

Mobile Robot for Remote Surveillance through Video Monitoring

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CERTIFICATE OF APPROVAL

The thesis titled “**Mobile Robot for Remote Surveillance through Video Monitoring**” has been accepted as partial fulfilment of the requirement for the BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING of Islamic University of Technology (IUT)

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Chapter 1

Introduction

1.1 Introduction

Surveillance is the careful, systematic surveillance of an individual or organization. Surveillance is most commonly necessary at national borders, public places, workplaces, and industry. It is mostly used to track activities. With rising crime rates, there is a need for a smart surveillance system that can operate with minimal human involvement. A robot can do programmed tasks, eliminating the need for manual labor, generating extremely accurate results, and overcoming human limits. Security is a fundamental aspect of our existence. And monitoring is an important part of it. Surveillance has a wide range of uses, from robbery and crimes against women to investigating sites with chemical, bio-hazard, and nuclear power facilities. The most recent application of surveillance is monitoring patients undergoing Covid-19. Regular fixed surveillance cameras have dead areas that reduce their efficacy, leaving the user powerless while attempting to manage the camera, highlighting the necessity for mobile surveillance systems. As a result, this article focuses on a surveillance robot that live broadcasts movies and photos and can be operated from a distant location [12]. In this project, we are using the three main modules: esp-32 camera with built-in Bluetooth, Wi-Fi, built-in antenna, and built-in 2MP camera. We will create an internet-based online control robot. The website also provides a live view of what the robot "sees". It has eight controls: forward, reverse, left, right, stop, vary the speed, vary the strength of light, and control pan and tilt. The esp32 camera's built-in Wi-Fi module provides an IP address when connected to the host computer. We will open the browser at the IP address of the esp32-camera module and now we can control the robot. Designing a Wi-Fi-controlled robot is at the center

of this project. Bluetooth technology has an average range of 10 meters, but due to the limited range of vehicles, the robot-controlled car has a range problem (limited range). We will solve this problem using the Wi-Fi module. If we use Wi-Fi on our robot, the connection and range can increase. Another important factor in the development of this project is that we use the internet instead of traditional hardware controls to reduce costs. This wireless-controlled robot car is controlled by a Wi-Fi model using our phone and computer. The web interface was created using programming in the Arduino IDE. The esp32 camera module uses a microcontroller to control this project. The esp32cam board offers easy hardware integration and coding using the Arduino IDE [5].

1.2 Literature Review

In [1] the authors developed an Android-based mobile robot for surveillance, utilizing the Arduino platform for processing and a software package for communication. The robot, which features an ultrasonic distance sensor for effective obstacle avoidance, can operate both remotely and autonomously. In autonomous mode, it navigates unknown environments without user intervention after initial setup. Experimental results demonstrated its flexibility and accuracy in avoiding obstacles, with a communication range of approximately 50 meters, making it a cost-effective solution for various surveillance applications. In [2] the authors present the design of a remote-controlled mobile robot that is operated by an operator using a servo console to control the robot's movement and position via live video feed. Through extensive testing, the system has demonstrated stable performance and reliable functionality, confirming its significant practical value. In [3] the authors propose a framework for a surveillance robot that overcomes limited range issues by utilizing IoT technology. The robot, which can be manually controlled via a laptop

or mobile device, is small enough to access areas inaccessible to humans. Wireless technology plays a crucial role in this project, making the robot highly efficient and cost-effective. This solution aims to replace human labor in monitoring tasks, providing effective and reliable surveillance. In [4] the authors developed a mobile-operated spy rover using an ESP32 microcontroller, featuring a camera that sends video to a mobile device for remote operation. The rover is designed to handle dangerous situations, such as hostage scenarios, by relocating hostages to safety and performing security and surveillance tasks more effectively than humans. In [5] the authors improved on earlier devices by replacing Bluetooth with Wi-Fi, thereby extending the robot's operational range. They implemented a web-based interface for controlling the robot, which can be used in defense applications such as detecting landmines and bombs. The device size can be adjusted according to specific requirements. Future improvements include applications in harvesting, fire stations, domestic uses, and enhancing the robot with artificial intelligence for autonomous operation. In [6] the authors developed a Surveillance Robot Car with pan-tilt capabilities and advanced features for security and surveillance. They incorporated an ESP32-CAM module for live streaming, controlled via a web interface. It is designed for diverse applications, including mining accidents, urban disasters, and agricultural surveillance, providing real-time data transmission and video monitoring to enhance safety and security. In [7] the authors developed a remotely controlled robot with a wireless night sensor camera for live video streaming, a metal detector for identifying metal components and mines, and GPS trackers for locating landmines. The robot aims to reduce casualties in border areas and assist in patrolling and reconnaissance. Future improvements will focus on enabling the robot to operate in water and reducing its size and weight. In [8] the authors utilized a Raspberry Pi to remotely control a robot using a smartphone. They found that the system's

response time to commands from the smartphone was negligible, indicating swift processing and execution. Experimental results demonstrated the robot's capability to quickly fetch high-quality video at up to 15 frames per second. They highlighted the advantages of using smartphones over traditional computers and laptops, emphasizing enhanced reliability and ease of use in their system design. In [9] the authors developed a mobile robot integrated with an IoT monitoring system, utilizing a P.I.D. controller to maintain a 30 cm distance from the wall and applying a Wall-Following algorithm to generate environment maps and input matrices for shortest path calculations using Breadth-First Search. Effective communication between the central module, auxiliaries, and server facilitated early detection of falls in elderly individuals, allowing for prompt assessment and assistance. Control and monitoring were managed via a custom mobile application. Future work includes experimenting with other pathfinding and control algorithms and developing printed circuit boards for the system's modules. In [10] the authors designed and implemented a mobile robot for surveillance and security applications, aiming to lower costs and power consumption using low-cost open-source hardware like Arduino and Raspberry Pi. The robot is wirelessly connected to the control station via a low-power ZigBee module, enabling remote control and monitoring of environmental events. It is equipped with sensors, including a camera, temperature sensor, and range sensor, to detect human motion, monitor room temperature, and measure the distance of surrounding obstacles. Testing showed the robot can operate continuously for about 6.5 hours at a motor shaft speed of 25 rpm before needing a battery recharge. In [11] the authors designed an economical and easy-to-implement surveillance robot aimed at enhancing security systems. They proposed incorporating face recognition and video recording capabilities to improve the robot's effectiveness. The project emphasizes the potential of robotics to transform security tasks, making the

surveillance robot a valuable asset for monitoring and protection. In [12] the authors outlined the design of a surveillance robot aimed at providing efficient and user-friendly monitoring capabilities, including vision and motion detection. The robot features a modular and versatile structure, allowing for future upgrades and improved accessibility. It is designed to be cost-effective and efficient, reducing the need for human labor in surveillance tasks. In [13] the authors proposed a Raspberry Pi-based surveillance camera using a webcam, enabling image and video transmission over the Internet for extensive coverage. This system surpasses conventional CCTV cameras, drone cameras, and camera traps by allowing remote monitoring and control of a robotic circuit. Despite using secure network protocols, they noted that human errors could introduce vulnerabilities and potential hacking risks. In [15] the authors proposed a framework for a surveillance robot that utilizes IoT to overcome limited-range issues. The robot can be controlled manually via a laptop or mobile device and can also perform automatic monitoring. Its small size allows it to access areas inaccessible to humans. The robot employs wireless technology, making it highly efficient and cost-effective, thereby replacing human labor in monitoring tasks. In [16] the authors proposed a low-cost, IoT-enabled surveillance system that is lightweight and easy to install. The system uses an infrared sensor to detect activity and then takes a picture, which is sent to the user via the Telegram app. Additionally, it includes a smoke and fire detector for enhanced safety. In [17] the authors developed a robot for efficient surveillance that operates with gesture-based locomotion. Utilizing an ESP32 cam module, the robot is Wi-Fi-based, limiting its surveillance range to Wi-Fi coverage. It is powered by Li batteries and can also be controlled using a transmitter-receiver system, enhancing its efficiency. In [18] the authors proposed a cost-efficient robot that provides reliable surveillance and aids in sanitization, designed for small spaces like homes,

offices, and warehouses. The robot can operate in both manual and automatic modes, with manual control via a website. It operates on two levels: surveillance using an ESP32-cam module that live-streams, detects objects and captures images of sudden movements, and sanitization using an Ultraviolet (UV-C) light with a wavelength of 222nm that destroys pathogens while being safe for humans.

1.3 Motivation

The motivation behind the "Remote Mobile Robot Surveillance using the ESP32-CAM" project is to improve security measures in a more adaptable, effective, and economical way. While traditional surveillance systems work well, they have several significant drawbacks. These include expensive installation fees, limited coverage areas, and fixed installation points. It is difficult to carry out thorough monitoring in such circumstances, particularly in big or dynamic situations. The Internet of Things (IoT) development presents fresh chances to overcome these obstacles. Our project uses ESP32-CAM modules to build a mobile robot with a remotely operated camera. This new system not only solves the weaknesses of the traditional continuous monitoring system but also has many significant advantages:

Increased flexibility and coverage: With the ability to move to different positions, the mobile robot provides Strong cover and full protection compared to cameras that stand, where. we can send them to different environments such as hospitals, offices, homes, offices, and public places.

Live Video Streaming and Remote Control: The ESP32-CAM modules work together to provide live video streaming and remote control, allowing users to view and control the robot anywhere connected to the Internet through a PC interface or by phone.

Cost-effectiveness: The system is less expensive than traditional surveillance setups since the ESP32-CAM modules are reasonably priced.

