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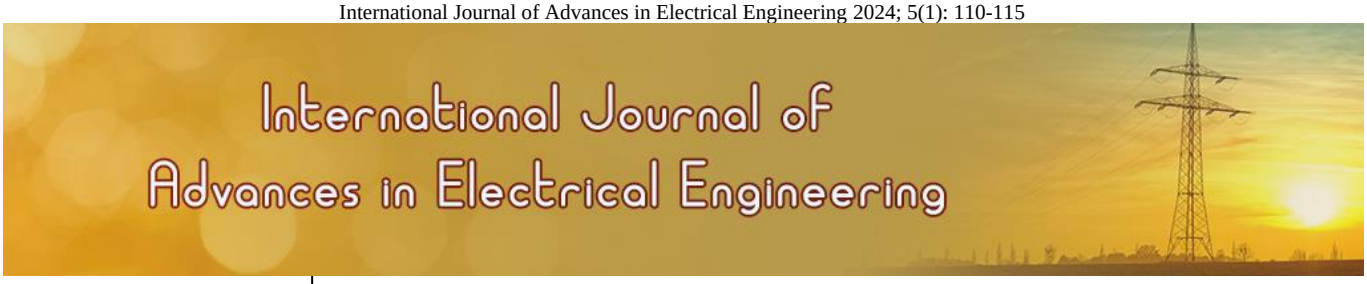

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Medicine delivering and patient parameter monitoring robot

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Abstract
In the rapidly evolving landscape of medical technology, the infusion of robotics presents a promising avenue for enhancing patient care and safety in hospitals. This research paper introduces MedRobo, an automated robotic system designed to deliver medicines and monitor crucial patient parameters including heart rate, blood pressure, temperature, and SpO2. The implementation of MedRobo aims to minimize human- to-human contact within healthcare facilities, thereby reducing the risk of transmission of contagious diseases such as COVID- 19 among medical staff and patients. The system utilizes Radio- frequency Identification (RFID) for navigation and identification, alongside a line follower algorithm guided by infrared sensors for precise locomotion to patient locations. The integration of Internet of Things (IoT) technology enables real- time data acquisition and transmission to the cloud, facilitating immediate access by healthcare professionals. Additionally, the deployment of a GSM Module ensures prompt communication with doctors when patient readings deviate from normal thresholds. This paper details the design, implementation, and operational efficacy of MedRobo, exemplifying its potential to revolutionize patient care delivery and safety in medical environments.

Keywords: MedRobo, RFID technology, IoT, GSM module, medicine delivery, contactless healthcare, automation, patient care, sensors

Introduction
The advent of robotic assistance in healthcare settings offers a transformative approach to managing and enhancing patient care, especially in environments burdened by infectious diseases and staffing shortages. The utilization of robots like MedRobo can play a pivotal role in handling routine tasks, such as delivering medication and monitoring patient vital signs, thereby reducing the workload on human staff and limiting their exposure to potential health risks. This research delves into the capabilities and benefits of implementing a robotic system specifically designed for use in hospital settings to address both operational efficiency and patient safety concerns. The integration of advanced technologies such as RFID, IoT, and automated navigation systems into healthcare services provides a glimpse into the future of medical care, where technology and health management converge to create safer, more efficient hospital environments. This paper will explore the background, objectives, and scope of the MedRobo project to establish a comprehensive understanding of its potential impact on modern healthcare.

Background
The advent of robotic assistance in healthcare settings offers a transformative approach to managing and enhancing patient care, especially in environments burdened by infectious diseases and staffing shortages. The utilization of robots like MedRobo can play a pivotal role in handling routine tasks, such as delivering medication and monitoring patient vital signs, thereby reducing the workload on human staff and limiting their exposure to potential health risks. This research delves into the capabilities and benefits of implementing a robotic system specifically designed for use in hospital settings to address both operational efficiency and patient safety concerns. The integration of advanced technologies such as RFID, IoT, and automated navigation systems into healthcare services provides a glimpse into the future of medical care, where technology and health management converge to create safer, more efficient hospital environments. This paper will explore the background,

objectives, and scope of the MedRobo project to establish a comprehensive understanding of its potential impact on modern healthcare.

Objectives

The concept of integrating robotics into healthcare is not new, but recent advancements in technology have enabled more sophisticated applications like MedRobo. Traditionally, the role of robots in healthcare has focused largely on surgical assistance and logistical tasks, such as transporting supplies and meals. However, the outbreak of the COVID-19 pandemic highlighted a critical need for innovations that minimize direct human contact and enhance infection control protocols.

