ABSTRACT

This project presents the design and implementation of a cost-effective surveillance robot using the ESP32-CAM module, aimed at enhancing security in residential, industrial, and commercial, environments. The robot is equipped with a camera for live video streaming and is controlled wirelessly through a mobile device or web interface. The ESP32-CAM module serves as the core component, providing real-time video feed, image capture, and wireless communication capabilities. The robot operates autonomously or through remote control, featuring obstacle detection and avoidance mechanisms. Its compact design and low power consumption make it suitable for various applications, including indoor and outdoor surveillance. The low-cost nature of the ESP32-CAM module allows for scalable deployment, enabling the implementation of a fleet of surveillance robots for broader coverage at a fraction of the cost of traditional systems. This project highlights the potential of embedded systems and wireless technologies in creating innovative, budget-friendly security solutions tailored to meet the demands of modern surveillance.

OBJECTIVES:

The primary objective of this project is to develop a mobile surveillance robot utilizing the ESP32-CAM module that can:

- Provide real-time video surveillance over a Wi-Fi connection.
- Be controlled remotely via a mobile or web-based interface.
- Include basic obstacle detection and avoidance functionality to navigate autonomously.
- Be lightweight, energy-efficient, and easy to deploy in different environments.
- Serve as a low-cost, scalable alternative to traditional surveillance systems, enhancing security with minimal human intervention.

CHAPTER 1

INTRODUCTION

With the increasing demand for security in residential, commercial, and industrial settings, surveillance systems have become critical for asset protection and monitoring. Traditional surveillance setups often depend on fixed cameras and extensive wiring, making them costly and rigid. However, advancements in wireless communication and embedded systems have led to the creation of low-cost, portable, and efficient surveillance solutions. This project presents a surveillance robot designed using the ESP32-CAM module, a budget-friendly microcontroller equipped with an integrated camera and Wi-Fi functionality.

The ESP32-CAM module enables live video streaming and remote monitoring, making it well-suited for surveillance applications. Unlike conventional fixed-camera systems, this mobile robot offers dynamic monitoring by patrolling specified areas autonomously or being manually controlled to inspect specific locations. Users can wirelessly control the robot through a smartphone or web interface, allowing real-time viewing of the video feed and movement control. The robot also features basic obstacle detection and avoidance, facilitating autonomous navigation. These capabilities make the system highly versatile and adaptable to various indoor and outdoor environments.

Compared to traditional systems, this surveillance robot provides several advantages: it can cover large areas with mobility, is cost-effective thanks to the affordable ESP32-CAM module, offers flexibility for deployment in diverse locations, and enables remote monitoring with real-time video access over Wi-Fi, allowing users to oversee their premises from anywhere.

CHAPTER 2

LITERATURE SURVEY

1.Smart ESP32 based Surveillance car with Temperature & Fire Detection:

Published in: 2023 Department of Electronics and Communications, Sagar Institute of Science & Technology, Bhopal, Madhya Pradesh, India.

Author: Sahil Rizvi, Deepak Koge, Kashi Prajapati

A cost-effective surveillance robot using the ESP32-CAM has been developed for both indoor and outdoor monitoring, combining security and fire control capabilities. With Wi-Fi and Bluetooth connectivity, the robot enables remote control, high-quality imagery, and real-time video transmission. Equipped with flame and temperature sensors, it detects and responds to fires, and the ESP32-CAM provides live monitoring, making it ideal for remote fire detection and suppression.

2.Robotic car using NodeMCU ESP8266 Wi-Fi Module:

Published in: 2023 9th International Conference on Advanced Computing and Communication Systems

Author: Siddesh G K, Rakesh Kumar Patel, Saiyan Maitra

The ESP32-CAM module enables this robot to collect visual data and maintain a Wi-Fi connection for remote control within range. Its movement is powered by an L298N motor driver connected to four DC motors, allowing precise control of each wheel. Visual data is transmitted to a connected device, such as a smartphone, for real-time monitoring. Built with a durable plastic base, this robot is suited for rugged environments like industrial sites or underground mines.

3.IOT Surveillance Robot Using ESP-32 Wi-Fi CAM & Arduino:

Published in: 2022 Department of Electronics and Communication Engineering, Balaji Institute of Technology and Science, Warangal, Telangana, India

Author: Dr . Nookala Venu

This project develops a spy robot that automatically detects and reports border trespassers to nearby security units, aiding military operations in high-risk areas. Based on a Raspbian operating system, this IoT-enabled robot platform allows remote monitoring and control, enhancing safety, reducing human error, and strengthening national security. It features a Raspberry Pi, night vision camera, and sensors.

4.Real time Surveillance using ESP32 Cam module:

Published in: 2023 Grenze International Journal of Engineering & Technology (GIJET)

Author: Varsha Dange, Pritam Shinde, Nikhil Shinde

The system uses a machine learning algorithm to detect fog in images captured by a camera, providing alerts to farmers if fog levels are too high. Field tests showed high accuracy and low false alarms, confirming the system's effectiveness. This camera-based fog detection offers a valuable tool for farmers to protect crops from fog-related damage, particularly during high-humidity months from October to March.

5. Internet Regulated ESP32 Cam Robot:

Published in: 2023 7th International Conference On Computing, Communication, Control And Automation (ICCUBEA)

Author: Kartikeya Verma, G S Charan, Anish Pande, Yassin Adam Abdalla, D Marshiana, Chandan Kumar Choubey

Continuous monitoring is crucial for crime prevention, public safety, and disease control. A surveillance system using an ESP32-CAM, WiFi module, motor driver, and FTDI USB-UART interface provides a safer alternative to human involvement, protecting personnel like doctors and nurses from exposure to severe diseases while allowing remote observation and assessment.

6. Remotely Controlled Firefighting Robot with ESP32-CAM Module:

Published in: 2023 2nd International Engineering Conference on Electrical, Energy, and Artificial Intelligence (EICEEAI)

Author: Ayman Yahya, Arbad Sarhan, Lewaa Omar, Majd Derar, Bassam Al-Qadi, Samer Alsadi, Tareq Foqha, Louai A. Maghrabi, Mohammad Kanan

Firefighting robots are designed to assist in hazardous conditions too dangerous for human firefighters. This study presents a prototype of a Wi-Fi-controlled firefighting robot with an ESP32-CAM module and water pump, allowing real-time video streaming from fire scenes. This enables operators to make informed decisions, navigate effectively, and locate trapped individuals during rescue operations.

CHAPTER 3

SYSTEM DESCRIPTION

HARDWARE SPECIFICATIONS

(a)Arduino Uno:

Fig. 1: Arduino Uno

It is an easy USB interface. This allows interface with USB as this is like a serial device. The chip on the board plugs straight into your USB port and supports on your computer as a virtual serial port. The benefit of this setup is that serial communication is an extremely easy protocol the microcontroller brain which is the ATmega328 chip. It has more number of hardware features like timers, external and internal interrupts, PWM pins and multiple sleep modes.

(b)ESP32 - CAM:

Fig. 2: ESP32 - CAM

The **ESP32-CAM** is a low-cost microcontroller board with a built-in camera module and integrated Wi-Fi, ideal for wireless video streaming and image capture. It uses the ESP32-S chip, offering dual-core processing and Bluetooth capabilities. The module supports real-time video over a network and has a microSD slot for storing captured images or videos. The ESP32-CAM is perfect for surveillance, smart home, and IoT projects due to its affordability and versatility.

(c)Servo Motor:

Fig. 3: Servo Motor

A **Servo Motor** is an electromechanical device used for precise control of angular or linear position, speed, and torque. It operates using a feedback mechanism, which allows it to maintain accuracy. Typically, it includes a motor, a control circuit, and a position sensor. Servo motors are commonly used in robotics, automated systems, and remote-controlled vehicles for tasks requiring exact movements.

(d)L298N Motor Driver:

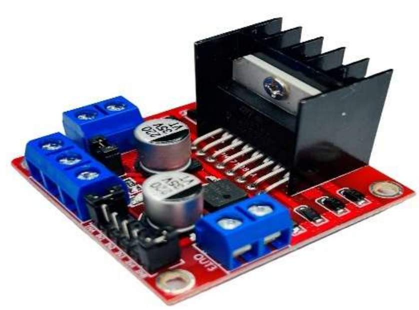

Fig. 4: L298N Motor Driver

The **L298N motor driver** is a dual H-Bridge motor driver IC that allows control of the speed and direction of two DC motors simultaneously. It can drive motors with voltages from 5V to 35V and currents up to 2A per channel. The L298N is commonly used in robotics and embedded projects to control motor movements easily.

(e)Gear Motors:

Fig. 5: Gear Motors

A **gear motor** is a combination of an electric motor and a gear system designed to reduce the speed and increase the torque output of the motor. The gear mechanism allows the motor to provide higher power at lower speeds, making it ideal for applications that require precise control and higher mechanical force, such as in robotics, automation, and vehicles.

(f)Lithium Ion Battery:

Fig. 6: Lithium-ion Battery

A **lithium-ion (Li-ion) battery** is a type of rechargeable battery that uses lithium ions as the key component in the electrochemical process for storing and releasing energy. These batteries are known for their high energy density, lightweight design, and long cycle life, making them ideal for use in portable electronics, electric vehicles, and renewable energy storage.

SOFTWARE SPECIFICATIONS

Arduino ide

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board. The Arduino platform has become quite popular with people just starting and anyone interested in creating interactive objects or environments. Arduino can interact with buttons, LEDs, motors, speakers, GPS units, cameras, the internet, and even your smart-phone or your TV! This flexibility combined with the fact that the Arduino software is free, the hardware boards are pretty cheap, and both the software and hardware are easy to learn has led to a large community of users who have contributed code and released instructions for a huge variety of Arduino-based projects

There are many varieties of Arduino boards (explained on the next page) that can be used for different purposes. Some boards look a bit different from the one below, but most Arduinos have the majority of these components in common.

Fig. 7: Arduino ide

Arduino code :

```
#include "esp_camera.h"
#include <WiFi.h>

//
// WARNING!!! Make sure that you have either selected ESP32 Wrover Module,
//            or another board which has PSRAM enabled
//
// Adafruit ESP32 Feather

// Select camera model
//#define CAMERA_MODEL_WROVER_KIT
//#define CAMERA_MODEL_M5STACK_PSRAM
#define CAMERA_MODEL_AI_THINKER

const char* ssid = "Airtel_Murali";   //Enter SSID WIFI Name
const char* password = "mura_12345";   //Enter WIFI Password


#if defined(CAMERA_MODEL_WROVER_KIT)
#define PWDN_GPIO_NUM    -1
#define RESET_GPIO_NUM   -1
#define XCLK_GPIO_NUM    21
#define SIOD_GPIO_NUM    26
#define SIOC_GPIO_NUM    27

#define Y9_GPIO_NUM      35
#define Y8_GPIO_NUM      34
#define Y7_GPIO_NUM      39
#define Y6_GPIO_NUM      36
#define Y5_GPIO_NUM      19
```

```
#define Y4_GPIO_NUM      18
#define Y3_GPIO_NUM       5
#define Y2_GPIO_NUM       4
#define VSYNC_GPIO_NUM   25
#define HREF_GPIO_NUM    23
#define PCLK_GPIO_NUM    22


#elif defined(CAMERA_MODEL_AI_THINKER)
#define PWDN_GPIO_NUM     32
#define RESET_GPIO_NUM    -1
#define XCLK_GPIO_NUM      0
#define SIOD_GPIO_NUM     26
#define SIOC_GPIO_NUM     27

#define Y9_GPIO_NUM       35
#define Y8_GPIO_NUM       34
#define Y7_GPIO_NUM       39
#define Y6_GPIO_NUM       36
#define Y5_GPIO_NUM       21
#define Y4_GPIO_NUM       19
#define Y3_GPIO_NUM       18
#define Y2_GPIO_NUM        5
#define VSYNC_GPIO_NUM    25
#define HREF_GPIO_NUM     23
#define PCLK_GPIO_NUM     22

#else
#error "Camera model not selected"
#endif
```

```
// GPIO Setting
extern int gpLb =  2; // Left 1
extern int gpLf = 14; // Left 2
extern int gpRb = 15; // Right 1
extern int gpRf = 13; // Right 2
extern int gpLed =  4; // Light
extern String WiFiAddr ="";

void startCameraServer();

void setup() {
  Serial.begin(115200);
  Serial.setDebugOutput(true);
  Serial.println();



  pinMode(gpLb, OUTPUT); //Left Backward
  pinMode(gpLf, OUTPUT); //Left Forward
  pinMode(gpRb, OUTPUT); //Right Forward
  pinMode(gpRf, OUTPUT); //Right Backward
  pinMode(gpLed, OUTPUT); //Light

  //initialize
  digitalWrite(gpLb, LOW);
  digitalWrite(gpLf, LOW);
  digitalWrite(gpRb, LOW);
  digitalWrite(gpRf, LOW);
  digitalWrite(gpLed, LOW);

  camera_config_t config;
  config.ledc_channel = LEDC_CHANNEL_0;
```

```
config.ledc_timer = LEDC_TIMER_0;
config.pin_d0 = Y2_GPIO_NUM;
config.pin_d1 = Y3_GPIO_NUM;
config.pin_d2 = Y4_GPIO_NUM;
config.pin_d3 = Y5_GPIO_NUM;
config.pin_d4 = Y6_GPIO_NUM;
config.pin_d5 = Y7_GPIO_NUM;
config.pin_d6 = Y8_GPIO_NUM;
config.pin_d7 = Y9_GPIO_NUM;
config.pin_xclk = XCLK_GPIO_NUM;
config.pin_pclk = PCLK_GPIO_NUM;
config.pin_vsync = VSYNC_GPIO_NUM;
config.pin_href = HREF_GPIO_NUM;
config.pin_sscb_sda = SIOD_GPIO_NUM;
config.pin_sscb_scl = SIOC_GPIO_NUM;
config.pin_pwdn = PWDN_GPIO_NUM;
config.pin_reset = RESET_GPIO_NUM;
config.xclk_freq_hz = 20000000;
config.pixel_format = PIXFORMAT_JPEG;
//init with high specs to pre-allocate larger buffers
if(psramFound()){
  config.frame_size = FRAMESIZE_UXGA;
  config.jpeg_quality = 10;
  config.fb_count = 2;
} else {
  config.frame_size = FRAMESIZE_SVGA;
  config.jpeg_quality = 12;
  config.fb_count = 1;
}

// camera init
```

```
  esp_err_t err = esp_camera_init(&config);
  if (err != ESP_OK) {
    Serial.printf("Camera init failed with error 0x%x", err);
    return;
  }

  //drop down frame size for higher initial frame rate
  sensor_t * s = esp_camera_sensor_get();
  s->set_framesize(s, FRAMESIZE_CIF);

  WiFi.begin(ssid, password);

  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected");

  startCameraServer();

  Serial.print("Camera Ready! Use 'http://");
  Serial.print(WiFi.localIP());
  WiFiAddr = WiFi.localIP().toString();
  Serial.println("' to connect");
}

void loop() {
  // put your main code here, to run repeatedly:

}
```

Block diagram:

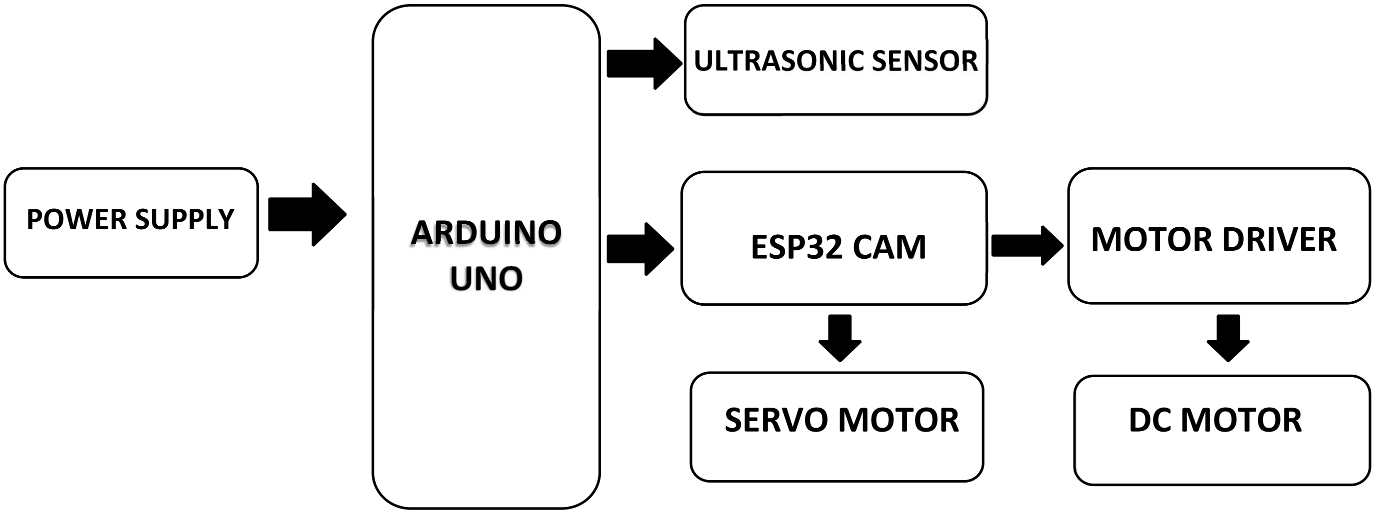

Fig. 8: Block diagram of Surveillance Robot

Description:

- **Power Supply:** 3.3V to 5V
- **Arduino uno:** Arduino Uno is a open-source microcontroller board based on the ATmega328P, featuring 14 digital I/O pins and 6 analog inputs.
- **Ultrasonic sensor:** An ultrasonic sensor measures distance by emitting high-frequency sound waves and calculating the time it takes for the echo to return.
- **ESP32 Camera:** The ESP32-CAM is a low-cost microcontroller module with an integrated camera and built-in Wi-Fi and Bluetooth, ideal for IoT applications. It

supports real-time video streaming, image capture, and remote control via wirelesscommunication.

- **Servo motor:** A servo motor is a precision-controlled motor that uses feedback to rotate to a specified angle, making it ideal for applications requiring accurate motion control. It is commonly used in robotics, automation, and remote-controlled systems.

- **Motor Driver:** A motor driver is an electronic device that controls the speed and direction of motors by receiving low-power control signals from a microcontroller. It acts as an interface between the motors and the control circuits, enabling efficient motoroperation.

- **DC Motor:** A DC motor is an electric motor that converts direct current (DC) electrical energy into mechanical motion. It is widely used in robotics and automation due to its simple control, speed variation, and reliable performance.

CHAPTER 4

METHODOLOGY

Step1: Design the system architecture and select components: ESP32-CAM for video streaming, motor driver (L298N/L293D) for motor control, DC motors for mobility, and a rechargeable power supply.

Step2: Assemble the robot chassis, attach DC motors, mount ESP32-CAM, motor driver, and sensors. Wire the components, connect the motor driver and sensors to ESP32-CAM, and set up the power supply.

Step3: Program the ESP32-CAM using Arduino IDE/ESP-IDF for Wi-Fi, camera control, motor movement, sensor processing, and communication with a web interface.

Step4: Integrate hardware and software, configure Wi-Fi for streaming and remote control, and test the web/mobile interface for smooth control and video feed.

Step5: Process sensor data for obstacle detection and implement an algorithm for autonomous navigation, adjusting the robot's path based on sensor inputs.

Step6: Test integration to ensure smooth operation of components and verify remote control functionality through Wi-Fi. Debug any issues for optimal performance.

Software model Development:

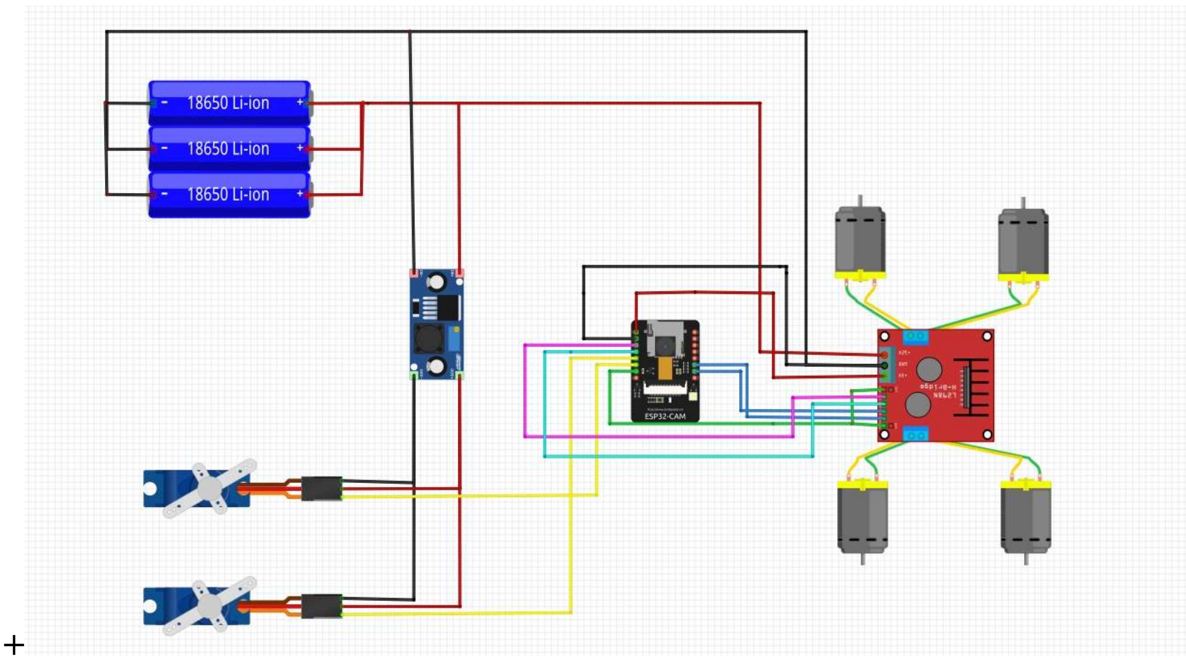

Fig. 9: Software model

Hardware Model Development:

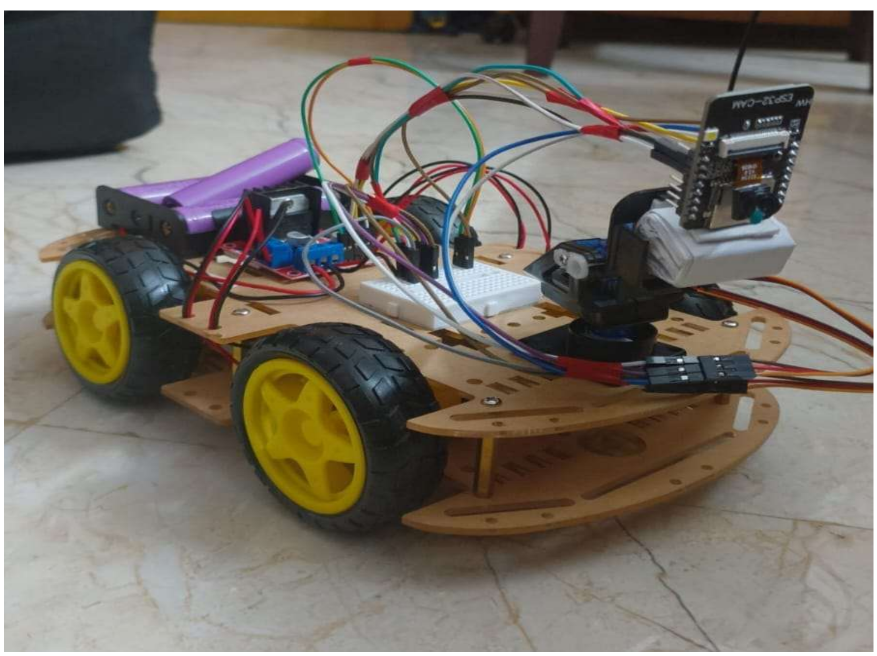

Fig. 10: Hardware model

CHAPTER 5

CONCLUSION

In this paper, a cost-effective surveillance robot is presented, developed using the ESP32-CAM module, which offers a robust solution for real-time monitoring and security applications. By harnessing the integrated camera, Wi-Fi connectivity, and computational power of the ESP32-CAM, the system enables live video streaming, remote control operations, and autonomous navigation. This mobile robot is capable of performing surveillance tasks in predefined areas, utilizing obstacle detection sensors to avoid collisions, making it suitable for both indoor and outdoor deployment scenarios.

The key advantages of this system lie in its mobility, scalability, and cost-efficiency, addressing the limitations of conventional static surveillance solutions. The ability to remotely access real-time video feeds and control the robot via a mobile app or web interface provides users with increased flexibility, enhancing overall security without the need for continuous human oversight. Furthermore, the inclusion of sensors for autonomous obstacle detection and avoidance facilitates independent operation, reducing reliance on manual intervention.

