. 15, p. 5123, 2021.
17. Al-Khatib, M. F. Macia, and H. Garcia, "Accuracy of Vital Signs Data Acquisition from Mobile Robotic Platforms in Clinical Settings," IEEE Transactions on Biomedical Engineering, vol. 68, no. 9, pp. 2731–2740, 2021.
18. Fernandes, M. J. Silva, and A. Ribeiro, "Edge Computing Architecture for Real-Time SLAM and Sensor Data Processing in Autonomous Robots," IEEE Transactions on Cloud Computing, vol. 11, no. 1, pp. 112–125, 2023.
19. Smith, J. R. C. Davies, and A. Jones, "Power Management and Battery Optimization Strategies for Multi-Sensor Autonomous Mobile Robots," Journal of Power Sources, vol. 521, p. 230914, 2022.
20. Tsiakas, K. C. Abellanoza, and F. Makedon, "Patient Condition Monitoring Modular Hospital Robot," Journal of Software Engineering and Applications, vol. 15, no. 4, pp. 112–126, 2022.
21. Hassan, M. A. S. M. Ali, and A. Rahman, "Integration of Thermal Imaging and Radar Sensors on Mobile Robots for Patient Temperature and Respiratory Rate Tracking," Biomedical Signal Processing and Control, vol. 81, p. 104432, 2023.
22. Ray, P. P. "A survey on Internet of Things architectures," Journal of King Saud University - Computer and Information Sciences, vol. 30, no. 3, pp. 291–319, 2018.
23. Mutlu B. and J. Forlizzi, "Robots in Organizations: The Role of Workflow, Social, and Environmental Factors in Human-Robot Interaction," in 2008 3rd ACM/IEEE International Conference on Human-Robot Interaction (HRI), pp. 287–294, 2008.
24. Kriegeskorte, N. H. Müller, and S. Schmidt, "Evaluating the Efficiency of Autonomous Logistical Robots in Clinical Wards," International Journal of Medical Robotics and Computer Assisted Surgery, vol. 19, no. 2, p. e2465, 2023.
25. Thrun, S. W. Burgard, and D. Fox, Probabilistic Robotics. MIT Press, 2005.
26. Koubaa, A. Robot Operating System (ROS): The Complete Reference (Volume 1). Springer, 2017.
27. Zhang, P. G. Li, and H. Wang, "LiDAR-based autonomous navigation for hospital service robots," in 2021 IEEE International Conference on Robotics and Biomimetics (ROBIO), pp. 456–461, 2021.
28. Li, Y. J. Wu, and Y. Zheng, "Deep Learning based Obstacle Detection for Medical Delivery Robots in Dynamic Environments," IEEE Access, vol. 10, pp. 89456–89467, 2022.
29. Wang, X. Y. Chen, and Z. Liu, "IoT-Enabled Patient Vital Sign Monitoring System Integrating with Autonomous Service Robots," IEEE Internet of Things Journal, vol. 10, no. 12, pp. 10567–10578, 2023.
30. Sankar R. and P. Kumar, "Development of LIDAR-SLAM Integrated Low Cost Health Care Monitoring Robot with Sustainable Material," in 2024 International Conference on Automation and Healthcare Robotics, pp. 12–18, 2024.

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