

AUTONOMOUS HOSPITAL PORTER ROBOT WITH REAL-TIME PATIENT MONITORING SYSTEM

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ABSTRACT: Modern hospitals face increasing challenges in managing patient care and internal logistics efficiently. Manual transportation of medical supplies and lack of continuous patient monitoring often lead to delays and increased workload on healthcare staff. The proposed system presents an integrated solution that combines an autonomous hospital porter robot with a real-time patient monitoring system to enhance healthcare efficiency and patient safety. The robot is developed using a Raspberry Pi controller and is capable of performing tasks such as medicine delivery and sample transportation within hospital environments. It utilizes sensor-based navigation for obstacle detection and safe movement. In parallel, wearable biomedical sensors connected to an ESP32 module continuously monitor vital parameters including heart rate, body temperature, and oxygen levels. The collected data is transmitted wirelessly via Wi-Fi to a cloud platform for real-time access by healthcare professionals. The system also includes an automated alert mechanism to detect abnormal conditions and notify medical staff immediately. During emergencies, the robot prioritizes navigation for rapid response. This system reduces manual workload, improves operational efficiency, and supports continuous patient monitoring in smart healthcare environments.

Keywords: Autonomous Hospital Robot, Patient Monitoring System, Real-Time Monitoring, IoT-Based Healthcare, Biomedical Sensors.

I. INTRODUCTION

The healthcare sector is rapidly evolving with the adoption of advanced technologies to improve efficiency and patient care. Hospitals face challenges such as increasing patient load, limited medical staff, and the need for continuous monitoring of patients. These challenges often lead to delays in routine tasks like medicine delivery and can affect the overall quality of healthcare services. Therefore, there is a growing demand for intelligent and automated systems that can assist healthcare professionals and enhance hospital operations. Autonomous robots have emerged as an effective solution for handling repetitive and time-consuming tasks in hospital environments. These robots are capable of navigating independently using sensors and path-planning techniques, enabling them to perform functions such as medicine delivery, sample transportation, and logistical support. At the same time, realtime patient monitoring systems using IoT technology allow continuous tracking of vital parameters such as heart rate, body temperature, and oxygen levels, ensuring timely medical intervention and improved patient safety.

This paper focuses on the integration of an autonomous hospital porter robot with a real-time patient monitoring system to create a smart healthcare solution. The combined approach enhances operational efficiency, reduces manual workload, and enables continuous monitoring of patient health conditions. By leveraging robotics and IoT technologies, the system supports faster response during emergencies and contributes to the development of advanced and efficient healthcare environments.

This paper presents an integrated approach that combines an autonomous hospital porter robot with a real-time patient monitoring system. The proposed concept aims to enhance hospital automation by enabling efficient task execution and continuous health monitoring. By merging robotics and IoT technologies, the system improves patient safety, reduces manual workload, and supports faster response during emergency situations, contributing to the development of smart healthcare environments. In recent years, the concept of smart healthcare has gained significant attention due to the increasing demand for efficient, reliable, and contactless medical services. The integration of robotics and Internet of Things (IoT) technologies plays a crucial role in transforming traditional healthcare systems into intelligent and automated environments. Autonomous robots are being widely adopted for logistics, assistance, and service delivery within hospitals, while IoT-based monitoring systems enable continuous tracking of patient health conditions. This combination not only enhances operational efficiency but also ensures better utilization of healthcare resources.

Despite these advancements, there is still a gap in developing a unified system that effectively integrates autonomous robotic delivery with real-time patient monitoring. Many existing systems focus on individual functionalities rather than a combined approach. Therefore, integrating these technologies into a single system can provide a comprehensive solution that enhances hospital efficiency, ensures continuous monitoring, and supports intelligent healthcare services. Furthermore, the need for contactless healthcare solutions has increased significantly, especially in situations involving infectious diseases and high-risk environments. Autonomous hospital robots can reduce direct human interaction during routine tasks, thereby minimizing the risk of infection and improving safety for both patients and healthcare staff. At the same time, realtime monitoring systems provide instant access

to patient data, allowing timely decision-making and rapid medical response.

II. LITERATURE REVIEW

The integration of autonomous robotic systems and real-time patient monitoring has become a significant research area in modern healthcare. Autonomous hospital porter robots are designed to perform tasks such as medicine delivery, sample transportation, and logistical support, reducing the workload of healthcare staff. These robots utilize sensor-based navigation and path-planning techniques to operate efficiently in dynamic hospital environments. Recent research highlights the benefits of combining robotics and IoT to enhance hospital efficiency, improve patient safety, and support contactless healthcare services. However, most existing systems focus on either robotic automation or patient monitoring independently. Only a limited number of studies attempt to integrate both functionalities into a single system. Therefore, the integration of autonomous robots with real-time patient monitoring presents a promising solution for smart healthcare environments by enabling efficient task execution, continuous monitoring, and timely medical response.