Ease of Use: The system's user-friendly design allows users to easily access and manage the robot using a web-based interface or a dedicated mobile application.

Through the provision of a reliable and user-friendly remote surveillance system that leverages the capabilities of the ESP32 and ESP32-CAM, our project aims to increase security in a variety of circumstances.

1.4 Problem Statement

Security is always needed in different places. Current security measures include CCTV camera monitoring and other means of surveillance. Most of these systems are static and can only cover a limited area. These processes are usually done by hand or computer. It cannot be used to cover large areas and cannot be used on any mobile device. In short, we can say that these systems do not work well which makes it necessary to create an effective and remote protection system. The purpose of this project is to create a security system that can be controlled from a computer or phone. Includes a robot with an aerial camera. The robot records high-definition video and transmits it to the computer or mobile device used to control the robot.

1.5 Objectives

1. Designing and implementing a mobile robot platform equipped with surveillance capabilities.
 - Design: This design shows the structure and function of a mobile robot. This includes choosing the right equipment such as the robot, motor, camera module (ESP32-CAM), and other necessary components.

- Implementation: This step involves physically assembling the robot according to the design. This includes installing equipment, designing cables and communications, and ensuring that the system works as intended.
2. Developing a user-friendly interface for remote operation and monitoring of the (MR-RSVM).
- User-friendly interface: Creating an easy-to-use interface for individuals without technical experience. This interface should be easy to access, providing clear control and feedback.
 - Operation and monitoring: A network connection must allow users to control the robot and monitor the video signal visually. This can be done through a web platform or a mobile app, so it can be accessed from a given location or anywhere using the NGROK application or Blynk app with an internet connection.
3. Integrating wireless communication technology to enable real-time video transmission and control.
- Wireless communication technology: We use technology such as Wi-Fi provided by the ESP32cam module to enable the robot to communicate with the user's device wirelessly.
 - Real-time Video Transmission and Control: Ensures that the video captured by the esp32 camera of the robot is transmitted to the user's device in real-time. In addition, the user must be able to send commands to control the robot directly. This enables immediate monitoring and quick response to any monitoring needs.
4. Conducting performance evaluation and validation tests to assess the effectiveness and reliability of the MR-RSVM system.

- Performance Evaluation: This includes testing the quality of video streams, response to control commands, and the robot's ability to navigate different environments.
- Validation Testing: Verify that the system is working reliably and consistently.

1.6 Scope of work

This project's scope includes designing, creating, and testing a prototype system of MR-RSVM. The system will have remote control via an intuitive web interface, and real-time video streaming. The focus will be on addressing the challenges associated with traditional surveillance methods and providing an innovative solution that enhances situational awareness and operational efficiency in various environments.

Chapter 2

Proposed Design and Methodology

Internet of Things (IoT) technology has come a long way in the field of mobile control. This article examines the design and methodology of mobile security systems, with an emphasis on the use of the ESP32-CAM module and related technologies to enhance security and monitoring capabilities. The main research topics are the creation of monitoring systems, IoT services, intelligent monitoring, and ESP32-CAM applications in mobile devices.

2.1 What is a Mobile Robot for Remote Surveillance Through Video Monitoring (MR-RSVM)?

Mobile robot for remote surveillance through video monitoring are advanced robotic systems designed to perform surveillance, monitoring, and remote operation tasks in diverse environments. These robots are equipped with sophisticated technology and a variety of components to enable their functionality and operation [19].

2.2 Wireless Controlled Surveillance Robot

2.2.1 Description

A mobile robot is a machine that is positioned or mounted on a moveable platform and may operate according to specific instructions. Today, mobile robots are used in a variety of sectors. Many of the complicated robots that we see today evolved from smaller mobile robots. This technology has enabled several new uses in the sector. The integration of mobile devices and robotics is generating new ideas in a variety of industries. Mobile devices are often employed in industrial applications due to their portability and greater battery life than laptops. They also provide a data plan through a cell phone carrier, which is useful since we may communicate with the

mobile robot once the connection is established. Mobile robots may be grouped into several categories. The tracked robot utilizes tracks to move around. However, such robots are expensive to produce. Furthermore, they are less flexible than wheeled robots. Wheeled robots are robots that utilize wheels to move. Such robots can only move on smooth, level surfaces. The third category is legged robots, which are modeled on human anatomy. They have legs that allow them to move around. These robots are tough to design [19].

2.2.2 Proposed System

The new era of technology, such as Android and GSM, has revolutionized communication. Today, most individuals have access to mobile phones, and the globe has become a global village. A mobile phone may be used to reach anyone at any time. It can spark innovations and ideas that will help it improve its capabilities even more. Infrared, Bluetooth, and Wi-Fi technologies created in recent years demonstrate that advancements are conceivable, and these enhancements have improved our lives and how we live. Remote administration of various home and business products is becoming increasingly popular, and many systems now offer such capabilities. Mobile robots are robots that can move and interact with their surroundings rather than being fixed in one location. Because of their enormous potential and many applications in business, military, security, and entertainment, several laboratories and research groups at various institutions and organizations are solely dedicated to mobile robot research. The robot was specifically built for surveillance reasons. A control mechanism is provided, as well as a video transmission facility. High-speed picture transmission is used to transmit video effectively. Initially, the robot will be fitted with an esp32cam, which will record the scene in front of it and upload the photographs to the server, where the user will control and view the live broadcast [19]. The system consists of two main parts; One

is the user part and the other is the robot part. Here the user unit may have a laptop or mobile computer to communicate with the robot end. Thus, the user segment can be more mobile than the traditional fixed computer system by using laptops or mobile computers. Communication can be achieved using RF technology using the ESP-32 camera device or using Wi-Fi technology, but this comes at a small cost. So, to realize the idea of raising the level, we can connect some of the users to the internet, which is the main idea of the internet. The user's system connects to the internet using Blynk and NGROK software. Blynk software is nothing but the corresponding NGROK software that converts local IP addresses to global IP addresses. With this Blynk and NGROK software, we can send commands and easily control the robot car. In the end, the robot uses an ESP32 camera mounted on the body or chassis of the robot, which is an important part of the car. Under the chassis, the wheels are connected to a 300-rpm single-speed DC motor. Each motor requires a 12 V power supply, which is provided through an external power supply. The DC motor is connected to the motor control. The microcontroller is written with IDE software for proper control of the robot. When the ESP32 camera module connects to Wi-Fi, it generates an IP address. To operate the robot, open a browser and enter the IP address of the ESP32 camera [15].

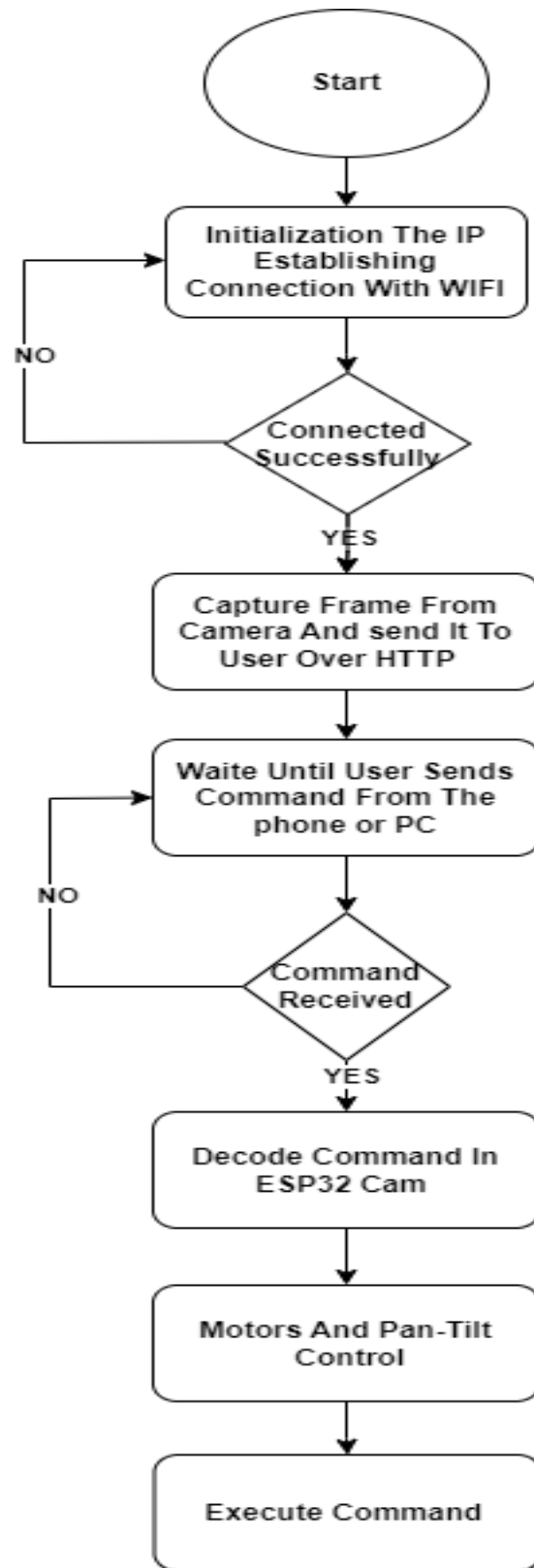


Figure 1. System Workflow

2.3 Methodology

2.3.1 Reading Research Papers

After establishing a solid foundation supported by attention to detail and an extensive literature review, it became clear that our desire for knowledge needed more nourishment. We continued our rigorous and exhaustive research, analyzing large scientific papers, technical papers, and technical materials for visual monitoring and video surveillance, due to an insatiable appetite for understanding.

