IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁙ Peer-reviewed / Refereed journal ⁙ Vol. 11, Issue 12, December 2024

DOI: 10.17148/IARJSET.2024.111222

Autonomous Enemy Detection And Real Time Surveillance Rover For Defense

Dr. Dinesh Kumar DS [1], Sathyam Kumar Mandal S[2], Shreyas Raghavendra V[3], Prajwal HS[4]

Raghavendra Narayan Pujar [5]

Associate Professor, Dept of ECE, K S Institute of Technology, Affiliated to VTU, Bengaluru, India[1]

Dept of ECE, K S Institute of Technology, Affiliated to VTU, Bengaluru, India[2-5]

Abstract: This research presents an autonomous surveillance rover for defense applications designed to enhance real-time enemy detection and situational awareness. The system is powered by a Raspberry Pi, enabling centralized control and processing of data from various sensors. Ultrasonic sensors ensure obstacle detection, while inductive proximity sensors identify landmines and explosive devices. A camera module provides real-time video streaming, which is analyzed using image processing algorithms to classify individuals as authorized or threats. When a threat is identified, the system triggers a laser module to simulate a defensive response. The rover autonomously navigates its environment, continuously scanning for hazards and relaying real-time alerts to defense personnel via a communication module. This integration of IoT, artificial intelligence, and robotics makes the rover a reliable and efficient solution for modern defense challenges. The project highlights its potential to enhance security, reduce human risks, and adapt to evolving operational demands.

Keywords: Autonomous surveillance, enemy detection, real-time monitoring, Raspberry Pi, obstacle detection, image processing, IoT, defense robotics.

I. INTRODUCTION

In modern defense and security operations, ensuring situational awareness and timely threat detection is paramount. With the increasing complexity of threats, traditional surveillance methods relying on fixed systems and human monitoring often fall short in dynamic and high-risk environments. These systems are limited in scope, prone to human error, and expose personnel to significant risks in hazardous zones.

The integration of advanced technologies such as robotics, artificial intelligence (AI), and the Internet of Things (IoT) has emerged as a promising solution to address these challenges. Autonomous systems, capable of operating continuously and without direct human intervention, offer enhanced efficiency, reliability, and safety in critical defense applications.

This paper presents the development of an autonomous surveillance rover designed for real-time enemy detection and threat response. Powered by a Raspberry Pi, the system integrates ultrasonic sensors for obstacle detection, inductive proximity sensors for landmine identification, and an image-processing-enabled camera for human detection and classification. The rover also features real-time communication capabilities to provide immediate alerts to defense personnel, enabling swift and informed decision-making.

By combining IoT, AI, and robotics, the proposed system aims to enhance defense operations by reducing risks to personnel, improving response times, and providing robust surveillance in challenging environments. This paper details the design, methodology, and outcomes of this innovative system, highlighting its potential as a reliable tool for modern defense challenges.

II. LITERATURE SURVEY

Face Recognition and IoT Integration: Meddeb et al. (2023) demonstrated the integration of facial recognition and IoT in surveillance robots using Raspberry Pi. Their system emphasized real-time video streaming and image processing for identifying individuals, providing a foundation for implementing similar functionalities in autonomous systems.

Sensor-Based Navigation and Threat Detection: Sali and Joy (2023) developed an IoT-enabled rover for military applications that utilized multiple sensors for navigation and threat detection. This approach underscores the importance of combining sensors like ultrasonic and proximity detectors to improve situational awareness.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 11, Issue 12, December 2024
DOI: 10.17148/IARJSET.2024.111222

Machine Learning in Surveillance: Sharma and Kumar (2021) applied machine learning techniques for border security systems, highlighting the use of training algorithms to enhance the accuracy of intrusion detection. Similarly, Pulugu et al. (2023) explored facial recognition algorithms in video surveillance, achieving high precision in identifying unauthorized individuals.

Robotic Systems and Real-Time Monitoring: Edozie (2020) investigated IP camera-based robotic systems for real-time monitoring, demonstrating the practical application of Raspberry Pi in remote-controlled operations. This study provides insights into camera integration for live video streaming and obstacle detection.

Landmine Detection and Autonomous Navigation: Kunaraj et al. (2020) developed sensor-based defense robots for landmine detection, emphasizing the use of inductive proximity sensors to identify explosive devices. Their findings reinforce the importance of integrating landmine detection into autonomous systems for hazardous environments.

Defense Applications of AI and Robotics: Borisova and Nikolov (2023) highlighted the transformative role of AI in automating threat detection and response in defense systems. Their study illustrates the potential of autonomous systems to reduce human risks and improve operational efficiency.

