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Arduino-Based Autonomous Delivery Robot with Obstacle Avoidance

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Abstract - The rapid advancement of automation and embedded systems has led to the development of intelligent robotic solutions for real-world applications. This paper presents the design and implementation of an Arduino-based autonomous delivery robot capable of transporting objects without human intervention. The system integrates ultrasonic sensors for obstacle detection, a motor driver module for motion control, and an Arduino microcontroller for decision-making. The robot operates in a closed-loop system where it continuously senses its surroundings, processes data, and performs appropriate actions. The proposed system is cost-effective, energy-efficient, and suitable for applications in hospitals, warehouses, offices, and educational institutions. The study demonstrates the feasibility of low-cost autonomous delivery systems and provides a foundation for future enhancements using advanced technologies such as IoT and artificial intelligence.

Key Words: **Arduino, Autonomous Robot, Ultrasonic Sensor, Obstacle Avoidance, Embedded Systems, Delivery Robot**

1. INTRODUCTION

Automation and robotics have become integral components of modern technological advancements [1],[3]. Autonomous delivery systems, in particular, are gaining importance due to their ability to reduce human effort and improve operational efficiency [1], [10]. These systems are widely used in logistics, healthcare, and industrial sectors [10]. This research focuses on the development of an Arduino-based autonomous delivery robot designed to transport small objects efficiently.

Fig-1: Delivery Robot

The robot uses sensor-based navigation and embedded control techniques to operate independently in indoor environments [3],[4]. Unlike conventional delivery methods, autonomous robots minimize human intervention and enhance safety [9]. However, existing systems are often expensive and complex [11]. Therefore, this work aims to design a simple, cost-effective, and efficient delivery robot using basic electronic components and embedded programming.

2. LITERATURE SURVEY

Recent research in autonomous robotics highlights significant developments in navigation, sensing, and control mechanisms [3],[8],[9]. Arduino-based robotic systems have gained popularity due to their affordability, flexibility, and ease of implementation [4],[10].

Several approaches have been proposed for autonomous navigation, including:

- Line-following robots using infrared sensors
- RFID-based navigation systems
- Obstacle avoidance using ultrasonic sensors

Among these, ultrasonic sensor-based navigation is widely preferred due to its simplicity and reliability [4],[10]. These sensors enable real-time distance measurement, allowing robots to detect obstacles and respond accordingly.

Advanced systems incorporate technologies such as:

- Artificial Intelligence (AI)
- Machine Learning (ML)
- Internet of Things (IoT)

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However, such systems increase complexity and cost. Therefore, this project focuses on a simplified approach that demonstrates core autonomous functionalities while maintaining affordability and scalability.

3. BLOCK DIAGRAM

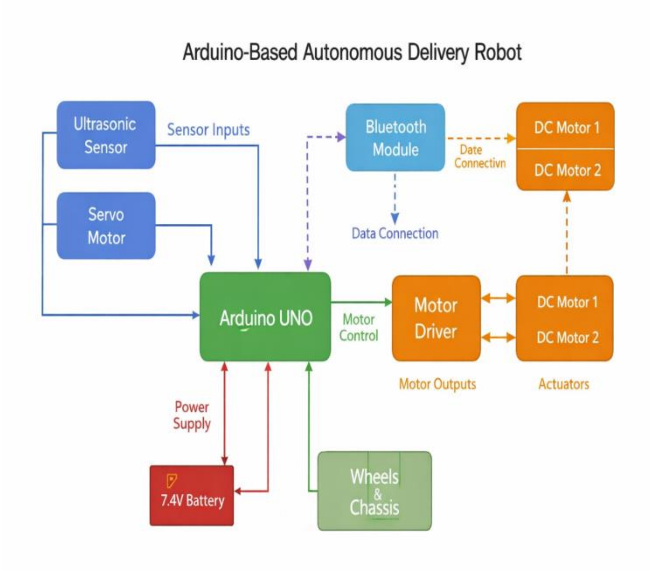

Fig-2: Block Diagram

3.1 Block Diagram Explanation

The block diagram of the Arduino-based autonomous delivery robot illustrates the interaction between sensing, processing, control, and actuation units for achieving autonomous navigation.

