

## Police Patrolling and Surveillance Vehicle

Under the guidance of: **Mr. U. S. Shirshetti**

**Sneha S. Kale**

*Information Technology*

Sou. Venutai Chavan Polytechnic Pune  
Pune, India

[kalesneha2008@gmail.com](mailto:kalesneha2008@gmail.com)

**Shourya Y. Shinde**

*Information Technology*

Sou. Venutai Chavan Polytechnic Pune  
Pune, India

[shouryashinde128@gmail.com](mailto:shouryashinde128@gmail.com)

**Vrushali R. Ghadge**

*Information Technology*

Sou. Venutai Chavan Polytechnic  
Pune, India

[vrushaliraj2006@gmail.com](mailto:vrushaliraj2006@gmail.com)

**Satyam S. Tilekar**

*Information Technology*

Sou. Venutai Chavan Polytechnic Pune  
Pune, India

[satyamtilekar323@gmail.com](mailto:satyamtilekar323@gmail.com)

*Security and surveillance have become essential in modern urban environments due to increasing safety concerns. This paper presents the design and development of a Police Patrolling and Surveillance Vehicle, a compact robotic system capable of remote monitoring, real-time tracking, and controlled movement.*

*The system integrates Arduino Uno, ESP8266 WiFi module, GPS module, GSM module, motor driver (L298N), and camera unit to create a multi-functional surveillance platform. The vehicle can be operated remotely through a mobile application while providing live video streaming and location updates.*

*An alert mechanism is incorporated to notify authorities in case of suspicious activity. The system also supports solar charging, making it suitable for continuous operation. The proposed model demonstrates improved monitoring efficiency, reduced human effort, and practical implementation of IoT in security applications.*

**Keywords — Surveillance, IoT, Arduino, GPS Tracking, Smart Vehicle, Embedded Systems.**

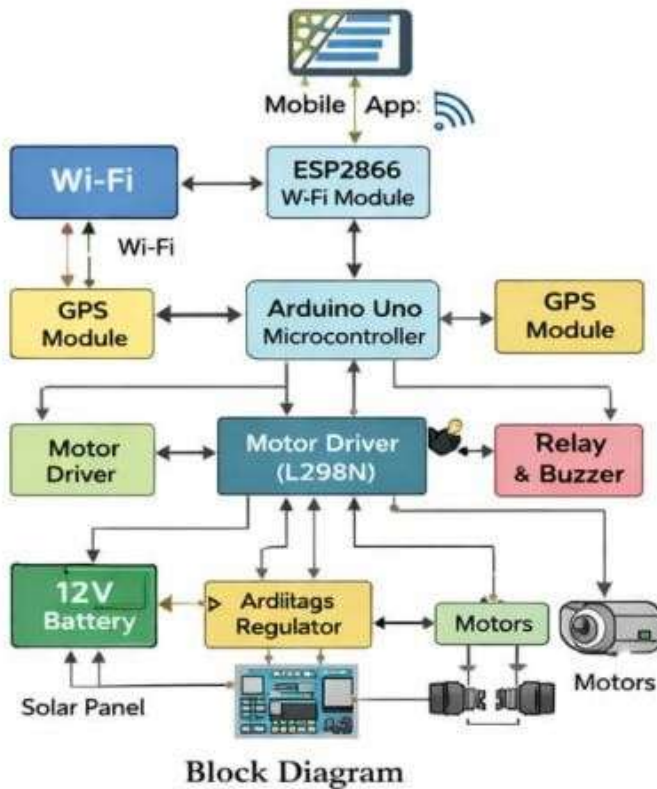
### I. INTRODUCTION

The rapid advancement in technology, particularly in the fields of embedded systems, wireless communication, and

robotics, has significantly influenced modern security systems. With increasing population density and urban expansion, maintaining safety and security has become more challenging. Traditional patrolling methods involve manual monitoring by police personnel, which is often time-consuming, labor-intensive, and limited in efficiency. In critical areas such as border zones, industrial sites, and crowded public places, continuous monitoring is required to ensure safety. However, human patrolling may not always be reliable due to fatigue, environmental conditions, and limited visibility during nighttime operations. Therefore, there is a growing need for automated surveillance systems that can operate efficiently with minimal human intervention. The Police Patrolling and Surveillance Vehicle is designed to address these challenges by providing a smart and automated solution. The system integrates real-time monitoring, wireless control, and location tracking features into a single platform. It can be remotely controlled using a mobile application, allowing authorities to monitor different areas without physical presence.