We are determined to dig deep into the history of education and immerse ourselves in a rich collection of scientific papers that demonstrate discoveries and revolutionary research leading to the growth of mobile robots in the field of remote security. On the one hand, we chose a strong approach to the company's history, the interest of the market, the emerging problems, and the opportunities ahead. In completing this intellectual journey, we have carefully reviewed the technical literature, uncovering the complexities of modern systems, analyzing the underlying systems, and uncovering the best practices that are driving the field of mobile robotics. In progress.

This endless search for information is more than a hobby but is a serious effort to uncover the complexities and complexities embedded in the fabric of the Mobile Robot's observational system. It has given us a unique insight, allowing us to predict what will happen in the future and understand the main principles that define this fascinating area. We strengthen this information economy with intelligent weapons, preparing to enter the dangerous terrain of Mobile Robots working with remote monitoring with incredible reliability and unparalleled experience.

2.3.2 Requirement Analysis

Before starting the project “Mobile Robot for Visual and video surveillance”, it is necessary to review the most important factors for effective implementation:

- The system will enable real-time monitoring of the robot’s environment, providing security specifically. To the food worker.
- Utilize the camera to perceive the environment and detect objects or movements of interest for effective surveillance.
- Users should have the ability to remotely control the robot’s movement and camera orientation via a web-based interface or mobile application.
- Designing a robot that works efficiently on battery power for long-duration surveillance sessions, optimizing power consumption for extended operation.
- Create a reliable communication channel to transfer video data to the user robot using the HTTP communication protocol [18].
- Implementation of systems to protect the privacy and security of recorded video data, including encryption and control systems.
- Development of Intuitive and User-Friendly Sensors for Accessing Tracking Input and Controlling Robot Motion and Camera Positioning.
- Ensuring that the robot can cross different terrains for internal and external safety, control, and effective monitoring.
- The solution must be efficient compared to traditional security systems and protect important services.

2.3.3 Selection of Proper Components

To achieve safe and dependable mobile robots for remote Surveillance capabilities, Mobile Robots for Remote Surveillance automobiles require a sophisticated combination of many components and technology. These components collaborate to collect surrounding data and allow users to control the vehicle's actions. Advanced devices such as the esp32cam collect important information about the environment, allowing the car to recognize objects, recognize road signs, and accurately measure the situation. This data is analyzed by users who make real-time decisions based on the given situation.

These judgments are translated into actual actions via control systems and actuators, which regulate the vehicle's speed, steering, and braking. Furthermore, complex software and algorithms are critical in assuring the flawless integration and coordination of various components. In each stage of the mobile robots for remote Surveillance, we used their respective components to get accurate data.

In the perception stage, we used esp32camera to supply visual data to the mobile robots, allowing us to distinguish objects.

1- ESP32 CAM

The ESP32 CAM module is a useful component for data gathering and perception activities. The core capability of the ESP32 CAM is its integrated camera module, which captures visual data and integrates it into the mobile robot for remote surveillance system. The ESP32-CAM module is powered by DC power. The ESP32-CAM's suggested operating voltage is 5V DC. It features a built-in voltage regulator that allows it to accept input voltages ranging from 5V to 12V, with 5V being the optimal voltage. It is worth noting that the ESP32-CAM does not accept AC power. The camera module provides important visual information to the vision

algorithm by taking photos and videos around the vehicle. This visual data helps in object identification, lane keeping, traffic sign recognition, and other computer vision functions required for autonomous navigation. The ESP32 CAM's networking options, like Wi-Fi, allow for easy integration with the internal systems of the autonomous vehicle. It allows collected visual data to be sent to additional processing units or central control systems for further analysis and decision-making. This connectivity also enables remote monitoring and control, as well as real-time feedback and modifications [6-3-5-17].



Figure 2. Esp32-cam

2- DC Gear Motor 300RPM

A gear motor with a speed of 300 RPM (Rotations Per Minute) is a motor that rotates at a rate of 300 full revolutions per minute. Gear motors combine an electric motor with a gearbox, which decreases output speed while boosting torque. This combination allows accurate speed control and increases the performance of the vehicle [18].

When connecting a powered motor to a self-propelled vehicle, it usually needs to be connected to a train or wheels to provide the necessary power and motion. The speed

and speed of the motor gear depend on factors such as the weight and size of the vehicle, the required speed and maximum speed, and the location of the vehicle [10].

The voltage of a gear motor working at 300 RPM might vary. A usual voltage range for gear motors in this speed range, however, is 12V to 24V. Motors in this voltage range are commonly employed in robotics, automation, and small-scale machines [15].



Figure 3. DC Gear Motor

3- Motor Driver(L298)

Motor drivers act as an interface between motors and control circuits. They are essential because motors require a high amount of current, while control circuits operate on low current signals. The primary function of motor drivers is to take a low-current control signal and convert it into a higher-current signal capable of driving a motor [3].

The motor driver module is a circuit designed specifically to run motors, typically used for motor interfacing. The L298N is a popular dual H-bridge motor driver that

allows for both speed and direction control of DC motors simultaneously. It can drive DC motors with a voltage range between 5V and 35V, and it supports a peak current of up to 2A per channel. This module is highly effective for interfacing motors in various applications [5].

The L298N motor driver plays a crucial role in the movement of robots by combining two techniques: Pulse Width Modulation (PWM) for speed control and H-Bridge for direction control. The IC has two input pins: one for the internal logic circuit and another for the H-bridge, which drives the motor. It also has four output pins to which two DC motors can be connected [7].

The H-bridge connection is critical for bi-directional control of the motor, allowing the robot to move forward, backward, left, and right. The power supply for the motors typically comes from a 12V battery, which is accurately provided to the motors via the motor driver. The motor driver is controlled by actuating signals from the microprocessor [18].

The L298N Is a twin-motor controller, meaning it can manage two motors simultaneously. To control four motors, two motors need to be connected in parallel to each slot. It can supply up to 2A per channel, making it a cost-effective and popular choice for hobbyist projects. Additionally, the L298N module features an onboard 12V to 5V regulator, the IC 7805, which can power other boards requiring 5V, adding to its versatility and utility in various applications [18].



Figure 4. Motor Driver (L298)

4- DC-DC Voltage Regulator

A voltage regulator is an electrical device or circuit that maintains a constant voltage regardless of input voltage or load conditions. It takes a variable input voltage and produces a constant regulated output voltage within a given range [17].

The main task of an electrician is to guarantee that equipment or electronic devices receive a constant and reliable power supply, protect them from voltage fluctuations, and provide adequate performance. Electronic controls are commonly found in electronic systems such as power supplies, microcontrollers, sensors, and integrated circuits [17].

Voltage Regulators can be divided into two categories: Linear Voltage Regulators and Voltage Regulators.

Linear Voltage Regulator: The linear voltage regulator controls the output voltage through a series of transistors. It works by dissipating other forces such as heat, making it easier and more efficient than the transformers. When low noise and simplicity are more important than performance, are often used by network operators [25].

A variable voltage regulator controls the output voltage using a variable device such as a transistor or semiconductor switch. It works by quickly switching the input

voltage on and off, and then monitoring and adjusting the output voltage to achieve the desired output value. Flexible systems work well but are difficult to design and implement [26].

The voltage regulator is available in different voltage and current capacities to meet the needs of different applications. They can have a fixed or variable output voltage, providing configuration flexibility.

When choosing an electrical regulator, consider the distribution of the required input voltage, current capacity, efficiency, temperature limit, and other characteristics such as over-protection or fire resistance to guarantee that the control voltage – meets application requirements and provides the required stability. And the reliability of your electronic system, see the data sheet and specifications provided by the manufacturer.



Figure 5. DC-DC Voltage Regulator

5- Servos (SG90) and Pan and Tilt camera mount (2 Axis)

The main function of the servos motor and pan and tilt is to hold the Esp32-CAM and give it more flexible movement into up, down, left, and right. We have two servo motors, one of them used to control the movement of the up and downside, the other servo motor to control movement to the left and right side. The ESP32-CAM hosts

a web server that shows video streaming and buttons to control the servo motors to move the camera [17-16].



Figure 6. Servos (SG90) and Pan-Tilt

6- Lipo Battery

Is a type of rechargeable battery that uses lithium-ion technology. LiPo batteries are widely used in various electronic devices, such as smartphones, laptops, drones, radio-controlled vehicles, and other portable electronics. They have become popular due to their high energy density, lightweight design, and ability to deliver high currents. In our project, we used a lipo battery 12V [18].

LiPo batteries come in various types and sizes, consisting of separate cells connected in series and parallel. Each LiPo cell has a nominal voltage of 3.7V. Connecting cells in series increases the voltage (e.g., 7.4V for 2 cells, 11.1V for 3 cells) while connecting cells in parallel increases capacity [1]. Battery configurations are denoted by codes like 2S2P, indicating 2 cells in series and 2 sets in parallel.

Higher voltage means more power and higher capacity offers longer runtimes. Lipo batteries are a special type of LiPo that can be charged up to 4.35V per cell, compared to the 4.2V maximum for regular LiPos.

The C rating, found on battery labels, indicates the discharge rate, representing how fast the battery can be safely discharged. For example, a 50C, 5000mAh battery can

handle a discharge rate of 250A. Batteries often have two C ratings: a continuous rating for sustained load and a burst rating for short bursts. However, C ratings can be overstated by manufacturers [14].

Internal Resistance (IR) is crucial but not stated on the battery. It measures the difficulty in delivering energy to the motor and speed control, affecting the battery's efficiency. Higher IR means more difficulty and less efficiency.

