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Smart Delivery Bot: An Autonomous Indoor Delivery System Using Embedded Technology

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Abstract: *The increasing demand for efficient, contactless deliveries in indoor environments has highlighted the challenges in last-mile logistics, particularly in cost, scalability, and operational efficiency. To tackle these challenges, we have developed the Smart Delivery Bot (SDB)—an autonomous robot designed to seamlessly transport items within indoor spaces such as offices, hospitals, and restaurants. The SDB is powered by an Arduino Uno microcontroller, which serves as the central processing unit, coordinating various sensors and actuators to ensure smooth navigation and obstacle avoidance. Additionally, the bot is equipped with a camera that provides a live video feed to monitor its surroundings in real-time. This smart system decreases human involvement, speeds up workflows, and boosts productivity by simplifying the transport of goods indoors. The system uses Bluetooth for communication, detects obstacles in real-time, and streams live video to ensure deliveries are accurate, quick, and safe. The bot uses infrared (IR) sensors for following paths, ultrasonic sensors for avoiding obstacles, and an ESP32-CAM module for constant real-time monitoring.*

Key Word: *Arduino Uno, SDB, Autonomous Robot, IR Sensor, Ultrasonic Sensor, ESP32-CAM, Bluetooth, Delivery Bot*

I.INTRODUCTION

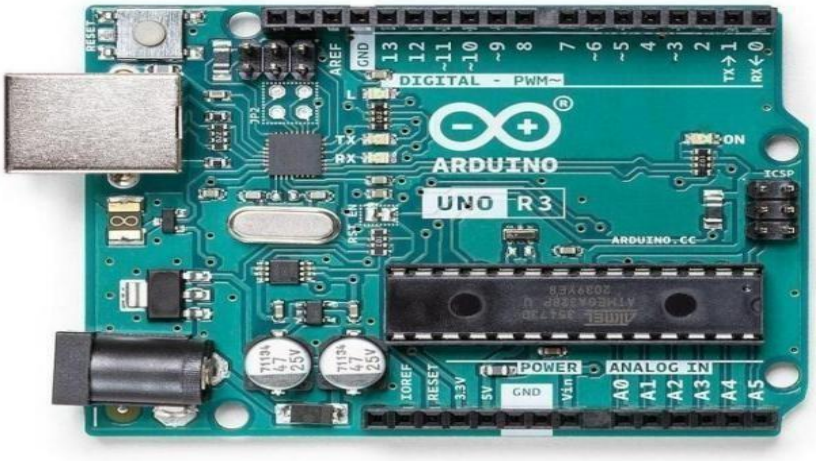
The quick rise of automation and smart technology has led to new ways to improve how things are delivered indoors. One of these new tools is the Smart Delivery Bot (SDB), a robot that can deliver things by itself without anyone guiding it. You can see it in action in offices, hospitals, retail stores, and restaurants. At its core is an Arduino Uno, which works like its brain, controlling everything to help the robot move smoothly and accurately? It uses different types of sensors, like ultrasonic and infrared (IR), to detect obstacles and measure distances. This helps it move around safely and efficiently. The robot can communicate wirelessly because it has a Bluetooth HC- 05 module. This means people can send it commands from afar using a special software application. It also features an ESP32-CAM module, providing live video so people can watch what the robot is doing in real-time. The Smart Delivery Bot follows a set route but is smart enough to change its path if it encounters something in its way. After finishing its delivery, it can return to where it started. This feature makes the SDB ideal for boosting productivity in indoor settings where the environment is controlled.

II.METHODOLOGY

The Smart Delivery Bot is a type of robot that can move and navigate by itself. It uses different parts that work together to achieve this. The most important part is the Arduino Uno, which acts like the bot's brain. This part gets instructions from the Bluetooth module and tells the motor driver how to move the bot. It also uses information from ultrasonic and infrared sensors to help the bot avoid obstacles.