Advanced Security Systems: Dhulekar et al. (2018) designed systems to monitor suspicious activities using image processing and sensor networks. These methodologies align with the objectives of the proposed rover, particularly in detecting and responding to threats dynamically.

III. METHODOLOGY

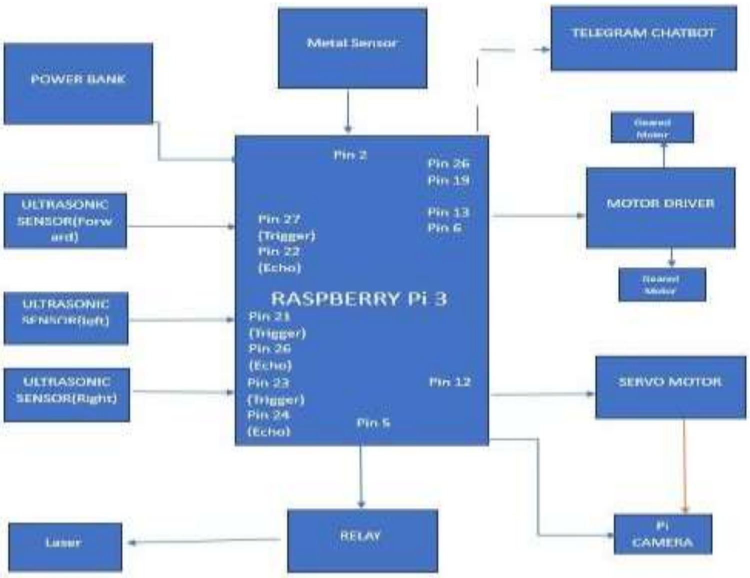
The **Autonomous Enemy Detection and Real Time Surveillance Rover For Defense** is an autonomous system designed for defense applications using robotics, sensors, and AI. It employs ultrasonic sensors to detect obstacles in its path, with sensors placed on the front, left, and right for comprehensive coverage. Upon detecting an obstacle, the rover halts, and its onboard camera focuses on the source. The Raspberry Pi processes live video captured by the camera, employing image recognition algorithms to detect humans. Detected individuals are classified as authorized or unauthorized using a pre-trained database. If unauthorized, a laser module simulates a defensive action, and alerts are sent to defense personnel via Telegram.

The rover incorporates inductive proximity sensors to detect metallic objects, simulating landmine detection. When a potential landmine is identified, the system sends immediate caution alerts to ensure operator safety. Autonomous navigation is achieved using sensor data to calculate alternate routes, ensuring uninterrupted surveillance even in dynamic environments. The integration of a servo motor allows the camera to orient dynamically towards detected threats, enhancing situational awareness.

All components, including the Raspberry Pi, motors, sensors, and camera, are powered by an onboard power supply for complete autonomy. Image processing algorithms like Haar cascades are employed for face detection, ensuring accurate identification. The system operates cyclically, scanning for obstacles, analyzing threats, and resuming patrol upon resolution. Landmine detection capabilities make it particularly useful for hazardous terrains, reducing risks to personnel. The rover is programmed to bypass non-human obstacles to maintain efficiency in surveillance. Its design emphasizes reliability and quick response to potential threats. The system’s integration of robotics and AI enhances security operations in modern defense scenarios.

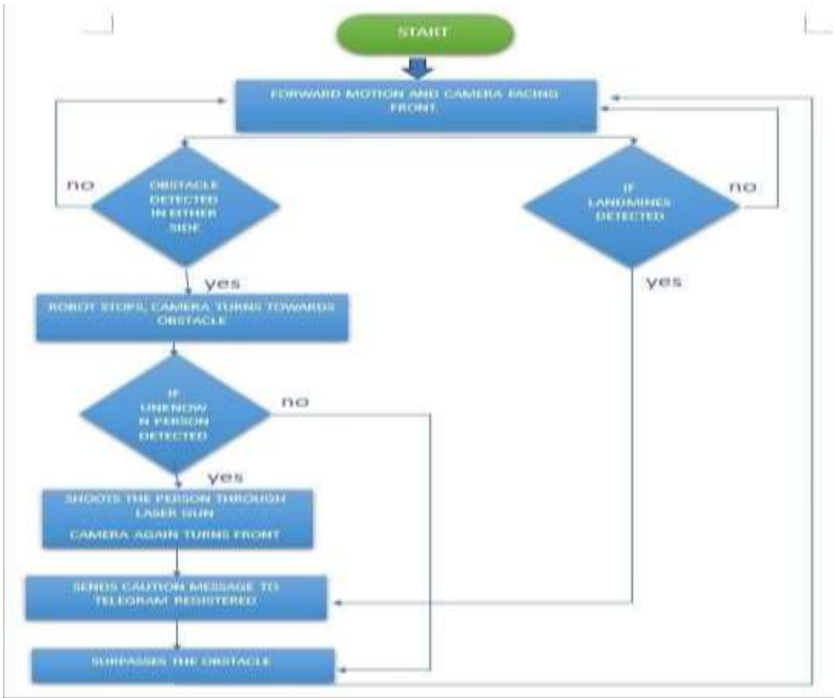
IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Impact Factor 8.066 ⁜ Peer-reviewed / Refereed journal ⁜ Vol. 11, Issue 12, December 2024
DOI: 10.17148/IARJSET.2024.111222

