

MediAstra (The Autonomous Robot)

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Abstract - Efficient and reliable medicine delivery within hospitals is a critical requirement for ensuring timely treatment and reducing the workload on healthcare staff. Manual distribution often results in delays and inefficiencies, especially in large healthcare facilities. This paper presents MediAstra, an autonomous medicine delivery robot designed to automate hospital logistics. The system integrates a Raspberry Pi 4 and Arduino Uno for coordinated control. IR sensors enable path following, ultrasonic sensors provide obstacle detection, and a camera module performs QR code-based room identification. A servo motor with keypad-based password access ensures secure medicine dispensing. The six-wheel chassis enhances mobility over uneven indoor surfaces. Additionally, a mobile application provides real-time tracking and delivery notifications. The proposed system improves efficiency, reduces human workload, and enhances security in hospital medicine distribution.

Key Words: Autonomous Robot, Medicine Delivery, Raspberry Pi, Arduino Uno, IR Sensors, QR Code Detection, Ultrasonic Sensors, Smart Healthcare

1. INTRODUCTION

Effective medicine distribution is a crucial aspect of hospitals running efficiently and providing good patient services, but manual distribution by hospital staff can be prone to delays and extra workload. To solve this problem, this project proposes the use of MediAstra, a self-guided medicine delivery robot that will be used to automate hospital logistics in a safe and trustworthy way. The project is based on a Raspberry Pi 4 controller that manages IR sensors for path tracking, a Pi Camera for QR code-based room detection, and ultrasonic sensors for real-time obstacle detection. A servo motor-controlled container with a 4x4 keypad provides safe access to medicines, while a six-wheel stair-climbing robot body provides smooth motion on irregular surfaces. Moreover, a mobile app provides real-time tracking and delivery status updates.

1.1 Problem Definition

Hospitals face significant challenges in ensuring timely, accurate, and secure medicine delivery to patients. Manual delivery by nurses or attendants often results in delays,

increased workload, and higher chances of distribution errors. In large healthcare facilities, staff must travel long distances, which disrupts critical patient care duties. Additionally, traditional systems lack real-time tracking and verification, creating accountability and security issues. Therefore, there is a need for an autonomous and reliable robotic solution to improve hospital logistics efficiency.

1.2 Objective

The objective of this project is to develop an autonomous medicine delivery robot capable of efficiently transporting medicines within hospital environments. The system integrates IR sensors for path navigation, a camera module for QR code-based room identification, and ultrasonic sensors for real-time obstacle detection. A servo-controlled container with keypad-based authentication ensures secure medicine access. A mobile application provides real-time tracking and delivery notifications to enhance reliability and operational efficiency.

2. SYSTEM DESIGN AND IMPLEMENTATION

The MediAstra system integrates hardware and software components to achieve autonomous navigation, secure medicine dispensing, and real-time monitoring. The overall design consists of Raspberry Pi 4 and Arduino Uno working in coordination to control sensors, actuators, and communication modules. The system architecture is represented through the block diagram and circuit diagram, illustrating the interaction between navigation, detection, and control units.

2.1 Literature Review

The field of healthcare robotics and hospital automation has seen significant advancements in recent years, with researchers exploring robotic delivery systems, autonomous navigation methods, and IoT-based solutions to enhance hospital efficiency. Automated Guided Vehicles (AGVs) and mobile service robots have been introduced in hospitals to transport medicines, samples, and documents, reducing staff workload and improving logistics.

Line-following robots have been widely studied as a cost-effective navigation method, where Infrared (IR) sensors are used to detect black paths on the floor, providing simple yet reliable guidance [1]. To improve room identification, QR code-based navigation has emerged as a promising approach, enabling robots to localize themselves by reading QR markers placed along corridors or at doorways [2]. Ultrasonic sensing technologies have been integrated into mobile robots to achieve real-time obstacle detection, ensuring safer navigation in crowded environments such as hospitals [3].

Mobile applications and IoT-based communication platforms have also been developed to facilitate interaction between hospital staff and delivery robots. These applications enable real-time notifications, live tracking, and status monitoring, ensuring transparency and reliability of the delivery process [4]. Furthermore, robotics research has also focused on stair-climbing mechanisms, inspired by planetary rovers, which allow robots to traverse irregular hospital terrains, ramps, and small staircases [5].