Here is a breakdown of the parts used in the bot:

- **Arduino Uno:** The Arduino Uno acts like the brain of the Smart Delivery Bot, handling all control and communication tasks. It takes in information from infrared (IR) and ultrasonic sensors, helping the bot make decisions about where to go instantly. Commands come through Bluetooth and are turned into signals that move the motors using the L298N driver. The Arduino Uno is easy to use and adaptable, making it perfect for quickly testing new ideas and applications that need fast responses. It ensures all the bot's parts work together seamlessly, allowing it to operate on its own efficiently.
- **Bluetooth Module (HC-05):** This part lets the bot communicate wirelessly with a mobile app called Serial Bluetooth Terminal. This allows users to send movement commands to the bot from a distance. It operates on a 2.4 GHz frequency, which is common for wireless communications.
- **Ultrasonic Sensor (HC-SR04):** This sensor measures the distance between the bot and any obstacles. It can measure distances from 2 cm up to 400 cm and is quite accurate, with a precision of about 3 mm.



- *Figure 1: Microcontroller - Arduino Uno*

- **Infrared (IR) Sensor:** This sensor detects objects in the path of the bot. If it finds an obstruction, it helps the bot change its path to avoid a collision.
- **Motor Driver (L298N):** This component controls how fast the bot's motors turn and in which direction they move. It receives instructions from the Arduino Uno. It can handle voltages from 5V to 35V and up to 2A of current for each channel it controls. The bot is moved by four wheels powered by DC motors working on 6V–12V, providing enough power to carry the bot and its load.
- **Camera Module (ESP32-CAM):** This small and compact camera provides a live video feed that helps monitor the bot as it navigates. It features a 2MP camera and streams video over Wi-Fi, so users can track the bot's movement from afar. Its small size and powerful processing features make it fitting for boosting the bot's ability to perceive its environment.
- The workings of the bot were programmed using the Arduino IDE. This software was used to write, test, and then upload the necessary control code to the Arduino Uno using a USB cable, ensuring the Smart Delivery Bot operates as planned.

III.PROPOSED WORK

The Smart Delivery Bot is a machine designed to move on its own inside buildings to deliver items. It is made up of various parts that work together to help it navigate and reach specific places. The bot uses Ultrasonic sensors to follow a "T" shaped path. It constantly checks distances and adjusts its speed using an Arduino Uno microcontroller. Users can direct the bot to locations like Table "A" or Table "B" by sending commands via a Bluetooth Module (HC-05), the Bluetooth module takes 4 commands A and B for reaching the destination and respectively V and U for performing U-Turn to reach the Initial position. At the front, IR sensors detect obstacles. If there is something in its way, the bot can stop or change its route to avoid collisions, ensuring safe movement.

For monitoring, the bot includes an ESP32-CAM module that streams live video over Wi-Fi, allowing users to watch the delivery live. An L298N motor driver controls four wheels on the bot, which move precisely according to sensor input and instructions. The whole system is powered by lithium-ion batteries, and an LM7805 voltage regulator keeps the power steady at 5 volts. The bot is designed with a flexible setup, allowing for future improvements like voice commands, cloud connectivity, or using smart technology to predict paths.

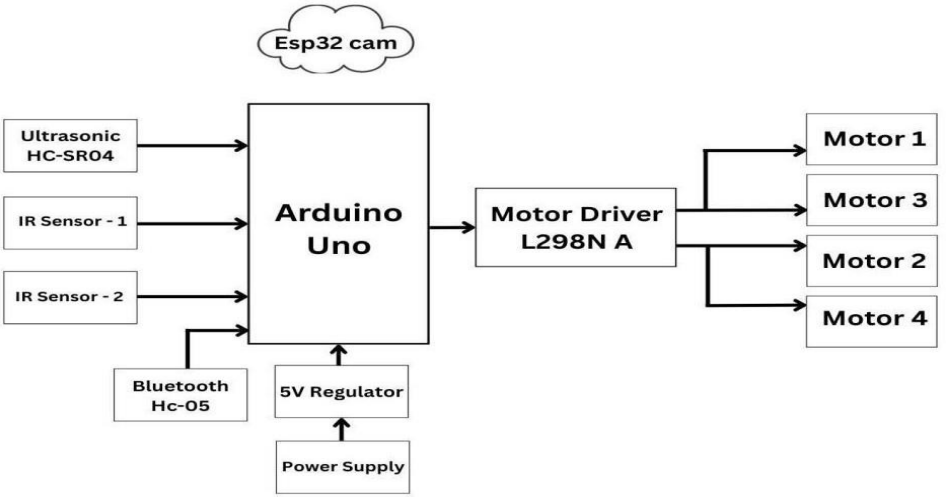


Figure 2: Block Diagram of Proposed work

Instead of using methods like time delay for route planning, the Smart Delivery Bot follows pre-set paths to reach its destinations. It relies on sensors, predefined waypoints, and real-time video feedback from the ESP32-CAM camera to navigate accurately and safely. The bot operates by following pre-planned movement instructions, moving in a "T" pattern and turning left or right based on commands. After completing a delivery, it returns to its starting point. This design ensures the bot follows its specified path closely. Here is the diagram showing how the Smart Delivery Bot's circuit is set up.