Understanding voltage, capacity, C rating, and internal resistance is essential for selecting and using LiPo batteries effectively [14].



Figure 7. Lipo Battery

7- Wheels

Wheels are simple machines for reducing the force of friction. Dragging something over rough ground is hard work, but wheels make it much easier by allowing the object to roll along [5].



Figure 8. Wheel

2.3.4 Project Design

Develop a detailed plan for the project, create schematics, and diagrams that illustrate where the components should be and how the components will work together.

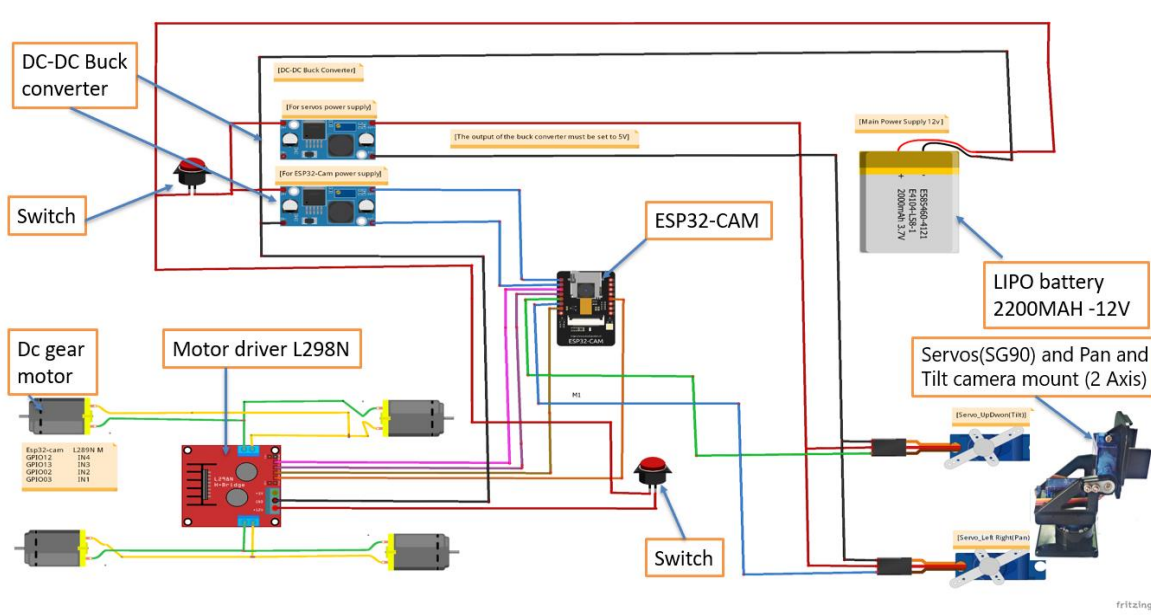


Figure 9. Circuit Diagram of the Project

2.3.5 Component Testing

Component testing is a crucial phase in the implementation methodology to ensure that each component functions correctly before integrating them into the final system.

- Verifying the functionality of the ESP32-CAM module, ensuring it can capture and transmit video.

- Ensuring that the ESP32-CAM programmer can upload code to the ESP32-CAM module.
- Confirm that the DC gear motors function correctly and provide the required torque and speed.
- Testing the motor driver's ability to control the DC gear motors.
- Ensuring the DC-DC voltage regulator provides a stable output voltage.
- Checking the wheels for proper fitting and smooth rotation.
- Verifying the battery's capacity and output voltage.
- Ensuring the pan-tilt mechanism operates smoothly and accurately.
- Ensuring the jumper wires provide reliable electrical connections.

2.3.6 Project Prototyping

we are Building a prototype for the mobile robot to test the feasibility and functionality of the design by Assembling the prototype using the selected components and materials. We will Integrate the ESP32-CAM module, motors, motor driver, DC-DC voltage regulator, and other components as shown in Figure 9.

We will Develop initial software to control the robot and capture video feeds then Conduct preliminary tests to ensure the prototype functions as intended.

2.3.7 Testing and Validation

Performing functional testing to verify that all components and subsystems work correctly then Conducting performance testing to assess the robot's speed, battery life, video quality, and remote-control responsiveness.

2.3.8 Project Implementation

2.3.8.1 Software Tools

There are 2 software used in this project:

Arduino IDE: The Arduino IDE (Integrated Development Environment) is an open-source software development tool that lets you create and upload code to the Arduino board. It offers a basic and straightforward interface for programming and troubleshooting Arduino devices. The Arduino board is a microcontroller-based development board that may be used for a variety of purposes, including the Arduino (Integrated Development Environment, or IDE), which is a free and open-source development environment for developing and downloading Arduino code. It offers an easy-to-use environment for programming and troubleshooting Arduino boards. Arduino IDE is an Arduino development board that may be used for robotics, smart devices, and Internet of Things applications [15-16].

Arduino IDE is the software used to install ESP32-Cam, in Arduino IDE software C++ language is used to create different boards. The Arduino IDE software program has many features that allow you to interact with the programming board without difficulty, this system has many features. The first is the empty base (), which contains the base method of this method, and the second is the empty loop (), which contains the part of this method that must be executed always, or we can say loop. The board used for the example is the ESP32-Cam and is configured using the Arduino IDE software, the motherboard is configured to enable the basic functions of a small DC motor, as well as a servo and a special library included. Installed. The Arduino IDE software program controls the ESP32-Cam digital camera [10-18].

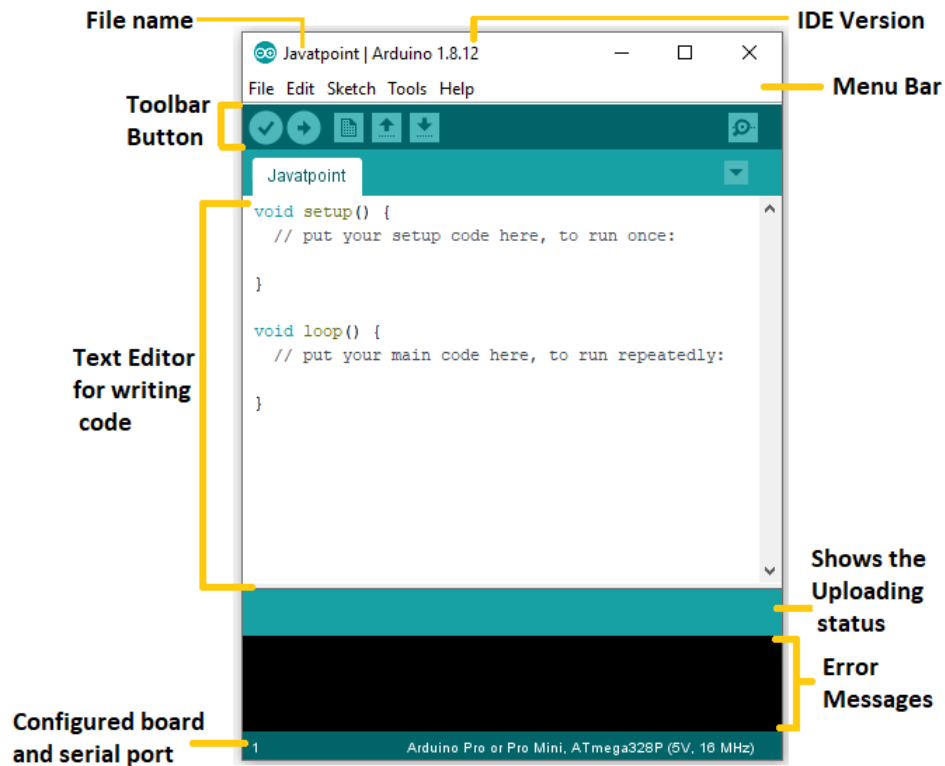


Figure 10. Arduino IDE Interface

ESP32 Cam Web Server: A web server is a device that saves, approaches, and serves online pages to internet clients, which can range from browsers on PCs to mobile apps on smartphones. The communication between the client and the server takes place through the use of a unique protocol known as Hypertext Transfer Protocol. The customer uses a URL to request a specific web page, and the server responds with the content of that page or an error message if the web page is not always accessible.

The internet server is a location for sending and receiving facts, as well as organizing and storing them. The internet server can also display this information on an online web page. The server talks with the user via a protocol known as the Hypertext Transfer Protocol Secure. When a request is issued to this server, the server responds

with a code (for example, code 200, which signifies that the relationship is set up quickly, or code 404, which signals that the deal isn't always correct) [18].

2.3.8.2 Steps of Implementation

Initial Setup and Configuration:

The first step is to connect the ESP32-CAM to a suitable device that supports video. This is usually done using a tool like the Arduino IDE. We need to connect the ESP32-CAM to the computer using the ESP32-CAM tool and follow the flashware process.

After flashing, configure the Wi-Fi settings so that the ESP32-CAM can connect to your network. This usually involves changing the firmware code to include the Wi-Fi SSID and password, then compiling and uploading the ESP32-CAM software.

The motor vehicle receives the control signal from ESP32-CAM GPIO pins to drive the motor.

Wiring DC Gear Motors: Connect DC Gear Motors to make an output motor. These motors provide movement to the robot.

Power Management:

Power Management: Use DC-DC power regulation to decrease a 7.4V LiPo battery to the needed 5V for the ESP32-CAM and driver.

Power Distribution: Connect the esp32-cam's 5V output to the servo chip so that all components receive continuous power. Correct electrical management is important to reduce energy consumption, which can lead to unpredictable behavior.