The ultrasonic sensor serves as the primary sensing component, continuously detecting obstacles by measuring the distance to nearby objects. The servo motor is used to rotate the ultrasonic sensor, enabling environmental scanning over a wider range. These sensor inputs are fed into the Arduino Uno microcontroller, which acts as the central processing unit of the system [3], [4].

The Arduino processes the incoming data and makes real-time decisions based on predefined control logic. Depending on the detected obstacle conditions, it generates appropriate control signals. These signals are sent to the motor driver (L293D), which acts as an interface between the low-power control unit and high-power motors.

The motor driver controls the DC motors, which function as actuators responsible for the movement of the robot. The motors drive the wheels and chassis, enabling forward, backward, and turning motions.

Additionally, a Bluetooth module is incorporated to allow optional wireless communication for manual control or monitoring. It exchanges data with the Arduino, providing flexibility in operation.

The entire system is powered by a 7.4V battery, which supplies energy to the Arduino, motor driver, and other components. The system operates in a closed-loop manner, where continuous feedback from sensors allows the robot to adjust its movement dynamically for effective obstacle avoidance and navigation.

4. SYSTEM HARDWARE DESIGN AND ARCHITECTURE

4.1 System Overview

Arduino-based autonomous delivery robot capable of performing navigation and obstacle avoidance in indoor environments. It integrates sensing, processing, control, and actuation units to achieve autonomous operation. The ultrasonic sensor is used to detect obstacles in real time, while the Arduino Uno microcontroller processes the acquired data and makes navigation decisions [3], [4].

Based on the processed sensor information, control signals are generated and transmitted to the motor driver, which regulates the motion of the DC motors. This enables the robot to move forward, stop, or change direction as required. The system operates on a closed-loop control mechanism, ensuring continuous monitoring of the environment and dynamic adjustment of movement for safe and efficient navigation.

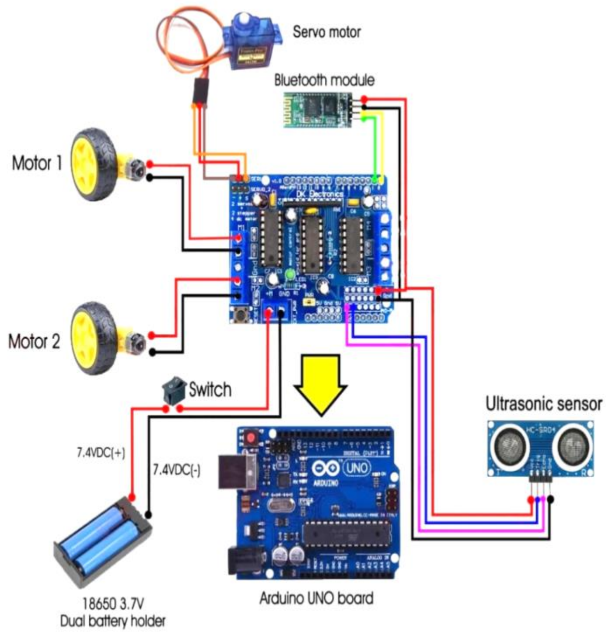

Fig-3: Architecture of the Arduino-based autonomous delivery robot

The overall design emphasizes simplicity, low cost, and ease of implementation, making it suitable for educational purposes as well as small-scale autonomous delivery applications.

4.2 Hardware Components

The key hardware components used in the system include:

- Arduino Uno: Acts as the central controller
- HC-SR04 Ultrasonic Sensor: Measures distance to obstacles
- L293D Motor Driver: Controls motor direction and speed
- DC Gear Motors: Provide movement
- Servo Motor: Enables directional scanning
- HC-05 Bluetooth Module: Allows optional manual control

These components work together to ensure smooth and efficient operation of the robot.

