Autonomous Surveillance and Response Rover with Image Processing for Border Security and Critical Infrastructure Monitoring

Theme: AI and Machine Learning, Internet of Things (IoT)

INTRODUCTION

The ASRR is an autonomous robotic platform designed to enhance surveillance capabilities in diverse environments, from remote border regions to urban settings. Equipped with a suite of advanced sensors, cameras, and communication systems, the ASRR is capable of autonomously patrolling and monitoring its surroundings, continuously gathering and analyzing data in real time.

PROPOSED METHODOLOGY

To ease the surveillance, and bring in more reliable technology to help the front-line security personnel, Autonomous Surveillance and Response Rover (ASRR) is built, embedded with environment monitoring sensors, along with a camera and weapon. With the help of the camera mounted, the area's live feed can be obtained at the control station. The speciality of this camera is that, with the integration of Object Detection, any human threat, who could be an intruder at the border or a terrorist in his hideout, can be identified and reported to the control station. This added security feature is the key to our research. Our novelty lies in the integration of Intruder Detection along with a weapon to fire in case of emergencies. Along with this, the environmental conditions are also lively and monitored by the required sensors. Any abnormal values in these sensors would generate an alert to the controller. Our rover has both automatic and manual modes, enabling us to respond to any anonymous activity as noticed by the rover and switch to manual mode for remote operation. With the help of the gun mounted over the rover, the rover can be used to threaten or eliminate the threat, which the operators in the control station can decide. The key point to be noted here is that ASRR is a multi-purpose rover, that can enhance

security by remote surveillance, can undergo search missions with manual control and undertake environmental monitoring. In addition to military applications, they can also be used for the surveillance of mining activities or at any place that is not easily accessible by everyone.

MODES OF OPERATION IN ASRR

In Autonomous Mode, the ASRR works based on adaptive navigation, with the principles of obstacle avoidance. They can move on their own and still send the live feed through Wi-Fi. In Manual Mode, the ASRR is remotely controlled from the control station, with the help of Wi-Fi. The movements of the rover can be controlled by the application, while the live feed of the camera can be visualized on the server. The controller has access to move the camera and gun to the required angle for surveillance and shoot if needed. In either case, once an intruder is identified, an alert is raised to the controller. For surveillance, we have ESP32 CAM and a couple of sensors. For responsiveness, we have a weapon mount and buzzer to warn or eliminate the threat.

HARDWARE AND SOFTWARE USED

Hardware Components include,

- ESP32 and ESP32 CAM
- Arduino NANO
- MG996R and MG90S
- Servo Motors
- L298 H-Bridge and 60 RPM DC Motors
- HC SR-04 Ultrasonic Sensors
- DHT11 Temperature and Humidity Sensors
- MQ135 Gas Sensors
- Regulator Circuit (LM7805, 100 microFarad and 1000 microFarad Capacitors)

Software includes,

- Blynk IoT Platform

- Local Web Server hosted through Wi-Fi
- Intruder Detection using Python
    - Single Shot Detection (SSD)
    - Non-Maximum Suppressions (NMS)