Assembling the Robot:

Motor Mounting: Fixing of DC motor to the motor or chassis. We are Making sure the motor is properly installed and positioned to ensure smooth movement. The add-on includes ESP32-CAM and security driver installation. Insert ESP32-CAM to increase the monitoring level.

Pan-Tilt Bracket: Provides a tilting mechanism for the robot's front camera. This allows the camera to move automatically, improving its tracking and monitoring capabilities.

Checking the connections: Using solder and heat shrink tubing to secure all electrical connections. This prevents loose connections that can cause malfunctions.

Organizing Wires: We Organize Wires and bundle the wires to keep the interior of the robot tidy. This helps prevent tangling and interference during movement.

ESP32-CAM Programming:

We need to write ESP32-CAM Programming code to capture video from the ESP32-CAM camera and transfer it over Wi-Fi. This usually means creating an MJPEG or HLS stream. We need to use ESP32-CAM to create a simple web service that supports video web pages. This page should be accessible from any device on the same network or from a different network by using the NGROK application.

Motor Control:

Control code: We must create code to transmit control signals to the drive based on user input. This involves providing GPIO pins for motor control, zooming, rotating, switches, and so forth.

Web monitor move: Add a web interface control to send commands to the engine. These controls can be virtual buttons or joysticks that send HTTP requests to the ESP32-CAM, such as forward, backward, left, right, speed control, light control, and panning.

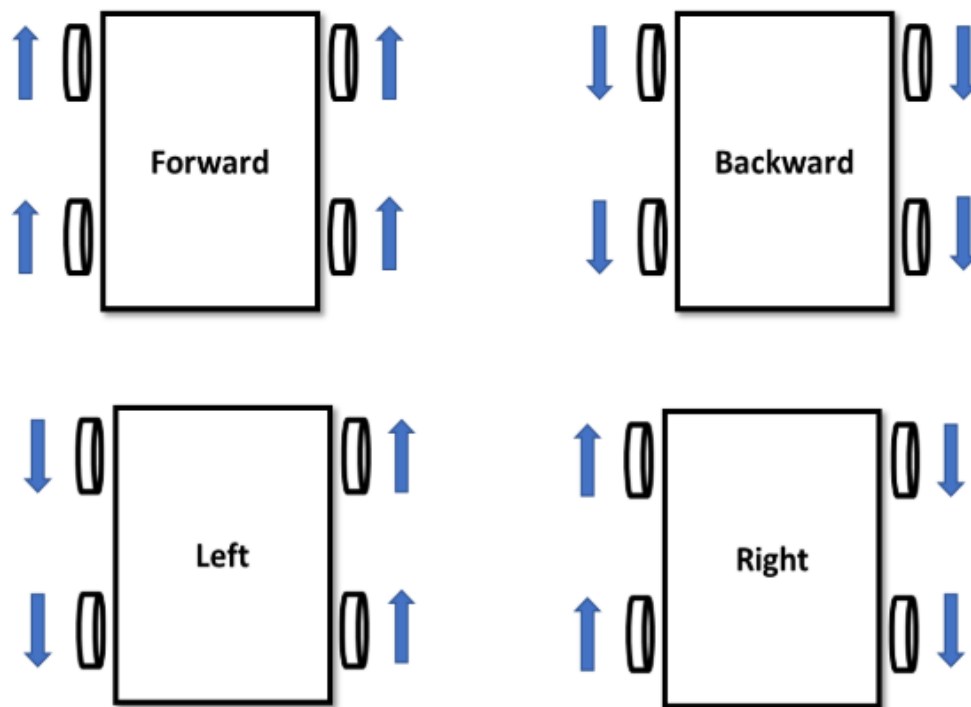


Figure 11. Robot Movement Direction Based on the Motor Movement

Component Testing:

Custom testing consists of testing each component (ESP32-CAM, motor, drive motor, and DC-DC power supply) individually to determine proper functionality before installing them in the system.

Motion Test: Performing a simple test to determine if the motor is responsive enough to handle the signal. Check forward, backward, left, right, and reverse movements.

System Integration Testing:

Full System Test: Testing the complete system to ensure that all components function properly. This involves evaluating visual content, motor control, and network connectivity. The design has a pan-tilt correction mechanism for smooth and precise camera movements. Changing engine control codes to get the optimal response (See Figure 9).

Remote Control Setup:

User-Friendly Design: Making the web interface intuitive and easy to use. It should include video streaming and motor control buttons for forward, backward, left, right, and pan-tilt.

Integration: Ensuring that the interface interacts well with the ESP32-CAM and motor driver.

Stable Wi-Fi connection: it should Make sure the ESP32-CAM has a stable Wi-Fi connection. This may include changing Wi-Fi settings or increasing signal strength.

Security Features: Basic online security measures like password protection should be added to prevent intrusions.

2.4 Advantages and Disadvantages

The use of mobile robots in remote surveillance marks a significant leap in security and monitoring technology. Traditional surveillance solutions, such as fixed CCTV cameras, are frequently limited in coverage, have considerable installation costs, and are inflexible. Mobile robots with real-time video monitoring capabilities, such as those powered by ESP32-CAM modules, provide a more adaptable and cost-effective alternative. These robots can explore different situations and provide powerful and comprehensive control that responds to security changes. Mobile

robots leverage the capabilities of IoT to improve real-time, remote control, and efficiency, making them the perfect tool for today's security operations [4].

2.4.1 Advantages

1. Improved coverage and coverage changes:

Mobility: Mobile robots don't stay in one specific location, allowing them to cover more areas within an installation. This is especially useful in large or complex environments such as factories, shopping malls, and universities, where the camera may miss an important point [3].

Compatibility: These robots can be manually programmed or controlled to change their security methods based on their current needs. For example, they can be instructed to maintain a high-security facility at various times, providing active coverage.

2. Monitoring and time management:

Rapid response: Robots equipped with ESP32 and ESP32-CAM modules broadcast video in real-time, allowing security personnel access to visual information in emergencies in the security area [8].

Remote operation: Users can use the Internet to operate the robot from anywhere. This is especially useful in situations where physical presence is not possible or safe. For example, security personnel can monitor and control the robot from a central control room or even at home [2]

3. Cost of operation:

Low installation cost: Traditional CCTV systems require extensive cabling and equipment, which can be expensive. Mobile robots eliminate the need for such installations, greatly reducing initial setup costs [1-13].

Reduced maintenance: Mobile robots are often easier to maintain than fixed systems. It does not suffer from the wear and tear associated with the permanent installation, and it can be repaired without damaging the structure.

4. Range:

Multiple applications: These robots can be used in many different places, such as homes, offices, warehouses, and public places. They can adapt to different security needs, such as patrolling, monitoring dangerous areas, and monitoring large gatherings [5].

Improved performance: In addition to visual inspection, mobile robots can use other sensors (such as thermal cameras, and gas sensors) to detect different environmental conditions, improving their overall performance.

5. User-friendly interface:

Ease of use: The control interface of these robots is designed to be user-friendly, often using a screen that allows users to control the robot and watch videos live fast. This research clarifies that even workers without technical experience can work well in the system [6].

2.4.2 Disadvantages

1. limited battery life:

Mobile robots use batteries, which lowers their functioning duration. Depending on the robot's battery capacity and energy usage, the battery may need to be charged or changed regularly, thereby disrupting current monitoring tasks [20].

2. Connectivity Issues:

Remote control performance and timely picture recording rely significantly on a stable network. In regions without Wi-Fi or with limited Internet connectivity, video streaming may be sluggish or sporadic, and operational commands may be delayed or lost, impacting overall performance [21].

3. Weaknesses in interference:

Signal Interference: Other devices that use the same radio frequency as these robots may interfere with their wireless communications. This can cause television interference or loss of control or loss signal, especially in electromagnetic (EMI) situations.

4. Navigation issues:

Obstacle avoidance: Mobile machines need smart technology and algorithms to overcome obstacles. Smooth walking can be difficult in busy or built-up areas, such as industrial areas with moving machines [1].

Limitations: Not all mobile robots are designed to operate on difficult or uneven terrain. Machines may navigate stairs, ramps, and areas with rough or uneven surfaces, which can limit work opportunities [1].

5. Security concerns:

Like any other IoT device, mobile trackers are vulnerable to unauthorized access. Unauthorized access may lead to invasion of privacy or the use of robots. Internet security measures should be implemented to reduce these problems [11].

6. Initial Costs and Complexity:

Development costs: Although mobile robots can be expensive in the long run, initial development costs, including hardware resources, software development, and system integration, can be significant.

System Integration: Connecting various components such as cameras, sensors, motors, and communication equipment requires technical expertise. Ensuring trouble-free operation and system reliability can be difficult and resource-intensive.

2.5 Legal and Ethical Concern

2.5.1 Legal concern

Using mobile robots in in-house auditing raises several legal issues that must be appropriately addressed to comply with existing laws and regulations. One of the most important issues is privacy. Mobile devices equipped with cameras and sensors can randomly scan private areas without the user's permission, which violates privacy rules. It is essential to comply with data protection rules, such as the General Data Protection Regulation GDPR in Europe [22]. These rules provide tight guidelines for the collecting, storage, and sharing of personal data, ensuring that individuals' privacy rights are not abused.

Compliance with labor, state, and federal regulations is also important. Special permits or licenses may be required for the use of security robots, especially in public

or private areas. To avoid legal consequences, these robots must comply with all data protection and collection guidelines. Moreover, method concerns come to the fore in case the robot causes an accident or damage. Determining responsibility for events includes clear instructions and responsibilities for resolving possible problems [24].