The vehicle is equipped with a camera for live video streaming, enabling continuous observation of the environment. The GPS module provides real-time location data, which is essential for tracking and navigation. Additionally, the system includes an alert mechanism that

activates in case of suspicious activities, ensuring quick response.



## II. RELATED WORK

Over the years, various surveillance systems have been developed to improve monitoring and security. Traditional systems mainly relied on CCTV cameras, which are fixed in specific locations and have limited coverage. While these systems are useful for monitoring small areas, they cannot provide mobility or cover large regions effectively.

Drone-based surveillance systems were later introduced to overcome this limitation. Drones can capture aerial views and cover larger areas, but they have certain drawbacks such as limited battery life, high cost, and the need for skilled operators. Additionally, drones are not suitable for continuous long-duration monitoring.

Robotic surveillance systems have also been explored in recent research. These systems use embedded controllers, sensors, and wireless communication to perform monitoring tasks. Many of these systems focus on either movement control or video surveillance, but do not integrate all functionalities into a single system.

The proposed Police Patrolling Vehicle combines multiple features such as mobility, real-time video monitoring, GPS tracking, and alert mechanisms in one platform. Compared to existing systems, it provides a balanced solution that is cost-effective, efficient, and easy to implement. This makes it suitable for small-scale applications and academic projects.

## III. SYSTEM ARCHITECTURE

The Police Patrolling and Surveillance Vehicle's system architecture is made up of layers and modules that work together to make sure the vehicle runs smoothly and parts can be easily added. There are several functional layers in the architecture that work together to make real-time monitoring and control possible.

### A. Layers that work

#### 1. Layer of Input

The input layer has a mobile app that lets the user send commands to the car. These commands tell the system how to move and what to do.

#### 2. Layer for Communication

The ESP8266 WiFi module is what connects the mobile app to the car. It gets commands and sends them to the controller.

#### 3. The Control Layer

The Arduino Uno is the system's main controller. It takes in data and sends out control signals to different parts.

#### 4. Layer of Sensing

The camera module and GPS module are both in this layer. The GPS module tells you where you are, and the camera records live video.

#### 5. The layer that makes things happen

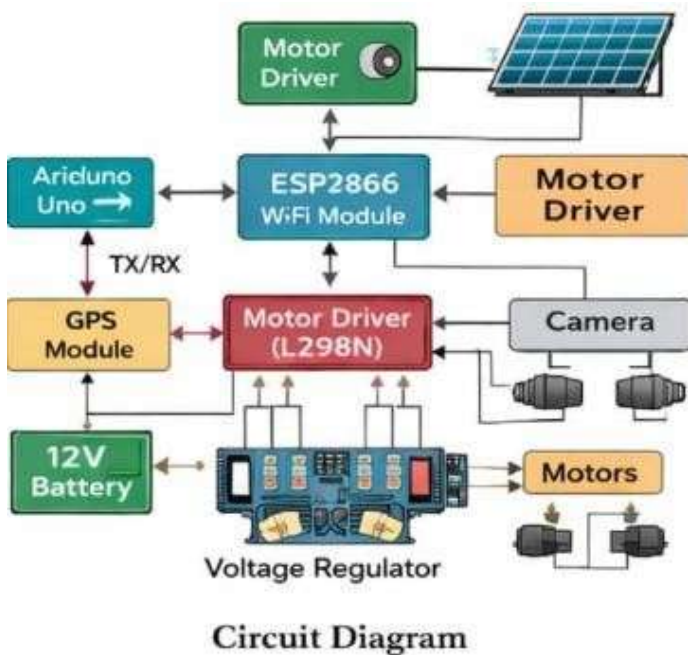
The L298N motor driver tells the motors how to move. You can use the relay and buzzer to set off alarms and control things.