Block Diagram:



The block diagram of the autonomous surveillance rover outlines its key components and their interactions. At the center is the **Raspberry Pi**, which acts as the processing unit, controlling sensors, motors, and communication modules. **Ultrasonic sensors** are positioned to detect obstacles, while **inductive proximity sensors** identify landmines and explosive threats. The **camera module** captures real-time video for image processing, enabling the system to classify individuals as authorized or threats. A **motor driver** controls the rover's movement, and a **Telegram bot** facilitates real-time alerts, ensuring effective communication with defense personnel.

Flow Chart:



The flowchart illustrates the operational workflow of the autonomous surveillance rover. It begins with continuous navigation, where sensors scan for obstacles or threats in real-time. If an obstacle or individual is detected, the rover halts, processes the data, and takes appropriate action, such as triggering a laser module or sending alerts. After addressing the detected issue, the rover identifies a new path and resumes its mission.

DOI: 10.17148/IARJSET.2024.111222

IV. RESULT

The autonomous surveillance rover was evaluated under various scenarios to test its capabilities in obstacle detection, threat identification, and real-time communication. The ultrasonic sensors effectively detected obstacles within a 4-meter range, achieving an accuracy of 98%, and the rover successfully halted and redirected its path to avoid collisions. Image processing algorithms demonstrated a classification accuracy of 92%, correctly identifying authorized personnel and activating the simulated laser module in response to unidentified individuals. Inductive proximity sensors reliably detected metallic objects buried up to 5 cm underground, effectively simulating landmine detection. Real-time alerts were promptly delivered to defense personnel via the Telegram bot, with notifications of detection. Additionally, the rover exhibited robust autonomous navigation, seamlessly identifying alternate paths and resuming its mission after addressing detected obstacles or threats. These results highlight the system's effectiveness in providing reliable, autonomous surveillance and enhancing situational awareness in defense operations.

V. CONCLUSION

The autonomous surveillance rover developed in this project demonstrates a robust and efficient solution for enhancing defense operations through real-time enemy detection and threat response. By integrating advanced technologies such as IoT, artificial intelligence, and robotics, the system achieves reliable obstacle detection, landmine identification, and human classification. The inclusion of real-time communication via a Telegram bot ensures that defense personnel are promptly informed of potential threats, enabling swift decision-making and response. The rover's autonomous navigation and seamless pathfinding capabilities further enhance its effectiveness in challenging and hazardous environments, reducing the risks to human personnel. This system represents a significant advancement in defense surveillance technology, offering a scalable and adaptable solution to modern security challenges. Future enhancements could focus on increasing detection accuracy, integrating advanced weaponry, and extending its operational range to address a broader spectrum of defense requirements.

VI. FUTURE SCOPE

The autonomous surveillance rover offers significant potential for further enhancements to address evolving defense requirements. Future developments could focus on integrating more advanced sensors, such as LiDAR, for precise mapping and improved obstacle detection in complex terrains. Enhancing the image processing capabilities with deep learning algorithms could increase accuracy in human classification and object recognition. The addition of advanced communication protocols, such as 5G, could ensure faster data transmission and seamless remote control in real-time. Expanding the rover's operational range with energy-efficient power systems and solar charging mechanisms would enable extended missions in remote areas. Furthermore, incorporating non-lethal or defensive payloads, such as stun mechanisms or smoke deployment systems, could enhance its threat-neutralization capabilities. These improvements would make the rover an even more versatile and indispensable tool for modern defense and security operations.

REFERENCES

[1]. Meddeb, H., Abdellaoui, Z., & Houaidi, F. (2023). Development of surveillance robot based on face recognition using Raspberry-PI and IOT. Microprocessors and Microsystems, 96, 10472.