While cell phone tracking equipment has many benefits, it is important to address the legal issues surrounding its use. This includes protecting confidential information, ensuring compliance, monitoring liabilities, and protecting intellectual property rights. By properly addressing these legal challenges, the use of mobile robots can be done legally.

2.5.2 Ethical Concerns

The use of mobile devices for monitoring work poses a variety of ethical considerations that must be addressed in order to guarantee that they serve a purpose and are used correctly. One of the first ethical issues is a possible breach of confidence. Safeguarding should be done transparently, with people's information and, where applicable, their consent. Ethics protection practices require clear boundaries to avoid unnecessary interference with privacy, ensuring that monitoring is limited to relevant areas. Another important ethical problem is discrimination and discrimination. Artificial intelligence and machine learning algorithms used in surveillance technologies must be created to eliminate biases that might lead to the incorrect targeting of specific populations. It is critical that these methods are used fairly and do not discriminate against persons based on race, gender, or other factors. Functional effect is another key factor to consider. The integration of robots into security operations may result in the layoff of security people. Social and economic consequences must be handled by offering training opportunities and looking into other work options for individuals impacted. Freedom and control are also ethical

challenges. Although robots can work independently, some level of human supervision is required to make the right decisions in complex situations. Clear questions must be asked about the decisions made by autonomous robots, explaining the robot's behavior in different situations. Safety risks associated with the use of protective equipment have a positive effect. These bots are associated with hacking and other cyber threats and can be used for malicious purposes. Establishing an effective cyber security system is important to prevent illegal access and ensure the appropriate use of technology. Understanding and detailing the use of monitoring tools is essential to maintaining public trust. In terms of transparency, it is important to provide clear information about how stored data is used, who can access it, and how long it is stored. Establishing an accountability system that includes criteria for monitoring and assessing the usage and effectiveness of security solutions helps to ensure ethical compliance. To address valid mobile device and remote monitoring issues, it is necessary to preserve privacy, avoid harassment and discrimination, assess impact and responsibility, provide independence and control, reduce security threats, and maintain openness and accountability. By resolving these ethical issues, we can introduce robots while protecting individual rights and encouraging justice and trust [23].

2.6 Application of the Mobile Robot for Remote Surveillance Through Video Monitoring (MR-RSVM)

1. Protection and Security:

MR-RSVM is used for protection and security in various places including factories, warehouses, public places, and border areas. Equipped with cameras, sensors, and other surveillance equipment, the MR-RSVM can scan specific areas, detect

intrusions, and provide real-time video to operators, enabling situational awareness and threat response [10].

2. Visual monitoring:

MR-RSVM allows real-time monitoring of different environments, helping workers to analyze problems without being physically present. These services are especially useful in dangerous or hard-to-reach areas where human presence is impossible or dangerous [6].

3. Industrial Surveillance:

Mobile robots are employed to patrol large areas like warehouses, manufacturing plants, and construction sites where human monitoring can be difficult.

Detect dangers: They may detect safety dangers, equipment faults, and environmental concerns like leaks or spills, therefore preventing accidents and ensuring compliance with safety laws [2].

Prevent Unauthorized Access: By monitoring entry points and restricted areas, they enhance security protocols [2].

4. Health care:

Mobile Robots are especially important during a health crisis like COVID-19, mobile robots are used in the following situations:

Patient monitoring: Robots with cameras in hospitals and homes medicine can scan patient rooms, helping medical staff see patients. Without direct physical contact [11-6].

Implementation of safety rules: Can ensure that patients support proper isolation or isolation.

Delivery: Some robots can deliver drugs and medical equipment, reducing human contact and the risk of spreading disease [11-6].

Chapter 3

Hardware Implementation and Results

The results chapter of this mobile robot for remote surveillance project report examines all of the findings and outcomes obtained via rigorous research, testing, and evaluation. This chapter will provide a comprehensive review of the mobile robot for remote surveillance system's performance, safety, and reliability. The chapter gives critical insights into the mobile robot's capabilities and limitations in remote surveillance. The findings given here provide a foundation for further discussion, highlighting significant successes, challenges, and recommendations for future developments in mobile robots for remote surveillance technologies.

3.1 Hardware implementation

The mobile robot is the front-end killer part of the system, which replaces the worker in the field. The hardware usually includes a mobile bus, ESP32-Cam, motors, motor drives, DC-DC voltage regulators, and a series of broken servos. The mobile robot allows free movement, which is necessary to perform the control functions assigned to the servo controller. ESP32-Cam, motor, drive motor, DC-DC power supply, servos, strap-tilt, and other components are loaded into the vehicle. When working, the mobile robot receives instructions from the users. This design has a strong chassis that provides stable performance and high load capacity, which allows the vehicle to perform well in various road conditions. The power supply module is the power source of the whole hardware system. The setup requires a 12V DC battery. Due to the different operating voltages of different chips, the voltage must be reduced. This design uses a non-isolated buck module with an input voltage of 12V DC and an output voltage of 5V and 3.3V and provides an output power of 75W, which is provided by the controller and the motor.

The camera is a free-standing 2-megapixel camera mounted on a platform in the center with a tilt system. During operation, the servo console can be controlled to move up and down, allowing the user to view the environment in detail.

For the system to work well at night or in low light, an ESP32-Cam table lamp is used. The operator can turn on the light from the web interface.

In this design, the car controller uses the ESP32-Cam. This component is responsible for sending the collected video data to the tracking controller. The router is used as a wireless communication module. During operation, the wireless communication module creates a LAN and the control unit that follows it searches for and connects to this LAN. The video image of the site is transferred to the display end through the interface. At the same time, the control signal of the controller is transmitted to the display terminal through the web interface, and then the air is transmitted to the mobile robot to control its movement [2].

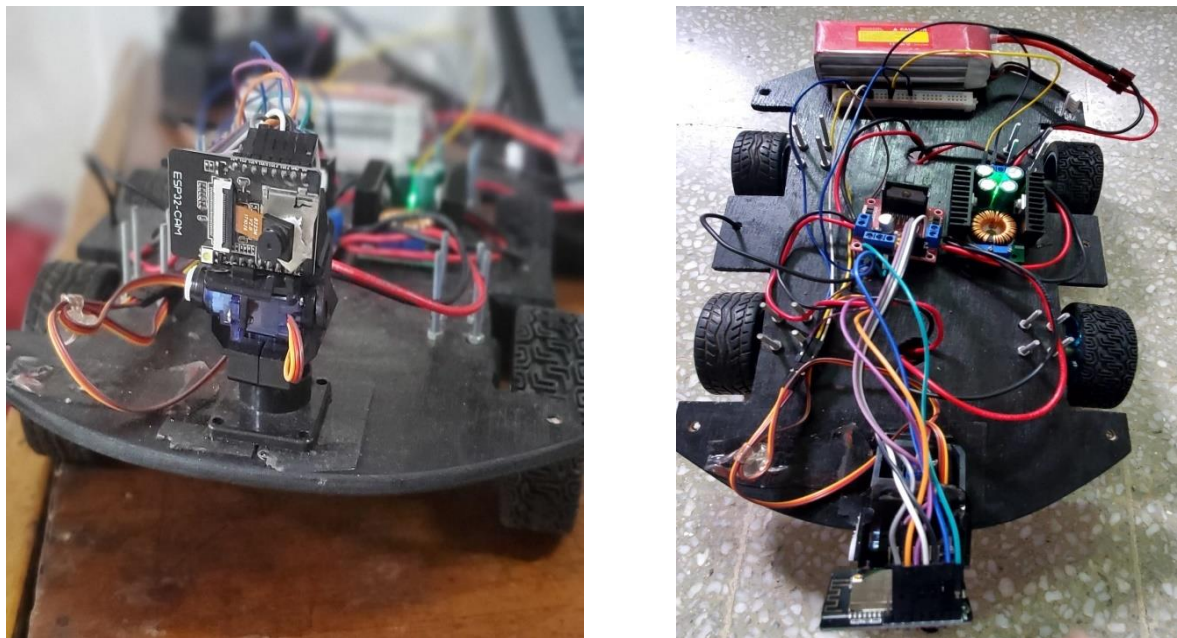


Figure 12. Mobile Robot for Remote Surveillance

3.2 Discussion of the Results

Our surveillance robot car has been thoroughly tested, displaying exceptional performance across key characteristics. The pan-tilt mechanism is very sensitive, enabling the robot to quickly shift its viewing angle and record multiple angles (see image). Using the ESP32-CAM module, the robot excelled in real-time monitoring, providing crisp and uninterrupted video streaming.

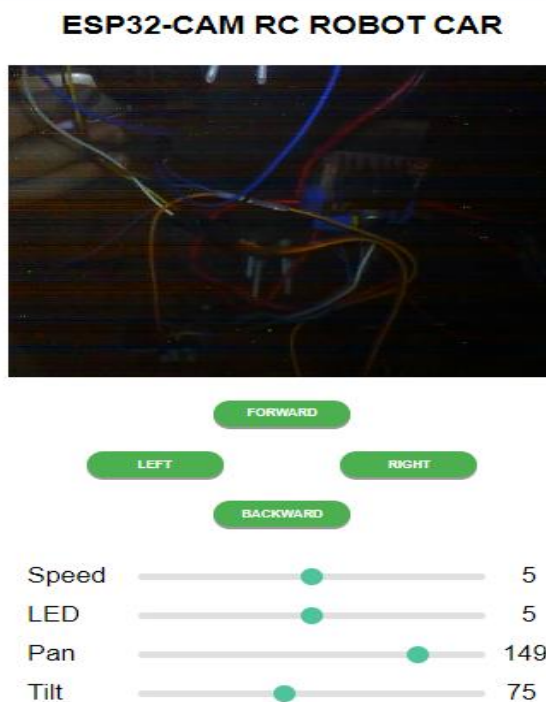


Figure 13. Web Interface to Control Robot

using a web interface [High-quality screenshots of real-time video feeds]. The robot moved smoothly and quickly in response to user orders for forward, backward, left, and right motions (see Figure 13). The integrated obstacle detection esp32-cam

proved incredibly successful, allowing the robot to navigate through tough areas with accuracy.

