# Autonomous Hexapod Robot with Environmental Sensing and Navigation

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## ABSTRACT

**In hazardous environments like mines, human safety is of utmost importance. This project presents the design and development of an Autonomous Hexapod Robot equipped with environmental sensing and navigation capabilities. The hexapod structure provides improved stability on uneven terrain, overcoming the limitations of wheeled robots. The system integrates air quality sensor MQ135, temperature and humidity sensor DHT22, GPS module for navigation and a camera module ESP32 CAM to enhance environmental monitoring. The main microcontroller used here is NodeMCU (ESP8266) to process sensor data and control movement, while a mobile application developed through MIT App Inventor enables remote monitoring and navigation. This project aims to improve safety and automation in hazardous environments by reducing human exposure to risks and at the same time ensuring efficient navigation and real-time data collection.**

**Keywords: Hexapod Robot, Environmental Sensing, Real-Time Navigation, Autonomous Robotics, Automation, Remote Monitoring**

## INTRODUCTION

Robots play a significant role in environments such as mines, disaster sites and industrial zones where human presence is hazardous. However, existing robots, such as wheeled robots, struggle on rough terrain and lack integrated environmental monitoring capabilities. A hexapod robot with six legs provides superior mobility over uneven and rocky surfaces, making it well-suited for challenging environments. Equipped with various sensors, the robot can detect harmful gases, measure temperature and humidity, and provide real-time visual feedback to operators. By incorporating autonomous navigation and environmental sensing, the robot, powered by 18 servo motors for precise movement, enhances remote monitoring and minimizes risks for humans in hazardous locations. Additionally, its adaptability allows it to traverse complex landscapes where traditional robots fail, ensuring improved situational awareness. This technology can be instrumental in disaster response, industrial safety and environmental monitoring, making operations more efficient and safer. With further advancements, such robots could be enhanced with AI-driven decision-making, enabling them to autonomously assess threats and take corrective actions in real time.

### Problem Statement

One of the primary challenges faced by robots operating in hazardous environments is limited mobility. Traditional wheeled robots often struggle to move smoothly on rocky, uneven or unstable surfaces, restricting their ability to navigate effectively in disaster zones, mines or industrial sites. Additionally, another significant issue is incompatibility, as integrating multiple sensors into conventional robots can lead to increased weight and reduced efficiency, ultimately affecting their performance. These challenges can be effectively addressed by implementing a hexapod robot equipped with built-in environmental sensors. With six independently controlled legs, the hexapod design provides superior movement control, allowing it to traverse rough terrains with stability and agility. Furthermore, the integration of environmental sensors enables real-time data collection without compromising efficiency, making it an ideal solution for monitoring hazardous locations while reducing risks to human operators.

### Scope and Relevance

A hexapod robot equipped with environmental sensors has a wide range of applications across various fields, enhancing safety, efficiency and data collection in challenging environments. In mining safety, the robot can detect toxic gases and monitor environmental conditions, preventing potential hazards for workers. In disaster response, it plays a crucial role in assisting rescue teams by navigating through earthquake-struck or collapsed buildings, where

human access is difficult or dangerous. For industrial inspection, the robot can be deployed in hazardous zones within chemical plants and factories, reducing human exposure to harmful substances while ensuring efficient monitoring. Beyond Earth, the robot proves valuable in exploration and research, aiding planetary exploration, remote sensing, and deep-sea research by navigating extreme terrains and collecting critical data. Additionally, in agriculture, the hexapod robot can monitor soil quality, temperature, and atmospheric conditions, helping farmers make informed decisions for better crop management and improved yield. Its versatility and adaptability make it a powerful tool for advancing safety, automation, and research in diverse fields.

## Objectives

This project aims to develop an Autonomous Hexapod Robot that can navigate smoothly across rough and uneven terrains while collecting real-time environmental data. The six legs of the robot, powered by 18 servo motors, ensure better stability and adaptability compared to traditional wheeled robots. The hexapod robot is equipped with sensors such as MQ135 to detect harmful gases, DHT22 to measure temperature and humidity, GPS to track its location, and a camera module, ESP32 CAM, to capture live video. A NodeMCU microcontroller processes this information, and a mobile application built using MIT App Inventor allows users to control and monitor the robot remotely. The robot's ability to autonomously navigate using predefined waypoints or manual control enhances its usability in hazardous environments. Its modular design allows for easy upgrades, making it adaptable for different applications, such as disaster response, industrial inspection and scientific exploration. The real-time data collected by the sensors can be transmitted to a central monitoring system, enabling efficient decision-making and situational awareness. Additionally, its compact and lightweight structure ensures energy efficiency, extending operational time in remote or dangerous locations.