A detailed analysis in [1]. Imad Ahmad et al, Development of an Autonomous Medicine Delivery Robot for Hospital Applications, - 2025. This paper explores the development of an autonomous medicine delivery robot for hospital applications using LiDAR sensors and SLAM algorithms for real-time navigation and mapping. The system demonstrates efficient obstacle avoidance and autonomous movement in dynamic environments. However, it mainly focuses on delivery tasks and does not integrate real-time patient monitoring functionalities. In reference [2]. Imen Mabrouk et al, Autonomous Mobile Robot for Medication Delivery in Hospitals with Web-Based Mission Control. - 2025. This paper proposes an autonomous mobile robot integrated with a web-based mission control system is presented for hospital medication delivery. The system enables real-time scheduling and monitoring using ROS2 and web technologies, improving task management efficiency. Nevertheless, it relies heavily on network connectivity and lacks integration with patient health monitoring systems.

[3]. John Allan Øllgaard et al, Healthcare Staff Satisfaction with Hospital Service Robots in Denmark and South Korea, - 2025. This study evaluates the acceptance of service robots among healthcare staff in hospitals. It analyzes factors such as usability, efficiency, and cultural differences in adopting robotic systems and analyzes healthcare staff satisfaction with hospital service robots, focusing on usability, efficiency, and user acceptance. The study shows that robots are positively received when they reduce workload and improve operational efficiency. However, it does not address technical system integration or real-time monitoring capabilities.

The work in [4] Mohamad Akhsan Rofiqi et al, Design and Implementation of a Remote Patient Monitoring System Based on IoT Using Wireless Sensor Networks. - 2025. This paper focuses on developing an IoT-based patient monitoring system using wireless sensor networks. It enables real-time tracking of vital parameters such as heart rate, pulse, and oxygen levels, with data transmitted to healthcare providers for analysis.

In, [5] Monitoring, Melvin Sajith et al, An Integrated Autonomous Mobile Robot for Smart Hospital Logistics and Patient. - 2025. This paper introduces a multi-functional autonomous robot capable of both logistics and patient monitoring. It an integrated autonomous mobile robot is proposed for smart hospital logistics and patient monitoring using AI, SLAM, and vision-based techniques. The system demonstrates multi-functional capabilities but involves high computational complexity and cost, making it less practical for low-resource environments.

In [6], Kalpana G. et al, MEDROBO: Automated Medicine Delivery and Patient Monitoring System. - 2025. This paper presents a robotic system that combines medicine delivery and patient monitoring using line-following mechanisms, RFID technology, and IoT platforms. The MEDROBO system integrates medicine delivery and patient monitoring using linefollowing navigation and RFID technology. The system ensures accurate delivery and monitoring; however, it lacks flexibility in dynamic environments due to its dependence on predefined paths.

The study referenced in [7] Sayat Ibrayev et al, Development of a Service Robot for Hospital Environments with LiDAR-Based SLAM. - 2024. This paper presents the development of medical services robot using 3D LiDAR and SLAM techniques for accurate navigation in hospital environments. It presents a service robot for hospital environments using LiDAR-based SLAM for accurate navigation and obstacle avoidance. The system improves localization performance but increases system cost and complexity due to advanced sensor requirements.

[8] Cristiana Rondoni et al, Navigation Benchmarking for Autonomous Mobile Robots in Hospital Environment. - 2024. This paper proposes a benchmarking framework to evaluate the navigation performance of autonomous robots in hospital environments using standardized tests and performance metrics. While the study provides useful evaluation methods, it does not implement a complete integrated healthcare system.

[9]. Nakhul Kalaivanan et al, AI Enhanced Multi-Robotic Systems for Inpatient Care and Diagnostic Support. - 2025. This paper introduces a multi-robot system integrated with AI, wearable sensors, and RF communication for patient monitoring and medicine delivery. The system demonstrates effective coordination and monitoring capabilities; however, it is validated only in simulated environments and lacks real-world deployment.

[10]. Mohamed Adlan Ait Ameer et al, Human-Robot Collaboration in Healthcare: Comprehensive Review of Key Components, Applications, and Future Research. - 2026. This paper provides a comprehensive review of human-robot collaboration (HRC) in healthcare, focusing on key components such as healthcare professional-oriented, patient centric, and system-critical factors.

III. OBJECTIVES

The main goal of this project is to design and develop an autonomous hospital porter robot integrated with a real-time patient monitoring system to improve healthcare efficiency and

patient safety. The primary goals of the project include the following:

1. Develop an autonomous hospital robot capable of efficiently performing medicine delivery and sample transportation using sensor-based navigation.
2. Implement a real-time patient monitoring system using biomedical sensors to continuously track vital parameters such as heart rate, temperature, and oxygen levels.
3. Enable real-time data transmission to cloud platforms using IoT technology for remote monitoring by healthcare professionals.
4. Design an automated alert system to detect abnormal health conditions and trigger immediate notifications.