4.3 Software Development

The system is programmed using the Arduino IDE, which supports C/C++ based programming. The control algorithm includes:

- Distance measurement using ultrasonic sensor
- Decision-making based on threshold values
- Motor control for navigation

The robot follows simple logic:

- Move forward if path is clear
- Stop if obstacle detected
- Turn left or right to avoid collision

5. WORKING PRINCIPLE

The robot operates on a continuous sensing and response mechanism. The ultrasonic sensor omits sound waves and measures the time taken for the reflected signal to return, enabling distance estimation of nearby obstacles [4]. The Arduino Uno microcontroller processes this sensor data in real time and determines the appropriate action [3].

When no obstacle is detected within a predefined threshold distance, the robot moves forward. If an obstacle is detected, the system halts and executes an alternative path strategy by turning left or right to avoid collision. This decision-making process is repeated continuously, allowing the robot to navigate autonomously in indoor environments [10], [17].

The motor driver receives control signals from the microcontroller and accordingly regulates the speed and direction of the DC motors, enabling smooth and precise movement. This closed-loop operation ensures reliable obstacle avoidance and efficient navigation.

5.1. Applications

The proposed Arduino-based autonomous delivery robot has a wide range of applications across various domains.

In the healthcare sector, it can be utilized for the delivery of medicines, medical supplies, and laboratory samples, thereby reducing human effort and minimizing the risk of contamination **[10].**

In industrial environments, the system can assist in material handling, inventory transportation, and intra-logistics operations, improving efficiency and reducing manual workload **[9].**

In the hospitality sector, the robot can be employed for food serving and room service in restaurants and hotels, enhancing customer experience and automation **[1].**

In offices and educational institutions, it can be used for document delivery and campus logistics. The system also serves as an effective educational tool for learning robotics, embedded systems, and automation concepts **[3].**

Furthermore, the robot can be integrated into smart environments and Internet of Things (IoT)-based systems to enable intelligent and automated delivery solutions **[8].**

5.2. Advantages and Limitations

Advantages

- Low-cost implementation
- Reduced human effort
- Improved efficiency and accuracy
- Safe navigation using obstacle detection
- Easy to design and maintain

Limitations

- Limited processing capability of Arduino
- Basic navigation (no mapping or localization)
- Limited battery life
- Suitable only for lightweight loads

6. RESULTS AND DISCUSSION

6.1 Experimental Results

The Arduino-based autonomous delivery robot was successfully designed, implemented, and tested under controlled indoor conditions. The performance of the system was evaluated based on key parameters such as obstacle detection accuracy, navigation efficiency, response time, and operational stability. The ultrasonic sensor demonstrated reliable obstacle detection within a range of **2 cm to 100 cm**, with optimal performance observed between **5 cm and 50 cm**. The robot was able to detect obstacles and respond appropriately by stopping or changing direction. The navigation system showed satisfactory performance in semi-structured environments. The robot successfully avoided obstacles in most test cases and maintained stable movement. The average response time for obstacle detection and action was observed to be less than **200 ms**, which is sufficient for real-time operation. The motor driver module ensured smooth and controlled motion of the robot. Directional movements such as forward, backward, left, and right turns were executed accurately. The integration of the servo motor for sensor scanning improved obstacle detection coverage, allowing better decision-making.

6.2 Performance Analysis

The system performance can be summarized as follows:

Table-1: Relation between parameters & their observed values.

Parameter	Observation
Detection Range	2 cm – 100 cm
Response Time	~150–200 ms
Navigation Accuracy	High in simple environments
Power Consumption	Moderate
Load Capacity	Lightweight objects only

The robot performed efficiently in environments with minimal complexity. However, performance slightly degraded in cluttered or dynamic environments due to limited sensing capability. The results indicate that the proposed system is effective for basic autonomous delivery applications. The use of an ultrasonic sensor provides a simple and low-cost solution for obstacle detection.

