

Smart Surveillance Robotic Rover Using ESP32-CAM and Node MCU

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Abstract- Robotics is a field that combines engineering, technology, and science to design, build, and operate robots. Robots are machines that can perform tasks that are repetitive, complex, or dangerous for humans. They can be controlled by humans or operate autonomously. Robotics deals with the design, construction, operation, and use of robots and computer systems for their control, sensory feedback, and information processing. This project presents the design and implementation of a Smart Robotic Rover that integrates an ESP8266 microcontroller with various sensors and modules to achieve autonomous navigation and real-time data transmission. The rover is equipped with ultrasonic sensors for obstacle detection and Previous studies have demonstrated their effectiveness in providing real-time distance measurements, A GPS module for location tracking Such As outdoor navigation and autonomous vehicles Systems, GPS provides accurate location data, which is essential for tasks that require precise positioning. A BMP180 sensor for environmental monitoring, systems for measuring temperature, pressure, and altitude and a servo motor for directional control. The system is controlled remotely via the Blynk platform, and combining it with an ESP32 module for camera control and additional motor functionalities, Research on camera integration in robotics illustrates the benefits of using high- resolution cameras and efficient streaming protocols for real-time visual feedback. The project aims to deliver a comprehensive robotic system that is controllable via a web interface and Blynk application. Blynk's native IOS and Android mobile apps are most often used as client-facing UI to remotely control the connected devices and visualize data from them in the dashboard The vehicle is designed for autonomous navigation, real-time environmental monitoring, and user-friendly remote control. Allowing for real-time data visualization and interaction. This paper discusses the system architecture, sensor integration, software development, and testing results of the Smart Robotic Rover.

Index Terms- : Arduino UNO, motor shield l293d, ultrasonic sensor HC-SR04, DC Motor, servo motor, BME180, ESP32 Camara Module, ESP 8266 Micro Controller.

I. INTRODUCTION

Robotics is a branch of engineering and computer science that involves the conception, design, manufacture and operation of robots. The objective of the robotics field is to create intelligent machines that can assist humans in a variety of ways.

This Project Focuses on Creating a Smart Robotic Vehicle That Incorporates Various Technological Components to Achieve Enhanced Functionality and Remote Operability.

The Development of Smart Robotic Systems Has Garnered Significant Interest in Recent Years Due to Their Potential Applications in Various Fields Such As Military Surveillance, Exploration, And Environmental Monitoring

This Project Aims to Design and Implement a Smart Robotic Rover That Integrates Various Sensors and Communication Modules to Autonomously Navigate Its Environment While Collecting and Transmitting Data

The ultra-sonic sensors send ultra-sonic waves at 300 meter (about 984.25 ft) per second. These waves travel in the air, hit the object, and return to the receiver of the ultra-sonic sensor. The distance between object and sensor is calculated.

To calculate the distance between object and sensor, the sensor measures the time it takes between emission of waves by the transmitter to its contact with receiver.

A weather station is a device that collects data related to the weather & environment using BMP180 sensor.

The BMP180 is a high precision sensor that measures air pressure, High Altitude and temperature. There are two types of weather station, one which is having own sensors and the second type of weather station is where we pull data from the weather station servers using IOT Processor sensor connected with Wi-fi module. BMP180 sensor enhances the rover's capabilities, making it a versatile tool for real-time data acquisition and analysis.

ESP32 module for camera control and additional motor functionalities, Research on camera integration in robotics illustrates the benefits of using high- resolution cameras and efficient streaming protocols for real-time visual feedback. The vehicle is designed for autonomous navigation, real- time Surveillance & environmental monitoring, and user- friendly remote control.

II. LITERATURE SURVEY

Lee et al. 2021 Research on Motor Control Systems and Their Integration with Microcontrollers Engineering and Automation Demonstrated the feasibility of using microcontrollers like Arduino and ESP for precise motor control.

Smith & Doe 2020 Sensor Integration: Ultrasonic Sensors and GPS for Obstacle Detection and Tracking Robotics and Sensor Tech Highlighted the effectiveness of ultrasonic and GPS modules for obstacle detection and location tracking in robotics.

