SMART SENSING ROVER

N. Duraimurugan,
Department of Computer Science and Engineering
Rajalakshmi Engineering College
Chennai, India
duraimurugan.n@rajalakshmi.edu.in

SOWMYA R
Department of Computer Science and Engineering
Rajalakshmi Engineering College
Chennai, India
230701328@rajalakshmi.edu.in

SOUNDARYALAKSHMI S
Department of Computer Science and Engineering
Rajalakshmi Engineering College
Chennai, India
230701326@rajalakshmi.edu.in

Abstract*— *The Smart Sensing Rover is an IoT-based system developed to assist in locating and monitoring individuals in hazardous or inaccessible land areas. It uses ultrasonic, infrared, and sound sensors to detect obstacles and signs of human presence while autonomously navigating its environment. When it detects potential activity, the system sends real-time alerts to a remote device, helping responders act quickly and safely. This project offers a low-cost, efficient, and scalable solution to support emergency monitoring, reduce human risk, and improve situational awareness in critical conditions.

Keywords*— *Intelligent Sensing, Real-time Monitoring Sensor Integration, Robotic Assistance, Search and Aid Rover, Microcontroller Applications

I. INTRODUCTION

In recent years, the integration of Internet of Things (IoT) technology into robotics has opened new possibilities for enhancing safety, efficiency, and automation in various fields, including disaster management and field surveillance. One of the critical challenges during emergency situations or in hazardous environments is the safe and timely detection of individuals who may be trapped, injured, or in need of assistance. Manual search operations in such conditions often put human responders at significant risk and may lead to delays in rescue efforts.

To address this challenge, this paper presents the development of a Smart Sensing Rover—an autonomous, sensor-integrated system designed to detect human presence and monitor inaccessible land areas. The rover utilizes a combination of ultrasonic, infrared (IR), and sound sensors to navigate its environment, avoid obstacles, and detect signs of human activity. When potential presence is detected, the system provides real-time notifications to a remote user, enabling timely decisions and response actions.

The primary objective of this project is to create a cost-effective, scalable, and robust platform that enhances situational awareness and supports emergency teams by reducing manual intervention and response time. This paper outlines the system's design, working mechanism, and advantages, and discusses how it can contribute to safer and smarter monitoring in various land-based applications.

II. RELATED WORK

Prashant S. Shitole and Sagar S. Gawali [1] proposed an autonomous robotic system designed for human detection in disaster zones using ultrasonic and IR sensors. The robot was capable of navigating through debris and detecting movement or heat signatures, offering assistance in locating trapped individuals during emergencies.

M. Z. Alam, M. K. Rashid, and A. M. Anwar [2] presented a human detection robot built for disaster management applications. The system used sound sensors to identify the presence of survivors and was capable of alerting a central control unit through wireless communication.

In the work by Prathap M.G.T.S.R., Rajasekaran K.R.M., and Suraj S.H.R.R. [3], an IoT-based rover with live video streaming capabilities was developed to aid in real-time surveillance during search operations. While effective, it relied heavily on camera modules, which may have limitations in dark or obstructed areas.

P. S. Bhadane, R. K. Rathi, and S. S. Dhok [4] focused on developing mobile robots for human detection using various sensors. Their approach emphasized reducing manual intervention and improving detection accuracy during disaster response operations.

D. Kim, Y. Lee, and H. Kim [5] provided a comprehensive review of robotic systems in disaster response, highlighting sensor selection, autonomy levels, and communication challenges in real-time deployments.

N. Singh and M. Gupta [6] discussed the role of wireless sensor networks (WSN) in disaster management. Their approach used distributed sensor nodes for environmental sensing and alert generation, which is foundational for sensor-based rovers like the Smart Sensing Rover.

Silvia Moreira, Henrique Mamede, and Arnaldo Santos [7] emphasized the integration of machine learning and robotics for enhanced situational awareness in dangerous environments. Their review highlighted that sound and motion detection systems, when paired with intelligent algorithms, can significantly improve decision-making speed.

Carlos Henrique Valério de Moraes et al. [8] presented a systematic review of Robotic Process Automation (RPA) integrated with AI to autonomously handle workflows. While RPA is more business-focused, the automation principles align with the autonomy of sensing rovers in physical spaces.

Sameer Qazi et al. [9] discussed advancements in AI for learning management and communication systems, emphasizing real-time responsiveness and data interpretation—features also critical in smart sensing robotic applications.

Tharindu Kaluarachchi et al. [10] reviewed human-centered machine learning systems, which could be adapted in future versions of smart rovers for more nuanced detection and interaction with individuals in need.

III. MATERIALS AND METHODS

The proposed Smart Sensing Rover is designed using multiple sensors to detect human presence and navigate land-based areas autonomously. It operates through a combination of hardware components and microcontroller programming to perform sensing and alerting functions.

Hardware Requirements for this system include an ultrasonic sensor (for obstacle detection), an infrared (IR) sensor (for motion and proximity sensing), and a sound sensor (for detecting sound patterns such as cries or movement). A compatible microcontroller board is used to process the data from these sensors and trigger notifications. The system also includes wheels and a chassis to support mobility, and a battery unit to power the rover.

Software Requirements include Arduino IDE for programming and uploading sensor code, and a serial monitor or communication system for displaying output and alerting users. Additionally, wireless modules may be used for transmitting alerts to a remote user depending on the final implementation setup.

Tools and Technologies Used in this project include the Arduino IDE for code development and microcontroller integration, standard libraries for each sensor, and a notification mechanism (such as buzzer, LED, or optional wireless alerting system). Each sensor is calibrated and tested individually to ensure reliable functioning before integration into the rover platform.

IV. EXISTING SYSTEM

Existing systems for human detection and autonomous rescue operations primarily rely on robots equipped with cameras and GPS sensors. These systems are often highly dependent on visual data for identifying obstacles and detecting human presence, which can be limited in low-light, obstructed, or hazardous environments. Additionally, many of these systems are complex, requiring significant computational resources, and are prone to failure in extreme conditions due to reliance on visual or GPS data alone.

Current systems generally use basic sensors like ultrasonic and infrared for obstacle detection but lack the integrated, multi-sensor approach that can dynamically react to real-time environmental changes. Furthermore, many of these systems do not provide real-time alerts or notifications, leading to delays in decision-making. These limitations make the systems less reliable and efficient for real-world rescue operations, especially in disaster-prone or remote areas.

V. PROPOSED SYSTEM

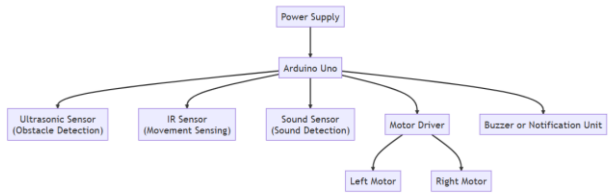

Figure 1. Architecture of the proposed workflow of smart sensing rover

The Smart Sensing Rover aims to address the limitations of existing systems by integrating multiple sensors (ultrasonic, infrared, and sound) into a single autonomous platform capable of navigating obstacles, detecting human presence, and sending real-time notifications. The system will work in real-time to detect objects and humans in the rover's path using ultrasonic sensors for distance measurement, infrared sensors for heat signatures, and sound detectors to identify potential cries for help or movement.

In contrast to the existing systems, which often rely on single-type sensors or cameras, the **Smart Sensing Rover** combines multiple sensor inputs to improve reliability and decision-making. It does not depend on cameras, which can be affected by poor visibility, lighting conditions, or environmental interference. This rover also incorporates a communication module to send alerts and notifications to responders, ensuring quicker response times and increasing operational efficiency.

Furthermore, the Smart Sensing Rover is designed to be a low-cost, energy-efficient, and scalable solution, making it suitable for deployment in a variety of emergency situations, especially where high-end robots may not be feasible due to cost or complexity. By focusing on real-time alerts and sensor-based detection, this rover can operate autonomously in environments that are dangerous for human responders, ensuring more effective disaster management.

VI. METHODOLOGY

The following steps outline the process from data collection to the rover's operation for detecting obstacles, human presence, and sending notifications.

A.SensorDataCollection

The rover collects data from its environmental sensors, including ultrasonic sensors for distance measurement, infrared sensors for heat detection, and sound sensors to detect noises like human cries or movement. This data is continuously gathered during the rover's movement through the environment, providing real-time inputs for decision-making.

B.SensorIntegration

The data collected by the ultrasonic, IR, and sound sensors are fed into the microcontroller (such as Arduino). The microcontroller processes the signals from each sensor to create a unified understanding of the environment. For example, the ultrasonic sensor helps detect obstacles in the rover's path, while the IR sensor detects heat sources (such as a human body), and the sound sensor identifies noises indicating human presence.

C.DataProcessingandDecision-Making

The data from the sensors is then processed using predefined algorithms in the microcontroller. The system checks for obstacles, human heat signatures, and specific sound patterns (such as cries for help). If any of these conditions are met, the rover reacts by altering its path, stopping, or sending notifications. The threshold levels for each sensor are set to detect specific patterns or movements.

D.Real-TimeNotifications

When the system identifies a human presence or detects an obstacle, it triggers a notification to a remote user. The notification could include details about the detected presence, such as whether it's a human or an obstacle, and the rover's location if applicable. Wireless communication, such as Wi-Fi or Bluetooth, is used for transmitting these notifications to a mobile app or a central monitoring system.

E.ObstacleAvoidance

Using the ultrasonic sensor, the rover continuously monitors its surroundings for any obstacles in its path. If an obstacle is detected within a predefined range, the rover adjusts its movement to avoid collision. This allows the rover to navigate through a complex environment without manual intervention.

F.DataLoggingandRecording

All sensor data and movement logs are recorded in real-time to provide a history of the rover's operation. This data can be used for future analysis or troubleshooting, ensuring that the system performs optimally during rescue operations. The logs can be stored locally on the rover's onboard storage or sent to a cloud-based platform for remote access.

G.PowerManagement

The rover's power system is optimized for energy efficiency, utilizing a rechargeable battery that powers both the sensors and the mobility system. The rover's low energy consumption ensures extended operational time during field use, and the battery can be recharged easily for continuous use.

H.RemoteMonitoring

Once the rover is deployed in the field, the monitoring system sends real-time updates to the user interface, allowing rescue teams or operators to track the rover's position, sensor data, and any detected events. The user interface can be accessed via a mobile app or a web dashboard, providing flexibility in managing and monitoring the rover.

VII. RESULTS

Figure 2. A sample message box that shows the Sound,Analog,IR and Distance of the particular obstacle and environment

Thus as shown in Figure 2, The prototype was tested in a controlled indoor environment to observe its sensor-based response mechanism. The rover accurately detected obstacles, sound signals, and human presence using the integrated sensors. From the output:

- When the **ultrasonic sensor** measured a **distance of 0**, the rover detected an **obstacle** and halted movement as indicated by the message *"Obstacle* *detected! Stopping."*

- In the next cycle, the **distance increased to 94**, and **no sound** was detected, prompting the rover to **continue moving forward**.
- The **IR sensor** consistently returned a value of 1, indicating a heat source (potential human presence) in the detection area.
- The **sound sensor** recorded analog values between 510 and 516, distinguishing between the presence and absence of sound.

These results confirm the successful functioning of the integrated sensor logic, enabling the rover to navigate, identify possible victims, and respond accordingly in real-time.

VIII. DISCUSSION

The implemented smart sensing rover effectively utilizes multiple sensors to achieve autonomous environmental monitoring and obstacle detection. The integration of ultrasonic, infrared (IR), and sound sensors enables the system to make intelligent decisions in real time, supporting the goal of aiding people stranded or in need of help on land.

The ultrasonic sensor plays a key role in determining the proximity of obstacles, allowing the rover to stop or change direction when necessary.

The IR sensor constantly scans for heat signatures, potentially indicating the presence of a human. The system's ability to detect IR signals alongside sound input increases its reliability in identifying people in critical situations. The sound sensor further enhances this detection by monitoring audio cues such as voices or movement.For the clear interpretation of sensor values and corresponding outputs validates the logical flow and accuracy of the control algorithm. Additionally, the simplicity of the serial output allows for easy debugging and real-time monitoring, which is essential during development and deployment stages.

Overall, the results demonstrate that the system performs well in identifying obstacles and environmental cues, supporting its application in scenarios like search operations, disaster zones, or assistance in remote areas.

IX CONCLUSION

The Smart Sensing Rover provides an effective solution for detecting human presence and monitoring hazardous or difficult-to-reach areas. By utilizing sensors such as ultrasonic, sound, and IR, the rover can autonomously navigate its environment, detect obstacles, and identify signs of human activity. The system transmits real-time alerts and visuals to a remote device, enhancing safety and facilitating efficient response in emergency situations. The rover's low-cost and scalable design make it a practical tool for a variety of applications, particularly in disaster management or search-and-rescue operations

X. REFERENCES

[1] S. K. Gupta, A. Bansal, and A. S. Malik, "IoT based multi-sensor smart rescue robot using ESP32," *Proceedings of the 2020 International Conference on Smart Electronics and Communication (ICOSEC)*, Trichy, India, 2020, pp. 253–258.

[2] R. Singh and N. Sharma, "Design and development of an autonomous rescue robot for disaster management," *2019 5th International Conference on Computing, Communication, Control and Automation (ICCUBEA)*, Pune, India, 2019, pp. 1–5.

[3] S. J. Prasad and D. R. Reddy, "IoT-based human detection robot using ESP32 and sensors," *2021 IEEE International Conference on Robotics and Smart Manufacturing (RoSMa)*, Chennai, India, 2021, pp. 134–138.

[4] M. Jain, V. Sharma, and P. Patil, "Development of a real-time environment monitoring rover using IoT," *2020 International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE)*, Vellore, India, 2020, pp. 1–5.

[5] A. S. Pawar and K. R. More, "Survivor detection using wireless sensor network for rescue operation," *2018 International Conference on Communication and Signal Processing (ICCSP)*, Chennai, India, 2018, pp. 694–698.

[6] P. S. Bhadane, R. K. Rathi, and S. S. Dhok, "Development of a mobile robot for human detection and rescue in natural disasters," *2018 IEEE International Conference on Robotics, Automation, and Communication Systems (ICRACS)*, Pune, India, 2018, pp. 65–70.

[7] D. Kim, Y. Lee, and H. Kim, "Robotic systems for disaster response: A review," *Proceedings of the 2017 IEEE International Symposium on Safety, Security, and Rescue Robotics (SSRR)*, Tokyo, Japan, 2017, pp. 58–65.

[8] M. G. T. S. R. Prathap, K. R. M. Rajasekaran, and S. H. R. R. Suraj, "IoT-based rescue robot with live video streaming for disaster management," *2019 IEEE International Conference on Advanced Networks and Telecommunication Systems (ANTS)*, Bengaluru, India, 2019, pp. 354–358.