#### 6. Power Layer

The system runs on a 12V battery that is charged by a solar panel. A voltage regulator makes sure that all the parts get a steady supply of power.

### B. Working Flow

- User sends command via mobile app
- ESP8266 receives command
- Arduino processes the command
- Motor driver controls vehicle movement
- Camera streams live video
- GPS sends location data
- Buzzer activates in case of alert



### IV. FEATURES

- The Police Patrolling and Surveillance Vehicle has cutting-edge features that make it more useful and functional for real-world security situations.
- This remote operation reduces the need for physical presence in risky or sensitive areas and ensures safer monitoring.
- The system uses the ESP8266 WiFi module to establish communication between the vehicle and the mobile device.
- Commands such as forward, backward, left, and right movement can be easily controlled through the application interface.
- Another important feature is the live video streaming capability provided by the camera module mounted on the vehicle.

- The camera continuously captures real-time video and transmits it to the user, enabling proper surveillance of the surroundings.
- This feature helps in monitoring suspicious activities and provides visual evidence if required.
- This allows the user to know the exact position of the vehicle at any given time.
- GPS tracking is especially useful in large areas where manual monitoring is difficult.

The system includes a GSM module that enables communication through mobile networks.

- This module can be used to send alerts or messages in emergency situations.
- The system also supports two-way communication, allowing authorities to interact when necessary.
- The use of a solar panel is an important feature that improves the energy efficiency of the system.
- The solar panel charges the battery during daytime, reducing dependency on external power sources.
- This makes the system suitable for continuous operation in outdoor environments.
- The power supply system is designed to ensure stable and reliable operation of all components.
- A voltage regulator is used to convert 12V supply to 5V, which is required by the Arduino and other modules.
- The vehicle is designed to be compact and portable, making it easy to use in different locations.
- The lightweight structure allows smooth movement and easy handling.
- It provides quick response to user commands, ensuring real-time control.

### V. METHODOLOGY

The methodology of the Police Patrolling and Surveillance Vehicle follows a structured pipeline that converts user commands and sensor data into automated movement, monitoring, and alert actions. The system integrates wireless communication, real-time video streaming, and location tracking to perform efficient surveillance. The overall operation includes receiving commands, processing data, controlling movement, and generating alerts when required.

### 5.1 Getting Data

Through different modules, the system gets real-time data from the user and the environment around them.

Some important parts are:

- User Input: A mobile app sends commands to the vehicle to control its movement.
- Camera Module: Takes continuous live video of the area around it for monitoring.
- GPS Module: Gives you the vehicle's location in real time.
- Sensor Data: The system constantly receives new information from different modules for processing.

The Arduino controller gets the data that was collected and processes it further.

### 5.2 Sending and Receiving Messages

The system processes the signals it gets before carrying out commands to make sure everything works right.

Steps in processing include:

Getting control signals through the ESP8266 WiFi module

Changing wireless signals into data that Arduino can read

Getting rid of noise or signals that aren't right

5.3 Control of Movement and Actuation  
The system controls the movement of the vehicle after it has processed the commands.

Control operations include: Sending control signals from the Arduino to the L298N motor driver

Using DC motors to steer the car in different directions

Controlling how fast and in what direction something moves

Making sure the vehicle moves smoothly and steadily

The motor driver connects the controller and the motors so that they can work together properly.

### 5.4 System for Watching and Monitoring

A camera module keeps an eye on the environment all the time.

Some of the monitoring features are:

- Taking live video of the area around you
- Sending video to the mobile app in real time
- Letting the user see places that are far away
- Giving people visual information to help them make decisions

This helps find suspicious activities and makes surveillance more effective.

### 5.5 Location Tracking and Communication

The system tracks the position of the vehicle and communicates important information.