MedRobo is devised as an answer to these challenges, leveraging automation to safely deliver medications and monitor essential health parameters without requiring physical interaction from nurses or other medical staff. This robotic system is particularly beneficial in isolation wards where the risk of contagion is highest. The use of RFID for navigation, combined with sensor-based technologies for patient monitoring, embodies a significant step forward in medical robotics, presenting a method not only to support patient care but also to protect healthcare workers under high-risk conditions.

Scope of the study

The primary objectives of the MedRobo project are to

- Develop a robotic system capable of delivering medications to patients autonomously, thereby minimizing the need for physical interaction between healthcare staff and patients.
- Implement a robust system for monitoring vital patient parameters such as heart rate, blood pressure, temperature, and blood oxygen saturation (SpO2) using integrated sensors.
- Enhance the safety of hospital environments by reducing the risk of communicable diseases transmission, focusing on safeguards for both patients and healthcare workers.
- Optimize the efficiency of hospital operations by automating routine tasks, thus allowing medical staff to allocate more time to critical care and other essential duties.
- Integrate advanced technologies like RFID, IoT, and real-time data processing to ensure accurate navigation, patient identification, and timely communication of health data for immediate medical response if anomalies are detected.
- Evaluate the system's effectiveness and reliability in a real-world hospital setting, ensuring that it meets all specified performance criteria and adheres to healthcare regulations.

Proposed system

The proposed system, MedRobo, integrates modern robotics and sensor technologies to address the critical need for non-contact medicine delivery and patient monitoring in hospitals. The primary functionalities of MedRobo include the automated delivery of medications and the real-time monitoring of vital signs such as heart rate, temperature, blood pressure, and SpO2.

MedRobo operates on a guided system using RFID technology for navigation and identification. The robot follows a predetermined path marked by a non-reflective line using a line follower mechanism that relies on infrared sensors. When MedRobo reaches a patient's room, it uses RFID to confirm the location and delivers the required medications through an automated dispensing mechanism similar to a vending machine.

For health monitoring, MedRobo is equipped with biomedical sensors that continuously measure the patient's vital signs. These data are then wirelessly transmitted to a central cloud-based system via IoT technology, enabling healthcare professionals to monitor patients' conditions remotely and in real-time.

The system is designed to send alerts to doctors through a GSM module if any of the monitored parameters fall outside the normal range, allowing for swift medical intervention. Overall, MedRobo aims to enhance patient care by ensuring timely medicine delivery and accurate health monitoring while minimizing the risk of infectious disease transmission in hospital settings.

System Overview

MedRobo is a highly integrated, autonomous robotic system designed for dual purposes: delivering medications and monitoring vital health metrics of patients within a hospital setting. The core system consists of several interconnected components and technologies that facilitate its operations, which are broadly categorized into navigation, medication dispensing, health monitoring, and data communication.

For navigation, MedRobo uses a combination of RFID technology and line-following signals, guided by infrared sensors, to navigate the hospital corridors autonomously. The path to each patient's room is defined by lines on the floor, which the robot follows, and doors marked with RFID tags that ensure the robot arrives at the correct destination.

The medication dispensing mechanism is akin to a compact, secure vending machine, storing and controlling access to pharmaceuticals until they are required by the patient, at which point they are dispensed safely.

MedRobo is equipped with an array of sensors capable of measuring various vital parameters such as heart rate, blood pressure, temperature, and SpO2. These sensors provide continuous, real-time health monitoring, which is essential for critical care.

Data from MedRobo is transmitted securely to a cloud-based platform via IoT technology. This platform allows healthcare staff to access and review patient data remotely and make informed decisions quickly. Alerts are sent automatically to medical staff through a GSM module if any patient's measurements deviate from their normal ranges, facilitating prompt medical intervention.

Together, these features make MedRobo a technological advancement geared towards enhancing patient care, optimizing workflow in medical environments, and ensuring safety through reduced physical contact amidst pandemic scenarios or other infectious environments.

Components and technologies

MedRobo incorporates several critical components and technologies that underpin its functionality and efficiency. The primary components include RFID tags and readers, infrared sensors, a line-following system, a medication dispensary mechanism, various biomedical sensors, and the integration of IoT for data handling and communication.