The installation of remote control via a smartphone or PC window demonstrated user-friendly operation, with effective control of the robot's motions.

The robot maintained a solid connection via Wi-Fi, ensuring constant live broadcasting and responsive control signals.

The interaction with the phone or PC window effortlessly delivered the live video feed acquired by the robot's camera, increasing the ease of monitoring and management. In conclusion, our surveillance robot car has effectively proved its capabilities in pan-tilt operation, real-time monitoring, directional motions, obstacle detection, smartphone-controlled operation, and PC/wireless communication. These findings validate the dependability and adaptability of our technology. It is positioned as an effective option for security, surveillance, and remote exploration.

To control MR-RSVM from anywhere we used the NGROK application where this application will generate a global IP address instead of the local IP address so this global IP address will allow us to control a robot from anywhere smoothly.

Chapter 4

Demonstration Of Outcome Based Education (OBE)

4.1 Introduction

Remote surveillance is an important part of the security system, which allows to monitor and protect different environments without being physically present. Traditional surveillance methods often involve stationary cameras that rely on a fixed field of view, which limits their effectiveness in covering large areas or in changing environments [11].

However, the appearance of mobile devices for monitoring has changed this area. A mobile robot with an advanced camera system offers many advantages when combined with visual surveillance.

They can cross complex terrain and reach hard-to-reach places, providing full coverage. Unlike static cameras, these robots can move and change their position instantly, ensuring that nothing suspicious is detected.

monitoring apps for mobile devices are great [13].

These robotic systems are also very valuable in industrial monitoring, construction sites, and critical infrastructure where human access can pose a risk.

4.2 Addressing COs and Pos

The following table shows the COs for EEE 4700/4800 (Project and Thesis)

Table 1. Addressing COs and POs

COs	CO Statement	POs
CO1	Identify a contemporary real-life problem related to electrical and electronic engineering by reviewing and analyzing existing research works.	PO2
CO2	Determine functional requirements of the problem considering feasibility and efficiency through analysis and synthesis of information.	PO4
CO3	Select a suitable solution and determine its method considering professional ethics, codes and standards.	PO8
CO4	Adopt modern engineering resources and tools for the solution of the problem.	PO5
CO5	Prepare management plan and budgetary implications for the solution of the problem.	PO11
CO6	Analyze the impact of the proposed solution on health, safety, culture and society.	PO6
CO7	Analyze the impact of the proposed solution on environment and sustainability.	PO7
CO8	Develop a viable solution considering health, safety, cultural, societal and environmental aspects.	PO3
CO9	Work effectively as an individual and as a team member for the accomplishment of the solution.	PO9
CO10	Prepare various technical reports, design documentation, and deliver effective presentations for demonstration of the solution.	PO10

CO11	Recognize the need for continuing education and participation in professional societies and meetings.	PO12
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The following table shows the aspects addressed for certain Program Outcomes (POs) addressed in EEE 4700/4800 for Project and Thesis.

Table 2. Aspects Addressed for Certain Program Outcomes

	Statement	Different Aspects	Put Tick (✓)
PO3	Design/development of solutions: Design solutions for complex electrical and electronic engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.	Public health	
		Safety	✓
		Cultural	
		Societal	✓
		Environmental	✓
PO4	Investigation: Conduct investigations of complex electrical and electronic engineering problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.	Design of experiments	✓
		Analysis and interpretation of data	✓
		Synthesis of information	✓
PO6	The engineer and society: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex electrical and electronic engineering problems.	Societal	✓
		Health	✓
		Safety	✓
		Legal	✓
		Cultural	
PO7	Environment and sustainability: Understand and evaluate the sustainability and impact of professional engineering work in the solution of complex electrical and electronic engineering problems in societal and environmental contexts.	Societal	
		Environmental	✓

PO8	Ethics: Apply ethical principles embedded with religious values, professional ethics and responsibilities, and norms of electrical and electronic engineering practice.	Religious values	
		Professional ethics and responsibilities	
		Norms	
PO9	Individual work and teamwork: Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.	Individual	
		Teamwork	√
PO10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	Comprehend and write effective reports	√
		Design documentation	√
		Make effective presentations	√
		Give and receive clear instructions	√
PO11	Project management and finance: Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	Engineering management principles	
		Economic decision-making	
		Manage projects	
		Multidisciplinary environments	

The following table explains or justifies how the COs and corresponding POs have been addressed in EEE 4700/4800 (Project and Thesis).

Table 3. Explanation of How the COs and Corresponding POs Have Been Addressed

COs	POs	Explanation/Justification
CO1	PO2	In our project, we've identified a contemporary real-life problem related to enhancing security using remote surveillance technology. By using ESP32-CAM modules. For example, during COVID-19 it was very dangerous to touch the patient or to be near them, so by using surveillance robots we can monitor them safely. So, by sending the robot, we can collect the information and analyze it to make a decision.
CO2	PO4	By using an esp32-cam and other components, our robot can do the task of surveillance effectively. Once the surveillance robot is operational, we will collect data from the robot, such as video streaming captured by an esp32-cam. After that, we analyze the data to identify patterns or anomalies and assess the system's performance
CO4	PO5	By employing modern tools like the ESP32 development boards, camera modules, and programming languages like Arduino IDE, ensuring our solution is grounded in current engineering practices.
CO6	PO6	Our surveillance robot positively impacts the health of individuals, such as there are toxic gases spread in some specific areas of the factory or in-house which will affect workers' health, by sending the robot to that area to collect the data, it will reduce the risk that workers will face. We can control the movement of the surveillance robot that's why it's safe for society
CO7	PO7	By decreasing the need for human patrols, the robot lowers carbon emissions and provides advanced environmental monitoring, contributing to sustainability.
CO8	PO3	We designed our project with the help of an esp32-cam to prevent accidents, monitor, and ensure safety by making the robot controllable.
CO9	PO9	We are working as a team to achieve the solution.

CO10	PO10	Document the design process, implementation details, and testing results of the mobile surveillance robot in technical reports and design documentation. Preparing presentations to effectively communicate the project objectives, methodology, and outcomes to stakeholders.
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4.3 Addressing Knowledge Profiles (K3 – K8)

The following table shows the Knowledge Profiles (K3 – K8) addressed in EEE 4700/4800 (Project and Thesis).

Table 4. Addressing Knowledge Profiles (K3-K8)

K	Knowledge Profile (Attribute)	Put Tick (√)
K3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline	√
K4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline	
K5	Knowledge that supports engineering design in a practice area	
K6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline	√
K7	Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the engineer's professional responsibility to public safety; the impacts of engineering activity; economic, social, cultural, environmental and sustainability	√
K8	Engagement with selected knowledge in the research literature of the discipline	√

The following table explains or justifies how the Knowledge Profiles (K3 – K8) have been addressed in EEE 4700/4800 (Project and Thesis).

Table 5. Explanation of How the Knowledge Profiles (K3-K8)

K	Explanation/Justification
K3	We apply knowledge of electrical circuit, power electronics, and data communication and networking.
K6	We integrate components such as the Esp32-cam, motor driver, pan, and tilt and buck converter. So, by doing this project we are gaining more experience with hardware, software, and techniques used in engineering domains. Apply engineering principles to overcome obstacles encountered during the project process
K7	Implementing remote mobile robot surveillance can enhance public safety and security by monitoring public spaces in real-time, reducing crime rates, and fostering a sense of safety. Additionally, it can contribute to environmental sustainability by decreasing the need for human patrol, lowering carbon emissions, and providing advanced environmental monitoring capabilities. Ethically, surveillance robots offer the potential to save lives by deploying them in risky environments, protecting individuals from harm.
K8	With the help of research related to our project's field, we Identified scholarly sources offering insights into mobile robotics and surveillance systems. We integrated relevant insights into our project design and validated solutions against established research.

4.4 Addressing Attributes of Ranges of Complex Engineering Problem Solving (P1 – P7)

The following table shows the attributes of ranges of Complex Engineering Problem Solving (P1 – P7) addressed in EEE 4700/4800 (Project and Thesis).

Table 6. Addressing Attributes of Ranges of Complex Engineering Problem Solving (P1-P7)

P	Range of Complex Engineering Problem Solving	Put Tick (✓)
Attribute	Complex Engineering Problems have characteristic P1 and some or all of P2 to P7:	
Depth of knowledge required	P1: Cannot be resolved without in-depth engineering knowledge at the level of one or more of K3, K4, K5, K6 or K8 which allows a fundamentals-based, first principles analytical approach	✓
Range of conflicting requirements	P2: Involve wide-ranging or conflicting technical, engineering and other issues	✓
Depth of analysis required	P3: Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models	✓

Familiarity of issues	P4: Involve infrequently encountered issues	
Extent of applicable codes	P5: Are outside problems encompassed by standards and codes of practice for professional engineering	
Extent of stakeholder involvement and conflicting requirements	P6: Involve diverse groups of stakeholders with widely varying needs	
Interdependence	P7: Are high level problems including many component parts or sub-problems	√

The following table explains or justifies how the attributes of ranges of Complex Engineering Problem Solving (P1 – P7) have been addressed in EEE 4700/4800 (Project and Thesis).