#### Tracking and communication include:

GPS module provides real-time location coordinates

Location data is sent to the user for monitoring

GSM module enables communication through mobile networks

Alerts or messages are sent in case of emergency

This ensures proper tracking and communication between the system and user.

### 5.6 Alert and Safety Mechanism

- The system includes an alert mechanism to enhance safety and quick response.
- **Alert features include:**
- Buzzer is activated when suspicious activity is detected
- Immediate warning signal is generated
- Alerts can also be sent through GSM module
- Helps in quick response to potential threats
- This improves the reliability and effectiveness of the surveillance system.

- GSM module enables communication through mobile networks
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### 5.7 Real-Time Control and System Integration

The final stage involves integrating all modules for realtime operation.

#### Control logic includes:

- Continuous communication between mobile app and ESP8266
- Arduino processes data and controls all modules
- Simultaneous operation of movement, monitoring, and tracking
- Real-time response to user commands and environmental changes

This integrated approach ensures smooth functioning of the entire system.

## VI. IMPLEMENTATION

The implementation of the Police Patrolling and Surveillance Vehicle involves the integration of hardware components and software logic to achieve real-time monitoring, remote control, and tracking functionality. The system combines embedded

programming, wireless communication, and motor control to create an efficient surveillance platform. All modules are connected and synchronized to ensure smooth operation of the vehicle.

### 6.1 Hardware Components

The hardware setup of the system consists of multiple components that work together to perform different functions.

#### Main components include:

- **Arduino Uno:** Acts as the central controller that manages all system operations
- **ESP8266 WiFi Module:** Provides wireless communication between the vehicle and mobile application
- **GPS Module:** Tracks the real-time location of the vehicle
- **GSM Module:** Enables communication and alert transmission
- **Motor Driver (L298N):** Controls the movement of DC motors
- **DC Motors:** Used for vehicle movement
- **Camera Module:** Captures live video for surveillance
- **Relay Module:** Controls alert system operations
- **Buzzer:** Provides audible alerts in emergency situations
- **Battery (12V):** Supplies power to the system
- **Voltage Regulator (12V–5V):** Provides stable voltage to electronic components
- **Solar Panel:** Charges the battery for continuous operation

All these components are interconnected to form a complete embedded system.

### 6.2 Software Tools and Programming

The system uses embedded programming and communication protocols to control operations.

#### Key tools include:

- **Arduino IDE:** Used to write and upload code to Arduino Uno
- **Embedded C Programming:** Used for implementing control logic
- **WiFi Communication Protocol:** Used by ESP8266 to connect with mobile application
- **Serial Communication:** Used for data transfer between Arduino, GPS, and GSM modules

The software ensures proper coordination between hardware components.

### 6.3 System Integration

The integration of hardware and software modules forms the complete working system.

#### Implementation flow includes:

- Mobile application sends command to ESP8266
  - ESP8266 receives signal and forwards it to Arduino
  - Arduino processes command and generates control signals
  - Camera module captures live video and sends it to the user
  - GPS module continuously updates location data
  - GSM module handles communication and alerts
- This integrated system enables real-time operation and monitoring.

### 6.4 Prototype Development

A working prototype of the surveillance vehicle is developed to demonstrate system functionality.

#### Prototype features include:

- Compact vehicle structure with mounted components
- Proper arrangement of modules for efficient working
- Secure wiring and connections
- Installation of camera for surveillance
- Integration of motor system for movement

The prototype is designed to be portable and easy to operate.

### 6.5 Testing and Validation

The system is tested to ensure proper functionality and performance.

#### Testing process includes:

- Checking communication between mobile app and ESP8266
- Verifying movement of motors in all directions
- Testing GPS for accurate location tracking
- Checking video streaming from camera
- Testing GSM module for communication
- Verifying alert system using buzzer

The system is tested under different conditions to ensure reliability.

### 6.6 Real-Time Operation

The final implementation supports real-time operation of the system.

#### Operational features include:

- Instant response to user commands
- Continuous video monitoring
- Real-time location tracking
- Immediate alert generation in case of suspicious activity
- Smooth coordination between all modules

This ensures efficient and reliable surveillance performance.