While these advancements demonstrate substantial progress in healthcare automation, challenges remain in integrating multiple technologies into a single, cost-effective, and scalable solution. Future research is expected to focus on improving robot adaptability, enhancing security in medicine delivery, and developing intelligent cloud-based management systems to achieve greater efficiency and accessibility in hospital logistics.

2.2 Block Diagram

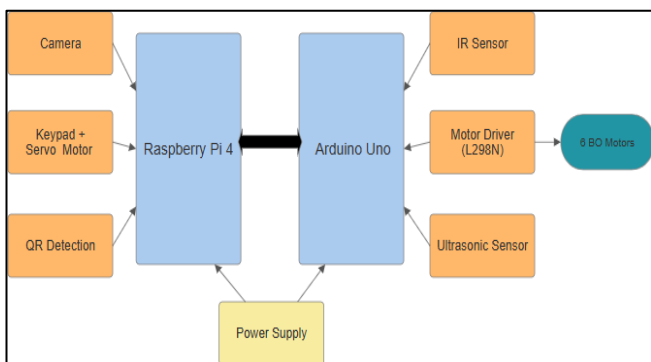


Fig 2.1 Block Diagram

This is the block diagram of the MediAstra system, which represents the overall working and functional architecture of the project. It illustrates the interaction between the major hardware components and control units used in the system. The design integrates the Raspberry Pi 4 and Arduino Uno for coordinated and efficient control of various operations.

The Arduino is responsible for handling low-level control tasks, including interfacing with sensors such as

the IR sensor for line following and the ultrasonic sensor for obstacle detection. It also controls the L298N motor driver, which regulates the movement and direction of the six BO motors used for navigation. Meanwhile, the Raspberry Pi performs high-level processing tasks such as camera-based QR code detection, keypad input verification, and servo motor operation for secure medicine dispensing. The power supply unit provides the required and stable voltage to both controllers and all connected modules, ensuring smooth and uninterrupted system operation.

2.3 Circuit Diagram

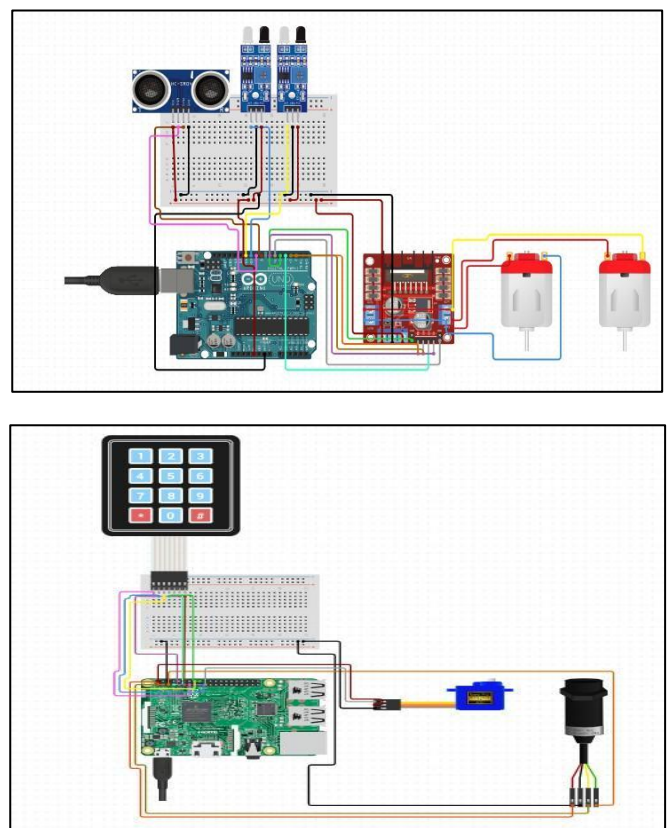


Fig 2.2 Circuit Diagram

2.4 Components

The MediAstra system consists of various hardware components that work together to achieve autonomous navigation, obstacle detection, secure medicine dispensing, and real-time monitoring. The major components used in the system are described below.