IV. METHODOLOGY

The system is developed by integrating an autonomous hospital porter robot with a real-time patient monitoring unit. The robot is built using a Raspberry Pi controller and utilizes sensors for obstacle detection and navigation to perform tasks such as medicine delivery and sample transportation within hospital environments. A wearable monitoring system based on ESP32 is used to collect patient vital parameters such as heart rate, body temperature, and oxygen levels. The collected data is transmitted wirelessly using Wi-Fi to a cloud platform for realtime monitoring by healthcare professionals.

A. System Architecture

The proposed system consists of two main modules: the autonomous hospital porter robot and the real-time patient monitoring system, interconnected through a wireless communication network. The robotic module is built using a Raspberry Pi controller, motor driver, and sensors such as ultrasonic or IR sensors for obstacle detection and navigation. It is responsible for performing tasks like medicine delivery and sample transportation within the hospital environment.

The patient monitoring module consists of wearable biomedical sensors connected to an ESP32 microcontroller, which continuously measures vital parameters such as heart rate, body temperature, and oxygen levels. The ESP32 transmits the collected data wirelessly using Wi-Fi to a cloud platform, enabling real-time monitoring by healthcare professionals. Both modules are integrated through IoT communication, allowing the system to function in a coordinated manner. An alert system is incorporated to detect abnormal health conditions and notify medical staff. The overall architecture ensures efficient automation, continuous monitoring, and timely response in healthcare environments.

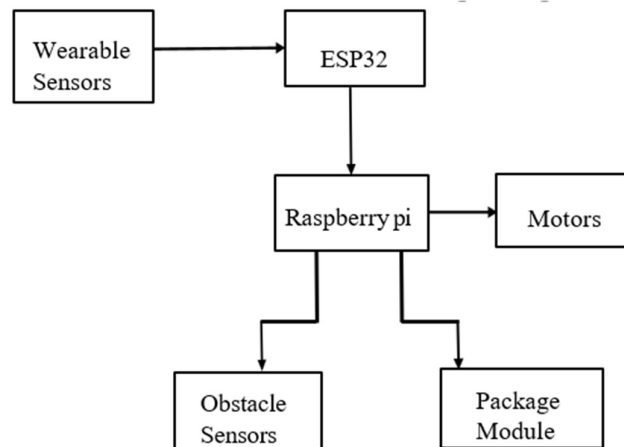


Fig 1: System Architecture

B. Component Descriptions and Interactions

a). Raspberry Pi: The Raspberry Pi acts as the main controller that processes inputs from sensors and manages overall robot operations. It receives obstacle data from the obstacle sensor and makes navigation decisions in real time. It sends control signals to the motor unit to move the robot in required directions. It coordinates with other components to execute delivery tasks efficiently.

- b). ESP32: The ESP32 functions as a communication and processing unit for patient monitoring data. It receives data from wearable sensors and processes the collected vital parameters. It transmits the processed data wirelessly using Wi-Fi for realtime monitoring. It ensures continuous data flow between sensors and monitoring systems.
- c). Wearable Sensors: Wearable sensors measure vital parameters such as heart rate, temperature, and oxygen levels. They continuously collect patient data in real time. They send the collected data to the ESP32 for processing. They enable continuous health monitoring and early detection of abnormalities.
- d). Motor: The motor unit is responsible for enabling movement of the robot. It receives control signals from the Raspberry Pi to perform navigation. It drives the wheels to move the robot forward, backward, or turn. It ensures smooth and controlled movement during delivery tasks.
- e). Obstacle Sensor: The obstacle sensor detects objects in the robot's path. It continuously scans the surroundings during robot movement. It sends real-time signals to the Raspberry Pi for decision-making. It helps the robot avoid collisions and navigate safely.
- f). Package Module: The package module acts as a storage unit for medicines or samples. It securely holds items during transportation within the hospital. It operates under the control of the robotic system. It enables efficient delivery and pickup of medical items.

The system is designed as an integration of an autonomous robotic unit and a real-time patient monitoring unit, connected through a wireless communication framework. The robotic unit consists of a Raspberry Pi controller, motor unit, obstacle sensors, and a package module. The Raspberry Pi acts as the central controller, processing sensor inputs and controlling the movement of the robot. The motor unit enables locomotion, while the obstacle sensor ensures safe navigation by detecting obstacles in real time. The package module is used for carrying medicines or samples within the hospital environment. The patient monitoring unit includes wearable sensors and an ESP32 microcontroller. The wearable sensors continuously measure vital parameters such as heart rate, body temperature, and oxygen levels. These sensors transmit the collected data to the ESP32, which processes and sends it wirelessly using Wi-Fi. This enables real-time monitoring of patient health data.