RFID tags and readers work in tandem to enable precise navigation and localization within the hospital. Each patient room and crucial junctions within the facility are equipped with specific coded tags that the robot's onboard RFID reader can detect and interpret to confirm its path and destination.

The line-following system, powered by infrared sensors, detects the marked lines on the hospital floors, directing the robot along these routes to ensure it maintains the correct trajectory toward the assigned destinations.

The medication dispensary system is designed with security and precision in mind, featuring compartments that can store and dispense a wide range of medicinal products based on programmed commands. This system allows MedRobo to deliver the right medication to the right patient at the scheduled times.

Biomedical sensors attached to the robot are used to assess vital parameters such as heart rate, blood pressure, body temperature, and blood oxygen saturation (SpO2). These sensors provide accurate and reliable readings that are vital for monitoring the health status of patients.

Integration with IoT is a crucial aspect that offers robust connectivity and data management capabilities. Through IoT, all the data collected from RFID inputs and biomedical sensors are transmitted securely to the cloud platform, enabling remote monitoring by medical staff and ensuring timely updates and interventions based on the health data received.

Additionally, a GSM module is incorporated to issue alerts to doctors instantly when abnormal readings are detected, ensuring a swift response to any potential health crises.

These components and technologies are thoughtfully integrated within MedRobo to ensure that it performs its tasks efficiently, safely, and with minimal human intervention, thereby optimizing patient care and safety in healthcare settings.

Implementation

The implementation of MedRobo encompasses the assembly and configuration of its mechanical framework, software programming, and the strategic integration of its IoT capabilities. This multi-layered process required precise coordination to ensure that all components function harmoniously and reliably.

Initially, the mechanical design was focused on ensuring MedRobo was maneuverable and sturdy enough to navigate hospital corridors and enter patient rooms without assistance. The software and control subsystem then integrated navigation algorithms, including RFID and line-following protocols, along with health- monitoring functions to operationalize the sensors' data collection.

Subsequently, the integration with IoT technology was vital to set up for robust data handling and real-time communication. This included establishing secure cloud storage solutions and configuring the GSM module for sending alerts to medical staff based on the patient data analyses.

Throughout the implementation phase, considerable attention was given to the user interface and the user experience to ensure that hospital staff could interact with MedRobo efficiently and intuitively, which is crucial for the adoption of technology in busy medical environments. The implementation process ultimately ensured that MedRobo was capable of performing its intended functions safely and efficiently, complementing the efforts of human medical staff with high reliability and precision.

Software and control

The software and control architecture of MedRobo is designed to ensure seamless operation and integration of its diverse functionalities. Central to this system is the microcontroller unit (MCU), which serves as the brain of the robot, processing inputs from the RFID and infrared sensors for navigation, and signaling the correct dispensary mechanisms. The chosen MCU for MedRobo is the Arduino Mega, due to its superior number of input/output pins that are essential for handling multiple sensors and actuators concurrently.

The software stack includes a real-time operating system (RTOS) that facilitates multitasking, crucial for simultaneously managing path finding, medicine dispensing, and vital signs monitoring. Programming languages utilized include C and Python, with C handling the lower-level operations for sensor data collection and motor controls, and Python managing higher-level functions such as data integration and communication tasks.

Communication protocols are an integral part of Med Robo’s operation, particularly the use of MQTT (Message Queuing Telemetry Transport) for IoT integration. This lightweight messaging protocol allows efficient transmission of telemetry data to the cloud platform, ensuring that data packets, even from multiple robots, are managed effectively without overwhelming network bandwidth.

Safety features in the software include error handling routines to manage potential failure modes such as sensor disruption or communication breakdown. Robust security measures are also programmed to safeguard patient data and prevent unauthorized access, employing encryption technologies and secure authentication methods.

Overall, the software and control systems combine to provide a responsive and reliable robotic assistant capable of conducting its duties with minimal human oversight. This foundation not only supports current functionalities but also allows for future upgrades that could expand MedRobo’s capabilities in medical environments.

Integration with IOT

The integration of Internet of Things (IoT) technology in MedRobo significantly enhances its capability to deliver real-time, efficient healthcare services. Key to this integration is the use of NodeMCU, a low-cost open- source IoT platform with built-in Wi-Fi capabilities, which connects various components of MedRobo to the internet. This IoT platform enables the seamless transmission and storage of collected health data to a cloud server.

To ensure the efficient operation of IoT functionalities, MedRobo utilizes MQTT protocol for lightweight data transmission, ensuring that data such as patient vitals and medication schedules are promptly and reliably communicated to healthcare professionals, regardless of their location. This real-time data exchange enables doctors to monitor patients continuously and make informed decisions rapidly.

Furthermore, the IoT integration facilitates remote diagnostics and maintenance of MedRobo itself, allowing technical teams to monitor the robot's operational status and

perform updates or repairs as necessary without physical interaction. This not only improves the longevity and performance of MedRobo but also reduces downtime and operational costs.

Additionally, IoT technology enhances the security framework of MedRobo by employing advanced data encryption and secure data transmission protocols to protect sensitive patient information against unauthorized access and cyber threats.

Through these various applications, the integration of IoT in MedRobo maximizes the utility and security of the robotic system, promoting safer, more efficient patient care and operational management within the healthcare setting.

Testing and Results

The testing phase of MedRobo was conducted in a controlled environment initially and subsequently in a real-world hospital setting to ensure accuracy, functionality, and reliability. The testing process was segmented into multiple phases, focusing on individual components as well as the system as a whole.

In the initial tests, the line following and RFID systems were evaluated to confirm their ability to accurately navigate and locate specific rooms or points in a simulated hospital environment. These tests confirmed that MedRobo could successfully follow the designated path without deviating and correctly identify room locations using RFID tags.

Subsequent tests involved the integration of the biomedical sensors. The sensors were calibrated and tested to check the accuracy of the data collected for vital signs, including heart rate, blood pressure, temperature, and SpO2 levels. The results were compared against standard medical devices to validate their reliability. The tests demonstrated a high degree of accuracy, with a margin of error within acceptable medical standards.

