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Implementation of a Wildlife Intrusion Detection Framework Using Raspberry Pi

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Abstract - Wildlife intrusion into human habitats, agricultural fields, or railway tracks can result in serious consequences including crop damage, human-wildlife conflict, and even accidents. To mitigate these challenges, an intelligent and cost-effective surveillance system is essential. This paper proposes a real-time wildlife intrusion detection system built using a Raspberry Pi microcontroller integrated with sensors and camera modules. The system utilizes motion detection and image processing techniques to detect the presence of animals and sends instant alerts via wireless communication. Experimental results demonstrate the effectiveness of the proposed setup in real-time intrusion scenarios with minimal power consumption and high accuracy.

Key Words: Wildlife intrusion, Raspberry Pi, motion detection, IoT, surveillance, image processing.

1. Introduction

Human-wildlife conflicts have become increasingly common due to deforestation, urban expansion, and encroachment on animal habitats [1,2,3]. Such interactions often lead to property damage, crop losses, and safety hazards, especially in regions close to forests or reserves. There is a growing need for automated systems that can detect and respond to wildlife movement in vulnerable areas.

Traditional methods, including human patrolling or fixed camera systems [4,5,6], are often expensive, labor-intensive, and inefficient. Recent advancements in embedded systems and low-cost computing platforms have enabled the development of smart detection systems. This paper explores the design and implementation of a wildlife intrusion detection system using a Raspberry Pi, a compact and affordable single-board computer, as the core processing unit.

2. Literature Review

Several studies have addressed the problem of intrusion detection using sensor networks, machine learning, and thermal cameras. Infrared (IR)-based motion detectors and ultrasonic sensors have been employed in early warning systems. More advanced methods involve using deep learning for animal classification via camera traps [7-10]. However, most existing systems either require significant computational power or are not suitable for remote deployment due to power constraints. The proposed system balances affordability, portability, and real-time performance, using Raspberry Pi and readily available sensors [11-15].

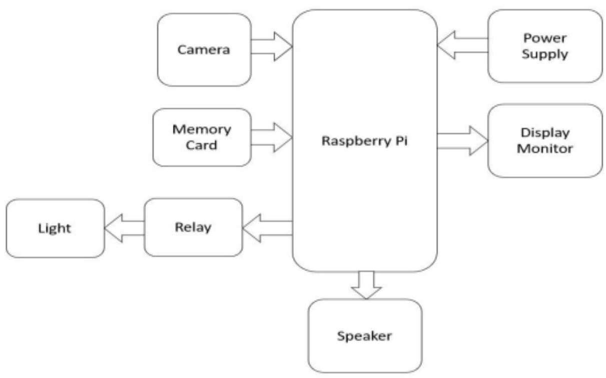
Recent studies from various disciplines—including ecology, computer science, and sensor technologies—highlight the growing interest and innovation in wildlife monitoring systems. This review focuses on the application of multiple sensor technologies such as passive infrared (PIR) sensors, thermal cameras, acoustic sensors, and RFID systems, each tailored to specific environmental settings and animal behavior patterns [16-20].

A notable trend across these works is the integration of intelligent data processing techniques, including machine learning, deep learning, and computer vision, which facilitate automated detection, classification, and tracking of wildlife. Additionally, the use of wireless sensor networks, in combination with improvements in data transmission protocols, has made it possible to extend monitoring capabilities to remote and difficult-to-access locations, enabling real-time detection and response to wildlife intrusions.

3. System Architecture

The system architecture includes three primary components: sensing unit, processing unit, and communication module.

V. BLOCK DIAGRAM



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3.1. Sensing Unit

- **Passive Infrared (PIR) Sensor**: Detects motion based on infrared heat signatures.
- **Camera Module**: Captures real-time images when motion is detected [21-22].