However, it has limitations when dealing with:

- Transparent or soft objects
- Irregular surfaces
- Complex environments
- The Arduino microcontroller offers ease of implementation but restricts computational capabilities. As a result, the system is limited to basic navigation and cannot perform advanced tasks such as mapping or path optimization.
- The integration of a servo motor for scanning enhances environmental awareness compared to fixed sensors. However, the system still lacks full 360° perception, which is essential for advanced navigation.
- Despite these limitations, the system proves to be:
- Cost-effective
- Easy to implement
- Suitable for educational and small-scale applications

6.3 Comparative Insight

- Compared to advanced autonomous robots:
- This system is simpler and cheaper
- It lacks AI-based decision-making and SLAM
- It is ideal for prototype and learning purposes

The experimental results validate that the Arduino-based autonomous delivery robot achieves its intended objectives. While it has certain limitations, it serves as a strong foundation for developing more advanced autonomous systems.

7. CONCLUSION

This paper presents the design and development of an Arduino-based autonomous delivery robot capable of performing delivery tasks efficiently. The system successfully integrates sensing, processing, and actuation units to achieve autonomous navigation. The project demonstrates that low-cost embedded systems can be effectively used for automation applications. Although the robot has certain limitations, it provides a strong foundation for future advancements. Overall, the system meets its objectives and highlights the potential of autonomous robots in improving efficiency and reducing manual workload in various sectors.

REFERENCE

[1] Yanmida, D. Z., Alim, S. A., & Imam, A. S. (2020). Design and implementation of an autonomous delivery robot for restaurant services. *ELEKTRIKA-Journal of Electrical Engineering*, *19*(3), 66-69.

[2] Ahmmed, F., Rahman, A., Islam, A., Alaly, A., Mehnaj, S., Saha, P., & Hossain, T. (2024). Arduino-controlled multi-function robot with Bluetooth and nRF24L01+ communication. *International Journal of Robotics and Control Systems*, *4*(3), 1353-1381.

[3] Oltean, S. E. (2019). Mobile robot platform with arduino uno and raspberry pi for autonomous navigation. *Procedia Manufacturing*, *32*, 572-577.

[4] Darji, K., Qureshi, A. R., Bhosale, V., Dubey, H., & Salvi, M. (2021). Autonomous car using ultrasonic sensor, Arduino controller.

[5] Al-Metari, M., Aziz, N. A. H., & Sadeq, L. (2021). Path Planning with Obstacle Avoidance.

[6] Akanda, M. R. K., Lazo, J., Carter, Q., & Roberts, H. (2024). Delivery Line Tracking Robot. *arXiv preprint arXiv:2401.07947*.

[7] Musitmani, S., & Chauhan, N. (2023, July). A GitHub actions workflow for continuous delivery of software on Arduino-based IoT devices. In *8th International Conference on Computing in Engineering and Technology (ICCET 2023)* (Vol. 2023, pp. 356-363). IET.

[8] Jain, R. K. (2022). Experimental performance of mobile robotic system by involving IoT technique. *J. Sci. Ind. Res*, *81*(6), 573-583.

[9] I., Jaradat, M. A. K., & Abdel-Hafez, M. F. (2020). Low-cost reduced navigation system for mobile robot in indoor/outdoor environments. *IEEE Access*, *8*, 25014-25026.

[10] *Samani, H., & Zhu, R. (2016). Robotic automated external defibrillator ambulance for emergency medical service in smart cities. IEEE Access, 4, 268-283.*

[11] Solomon, O. O., Musa, D. I., Hassan, N. A., Emmanuel, O., & Precious, K. (2024). Development of a Prototype Solar-Powered Autonomous Vehicle Prototype with Object Detection and Avoidance System using Raspberry-PI. *Jurnal Kejuruteraan*, *36*(4), 1365-1372.