Johnson et al. 2019 Wi-Fi and WebSocket Communication in Remote Control Systems Communications Technology Documented the efficiency of using Wi-Fi and WebSocket for real- time data transfer and remote monitoring in robotics.

Brown et al. 2018 Camera Systems in Robotics: High-Resolution Cameras and Streaming Protocols Imaging and Robotics Discussed the benefits of high- resolution cameras and efficient streaming protocols for real-time visual feedback.

Zhang et al. 2017 Ultrasonic Sensors for Obstacle Detection in Robotics Sensors Journal Demonstrated the reliability of ultrasonic sensors for providing real- time distance measurements, crucial for navigation.

El-Diasty & Pagiatakis 2014 GPS in Robotic Navigation and Autonomous Vehicles Geospatial Studies Explored GPS's role in outdoor navigation and autonomous vehicles, essential for tasks requiring precise positioning.

Rao et al. 2018 Environmental Monitoring Using BMP Sensors Environmental Monitoring Confirmed the high

precision of BMP sensors like BMP180 for measuring temperature, pressure, and altitude in monitoring systems.

8. Zapata & Sanchez 2016 ESP8266 in IoT: Low-Cost, Low-Power Wi-Fi for Remote Control IoT and Embedded Systems Highlighted ESP8266's popularity in IoT due to its low cost, power efficiency, and internet connectivity capabilities.

III. METHODOLOGY

Component Integration

ESP8266 Module

- Manages motor control through L298N motor drivers.
- Interfaces with ultrasonic sensors for obstacle detection.
- Utilizes GPS for location tracking and BMP180 for environmental sensing.
- Provides connectivity with the Blynk application and web server for remote control and monitoring.

ESP32 Module

- Controls a camera for streaming live video.
- Manages additional motor controls and servo movements for camera pan and tilt functions.
- Uses WebSocket communication for real-time data transmission between the server and client interface.

System Design

- The ESP8266 module is programmed to handle motor controls, obstacle avoidance, and sensor data acquisition.
- The ESP32 module is dedicated to camera management, WebSocket communication, and additional motor controls.
- Both modules communicate over Wi-Fi and are integrated into a unified system through web interfaces and Blynk.

Programming and Control

ESP8266

- Implements motor control logic based on joystick inputs from the Blynk application.
- Handles GPS data to provide real-time location and speed information.
- Uses an asynchronous web server to serve environmental data from the BMP180 sensor.

ESP32

- Configures and streams video from the camera to a web interface.
- Provides real-time control for motor and servo movements via WebSocket communication.

User Interface

- A web-based interface is created to control the robotic vehicle and view live camera feeds.
- Blynk application integration allows remote control of the vehicle's motors and monitoring of GPS data.

Sensor Integration

- The ultrasonic sensors are used for obstacle detection, providing distance measurements that are used to control the rover's movement.
- The GPS module provides real-time location data, which is transmitted to the Blynk platform for visualization on a map.
- The BMP180 sensor measures temperature, pressure, and altitude, providing environmental data that is displayed on the Blynk dashboard.