C. Algorithm

In order to automate hospital logistics while ensuring continuous patient supervision, the proposed system operates through a dual-module architecture consisting of an autonomous mobile robot and a real-time patient monitoring unit. The system's core functionality relies on embedded processing using a Raspberry Pi for navigation control and an ESP32 for physiological data acquisition and wireless transmission. The robotic subsystem performs autonomous navigation and task execution using sensor-driven decisionmaking. Obstacle detection sensors continuously scan the environment, allowing the system to dynamically adjust its movement path and prevent collisions. At the same time, the monitoring subsystem collects real-time biomedical signals and evaluates patient health conditions using predefined threshold logic.

System Operation and Data Processing: Input data is acquired from two primary sources: (i) environmental data from obstacle sensors for robot navigation, and (ii) physiological signals such as heart rate, body temperature, and oxygen saturation from patient-mounted sensors. The system processes these inputs in parallel to ensure uninterrupted operation of both logistics and monitoring tasks.

Input: Sensor data consisting of obstacle sensor readings and patient vital parameters (heart rate, temperature, SpO₂).

Output: System status representing navigation condition and patient health state (Normal / Obstacle / Critical Alert).

1. Initialize all hardware components including sensors, communication modules, and controllers (Raspberry Pi and ESP32).

2. Load predefined parameters such as navigation rules and threshold limits for heart rate, temperature, and oxygen level.

3. Continuously read data from obstacle sensors and patient monitoring sensors.

4. Perform navigation control:

- If an obstacle is detected, stop the robot and change its direction to avoid collision.
- Otherwise, continue moving toward the assigned destination.

5. Process patient health data:

- Compare heart rate, temperature, and SpO₂ values with predefined safe limits.

6. Execute robot navigation and patient monitoring simultaneously to ensure continuous operation. Transmit patient data wirelessly and update system status in real time. Store sensor readings and system responses for monitoring and analysis.

D. Software Implementation

The software implementation is divided into two main parts: robot control and patient monitoring. The robotic system is programmed using Python on the Raspberry Pi, where it controls motor movement and processes data from obstacle sensors. The program continuously reads sensor inputs and makes decisions such as moving forward, stopping, or changing direction, enabling autonomous navigation within the hospital environment.

The patient monitoring system is implemented using ESP32 programmed through the Arduino IDE. It interfaces with wearable sensors to collect vital parameters such as heart rate, body temperature, and oxygen levels. The ESP32 processes this data and transmits it wirelessly using Wi-Fi. Communication protocols such as HTTP or MQTT can be used to ensure efficient and reliable data transmission.

The system also includes real-time data handling and decision making logic. The software continuously compares sensor readings with predefined threshold values. If any abnormal condition is detected, an alert is generated and transmitted immediately. This enables quick response from healthcare professionals.

Additionally, the system supports continuous data flow and synchronization between modules. The Raspberry Pi handles robot control independently, while the ESP32 manages monitoring and communication. Both systems operate in parallel, ensuring efficient task execution and uninterrupted monitoring. The software is designed to be lightweight, responsive, and suitable for real-time healthcare applications.

F. Hardware Implementation

The hardware implementation consists of two main subsystems: the robotic unit and the patient monitoring unit. The robotic unit is built around a Raspberry Pi, which acts as the central controller. It is connected to a motor driver and DC motors that enable the movement of the robot. The robot chassis supports all components and includes a package module used for carrying medicines or samples within the hospital environment.

Obstacle detection is achieved using sensors such as ultrasonic or IR sensors mounted on

the robot. These sensors continuously scan the surroundings and send signals to the Raspberry Pi, allowing it to make real-time navigation decisions and avoid collisions. The integration of motors, sensors, and controller ensures smooth and safe movement of the robot. The patient monitoring unit consists of wearable biomedical sensors connected to an ESP32 microcontroller. These sensors measure vital parameters such as heart rate, body temperature, and oxygen levels. The ESP32 acts as an interface between the sensors and the communication system, collecting and transmitting data wirelessly.

V. CONCLUSION

The project demonstrates the successful integration of an autonomous hospital porter robot with a real-time patient monitoring system to improve healthcare efficiency and patient safety. The robotic unit effectively performs tasks such as medicine delivery and sample transportation while navigating safely using obstacle detection. At the same time, the patient monitoring system continuously tracks vital parameters and enables real-time data transmission for monitoring. The combined system reduces manual workload, supports contactless operation, and ensures timely detection of abnormal patient conditions. The use of simple and cost-effective components makes the system practical for real-world hospital environments. Overall, the project provides a reliable solution for enhancing hospital automation and improving the quality of healthcare services.

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