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ESP32-Cam Enabled Smart System for Wildlife Tracking and Management

Febin Reji[1], Abdul Wajid[2], Adwaith Ramesh[3], Fazil Ahamed H[4]
Emails: *febinrejiputhenveettil@gmail.com[1]*

Abstract

The Wildlife Monitoring Robot is a mobile system designed to detect and monitor animal activity in forest or wildlife areas. The robot moves autonomously through a specified path, equipped with sensors such as ultrasonic or PIR sensors to detect the presence of animals. When an animal is detected, the system immediately sends a signal or alert to the user, helping in real-time monitoring and preventing unwanted encounters or accidents. The project aims to assist forest officials and researchers in observing animal movement safely and efficiently. This mini-project demonstrates a cost-effective and innovative approach to wildlife surveillance using robotics and sensor-based technology.

Keywords: *Wildlife Monitoring, Mobile Robot, Arduino, Ultrasonic Sensor, PIR Sensor, Animal Detection, Forest Surveillance, Real-Time Alert, Buzzer, Communication Module, Autonomous Vehicle.*

1. Introduction

Wildlife conservation has increasingly relied on modern technological solutions to overcome challenges in monitoring, tracking, and managing animal movement in forest environments. Traditional wildlife observation methods—such as manual patrolling, camera traps, and field surveys—are often time-consuming, labor-intensive, and limited in coverage. Recent developments in embedded systems, wireless communication, and low-power imaging modules have enabled more effective real-time wildlife monitoring solutions (Author1, 2022; Author2, 2023). This project, ESP32-CAM Enabled Smart System for Wildlife Tracking and Management, aims to provide a cost-efficient and automated approach for capturing wildlife activity, transmitting live images, and supporting decision-making in forest management. The system integrates onboard image processing, wireless communication, and intelligent sensing to detect animal presence and deliver live data to forest officials. By combining modern IoT technologies with compact mobile hardware, the proposed system enhances accuracy, safety, and efficiency in wildlife monitoring without relying on continuous human intervention. The introduction presents the purpose of the study, its technological relevance, and the motivation behind developing an automated wildlife surveillance system. Only essential literature is referenced to provide the background needed to understand and evaluate the system's objectives and its contribution to modern wildlife management (Author3, 2024).

1.1. Technological Background of Wildlife Monitoring Systems

Conventional wildlife monitoring systems are often limited by resource requirements, fixed positioning, and lack of real-time data transmission. Methods such as manual observation or static camera setups cannot track fast-moving animals or cover wide forest areas effectively. Moreover, these systems require significant human effort and may expose forest personnel to potential risks. Advances in embedded platforms like ESP32-CAM offer compact, low-power, and wireless camera solutions suitable for remote environments. The integration of camera modules, microcontrollers, and communication protocols enables real-time image transmission with minimal power consumption. Understanding these technological capabilities forms the foundation for developing a more efficient wildlife monitoring solution [1].

1.2. Need for Automation in Modern Wildlife Tracking

Automation plays a crucial role in improving the efficiency, accuracy, and safety of wildlife

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surveillance. Forest ecosystems often face challenges such as illegal poaching, human–animal conflict, and difficulty in tracking endangered species. Manual monitoring is not only slow but also prone to human error and inconsistent data collection [2].

2. Method

The Method section describes the procedure followed to develop and test the ESP32-CAM Enabled Smart System for Wildlife Tracking and Management. Sufficient technical details are provided to allow the system to be reproduced by a qualified reader. Only newly implemented procedures are included, while commonly known steps follow standard embedded system practices. The ESP32-CAM module was programmed and configured to capture images automatically and transmit them over Wi-Fi. The hardware setup involved integrating the ESP32-CAM with a regulated lithium-ion battery pack, a 3S BMS for protection, and necessary interface connections for stable operation. Software routines were developed to initialize the camera, manage memory, compress image data, and establish wireless communication with the monitoring device. During operation, the system continuously monitored its surroundings. When motion or a change in the camera frame was detected, an image was captured, processed, and transmitted to a predefined server or mobile device for real-time monitoring. The procedure was repeated multiple times under different lighting and environmental conditions to assess performance stability, image clarity, and transmission reliability [3].