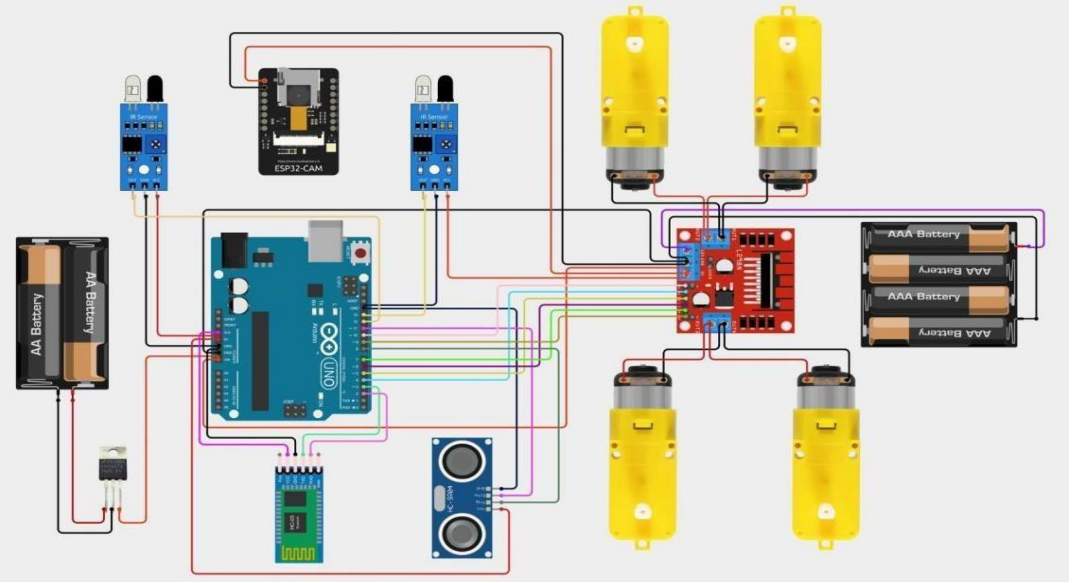


Figure 3: Circuit diagram of SDB

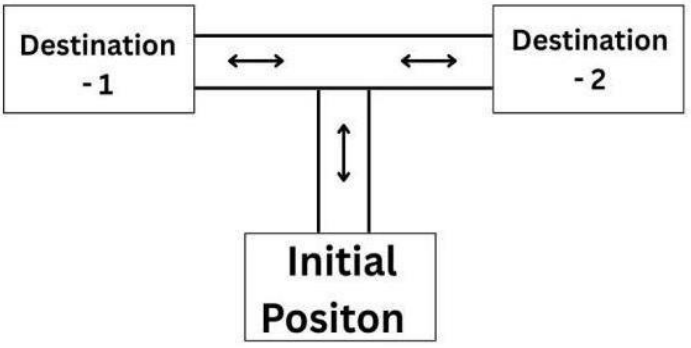


Fig 4: T- Shaped Path of SDB

IV.RESULTS AND DISCUSSION

After assembling the Smart Delivery Bot and programming it through the Arduino IDE, we tested it by sending commands via the Serial Bluetooth Terminal. The bot moved toward assigned destinations, detected walls from 50mm away, and turned to avoid them. Its sensors allowed it to avoid obstacles and change its path as needed to reach its destination. At the destination, it performed a U-turn and followed the path back to its starting point when given specific inputs. During testing, the movement, navigation, and obstacle avoidance all worked smoothly, ensuring the bot could deliver items indoors accurately and reliably. The project showed how we could use automation for effective and contactless item transport.