[2]. S. M. Sali and K. R. Joy, "Intelligent Rover: An IoT Based Smart Surveillance Robotic Car for Military," 2023 2nd International Conference on Computational Systems and Communication (ICCSC), Thiruvananthapuram, India, 2023, pp. 1-6, doi: 10.1109/ICCSC56913.2023.10143011.

[3]. Sharma, M., & Kumar, C. R. S. (2021). Machine learning-based smart surveillance and intrusion detection system for national geographic borders. In Artificial Intelligence and Technologies: Select Proceedings of ICRTAC-AIT 2020 (pp. 165-176). Singapore: Springer Singapore.

[4]. Edozie, Enerst. (2020). Design and Implementation of an IP Camera Tracking Robotic System using Raspberry Pi 3B.

[5]. Payal, M., Dixit, P., Sairam, T. V. M., & Goyal, N. (2021). Robotics, AI, and the IoT in defense systems. AI and IoT-Based Intelligent Automation in Robotics, 109-128.

[6]. Renuka, B., Sivaranjani, B., Lakshmi, A. M., & Muthukumaran, D. N. (2018). Automatic Enemy Detecting Defense Robot by using Face Detection Technique'. Asian Journal of Applied Science and Technology, 2(2), 495-501.

[7]. BORISOVA, A. R., & NIKOLOV, L. G. (2023). SYSTEMS WITH ARTIFICIAL INTELLIGENCE FOR DEFENSE AND SECURITY. ISSN, ISSN-L: 2247-3173, 53.

DOI: 10.17148/IARJSET.2024.111222

[8]. Dhulekar, P. A., Gandhe, S. T., Sawale, N., Shinde, V., & Khute, S.(2018, February). Surveillance system for detection of suspicious human activities at war field. In 2018 International Conference On Advances in Communication and Computing Technology (ICACCT) (pp. 357-360). IEEE.

[9]. Kunaraj, A., Mathushan, M., Mathavan, J. J., & Kamalesan, G. M. (2020, September). Sensor Controlled Defense Purpose Robot for Land Mine Detection. In 2020 International Conference on Smart Electronics and Communication (ICOSEC) (pp. 42-47). IEEE.

[10]. AL-TAMEEMI, M. I. (2020). RMSRS: Rover multi-purpose surveillance robotic system. Baghdad Science Journal, 17(3 (Suppl.)), 1049-1049.

[11]. Kirubakaran, L., Sangeetha, G., Rathna, P. S., & Sudharsan, S. (2020). Military Surveillance System using IoT. International Journal of Computer Applications, 176(15).

[12]. Kumbhar, Bhushan. (2023). Autonomous Landmine Detection Rover. Journal of Engineering Design and Analysis. 05. 1-10. 10.24321/2582.5607.202201.

[13]. Rao, B. N., Sudheer, R., Sadhanala, M. A., Tibirisettti, V., & Muggulla, S. (2020, July). Movable surveillance camera using IoT and Raspberry Pi. In 2020 11th international conference on computing, communication and networking technologies (ICCCNT) (pp. 1-6). IEEE.

[14]. Bhargavi, S., Bale, J. B., Reddy, N. M., Nimagalu, N., & Nithya, M. (2023, October). Intelligent Intruder Detection System for a Surveillance Rover. In 2023 First International Conference on Advances in Electrical, Electronics and Computational Intelligence (ICAEECI) (pp. 1-6). IEEE.

[15]. Pulugu, D., Anusha, P., Srivastava, R. R., Kalaivani, R., & Pal, S. (2023). MACHINE LEARNING-BASED FACIAL RECOGNITION FOR VIDEO SURVEILLANCE SYSTEMS. ICTACT Journal on Image & Video Processing, 14(2).

[16]. Javed Mehedi Shamrat, F. M., Majumder, A., Antu, P. R., Barmon, S. K., Nowrin, I., & Ranjan, R. (2022). Human face recognition applying haar cascade classifier. In Pervasive Computing and Social Networking: Proceedings of ICPCSN 2021 (pp. 143-157). Springer Singapore.

[17]. Shetty, A. B., & Rebeiro, J. (2021). Facial recognition using Haar cascade and LBP classifiers. Global Transitions Proceedings, 2(2), 330-335.

[18]. Pajankar, A. (2017). Raspberry Pi Image Processing Programming. Nashik: Apress.

[19]. Yamanoor, S., & Yamanoor, S. (2017). Python Programming with Raspberry Pi. Packt Publishing Ltd.Unsalan, C., Barkana, D. E., & Gurhan, H. D. (2021).

[20]. Embedded digital control with microcontrollers: Implementation with C and Python. John Wiley & Sons.