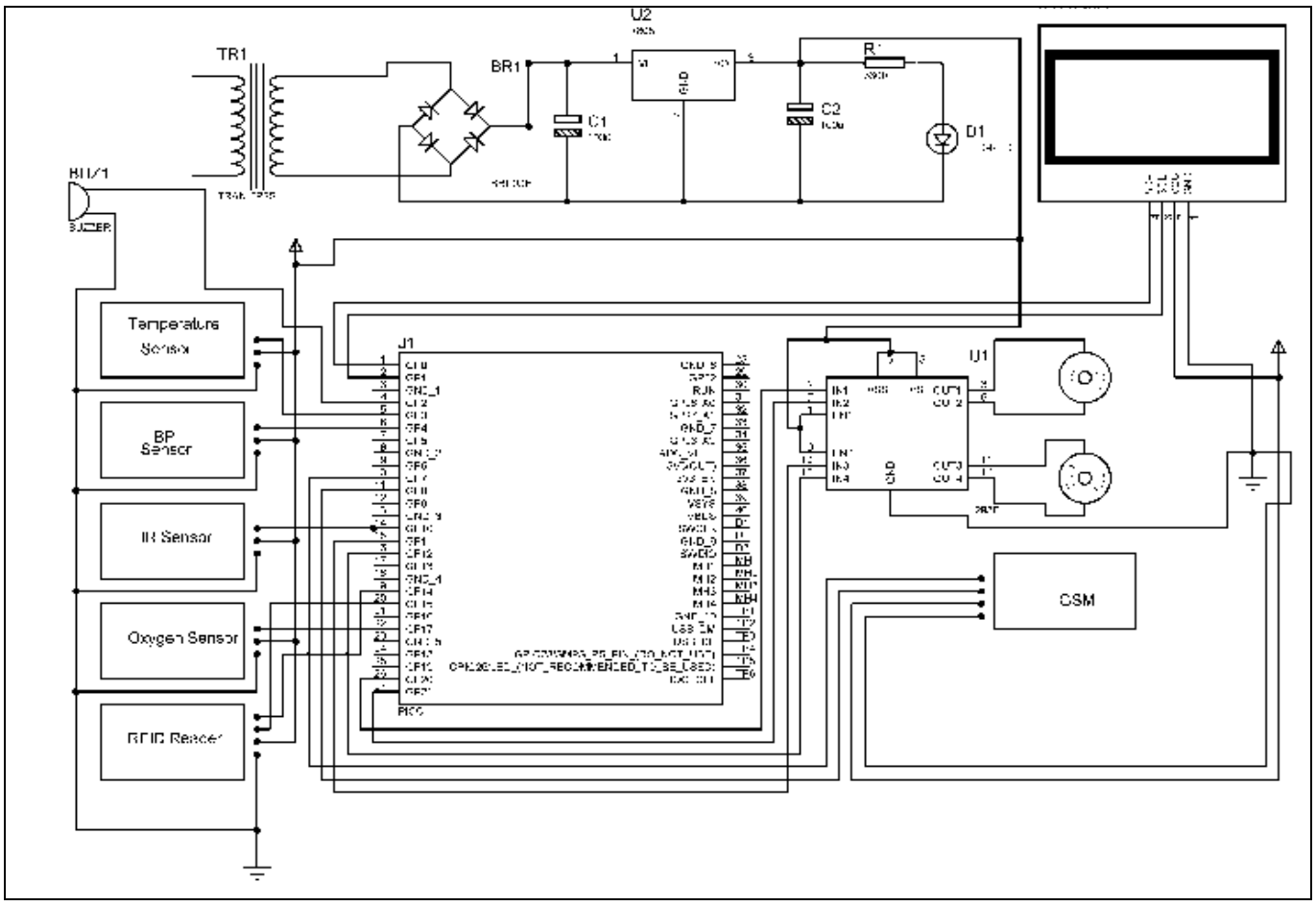

Fig 1: Schematic Diagram

Figure: Protype at Patient 1

Following the component tests, system-level testing was implemented, where MedRobo's ability to operate autonomously was evaluated. This included automated medicine dispensing based on preset schedules and emergency scenarios where the system had to alert medical personnel via the GSM module upon detecting abnormal patient vitals.

Figure: Protype at Patient 2

In the final phase of testing in a real hospital setting, MedRobo operated under typical working conditions to further evaluate its performance, including its interaction with hospital staff and patients. The feedback obtained was overwhelmingly positive, with particular praise for the robot's efficiency and the reduced need for direct contact between staff and patients.

Fig 2: Protype at Patient 1

Fig 3: Protype at Patient 2

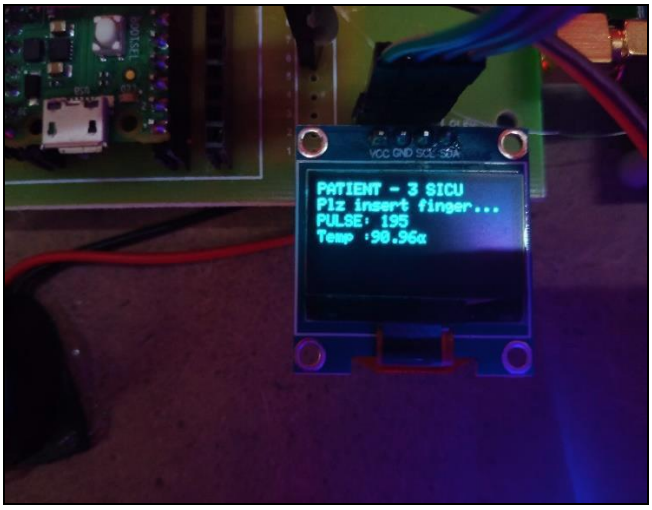

Fig 4: Protype at Patient 3

Overall, the test results demonstrated that MedRobo could operate efficiently and reliably, fulfilling its intended functions effectively. The successful integration of IoT components not only allowed for real-time monitoring and control but also enhanced the safety features, ensuring secure and private data handling. These results substantiate the potential of MedRobo as a valuable tool in modern healthcare environments, particularly in scenarios requiring minimization of human-to-human contact.

Conclusion

MedRobo, the innovative medicine-delivering and patient-monitoring robot, stands as a significant advancement in the realm of healthcare technology. Developed to address urgent needs in hospital settings, particularly under the extraordinary circumstances imposed by the COVID-19 pandemic, this robotic system serves a dual role. It not only ensures the safe delivery of medication directly to patients but also monitors vital health parameters accurately. The

implementation of systems such as RFID tracking and line following for navigation, combined with the integration of IoT for real- time data communication and storage, enhances the operational efficiency of healthcare services while minimizing the risk of virus transmission among hospital staff and patients. The extensive testing phases have validated MedRobo's functionality and reliability, indicating that it is well-equipped to assist in daily medical tasks and emergency responses effectively. As healthcare continues to evolve with technological innovations, MedRobo can be seen as a forward step towards safer, more efficient patient care, setting a benchmark for future developments in medical robotics.

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