## VII. PERFORMANCE ANALYSIS

The performance of the Police Patrolling and Surveillance Vehicle is evaluated based on various parameters such as response time, movement control, video monitoring quality, location tracking accuracy, and system reliability. The analysis is carried out by testing the system under different operating conditions to determine its efficiency and effectiveness in realtime surveillance applications.

### 7.1 Response Time and Control Performance

The response time of the system is an important factor that determines how quickly the vehicle reacts to user commands.

#### Key observations include:

- The system receives commands from the mobile application through the ESP8266 module.
- Arduino processes these commands and sends signals to the motor driver.
- The vehicle responds to movement commands such as forward, backward, left, and right with minimal delay.

- The overall response time is low, allowing real-time control of the vehicle.

- Fast response ensures smooth operation and better user control.

This indicates that the system is capable of providing efficient and real-time remote control functionality.

### 7.2 Movement and Navigation Performance

The movement performance of the vehicle is evaluated based on its ability to move smoothly and accurately.

#### Performance features include:

- The L298N motor driver effectively controls the DC motors.
- The vehicle moves in all directions without instability.
- Speed and direction control are consistent and reliable.
- The system maintains balance during movement.
- Navigation is smooth even on flat surfaces.

These results show that the system provides stable and controlled movement.

### 7.3 Video Monitoring Performance

The surveillance capability of the system depends on the performance of the camera module.

#### Observations include:

- The camera provides live video streaming to the user.
- Video transmission is smooth within the WiFi range.
- The system allows continuous monitoring of surroundings.
- Video quality is sufficient for basic surveillance tasks.
- Monitoring is effective in normal lighting conditions.

This ensures that the system can be used for real-time observation and security monitoring.

#### 7.4 Location Tracking Accuracy

The GPS module plays a key role in tracking the position of the vehicle.

##### Tracking performance includes:

- GPS module provides real-time location coordinates.
- The location data is accurate within acceptable limits.
- Tracking is continuous and reliable.
- The system helps in monitoring the vehicle position remotely.
- Useful for navigation in large areas.

This shows that the system can effectively track its position during operation.

#### 7.5 Communication and Alert System Performance

The communication system ensures proper interaction and alert generation.

##### Key features include:

- GSM module enables communication through mobile networks.
- Alerts can be sent during emergency situations.
- Buzzer provides immediate audible warning.
- Alert system works efficiently when triggered.
- Communication is reliable under normal network conditions.

This enhances the safety and responsiveness of the system.

#### 7.6 Power Efficiency and Stability

The power system is analyzed to ensure continuous operation.

##### Power performance includes:

- The battery provides sufficient backup for system operation.
- Voltage regulator ensures stable power supply to all components.
- Solar panel supports battery charging during daytime.
- Power distribution is efficient and stable.
- The system operates without power fluctuations.

This ensures long-duration operation and energy efficiency.

##### Limitations include:

- Performance depends on WiFi and network availability.
- Control range is limited by wireless communication range.
- GPS accuracy may vary slightly depending on environment.

### VIII. CONCLUSION

The Police Patrolling and Surveillance Vehicle successfully demonstrates the use of embedded systems and IoT technology in modern security applications. The system integrates various modules such as Arduino Uno, ESP8266 WiFi module, GPS module, GSM module, motor driver, and camera to create a compact and efficient surveillance platform. It allows remote control of the vehicle through a mobile application, enabling real-time monitoring without physical presence. The live video streaming and location tracking features improve surveillance capabilities and ensure better control over monitored areas.

The performance of the system shows that it can operate effectively under normal conditions. The vehicle responds quickly to user commands, and its movement is smooth and stable. The GPS module provides reliable location tracking, while the camera ensures continuous monitoring within the network range. The alert system helps in identifying suspicious situations and generating immediate warnings. Overall, the system reduces human effort and increases the efficiency of patrolling and monitoring operations.

Although the system performs well, certain limitations such as limited WiFi range, dependency on network connectivity, and reduced camera performance in low-light conditions exist.

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