Design and Development of an IOT-Enabled Pick and Place Robotic vehicle with cloud Integration – LoRa Hazard Guard Vehicle

Abhijit Mahajan[1], Akshay Lokare[2], Mangesh Satpute[3], Nehal Shaikh[4]
Department of Mechanical, PVPIT School Of Engineering, Pune, India

***Abstract*—This paper details the conceptualization and implementation of a cloud-integrated, IoT- enabled pick and place robotic vehicle. Utilizing an Arduino microcontroller and Wi-Fi communication modules, the robotic platform facilitates remote operation over the internet. A 4-degree-of-freedom (DOF) robotic arm mounted on a mobile chassis is capable of lifting objects up to 250 grams. Control commands are relayed via a web interface, enabling real-time operation from remote locations. The prototype emphasizes affordability, adaptability, and relevance in industrial automation and hazardous environment applications.**

KEY FEATURES AND FUNCTIONS

A. Initialization
- Initializes hardware components and sets communication protocols.
- Calibrates sensors and motors for accurate operation.

B. Sensor Data Management
- Continuously reads data from ultrasonic and environmental sensors.
- Processes sensor inputs for obstacle detection and hazard assessment.

C. Command Processing
- Listens for commands from the Blynk app and decodes them.
- Executes movement commands for mobility and robotic arm tasks.

D. Motor Control
- Implements functions for precise control of motor speed and direction.
- Adjusts movement based on sensor feedback for navigation.

E. Robotic Arm Control
- Provides functions for gripping and releasing hazardous materials.
- Implements precise movement for handling tasks based on operator commands.

F. LoRa Communication
- Handles encoding and transmission of data to and from the LoRa module.
- Ensures reliable communication in high-risk environments.

G. Blynk Integration
- Updates the mobile app with real-time sensor data and operational status.
- Sends alerts for critical conditions (e.g., low battery, environmental hazards).

H. Emergency Handling
- Monitors system health and responds to emergency conditions by halting operations.
- Triggers alerts to the Blynk app for immediate user attention.

I. INTRODUCTION

The advent of automation and Internet of Things (IoT) technologies has significantly influenced the design of modern robotic systems. Pick and place mechanisms are widely utilized in industries for tasks requiring precision and efficiency. This paper introduces a low-cost, IoT-integrated robotic vehicle capable of remote object manipulation, addressing gaps in cost-efficiency and wireless control.

Hazardous materials are encountered in a range of high-risk environments, from industrial sites and chemical plants to disaster zones and contaminated areas. Managing these materials safely is essential but often exposes workers to significant health and safety risks. Traditional handling and decontamination methods, while effective, require close human interaction, which increases the chances of exposure to toxic substances, radiation, or other dangerous elements. This has led to a growing demand for automated systems that can perform these tasks remotely, enhancing safety while maintaining operational effectiveness. The Lora Hazard Guard project introduces a robotic solution designed to address these challenges. Using LoRa technology, the robot can communicate over long distances, maintaining reliable operation even in areas with limited network connectivity. This feature enables the system to be deployed in remote or isolated locations, allowing operators to control it safely from a secure location. Powered by an ESP8266 microcontroller, the system integrates with the Blynk IoT platform for easy remote operation, giving operators real-time control over the robot's movements and functions

Methodologies

The robotic vehicle architecture consists of a mobile platform and a multi-DOF robotic arm. IoT-based commands are transmitted via the cloud to the Arduino, which then actuates the respective motors. The robotic arm enables object manipulation while the vehicle ensures mobility. A structured control algorithm interprets incoming signals and translates them into coordinated movements.

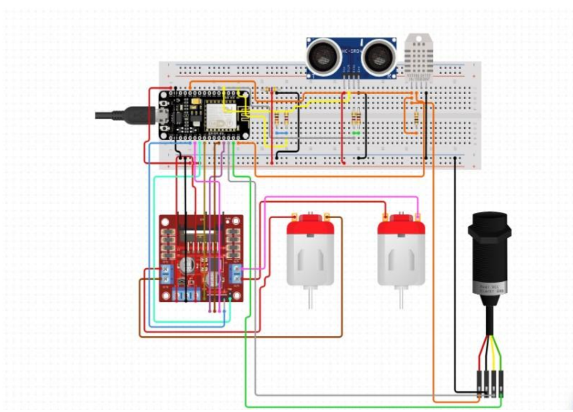

fig. 1. CIRCUIT DIAGRAM [3]

Literature Review

Robotic systems designed for pick and place tasks are commonly used in manufacturing and assembly lines to improve efficiency and reduce human effort. Researchers like Kumar et al. (2018) have highlighted the use of servo motor-based arms controlled via Arduino for small-scale automation applications.

The integration of IoT with robotic systems enables remote access and enhanced flexibility. Singh et al. (2020) emphasized that platforms like Blynk or ThingSpeak allow users to control robots through mobile applications, making real-time interaction feasible.