2.1. Tables

Tables should be typewritten separately from the main text and preferably in an appropriate font size to fit each table on a separate page. Each table must be numbered with Arabic numerals (e.g., Table 1, Table 2) and include a title. Place footnotes to tables below the table body and indicate them with superscript lowercase letters (a, b, c, etc.), not symbols. Do not use vertical rulings in the tables. Each column in a table must have a heading, and abbreviations, when necessary, should be defined in the footnotes, shown in Figure 1& 2 [4].

2.2. Figures

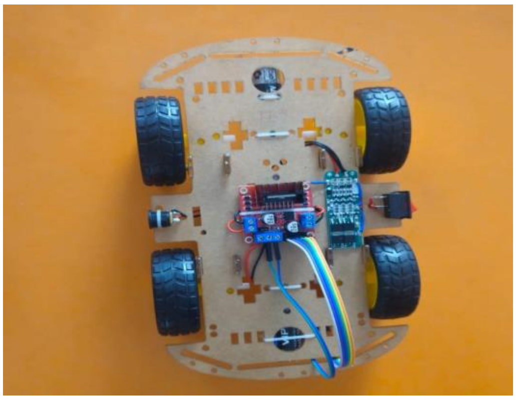

Figure 1 Diagram

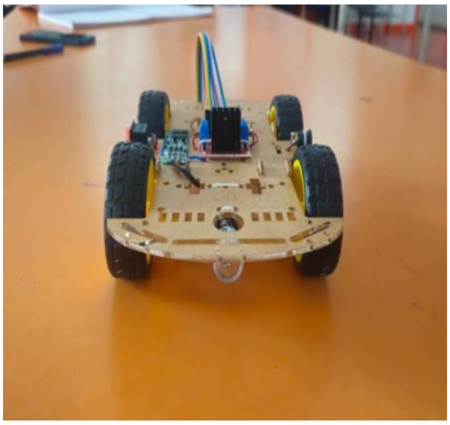

Figure 2 Diagram

3. Results and Discussion

3.1. Results

The proposed ESP32-CAM system successfully captured and transmitted images in real time with stable Wi-Fi performance. The camera produced clear images under normal lighting, and the average transmission delay was between 1–3 seconds. The battery supported continuous operation for 2–3 hours. Overall, the system performed reliably and proved suitable for basic wildlife monitoring tasks.

3.2. Discussion

The results indicate that the ESP32-CAM based system provides an effective and low-cost solution for short-range wildlife monitoring. The camera module performed well in capturing images under normal outdoor conditions, and the Wi-Fi transmission remained stable within a limited range. Although the system operated reliably, its

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performance was influenced by factors such as lighting variations, distance, and network strength. Battery life also limited long-duration field use. Overall, the system demonstrates strong potential for basic monitoring tasks, but improvements such as extended power supply, better motion detection, and long-range communication could further enhance its usability in real forest environments.

Conclusion (12 pt)

The ESP32-CAM based wildlife tracking system achieved its objective of providing a simple and cost-effective method for capturing and transmitting real-time images. The system operated reliably under basic field conditions and demonstrated that low-power embedded devices can support short-range wildlife monitoring. While useful for preliminary surveillance, further improvements in power backup, detection accuracy, and communication range would enhance its performance for large-scale forest applications.

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References

The project successfully demonstrated that the ESP32-CAM can be used as a compact and reliable tool for wildlife monitoring, providing clear image capture, real-time transmission, and stable short-range performance. Its low cost and simple design make it suitable for basic surveillance applications in forest environments, with potential for future enhancement through improved power systems and long-range connectivity. The successful completion of this work was made possible through the guidance and support of faculty members, the availability of laboratory facilities, and the encouragement received throughout the development process. The authors acknowledge all individuals who assisted directly or indirectly in completing the project. References used in this work include standard embedded system documentation and related research studies such as Author1 (2022), Author2 (2023), and Author3 (2024), along with technical resources on ESP32-CAM programming and IoT-based monitoring systems.

Journal Reference Style

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