BLOCK DIAGRAM

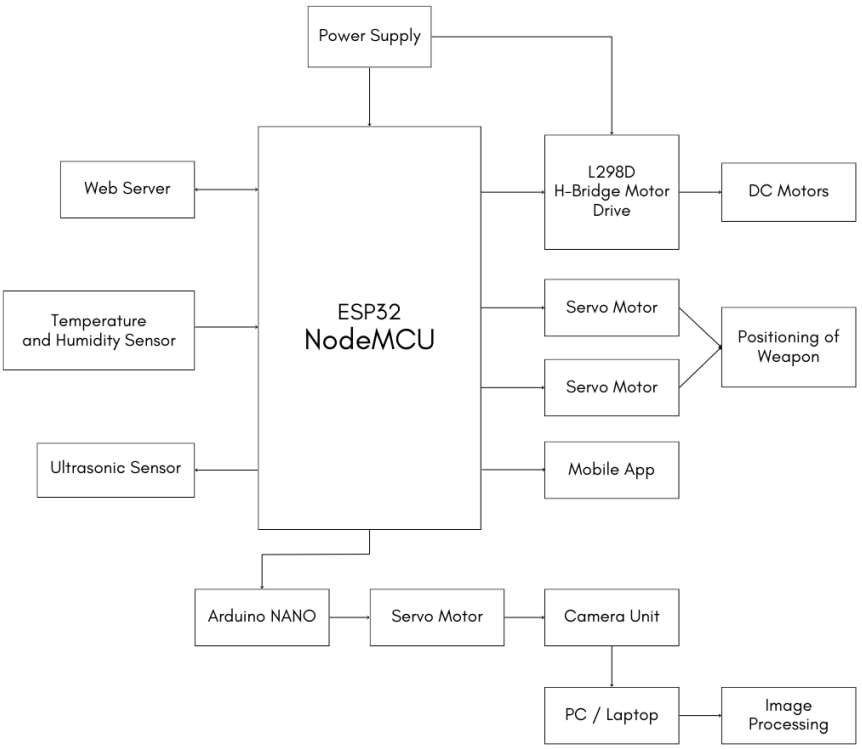

Fig.1: Integration of all the Hardware and Software Components in ASRR

FLOW CHART

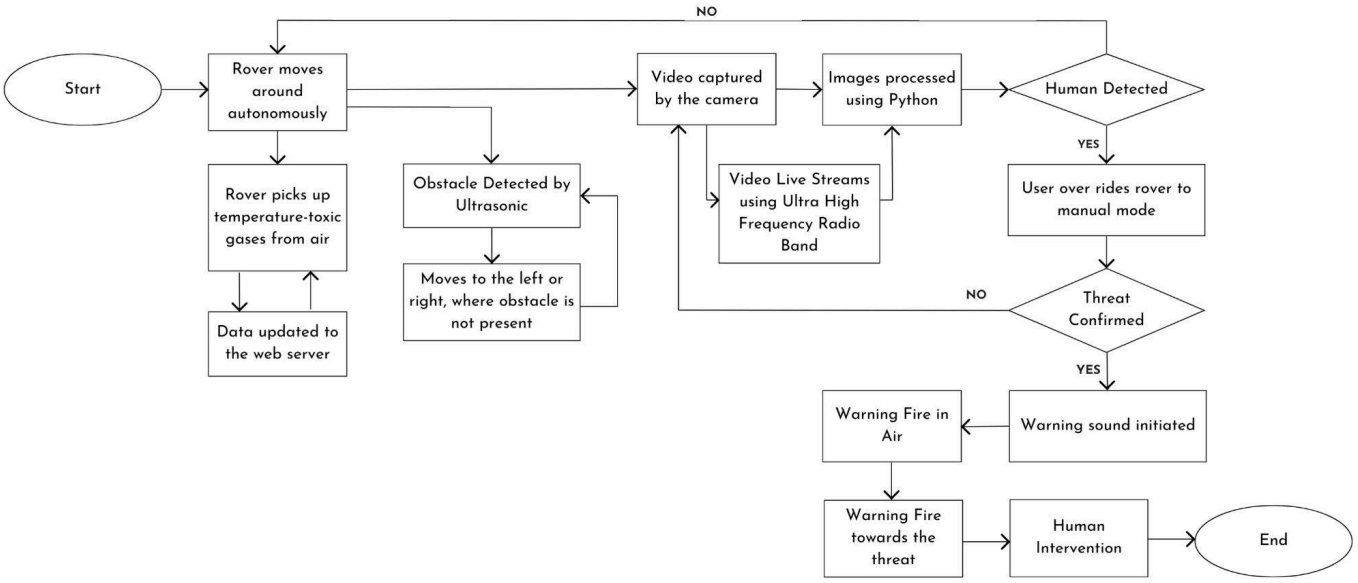

Fig. 2: Flow of Events in ASRR, in different types of mode

RESULTS AND OUTPUT

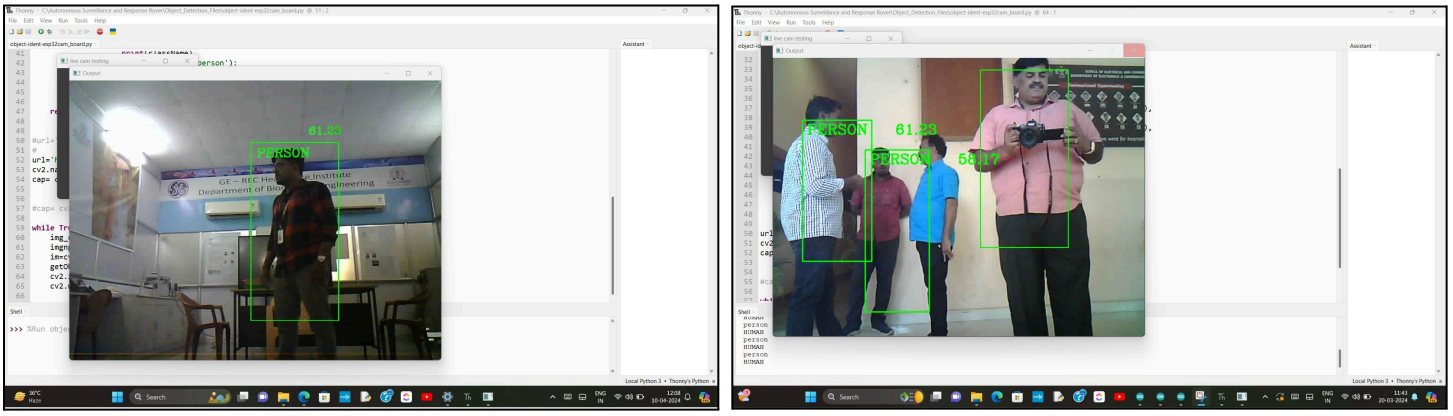

Fig.3: Image Processing to Identify any human in the surroundings

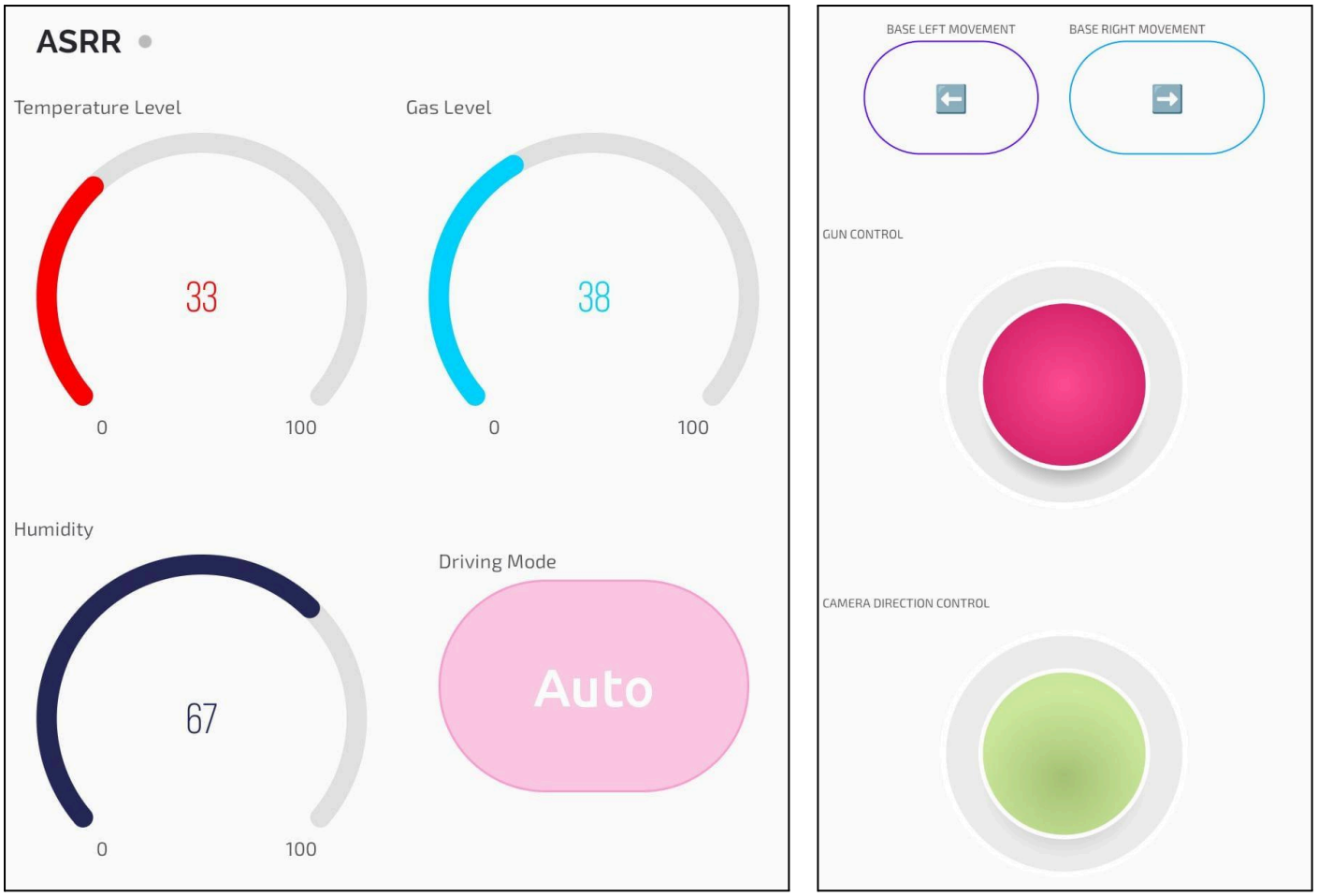

Fig. 4: All the Parameters and Controls of the ASRR in the Blynk Dashboard

NOVELTY

- We made use of ESP32 and Arduino NANO together, connected through serial communication for bringing in more mobility to ASRR
- A recent research study shows that the SSD Algorithm works best with low-resolution images. Hence, when used with ESP32 CAM, best results are obtained, despite the low resolution of the camera being low.
- The total cost of the project is only RS 7200, thereby cutting down the cost, and still obtaining a reliable technology.

APPLICATIONS

- **For Border Patrolling and Security:** This can be used to minimise human contact in remote border areas for patrolling. In case of a surprise attack, ASRR tends to identify it and the soldiers get time to plan a counterattack.
- **Hostage Rescue:** Since ASRR can be manually controlled, in case of hostage situations in hotels, like the case of the 2008 Mumbai Hotel Taj Palace Attacks, security forces can use ASRR to evaluate the surroundings, identify the threat and neutralise them without direct contact.
- **Mining Monitoring System:** This can be used in inaccessible areas to monitor the safety of workers and also record the environmental parameters.
- **Illegal Poaching:** They can be used to identify potential poachers in the deep forests, which can be communicated to the forest rangers using Ultra High Frequency Bandwidths to take necessary action to apprehend them.

FINAL PROTOTYPE OBTAINED: