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Implementation of Neo Sentinel Rover

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Abstract: The Neo Sentinel Rover is a compact security robot developed using a Raspberry Pi 4 and a set of basic sensors. It continuously monitors its surroundings using an ultrasonic sensor, fire sensor, sound sensor, and metal detector. When any unusual activity is detected, the rover activates a buzzer and immediately captures images or streams live video for remote monitoring. It also sends alert messages to notify the user in real time. This system offers a low-cost and reliable solution for security patrol, border monitoring, and remote surveillance, reducing the need for human presence in risky areas. Its simple design makes it easy to maintain, while its modular structure allows future upgrades and additional intelligence features.

Keywords: Raspberry Pi, Internet of Things, Security Rover, Video Streaming, Ultrasonic Sensor, Remote Surveillance.

I. INTRODUCTION

Security challenges in sensitive and unmanned locations demand systems that can observe, react, and report without relying on constant human presence. With advancements in compact processors and affordable sensors, mobile surveillance robots have become a practical and reliable option for such environments. The Neo Sentinel Rover is designed with this purpose in mind, functioning as a self-moving security unit capable of detecting unusual activities and providing real-time updates.

Using a Raspberry Pi 4 as its processing hub, the rover brings together multiple simple yet effective sensors like ultrasonic for obstacle detection, fire sensors for heat or flame identification, sound sensors for unexpected noises or bomb blast, and a metal detector for identifying hazardous metallic objects. These inputs help the rover build awareness of its surroundings and respond immediately through buzzer alerts, live video streaming, and captured images.

When any activity is detected, the rover reacts instantly by activating an onboard buzzer and capturing visual evidence through live video or still images. It also sends immediate alerts to the user, enabling quick remote decision-making without the need for physical presence. This combination of sensing, alerting, and mobility makes the rover suitable for a wide range of applications including border surveillance, military patrolling, restricted-zone monitoring, and environmental safety checks.

II. LITERATURE SURVEY

Recent studies on mobile surveillance robots show a growing shift toward compact, sensor-based platforms that can monitor restricted zones without continuous human involvement. Research on Raspberry Pi driven rovers highlights the effectiveness of real-time video streaming and remote alerts in improving security across sensitive environments. Other works emphasize the need for autonomous patrolling in border regions, where robots equipped with motion and obstacle-detection sensors help reduce risks faced by security personnel.

Multi-sensor monitoring vehicles integrating fire, sound, and environmental sensors further demonstrate how combining different sensing technologies enhances threat detection accuracy. Additional research on metal-detection robots shows the importance of automated scanning for identifying hidden metallic objects in public and high-security areas. Sound-activated surveillance models also illustrate how audio-based event detection can help identify emergencies faster and guide the robot's attention.

III. METHODOLOGY

The Neo Sentinel Rover is designed as an autonomous surveillance system capable of detecting hazards, monitoring environments, and sending real-time alerts. The Raspberry Pi 4 serves as the central processing unit, coordinating all

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sensors, controlling movement, processing data, and managing alerts. The system is powered by a solar panel connected to a voltage regulation module, ensuring uninterrupted outdoor operation without relying entirely on external power sources.

Data Acquisition: The rover collects environmental data using multiple sensors. An ultrasonic sensor detects obstacles and measures distances for safe navigation. A fire sensor monitors temperature changes and identifies potential fire hazards. A sound sensor listens for unusual noises such as loud impacts or suspicious activity. A metal detector identifies metallic objects for security or defence purposes. The Pi Camera captures images and streams real-time video, providing visual monitoring and supporting advanced detection features such as face and weapon detection.

Data Processing and Control: The Raspberry Pi processes all input data to determine the rover's response. Signals are sent to the motor driver to control DC motors for movement, while a servo motor adjusts the camera or performs additional mechanical actions. A ZigBee module allows wireless communication, sending alerts and status updates to a Telegram bot on the user's smartphone.

Output and Alerts: Upon detecting any abnormal condition, such as obstacles, fire, loud noises, or metal objects, the buzzer provides immediate local warnings. Simultaneously, alerts and live video are transmitted to the user for remote monitoring.

Data Management and Logging: All detected events, video streams, and sensor readings can be logged in the Raspberry Pi's memory for later analysis. This enables reviewing patterns of activity, improving future navigation strategies, and enhancing overall system reliability. Such data logging also supports reporting for defence or security operations, providing a detailed record of incidents and environmental conditions.

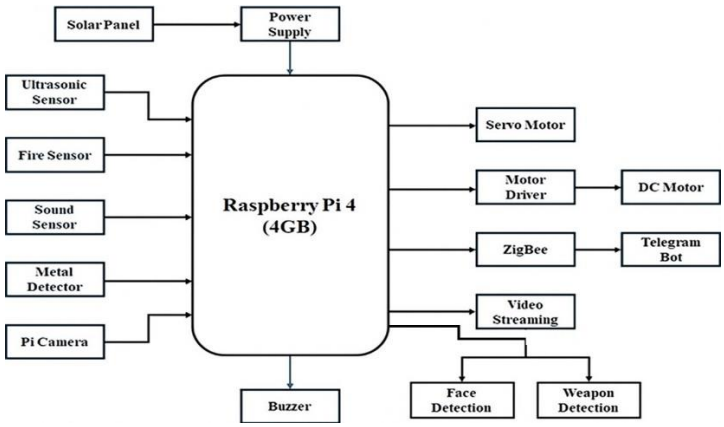

Figure 1: Block Diagram of Proposed System

IV. IMPLEMENTATION

The class diagram illustrates the static structure of the Neo Sentinel Rover system, highlighting the key classes, their attributes, and the relationships between them. It provides a clear overview of how different components, such as sensors, actuators, and the Raspberry Pi controller, interact within the system. This diagram serves as a blueprint for understanding the modular design and data flow in the rover.

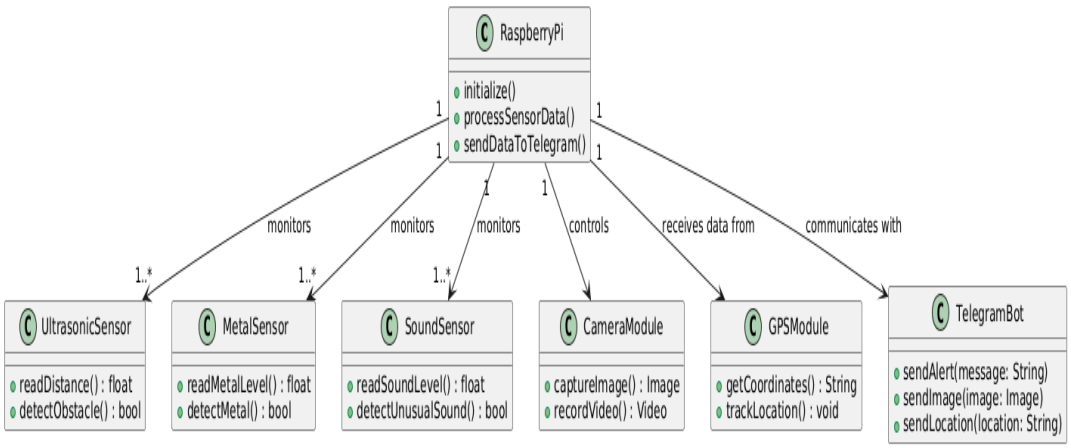

Figure 2: Class Diagram of Proposed System

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System Start-Up: The system powers on, the Raspberry Pi boots, and all sensors, the motor driver, and the Zigbee module get initialized.
At the center is the Raspberry Pi Controller class, which acts as the brain of the system, managing all operations and coordinating between sensors, actuators, and the camera.
The Sensor classes include the ultrasonic sensor, sound sensor, fire sensor, and metal detector. Each sensor continuously monitors its respective environment parameter—distance, sound, fire, or metal detection—and sends signals to the Raspberry Pi when a specific threshold or condition is met.
The Actuator class controls the motors for rover movement and the buzzer for alerts. Whenever a sensor triggers an event, the actuators respond immediately, either by moving the rover, activating the buzzer, or both.
The Camera class handles video streaming and image capturing. It works alongside the sensors to record events or monitor areas in real time. The camera can also adjust its position using servo control if motion or objects are detected

V. RESULTS

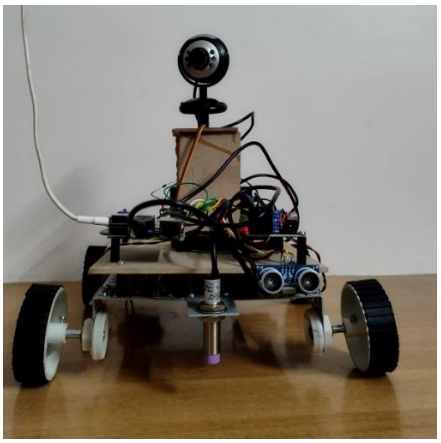

Fig 5.1: Prototype of Proposed System

This figure shows the complete assembled Neo Sentinel Rover Robot prototype.
It includes the Raspberry Pi controller, ultrasonic sensor, metal detector, camera module, motor driver, and chassis.
All components together form a functional surveillance rover capable of navigation, detection, and monitoring.

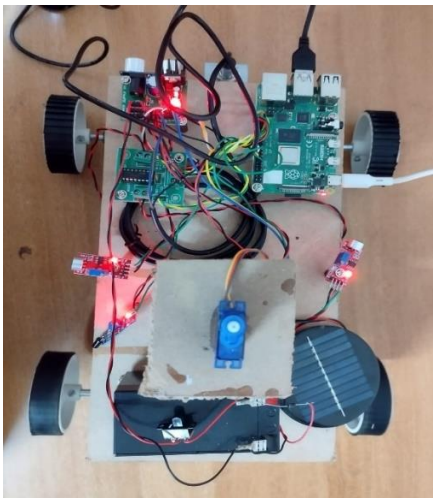

Fig 5.2: Forward Moving

This image displays the rover moving forward after receiving sensor input or user command.
The ultrasonic sensor continuously measures distance, and the motors drive the robot ahead safely.
It demonstrates the autonomous movement logic and obstacle-avoidance behaviour of the system.

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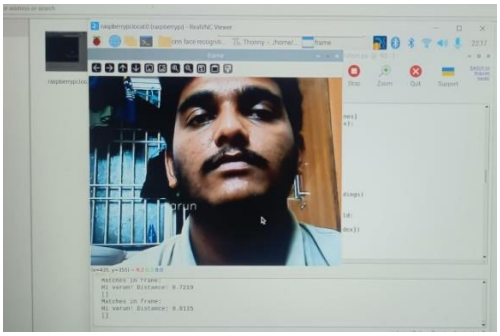

Fig 5.3: Working of Face Recognition

This figure shows the live face-recognition window running on the Raspberry Pi.
The system detects a face and matches it with the trained dataset, displaying the recognized person's name.
It confirms successful implementation of CNN-based face recognition for security verification.

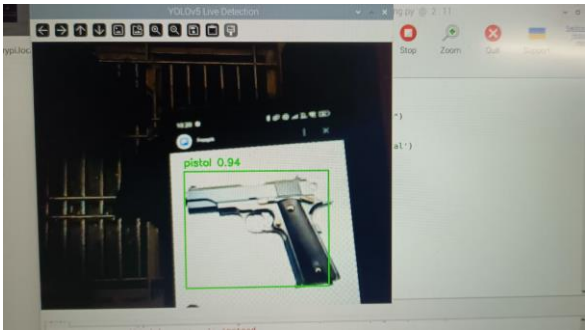

Fig 5.4: Working of Weapon Detection

The image displays YOLO-based object detection identifying a weapon in real time.
The detected pistol is highlighted with a bounding box and confidence score.
This proves that the rover can automatically recognize dangerous objects for security and alerting purposes.

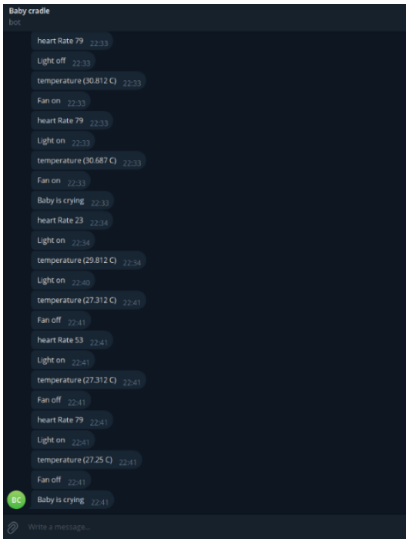

Fig 5.5: Telegram Bot

This screenshot shows the Telegram bot receiving real-time alerts from the rover.
Updates such as heart rate, temperature, cry detection, and device control commands appear instantly.
The bot enables remote monitoring and communication between the system and the user.

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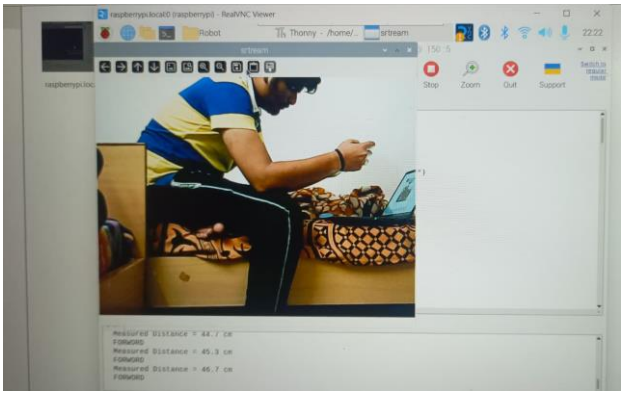

Fig 5.6: Live Streaming

This figure demonstrates the live video streaming feature of the rover.
The Raspberry Pi camera transmits real-time footage to the monitoring dashboard.
It allows the user to observe surroundings while the robot navigates, enhancing remote surveillance.

VI. CONCLUSION AND FUTURE SCOPE

The Neo Sentinel Rover successfully demonstrates a compact and efficient surveillance system capable of monitoring its environment in real time. By integrating ultrasonic, sound, fire, and metal sensors with video streaming and alert mechanisms, the rover can detect obstacles, hazardous events, and intrusions autonomously. The system ensures immediate notifications through buzzer alerts and remote messaging, enhancing security and monitoring without constant human intervention.
In the future, the Neo Sentinel Rover can be enhanced by incorporating AI-based object recognition to distinguish between different types of threats or intrusions. Adding longer-range sensors or integrating solar power could make it more suitable for large outdoor areas. Wireless mesh networking or GSM modules could allow operation in remote locations without internet dependency. Additionally, the system could be expanded to include advanced features such as automated navigation, obstacle avoidance with path planning, and integration with smart home or industrial security systems, making it more versatile and intelligent.

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I would like to express my sincere appreciation to everyone who supported and guided me throughout the development of this project.

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This project would not have been possible without the contributions of all these individuals, and I am sincerely thankful for their support.

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