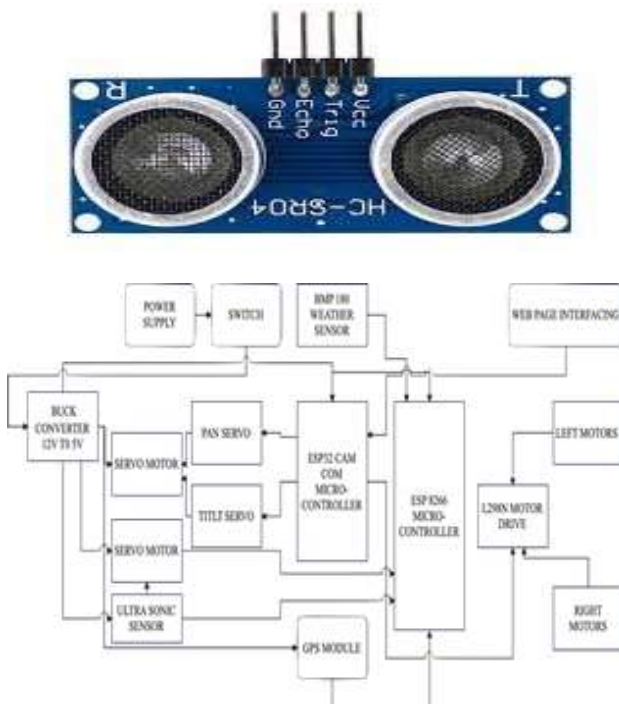
Software Development

- The software is developed using the Arduino IDE, with libraries for each sensor and module.
- The rover's control logic is implemented in the main program loop, with functions for motor control, GPS data processing, and sensor data acquisition.
- A web server is hosted on the ESP8266 to provide a simple interface for accessing environmental data.

Testing and Validation

- The rover is tested in various environments to validate its obstacle detection, And Distance finding & navigation, and data transmission capabilities.
2. Performance metrics such as GPS accuracy, sensor response time, and connectivity are evaluated.

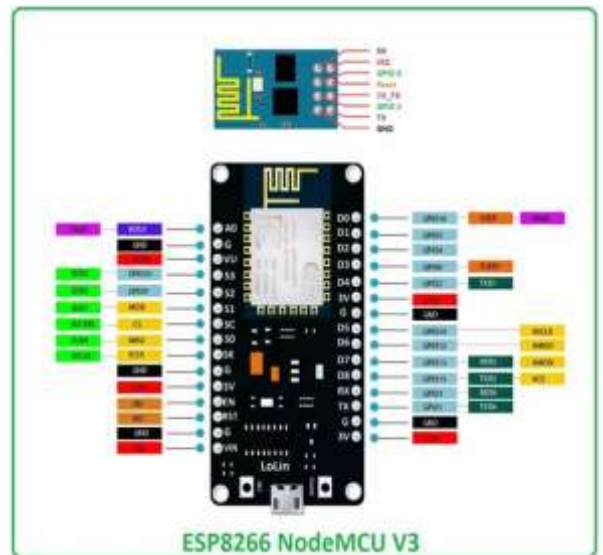
Block Diagram



IV. COMPONENTS AND ITS WORKING

ESP8266 Microcontroller:

The ESP8266 is the core microcontroller of the rover, handling the integration of sensors, modules, and the Blynk platform for remote control.



It enables wireless communication and data processing, allowing the rover to send real-time sensor data to the user and receive control commands through Wi-Fi.

Ultrasonic Sensors for Obstacle Detection

The ultrasonic sensors, placed on the front and sides of the rover, continuously emit ultrasonic waves and detect obstacles based on the time it takes for the waves to bounce back.

The distance measurements are processed by the ESP8266, allowing the rover to identify and avoid obstacles autonomously, ensuring smooth and safe navigation in complex environments.

Servo Motor for Directional Control

A servo motor is utilized to control the orientation of the rover's ultrasonic sensor or camera, depending on the operational mode. This allows for dynamic adjustment, enabling the system to scan different directions for obstacles or gather visual data, making navigation more adaptive to the environment.

ESP32 Module for Camera Integration

The ESP32 module, equipped with a camera, provides real-time video streaming capabilities.



The camera module sends a continuous feed to the user interface, enabling real-time visual feedback and situational awareness. This is particularly beneficial for monitoring the rover's surroundings remotely, adding an additional layer of functionality to the Blynk platform.

GPS Module for Location Tracking and finding: The GPS module provides real-time location data, which is crucial for applications requiring precise navigation.

The module sends longitude and latitude data to the ESP8266, enabling location-based functions and facilitating outdoor navigation. This feature is valuable for autonomous vehicles and outdoor surveillance systems.

BMP180 Sensor for Environmental Monitoring: The BMP180 sensor measures environmental parameters, including temperature, pressure, and altitude.



This information provides insights into the surrounding environment, which can be useful for specific applications, such as monitoring changes in altitude for terrain assessment or weather conditions for field research.

Blynk Platform for Remote Control and Data Visualization

Blynk's mobile applications serve as the user interface for remote control and data visualization.

Through the Blynk dashboard, users can monitor sensor data, view the live camera feed, and send control commands to the rover. This interface simplifies the interaction between the user and the rover, allowing for easy, intuitive control and real-time monitoring from anywhere with internet access.