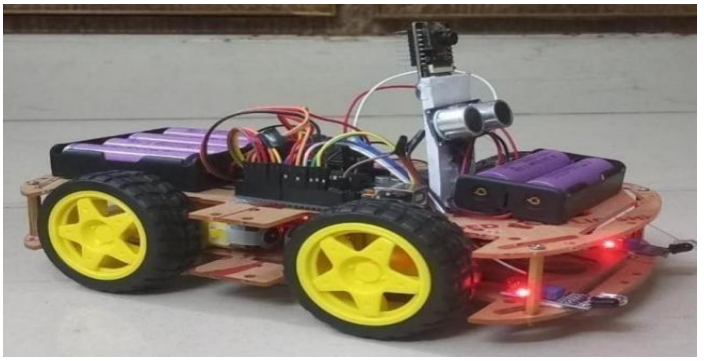


Figure 5: Working Model of SDB (Side view)

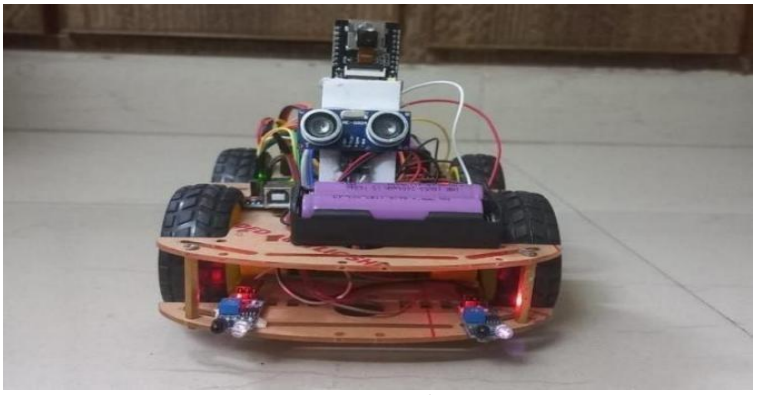


Figure 6: Working Model of SDB (Front view)

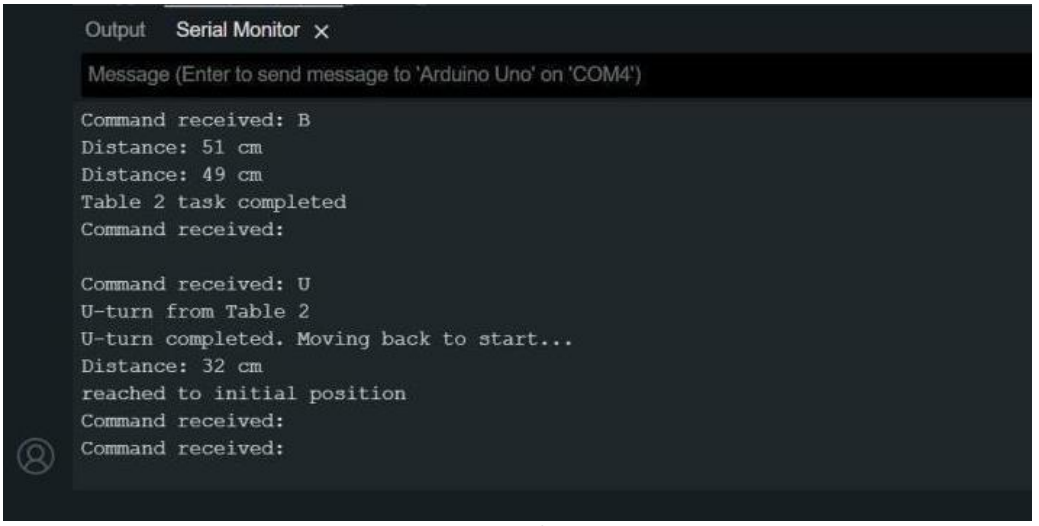


Figure 7: Output Window of SDB (Destination - B)

V.CONCLUSION

The Smart Delivery Bot is a reliable, efficient solution for automating indoor deliveries in spaces like offices, hospitals, and homes. It uses Bluetooth for receiving commands, ultrasonic and IR sensors for navigation, and motor control for movement, allowing it to transport items autonomously and safely. Equipped with an ESP32- CAM for real-time monitoring, the bot enhances security and accountability. Built using accessible components like the Arduino Uno and HC-05, the project demonstrates how simple, cost-effective hardware can be combined with smart programming to create practical, customizable robotics solutions.

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