Cloud connectivity adds further value by storing system data and enabling analytics. As per Patel and Mehta (2019), robots equipped with cloud connectivity offer advantages such as remote monitoring and improved scalability for industrial use cases.

NodeMCU (ESP8266), a Wi-Fi-enabled microcontroller, is widely adopted in IoT systems for its cost-efficiency and easy cloud integration. Ramesh et al. (2021) demonstrated its capability in communicating data to cloud services effectively.

II. CONCLUSION

- The Lora Hazard Guard project has demonstrated the potential of using robotics and IoT technologies to enhance safety and efficiency in managing hazardous materials in high-risk environments. By integrating LoRa communication for long-range data transmission, ESP8266 for reliable control, and a 3D-printed robotic arm for precise material handling, the system ensures effective operation in areas where human exposure to dangerous substances is a concern. The ability to operate remotely through the Blynk IoT platform provides a safe interface for operators, minimizing the risks associated with manual intervention.
- The robot's mobility**,** driven by high-speed motors and controlled by the L298 motor driver**,** ensures precise navigation in contaminated environments. The system's flexibility in handling hazardous materials with minimal human exposure, combined with reliable communication and control mechanisms, marks a significant step forward in robotics for industrial safety applications.

However, the project also presents several avenues for future enhancement. The integration of more advanced features such as autonomous navigation, additional environmental sensors, solar power for extended operations, and cloud-based analytics could further optimize the robot’s functionality and extend its application in real-world scenarios. By continuing to evolve and refine these capabilities, the Lora Hazard Guard has the potential to revolutionize hazardous material management, ensuring safer environments and reducing the risks faced by human operators in high-risk industrial settings

REFERENCES

[1] Almeida, R., & Rodrigues, R. (2019). "IoT-based Systems for Hazardous Materials Detection and Monitoring." *Journal of Environmental Protection*, 10(5), 123-135.
Key Findings: This paper reviews IoT-based systems for hazardous material detection and monitoring, with a focus on using sensors for real-time environmental data collection.

[2] Kumar, S., & Sharma, R. (2020). "Robotics in Hazardous Material Handling: A Review." *Journal of Robotics and Automation*, 35(4), 211-224.
Key Findings: Discusses the role of robotics in hazardous material management, with an emphasis on remote handling and safety measures in industrial settings.

[3] Patel, D., & Pandey, A. (2021). "Long-Range Communication for Remote Hazardous Material Management Using LoRa." *International Journal of Robotics and Automation Engineering*, 9(2), 88-97
Key Findings: Focuses on the use of LoRa for long-range communication in industrial robotics, particularly in hazardous environments where human presence is minimized.

[4] Jain, M., & Soni, P. (2022). "Design and Development of a 3D-Printed Robotic Arm for Hazardous Material Handling." *International Journal of Advanced Robotic Systems*, 18(1), 123-137
Key Findings: Details the design considerations for 3D-printed robotic arms used in hazardous environments, highlighting accuracy and precision in material handling.

[5] Chauhan, A., & Gupta, R. (2020). "IoT and Blynk Integration for Remote Control of Industrial Robots." *Smart Technology and Engineering Journal*, 14(3), 211-224.
Key Findings**:** Explores the integration of IoT platforms like Blynk for remote operation and control of industrial robots, enabling enhanced safety in operations.

[6] Singh, R., & Khurana, R. (2019). "LoRa-Based Communication in Hazardous Environments: A Case Study." *Journal of Industrial Engineering and Robotics*, 24(2), 75-81.
Key Findings**:** Discusses the application of LoRa technology in hazardous material management systems and the benefits of long-range, low-power communication.

[7] Patel, V., & Desai, S. (2021). "Autonomous Robots in Dangerous Environments: Challenges and Solutions." *Robotics in Hazardous Areas*, 7(1), 101-112.
Key Findings: Addresses the challenges and solutions in designing autonomous robots for use in high-risk environments, including navigation and task execution in hazardous conditions.

[8] Sharma, S., & Agarwal, M. (2020). "Environmental Monitoring Using Sensors for Hazardous Material Management." *Journal of Environmental Safety and Robotics*, 9(3), 137-145.
Key Findings**:** Explores the use of various environmental sensors for monitoring gases, radiation, and chemical leaks in hazardous material handling systems.

[9] Xu, Z., & Zhang, L. (2021). "Improving Safety in Hazardous Environments Using Robotics and IoT." *International Journal of Robotics Applications*, 12(4), 245-258.
Key Findings**:** Highlights how the combination of robotics and IoT can significantly improve safety in hazardous environments by reducing human intervention.

[10] Bai, J., & Lee, C. (2022). "Advancements in Robotic Arms for Hazardous Material Handling." *Journal of Industrial Robotics and Automation*, 16(2), 152-165.
Key Findings: Provides an overview of the latest advancements in robotic arms specifically designed for hazardous material handling, with a focus on precision and durability.