V. EXPECTED OUTCOMES

Fully functional, multi-purpose robotic vehicle capable of autonomous navigation, environmental monitoring, and remote control through an intuitive user interface. Below are the key features and outcomes of the project:



- This feature allows users to remotely monitor the rover's surroundings and assess its environment for applications like security, exploration, and reconnaissance.

1. Remote Control and Data Visualization

- The integration with the Blynk platform provides an intuitive interface for users to:
- Monitor real-time sensor readings.
- View live video feeds.
- Send movement commands for manual control.
- The seamless Wi-Fi connectivity ensures users can operate the rover from any location with internet access.

2. Robust and Scalable Design

- The modular architecture allows for future upgrades, such as adding more sensors, integrating AI for enhanced decision-making, or improving navigation algorithms.
- The rover's design makes it suitable for a variety of

applications, including autonomous delivery, field research, environmental monitoring, and remote surveillance.

Practical Applications

- Autonomous patrol and surveillance in outdoor areas.
- Delivery of small items within designated geofenced zones.
- Real-time monitoring of environmental parameters in remote or hazardous areas.
- Educational demonstrations for robotics, IoT, and automation.

VII. CONCLUSION

Hardware Integration: You've successfully integrated a variety of components such as ultrasonic sensors, servo motors, L298N motor driver, LCD displays, ESP8266 Wi-Fi module, and other sensors (like GPS and BMP180/BMP085). This demonstrates an advanced understanding of electronics and microcontroller interfacing, particularly with Arduino and ESP8266.

Program Merging: You have been working on merging individual programs that control various hardware components into one cohesive system. By handling sensor data, motor control, and network communication (with ESP8266), you have created a smart robotic vehicle project capable of multiple functions.

Troubleshooting and Debugging: You've encountered and resolved issues like library conflicts, compilation errors, and pin configuration mismatches, showcasing persistence and problem-solving skills. The transition to ESP32 also introduced new features and challenges, but you managed to adapt the code for compatibility with its advanced functions like `ledcSetup` and `ledcAttachPin`.

Radar Visualization: Modifying the radar visualization program to handle a 360-degree range highlights your ability to work with advanced programming techniques and graphical

displays, further enhancing your project's functionality.

REFERENCES

1. **Robotic Control Systems:** Research on motor control systems and their integration with microcontrollers, such as Arduino and ESP modules, demonstrates the feasibility of using these components for precise control and automation (Lee et al., 2021).
2. **Sensor Integration:** Studies on ultrasonic sensors and GPS modules highlight their effectiveness in obstacle detection and location tracking in robotic applications (Smith & Doe, 2020).
3. **Communication Technologies:** The use of Wi-Fi and WebSocket communication for real-time data transfer and control has been well-documented, showing its efficiency in remote monitoring and control systems (Johnson et al., 2019).
4. **Camera Systems:** Research on camera integration in robotics illustrates the benefits of using high-resolution cameras and efficient streaming protocols for real-time visual feedback (Brown et al., 2018).
5. **Ultrasonic Sensors in Robotics:** Ultrasonic sensors are widely used in robotics for obstacle detection due to their reliability and accuracy. Previous studies have demonstrated their effectiveness in providing real-time distance measurements, which are crucial for autonomous navigation (Zhang et al., 2017).
6. **GPS in Robotic Navigation:** The use of GPS in robotic systems has been extensively explored, particularly in applications such as outdoor navigation and autonomous vehicles. GPS provides accurate location data, which is essential for tasks that require precise positioning (El-Diasty & Pagiatakis, 2014).
7. **Environmental Monitoring with BMP Sensors:** BMP sensors, such as the BMP180, are commonly used in environmental monitoring systems for measuring temperature, pressure, and altitude. These sensors are known for their high precision and have been successfully integrated into various environmental monitoring projects (Rao et al., 2018).
8. **ESP8266 in IoT Applications:** The ESP8266 microcontroller has become a popular choice for IoT applications due to its low cost, low power consumption, and built-in Wi-Fi capabilities. It has been used in numerous projects for remote control and data transmission over the internet (Zapata & Sanchez, 2016).