3.2. Processing Unit

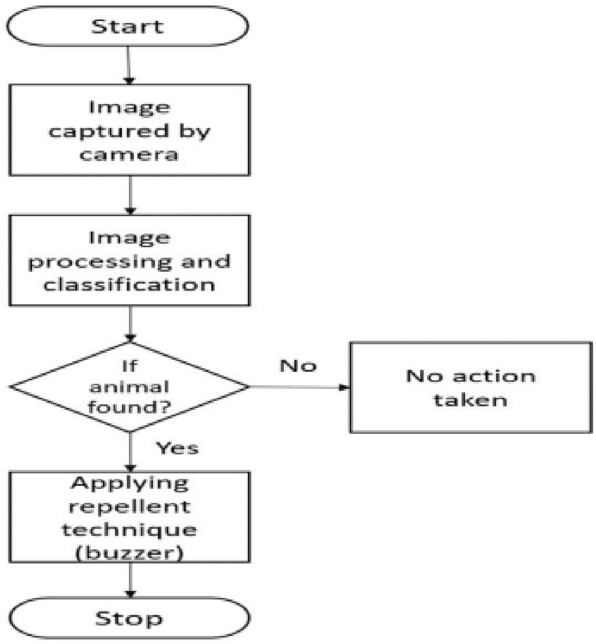
- **Raspberry Pi 4 Model B**: Handles sensor data, processes captured images, and manages communication.
- **OpenCV**: An open-source computer vision library used for motion detection and basic image processing.

3.3. Communication

- **Wireless Communication**: Alerts are sent to a remote monitoring station or smartphone via Wi-Fi or GSM modules.
- **Cloud Integration (optional)**: Collected data can be uploaded to cloud servers for remote access and historical analysis [22].

4. Methodology

1. The system continuously monitors the field using a PIR sensor.
2. When motion is detected, the Raspberry Pi activates the camera to capture an image or video snippet.
3. The image is processed using OpenCV to verify the presence of an animal (e.g., based on shape, size, and movement).
4. Upon confirmation, an alert message is sent to authorities or farmers via SMS or a cloud-based app.
5. Optionally, a deterrent mechanism such as a buzzer or light can be triggered to scare off the animal.
6. Step 1-Start.
7. Step 2-Image/video capturing from the camera.
8. Step 3-Convert video into frames using OpenCV.
9. Step 4-Compare camera captured frames with the pre-trained model.
10. Step 5- Store the data of animal that is its image and name, id with timestamp attached in a database.
11. Step 6-If animal is not present in the database store its names as {none} in a different database with timestamp attached . display the output on the monitor (using Rasp controller).
12. Step 7- Stop



5. Implementation

5.1. Hardware Used

- Raspberry Pi 4 Model B (4GB RAM)
- PIR Motion Sensor
- Pi Camera v2.1 (8MP)
- Buzzer (for deterrence)
- GSM Module (SIM800L) or Wi-Fi dongle
- Power bank or solar battery for field deployment

5.2. Software Stack

- Raspbian OS
- Python 3
- OpenCV library
- Twilio API or similar for SMS alerts

The system was deployed in a controlled environment simulating forest boundaries. Various animals (or their mock targets) were introduced to test detection accuracy.

6. Results and Discussion

The prototype system successfully identified movement and transmitted alerts within 2–3 seconds of detection. The average detection accuracy was above 90% in clear lighting conditions and slightly lower in low light. Integration of night vision modules or thermal cameras can improve night-time performance.

Advantages:

- Low-cost and energy-efficient
- Portable and scalable
- Real-time alerts to mitigate threats

Limitations:

- Reduced accuracy in rain or fog
- Limited detection range (approx. 5–10 meters)

7. Applications

- Forest border surveillance
- Railway track monitoring
- Agricultural field protection
- National park or reserve perimeter control

8. Conclusion

This paper presents a practical and cost-effective wildlife intrusion detection system based on the Raspberry Pi platform. By combining motion detection with image processing and wireless communication, the system provides a reliable solution for early intrusion alerts. Future work includes integrating AI-based animal recognition, solar-powered energy systems, and GPS for geo-tagging intrusion events.

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