2.4.1 Raspberry Pi 4B

The Raspberry Pi 4 Model B is a powerful single-board computer with a 1.5 GHz quad-core ARM Cortex-A72 processor, up to 8 GB RAM, and built-in Wi-Fi, Bluetooth 5.0, and Gigabit Ethernet. It supports dual 4K displays and offers USB 3.0 connectivity along with a 40-pin GPIO for

sensor and device interfacing. Its high performance and versatility make it ideal for IoT, robotics, and automation projects. In the MediAstra system, it performs high-level processing tasks such as QR code detection, keypad authentication, and servo motor control.



Fig 2.4.1 Raspberry Pi 4B

2.4.2 Arduino Uno

The Arduino Uno is an open-source microcontroller board based on the ATmega328P. It operates at 5V with a 16 MHz clock frequency and provides 14 digital input/output pins (6 PWM), 6 analog input pins, and a USB interface for programming and communication. It is widely used for prototyping and embedded applications due to its simplicity, affordability, and extensive library support. In this project, the Arduino Uno controls the motors, IR sensors, ultrasonic sensor, and Bluetooth module to manage the robot’s movement and obstacle detection.

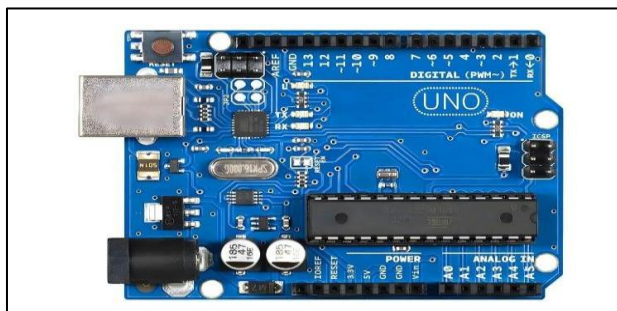


Fig 2.4.2 Arduino Uno

2.4.3 L298N Motor Driver

The L298N Motor Driver controls the direction and speed of the DC BO motors in the MediAstra robot. It uses an H-bridge configuration to drive two motors for forward, backward, left, and right movement. The key pin connections are ENA (10), ENB (5) for speed control, IN1–IN4 (9, 8, 7, 6) for direction, +12V for motor power, 5V OUT to Arduino, and GND as the common ground. It ensures efficient and stable motor operation.

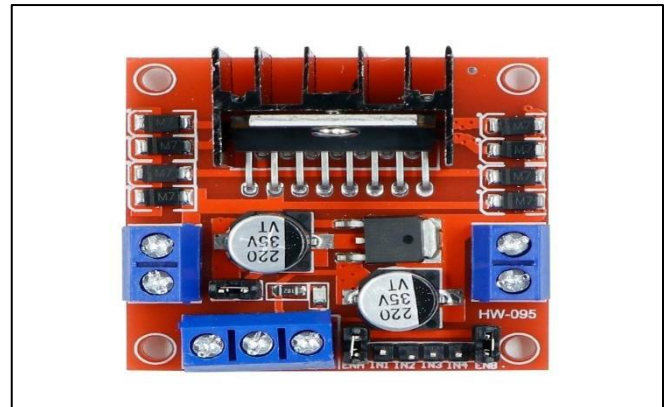


Fig 2.4.3 L298N Motor Driver

2.4.4 USB Web Cam

The CMOS Raspberry Pi Camera is used for QR code detection and room identification in the MediAstra robot. It captures high-quality images and transmits them to the Raspberry Pi for processing. The camera connects to the Raspberry Pi via the CSI (Camera Serial Interface) port, ensuring fast image transfer. It features a compact CMOS sensor that provides sharp images with low power consumption, enabling accurate recognition and efficient navigation during medicine delivery.



Fig 2.4.4 USB WebCam

2.4.5 Servo Motor

The Servo Motor in the Medi Astra robot is used to open and close the medicine container lid securely during delivery. It operates based on precise angular control, allowing the lid to rotate to a specific position when an authorized password is entered. The servo has three pins: VCC connected to 5V, GND to ground, and Signal to a Raspberry Pi GPIO pin for control. This mechanism ensures accurate, reliable, and automated medicine dispensing.



Fig 2.4.5 Servo Motor

2.4.6 3x4 Keypad

The 3x4 Keypad is used in the MediAstra robot to provide a secure password-based access system for medicine retrieval. It consists of 12 keys arranged in 3 columns and 4 rows, allowing users to enter numeric codes. The keypad connects to Raspberry Pi through GPIO pins, which detect key presses using a row-column scanning method. Its connections include 7 pins (4 row pins and 3 column pins) linked to digital GPIOs, VCC to 5V, and GND to ground. This ensures safe and authorized medicine delivery control.

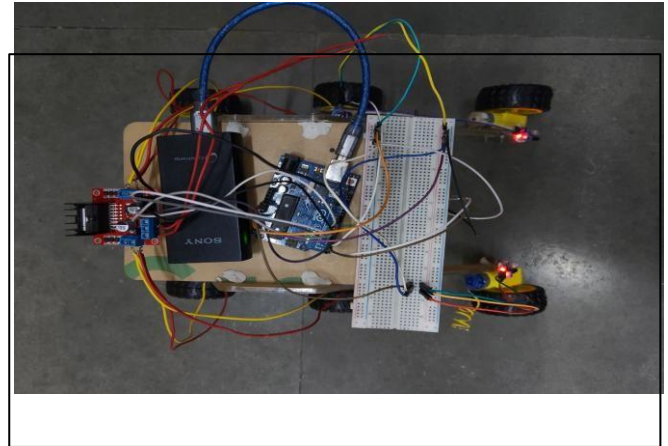


Fig 2.4.6 3x4 Keypad

3. RESULTS

The Fig.3.1 illustrates the Arduino Uno interfaced with the L298N motor driver, IR sensors, and ultrasonic sensor to form the primary motion control and navigation unit of the MediAstra robot. The Arduino sends control signals to the L298N motor driver, which drives the DC motors responsible for the robot's movement. The IR sensors are connected to detect the black line on the floor for path following, enabling the robot to navigate predefined routes autonomously. The ultrasonic sensor is used for real-time obstacle detection by measuring the distance between the robot and surrounding objects, allowing it to

stop or change direction to avoid collisions. This configuration ensures stable and precise control over motion, making it suitable for reliable indoor navigation within hospital environments.



The Fig. 3.2 illustrates the Raspberry Pi 4 interfaced with a camera module, 3x4 keypad, and servo motor, forming the intelligent control section of the MediAstra robot. The Raspberry Pi 4 processes images captured by the camera to detect and decode QR codes placed at different hospital rooms, ensuring accurate identification of the medicine delivery location. The 3x4 keypad is used as a security input system, allowing authorized personnel to enter a password to access the medicine container. Once the correct password is entered, the servo motor is actuated to open the lid, enabling secure medicine retrieval. After the process, the servo returns to its initial position to close the lid automatically. This setup enhances both security and automation in hospital logistics by ensuring that only authenticated users can access the delivered medicines.

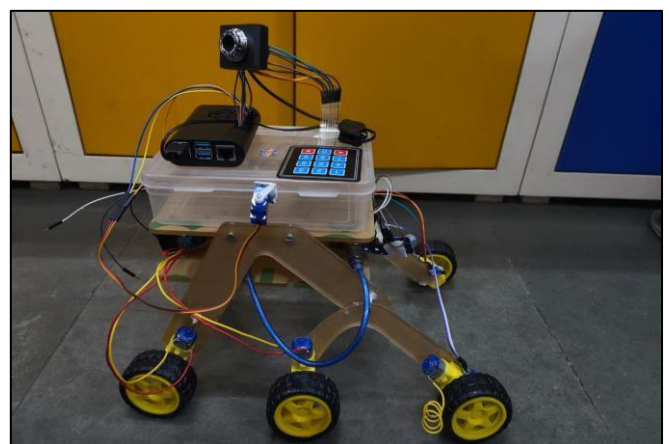


Fig 3.2 Raspberry Pi Connection Setup

The Fig 3.3 illustrates the working of the IR sensor-based line-following mechanism used for autonomous navigation in the MediAstra robot. The IR sensors continuously detect the contrast between the black line

and the white floor surface. When the sensor passes over the black line, it produces a low output signal, while on the white surface, it gives a high output. These signals are processed by the Arduino to adjust the motor speed and direction, ensuring the robot follows the path accurately. This system allows the robot to move smoothly along a predefined route within the hospital premises, ensuring reliable and efficient medicine delivery without the need for manual guidance.

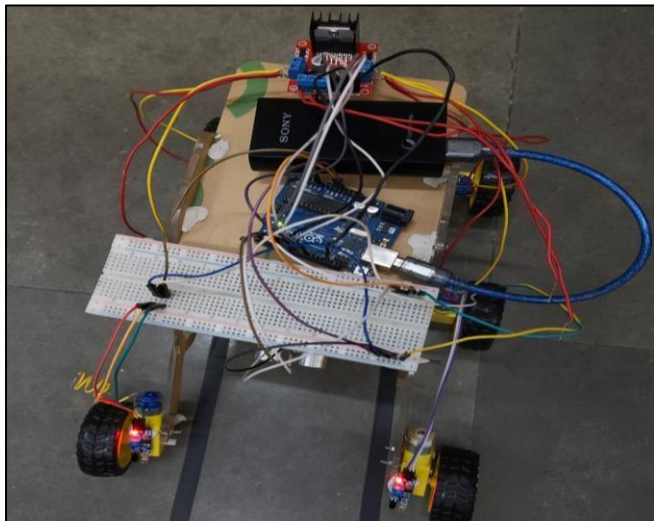


Fig 3.3 Path Following Mechanism

The Fig 3.4 illustrates the camera-based QR code detection mechanism used in the MediAstra robot for accurate room identification and medicine delivery verification. The camera, interfaced with the Raspberry Pi 4, continuously scans the surroundings as the robot follows its path. When it reaches a room, the camera captures the QR code placed near the door and processes the image to decode the information. The decoded data is compared with the preassigned delivery location stored in the system. If the QR code matches the designated room, the robot confirms its position and initiates the medicine delivery sequence. This ensures precise and error-free delivery to the correct recipient, enhancing the reliability and automation of the hospital logistics process.



Fig 3.4 QR Detection Mechanism

4. APPLICATIONS

1) Automated Medicine Delivery in Hospitals

MediAstra automates the process of delivering medicines from the hospital pharmacy to patient rooms, reducing the manual workload on nurses and staff. It ensures timely and accurate medicine delivery, improving efficiency and minimizing human errors.

2) Enhanced Hospital Workflow Management

By following predefined paths and QR-based room identification, the robot optimizes hospital logistics. It allows staff to focus on patient care instead of routine delivery tasks, resulting in smoother hospital operations.

3) Contactless Delivery for Infection Control

In sensitive hospital environments, MediAstra enables contactless medicine delivery, minimizing the risk of infection spread between patients and staff, especially during pandemic or quarantine situations.

4) Secure and Authorized Medicine Access

A keypad and servo-controlled lid mechanism ensure that only authorized personnel or patients can access the delivered medicines, maintaining safety and accountability in hospital operations.

5) Scalable Use in Smart Healthcare Systems

MediAstra's modular design and IoT-based connectivity make it adaptable for larger hospital networks. It can be expanded to transport samples, documents, or equipment, supporting future smart healthcare automation.

5. CONCLUSION

The *MediAstra* system presents an innovative and practical approach to automating medicine delivery within hospital environments. By integrating Raspberry Pi and Arduino platforms, the system effectively

coordinates tasks such as line following using IR sensors, obstacle detection through ultrasonic sensors, QR-based room identification via a camera, and secure medicine dispensing with a servo-keypad mechanism. This combination of hardware and intelligent control not only reduces manual workload but also ensures timely and accurate medicine delivery to patients. The prototype demonstrates how robotics and IoT can transform healthcare logistics by increasing efficiency, accuracy, and safety. Future improvements could include cloud integration for real-time hospital database connectivity, enhanced path mapping, and multi-robot coordination to create a fully autonomous hospital delivery network.

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