

# Gesture Controlled Logistics and Hazardous Material Handling Robot

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**Abstract**— This paper presents the design and implementation of a gesture-controlled robot for logistics and hazardous material handling, with primary applications in defence scenarios. The system is powered by hand gestures using flex sensors for hand/finger movements and an MPU6050 accelerometer to control the robot's direction. The robot features long-range communication via LoRa wireless modules, enabling operation over distances of up to 2 km. A first-person view (FPV) camera is mounted on the robot for real-time video feedback. The system is controlled by an ESP32 microcontroller, which integrates all the sensors and communication modules. This approach offers a safe and efficient solution for handling hazardous materials in defence zones, providing lightweight and portable capabilities for critical operations.

**Keywords**— Gesture control, defence, logistics, hazardous material handling, LoRa, FPV camera, ESP32, flex sensors.

## I. INTRODUCTION

The handling of hazardous materials in defence environments, such as military zones, combat areas, or disaster recovery operations, poses significant challenges. Traditional methods of handling these materials often put personnel at risk. To mitigate this, robotic systems offer an ideal solution by providing a safe and efficient means of performing dangerous tasks remotely. This paper discusses the design and development of a gesture-controlled robot intended for logistics and hazardous material handling, specifically for defence applications. The proposed system utilizes flex sensors and an MPU6050 accelerometer to capture hand gestures, allowing the operator to control the robot's movements and hand gestures wirelessly. The robot communicates over long distances using LoRa wireless modules, enabling operation in areas where traditional communication methods may be unavailable. An FPV camera is integrated to provide the

operator with real-time visual feedback, enhancing situational awareness during operations.

The ESP32 microcontroller acts as the central processing unit, managing the robot's sensors, movement, and communication.

This project provides an innovative solution for safe, efficient, and long-range handling of hazardous materials in defence applications, improving operational effectiveness while reducing risks to human operators.

## II. SYSTEM OVERVIEW / METHODOLOGY

The system is designed to enable gesture-controlled movement and material handling through a combination of sensors, wireless communication, and a microcontroller. The robot operates wirelessly and responds to hand gestures from the operator, providing an effective solution for handling hazardous materials, especially in defence environments.

- **System Components:**

1. **Gesture Control:** The primary mode of interaction with the robot is through hand gestures. The flex sensors placed on the operator's hand are used to detect finger movements, which are mapped to the robot's hand or arm movements. Additionally, the MPU6050 accelerometer detects the tilt of the operator's hand, which is translated into directional movement commands for the robot.

2. **Wireless Communication:** The system uses LoRa wireless modules to facilitate communication between the operator and the robot. The LoRa modules provide long-range connectivity, ensuring the robot can operate

up to distances of 1.5–2 km, which is essential for use in defence and hazardous environments.

3. Control System: The core of the robot is the ESP32 microcontroller, which acts as the central processing unit (CPU). It integrates the sensor data from the flex sensors and accelerometer and processes the movement commands. The ESP32 also handles wireless communication via LoRa modules, enabling remote control of the robot.

4. Robot Movement: The robot is powered by four DC motors two front motors (150 RPM) for high torque required in material handling and two rear motors (500 RPM) for rapid movement. The motors are controlled by the ESP32 microcontroller based on the operator’s gesture inputs.

5. Camera Feedback: A FPV camera is mounted on the robot to provide real-time video feedback to the operator. This allows the operator to monitor the robot's surroundings and its environment, ensuring the safe and efficient handling of hazardous materials.

• Methodology

The robot follows a simple, but effective control structure. The operator wears a glove equipped with flex sensors to detect finger gestures and an MPU6050 accelerometer to measure the tilt of the hand. The flex sensor data is used to control the robot's hands/fingers for handling tasks, while the accelerometer data is used to direct the robot’s movement in space.

The system's central controller, the ESP32 microcontroller, processes the sensor data and issues commands to the motors and wireless communication modules. Communication between the operator and robot is done through LoRa modules, which ensure long-range data transfer and allow for remote control over distances of up to 2 km.

III. HARDWARE IMPLEMENTATION

- Flex Sensors: These sensors are used to capture the operator's hand gestures, allowing control of the robot's hand/finger movements.
- MPU6050 Accelerometer: This component is used to detect the tilt of the operator's hand to control the robot’s directional movement.

- ESP32 Microcontroller: The central processing unit that integrates all the hardware components, processes the sensor data, and facilitates wireless communication.
- Motors: The robot is equipped with four motors: two front motors (150 RPM) for torque and two rear motors (500 RPM) for speed.
- LoRa Wireless Modules: These modules provide long-range communication (up to 2 km) between the robot and the operator.
- FPV Camera: A first-person view camera is mounted on the robot to transmit real-time video to the operator for enhanced situational awareness.

IV. SOFTWARE IMPLEMENTATION

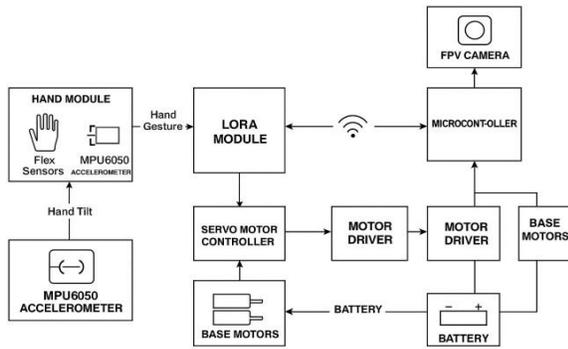
The software for the robot is developed using the Arduino IDE to program the ESP32 microcontroller. The code integrates libraries for flex sensors, the MPU6050 accelerometer, and LoRa communication. The software is responsible for interpreting the gesture data from the flex sensors, processing the accelerometer data for directional control, and sending commands to the motors and camera.

Additionally, the software ensures wireless communication is stable, and the real-time video feed is transmitted to the operator via the FPV camera.

V. TECHNICAL SPECIFICATION

Feature	Details
Control Type	Gesture (Flex + Accelerometer)
Communication Range	1.5–2 km (LoRa Wireless)
Motors	2x 150 RPM (Front) +2x 500 RPM (Rear)
Microcontroller	ESP32
Power Supply	Rechargeable Battery
Camera	FPV Wireless Camera
Structure Material	3D Printed Parts
Operating Time	2-3 Hours

## VI. TECHNICAL SPECIFICATION



## VII. PROPOSED SYSTEM



## VIII. CONCLUSION

This project successfully demonstrates the design and implementation of a gesture-controlled logistics and hazardous material handling robot. The system, based on flex sensors, accelerometer input, and LoRa wireless communication, provides reliable long-range control with real-time visual feedback. Its robust structure, portability, and defense-focused applications make it highly suitable for hazardous environments.

Future improvements can include AI-based autonomous navigation and enhanced load-handling capacity.

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