This project underscores the potential of the ESP32-CAM as a highly efficient alternative to higher-cost microcontroller platforms, delivering a lightweight, power-efficient, and compact solution for surveillance systems. Future enhancements could focus on refining the robot's navigation algorithms, incorporating advanced features such as motion detection, infrared night vision, and optimizing battery life to extend operational time. Ultimately, this surveillance robot serves as a versatile platform for various security and monitoring applications, offering a practical, scalable, and low-maintenance solution.

PROJECT GROUP PHOTO:

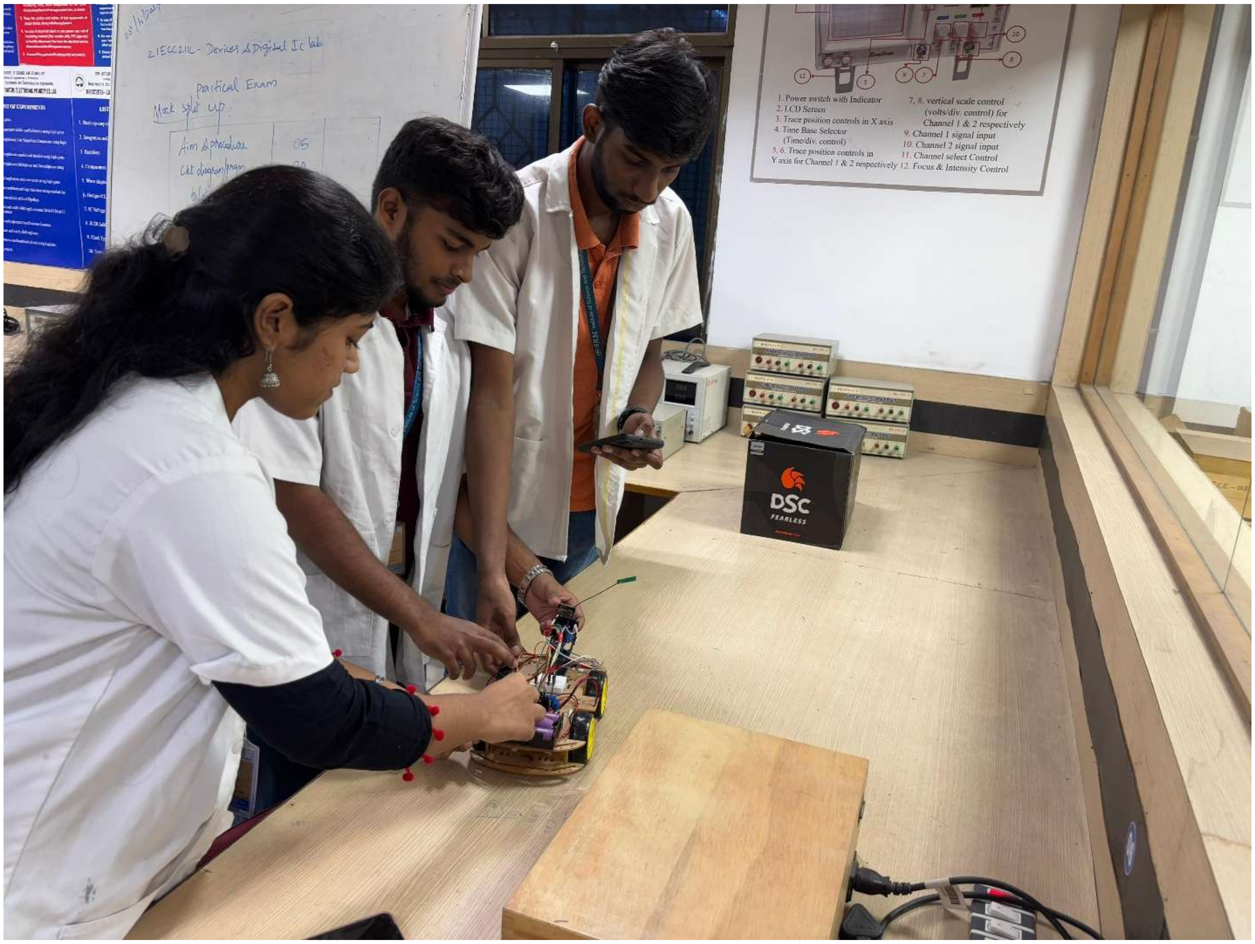

Fig. 11 Group photo with Project Model

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