## METHODOLOGY

The proposed system is designed to develop an Autonomous Hexapod Robot capable of navigating rough and uneven terrains while simultaneously collecting real-time environmental data. This system integrates mechanical movement, sensor-based monitoring, and wireless communication to enhance autonomous exploration and hazard detection. The robot features a six-legged design powered by 18 servo motors, providing superior mobility compared to traditional wheeled robots. Additionally, it is equipped with sensors to detect harmful gases, monitor temperature and humidity, and capture real-time visual data. The integration of GPS tracking further enables remote location monitoring, making it suitable for applications in disaster response, industrial inspection, and environmental research. The collected data is transmitted to a mobile application, allowing users to monitor conditions and control the robot wirelessly. The system ensures efficient data processing, real-time feedback and user-friendly control, making it a robust solution for hazardous environment monitoring.

## Mechanical Assembly

The mechanical assembly of the hexapod robot involves constructing a stable frame and attaching six legs, each controlled by three MG90 servo motors, totalling 18 servo motors. A servo motor shield is used to manage motor control, ensuring precise movement and coordinated leg articulation. The design ensures proper weight distribution, allowing the robot to traverse rough, rocky, or unstable terrains with stability. The frame material is selected for its lightweight yet durable properties to balance strength and energy efficiency.

## Sensor and Component Integration

To enable real-time environmental monitoring, the robot is equipped with multiple sensors and electronic components:

- MQ135 Gas Sensor: Detects harmful gases such as Methane ($CH_4$), Carbon Dioxide ($CO_2$), Ammonia ($NH_3$), and Benzene ($C_6H_6$), ensuring hazardous conditions are identified.
- DHT22 Temperature and Humidity Sensor: Measures atmospheric conditions, crucial for monitoring environmental parameters.
- GPS Module: Provides real-time location tracking, allowing users to monitor the robot's position remotely.
- ESP32 CAM Module: Captures live video feed, aiding in surveillance and navigation.
- 7.4V Li-ion Battery: Supplies power to all components, ensuring stable and continuous operation.
- NodeMCU Microcontroller: Acts as the central processing unit, handling motor control, sensor data collection, and wireless communication.
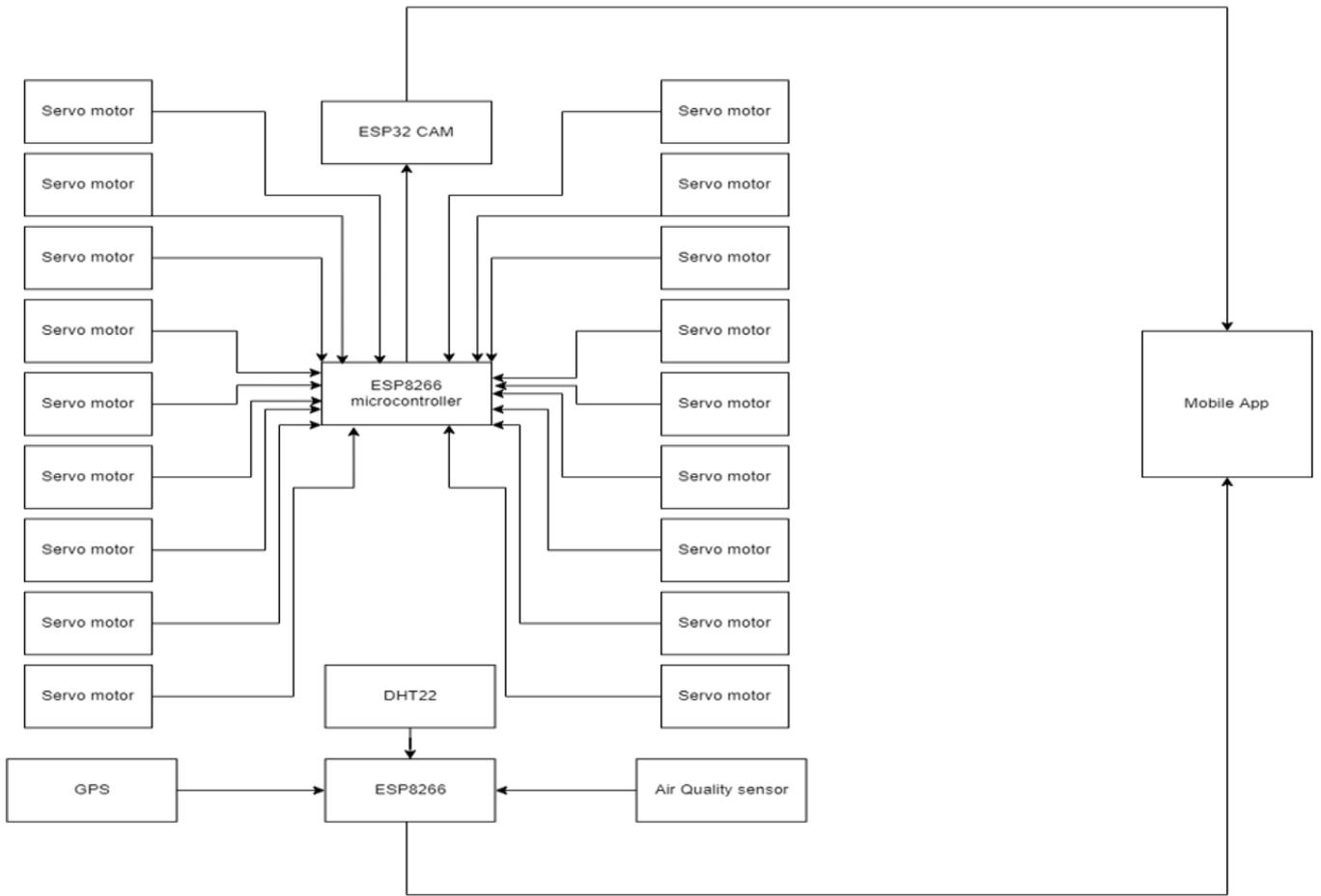
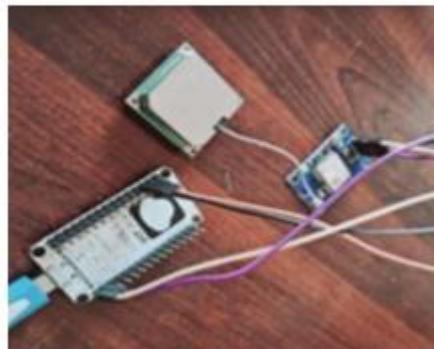**Fig 1 Block Diagram**

**RESULT**



**Fig 2: Sensor Integration**

The developed hexapod robot demonstrates enhanced stability and mobility on uneven terrains, making it suitable for autonomous navigation in challenging environments. The MQ135 sensor effectively detects air quality variations, while the DHT22 sensor provides accurate temperature and humidity measurements. The ESP32 CAM module streams real-time video with minimal delay, ensuring efficient remote monitoring. Additionally, the GPS module enables precise location tracking, enhancing navigation capabilities. The mobile application offers a user-friendly interface for remote control and real-time data visualization, improving accessibility and system efficiency. Overall, the system successfully integrates multi-sensor data acquisition, communication, and remote monitoring, making it a robust solution for environmental sensing and autonomous navigation.

## CONCLUSION

The Autonomous Hexapod Robot effectively integrates advanced mobility and real-time environmental sensing, making it ideal for deployment in hazardous conditions. Its six-legged design ensures superior stability, while leveraging smart navigation and sensor technology enhances safety, efficiency, and automation in environments where human access is limited. The integration of MQ135, DHT22, GPS, and ESP32 CAM enables comprehensive environmental monitoring, allowing the robot to detect air quality variations, track temperature and humidity, provide live video feedback, and maintain accurate location tracking. Additionally, the mobile application facilitates seamless remote control and real-time data visualization, ensuring efficient operation even in challenging terrains. With further improvements, this robot can be integrated into industrial, rescue, and surveillance operations, making it a crucial asset for next-generation autonomous systems. The adaptability of this system also makes it a valuable tool for space exploration, environmental monitoring, and disaster response, where real-time data collection and autonomous movement are critical for mission success.

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