Table 7. Explanation of How the Attributes of Range of Complex Engineering Problem Solving (P1-P7)

P	Explanation/Justification
P1	The project requires the knowledge of basic electrical and electronic circuits, and Knowledge of wireless communication protocols for remote control and data transmission.
P2	balancing mobility with stability for efficient navigation and steady video capture. We are optimizing battery life while meeting performance demands for speed and data processing. We are selecting camera resolution to balance video quality with bandwidth constraints. We are ensuring real-time monitoring with minimal latency while managing costs effectively.
P3	Environment Analysis: To understand the different environments the robot may encounter. Risk Analysis: Identifying potential risks and challenges in surveillance scenarios, such as obstacles, lighting conditions, and Data Analysis.
P7	The project has interconnected subsystems, including ESP32-CAM, motor driver, DC gear motor, servo motor and voltage regulator.

4.5 Addressing Attributes of Ranges of Complex Engineering Activities (A1 – A5)

The following table shows the attributes of ranges of Complex Engineering Activities (A1 – A5) addressed in EEE 4700/4800 (Project and Thesis).

Table 8. Addressing Attributes of Ranges of Complex engineering Activities (A1-A5)

A	Range of Complex Engineering Activities	Put Tick (✓)
Attribute	Complex activities mean (engineering) activities or projects that have some or all of the following characteristics:	
Range of resources	A1: Involve the use of diverse resources (and for this purpose resources include people, money, equipment, materials, information and technologies)	✓
Level of interaction	A2: Require resolution of significant problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues	✓
Innovation	A3: Involve creative use of engineering principles and research-based knowledge in novel ways	✓
Consequences for society and the environment	A4: Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation	✓
Familiarity	A5: Can extend beyond previous experiences by applying principles-based approaches	

The following table explains or justifies how the attributes of ranges of Complex Engineering Activities (A1 – A5) have been addressed in EEE 4700/4800 (Project and Thesis).

Table 9. Explanation of How the Attributes of Range of Complex Engineering Activities (A1-A5)

A	Explanation/Justification
A1	The project involves a budget for equipment and materials, equipment (robotic hardware, camera, communication modules), materials (construction materials for the robot chassis), and information (technical documentation, research papers).
A2	Designing a mobile surveillance robot to balance mobility with stability, optimize battery life while ensuring performance, and integrate hardware and software components seamlessly.
A3	This project includes implementing solutions for real-time video streaming, and remote-control functionalities using technologies and methodologies.
A4	Our mobile surveillance robot enhances security measures in various settings, improving situational awareness and response capabilities.

Chapter 5

Conclusion

The last chapter is the end of our comprehensive review, summarizing the progress achieved in the development of MR-RSVM and its impact on many stakeholders, including individuals, companies, and society. people. By considering the goals set at the beginning of our research, we can evaluate the extent to which they have been achieved and obtain important results that contribute to the ongoing debate MR-RSVM. Rapid technology development has changed MR-RSVM, leading to the future of MR-RSVM appearing as an available option.

As we approach the end of our study MR-RSVM, we take the time to reflect on the ideas, findings, and implications of our research.

5.1 Summary of the Findings

The MR-RSVM, equipped with pan-tilt capabilities and advanced features, represents a significant advancement in security and surveillance technology. The pan-tilt feature improves the robot's coverage and ability to negotiate different environments.

MR-RSVM demonstrates extraordinary adaptability. It can be used to include dangerous The ESP32-CAM module offers live streaming and a user-friendly web interface for easy remote operation. This combination provides a flexible and responsive system for monitoring and controlling different situations. A combination of intelligent control systems, including esp32 programming, motor, motor drive, and DC-DC regulator, enables the robot to make precise movements based on human control. Beyond traditional surveillance applications, the situations such as mine accidents and civil disasters, as well as agricultural monitoring, reflecting the

changes in global conditions. The ability of robots to transmit real-time data, video surveillance, and dynamic terrain navigation is an important tool for improving safety and security.

As technology advances, MR-RSVM represents a revolutionary change in security strategy, providing efficient, cost-effective, and flexible solutions for many applications. Its ability to monitor traffic, enforce safety rules, and respond effectively demonstrates its critical role in promoting a safe and secure environment. Remotely operated surveillance rovers are crucial in situations like mining accidents or urban disasters to assess damage and plan evacuation routes, ultimately saving lives. Monitor critical regions of Skilled professionals are sometimes dispatched in combat zones or enemy areas to monitor changes, but this comes with the danger of being captured by the enemy. However, recent technological advances have enabled remote monitoring of important zones using rovers rather than humans. In other cases, places may only require video monitoring for a limited time, therefore establishing permanent CCTV systems may be impractical, particularly in agricultural settings. For example, farms may only require video monitoring once crops have matured, but pastures must be monitored while cattle are grazing. Furthermore, the region's best suited for monitoring, such as meadows, fields, and hills, frequently lack power. In such instances, mobile video surveillance using the MR-RSVM is a more practical and cost-effective option than stationary surveillance systems. Mobile rovers are cost-effective and handy for the agricultural industry, as they do not require costly infrastructure, poles, or cables.

5.2 Limitations of the Study

A mobile robot used for video surveillance has several important parameters. First, their working time is limited by battery life and high power, requiring frequent charging or replacing the battery, which limits their effectiveness in monitoring time.

Communication and connectivity are another challenge, as these robots rely on stable and high-speed connections for real-time video transmission. Signal degradation and interference from other electronic devices can disrupt communications, causing latency issues and possible data loss.

Movement is also a concern; Mobile robots have difficulty traversing uneven terrain such as stairs, slopes, or chaotic environments, and obstacles such as closed paths or narrow paths may prevent traversal in certain areas. The field of view of the camera installed in these robots is limited and must always be installed to cover a large area. In addition, poor lighting conditions, light, or low camera can affect the quality of the image, making it difficult to capture the white image, it can be useful to capture images. Environmental factors such as dust, fog, or extreme temperatures can reduce the accuracy and reliability of the sensor.

In addition, human reviewers may be required to interpret video footage and identify hazards or errors. Automated systems have difficulty understanding and interpreting complex situations, which leads to the need for constant human supervision.

Leadership independence in decision-making is another serious challenge. Although advanced algorithms have been developed, complete tasks are still difficult to achieve, often requiring manual control, which delays response time and depends on human operators. Effective planning in a dynamic environment requires math and sophisticated solutions. Data security is important since video and data management transmitted over the network is easy to access and hack if not properly encrypted, raising serious security concerns. In addition, surveillance programs raise privacy concerns that are important for adherence to legal and ethical standards to protect individual privacy rights.

The cost of shipping high-end mobile devices can be prohibitive, and advanced features require a large initial investment. Regular maintenance and repair increase

labor costs, as regular maintenance is necessary to keep robots working and working efficiently. In addition, extreme weather conditions such as heavy rain, snow, or strong winds can damage the robot's performance and video quality, while environmental obstacles such as animals or debris fall. may damage the robot or prevent its operation. These parameters should be carefully considered and minimized to maximize the performance and reliability of the mobile robot security system.

5.3 Future Improvement

The future of mobile devices for remote video surveillance is rapidly evolving. As technology advances, we will see mobile robots with increasingly advanced video surveillance capabilities, altering the way we approach security and monitoring.

Robotic mobility will be one of the most significant aspects of progress. Advances in autonomous driving and obstacle avoidance technology enable these mobile devices to move slowly and precisely in difficult environments, allowing them to enter hard-to-reach areas and provide complete protection.

In addition, the integration of modern camera systems and video analysis will increase the ability of robots to capture high-quality images and identify potential risks or errors immediately. Innovations in computer vision, deep learning, and image processing enable these mobile robots to detect and track targets with unprecedented precision, providing valuable information to security personnel.

In addition, the combination of advanced communication technologies such as 5G and Wi-Fi 6 ensures uninterrupted and reliable data transmission, making video content available on devices Mobile is available at any time even in remote or difficult places. This allows security teams to respond quickly and effectively to any situation that arises.

The integration of solar cells into mobile robots for sensing is a major step forward in providing a continuous energy source. Solar panels allow the robots to assemble themselves during the day, greatly increasing their working hours without the need for manuals. This ability reduces the dependence on the port and reduces the need for human assistance, thus increasing the capacity and efficiency of the robot. In addition, the use of solar energy promotes green projects by reducing the carbon footprint associated with traditional energy sources and can result in long-term savings in electricity and battery replacement. These advantages make solar cells a valuable addition to mobile robotic systems, enabling long-term and reliable monitoring operations.

The use of modern battery technology such as lithium polymer (LiPo) and solid-state batteries increases the performance of mobile devices. LiPo batteries offer high power, lightweight design, and fast charging capabilities, which contribute to long service life and low downtime. On the other hand, solid-state batteries offer greater safety and stability thanks to solid electrolytes that reduce the risk of leakage and fire. They provide life and even higher energy density, enabling robots to run longer and with more battery changes. Together, these advanced battery technologies address key barriers to energy management, making mobile robotic security systems more efficient, safe, and reliable.

Using the most recent advances in robotics, computer vision, and artificial intelligence, the future of mobile robots for observation and video surveillance holds enormous promise. As these technologies advance, we may anticipate a new generation of mobile phones that will redefine security and surveillance norms, delivering unprecedented possibilities to defend communities and our assets.

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