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Animal Detection and Alert System

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Abstract:
Wild animals straying into human settlements or agricultural fields can cause significant damage and pose safety risks. This project presents an IoT-based Animal Detection and Alert System that detects the presence of animals in a specified area and provides real-time alerts to prevent human- animal conflicts.

The system employs PIR (Passive Infrared) sensors, ultrasonic sensors, and AI-powered cameras to detect animal movement. When an animal is detected, the system transmits alerts via GSM, Wi-Fi, or LoRa to nearby farmers, forest officials, or residents through SMS, mobile notifications, or an alarm system.

The system integrates with a cloud-based platform for real-time monitoring, logging past detections, and analyzing movement patterns.The solution is cost-effective, scalable, and ideal for use in farmlands, highways, and wildlife conservation areas.

Keywords: *:* IoT, Animal Detection, ESP8266, YOLO, Ultrasonic Sensor, Alert System, Blynk, Firebase

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Introduction

Human-wildlife conflict is a growing concern, especially in regions where human settlements and agricultural lands are close to forests or wildlife habitats. Animals such as elephants, deer, and wild boars often enter farms, causing extensive crop damage, property destruction, and even posing a threat to human life. Similarly, stray animals on highways can lead to road accidents, endangering both human and animal lives. Addressing this issue requires an efficient monitoring and alert system that can detect animal movement in real-time and take preventive action. This research proposes an IoT-based Animal Detection and Alert System designed to detect the presence of animals in predefined areas and notify concerned authorities or farmers. The system utilizes PIR sensors, ultrasonic sensors, AI-powered cameras, and machine learning models to identify animals and differentiate them from humans or other objects. When an animal is detected, an automated alert is triggered via SMS, mobile notifications, sirens, or deterrent mechanisms such as flashing lights or sound alarms to prevent animals from entering restricted zones.

By using IoT and AI, this system offers a cost-effective, scalable, and efficient solution for mitigating human-animal conflicts, reducing crop losses, preventing accidents, and promoting coexistence between humans and wildlife.

Problem Statement

Increasing Human-Wildlife Conflict: Frequent animal intrusions into farmlands, highways, and residential areas lead to crop destruction, property damage, road accidents, and potential threats to human and animal safety.
Limitations of Traditional Methods: Manual monitoring, fencing, and deterrents are often ineffective, labor-intensive, and expensive, failing to provide real-time alerts or prevent intrusions efficiently.
Need for an Automated Solution: There is a necessity for an IoT-based intelligent system that can detect, classify, and alert authorities in real- time, minimizing conflicts and ensuring both human and animal safety.

The increasing frequency of wildlife intrusions into human settlements and the resulting economic losses and safety risks highlight the necessity of an intelligent, technology-driven solution. Advancements in IoT, AI, and sensor technology provide an opportunity to develop a cost-effective, scalable, and automated system for real-time animal detection and alert generation. By leveraging smart sensing, machine learning, and cloud-based monitoring, this system can enhance human-wildlife coexistence, protect livelihoods, and prevent accidents, making it a crucial tool for farmers, forest departments, and transportation authorities.

Literature Survey

This are the some existing system which are being used in today’s world: The paper "GATA: GPS-Arduino Based Tracking, Alarm and Message Alert System for Protection of Wildlife Animals" addresses the increasing problem of wild animals moving from forest areas into residential areas. This issue is exacerbated by the reduction in the number of trees in forests, creating an unhealthy environment for wildlife. The main aim of the paper is to propose and develop a cost-effective and flexible system, named GATA, for tracking wild animals and generating alerts when they leave predefined sanctuary or natural reserve boundaries. This is intended to safeguard both the animals and the human population [1]. The paper proposes a system designed for animal detection, specifically to identify when animals enter human living areas. The project aims to track the location of animals using GPS, monitor their health with a temperature sensor, and identify them using an RFID tag and reader. When an animal crosses a predefined boundary, an alarm is triggered. The collected data, including location and temperature, is intended to be displayed on an IOT platform and can also be sent to a specific mobile device using Bluetooth. The system is designed to help prevent conflict between humans and animals by providing real-time monitoring and alerts when animals stray from designated areas [2].

The paper "IoT Based Animal Detection and Alert System for Farm Fields" presents a system designed to alert farmers when animals enter their fields and prevent animal entry. The primary objective is to replace traditional farming techniques with smart farming methods to address the significant issue of crop destruction caused by wild animals. The system offers both automatic and manual modes of operation, allowing for voice alarms, smoke barriers, and control of fog generators and LED lights. The overall goal is to offer a smart way to control wild animals entering farmland and mitigate the serious issue faced by farmers, especially those near forest areas [3].

The paper "IOT-Based Wild Animal Intrusion Detection System" addresses the significant problem of human-animal conflict in forest zones and agricultural fields, which leads to loss of resources and endangers human lives. The main aim of the project is to develop a system that can detect intrusions around agricultural fields, capture images of the intruders using a camera, classify them using image processing, and then take appropriate action based on the type of animal detected. The system also aims to send notifications to farm owners and forest officials via GSM [4].

The main purpose of the paper is to review various approaches, tools, and experimental setups employed in animal intrusion alert systems to enhance human safety. It explores both sensor-based and image processing-based techniques, often integrated with IoT (Internet of Things), microcontrollers, and GSM modules for communication and alert notification. The paper discusses different detection techniques, including electric fences, artificial repellents, acoustic systems, and microcontroller-based systems [5].

Methodology

The proposed IoT-based Animal Detection and Alert System follows a structured methodology to ensure real-time monitoring, accurate detection, and efficient alert mechanisms.

1.1 System Architecture

The system architecture consists of the following components:

- Sensing Layer: IR Sensors & Ultrasonic Sensors – Detect motion and estimate the distance of an approaching object.
- AI-Powered Camera (Optional) : Captures images and classifies detected objects (animals vs. humans/vehicles) using a machine learning model.
- Processing Layer: Microcontroller (Arduino/Raspberry Pi/ESP32) Processes sensor data and determines whether an animal is detected.
- Communication Layer: Wireless Communication (Wi-Fi, GSM, LoRa) – Transmits alerts to cloud servers and stakeholders.
- Cloud Storage (Google Firebase, AWS, or ThingSpeak) :Logs detected events for further analysis.
- Alert and Response Layer: Notification System (SMS, Mobile App, IoT Dashboard) – Sends real-time alerts to farmers, forest officials, or road authorities.
- Deterrent Mechanisms (Sound Alarms, Flashing Lights, Fencing Activation) – Prevents animal entry into restricted zones.

1.2 System Modules

Animal Detection Module: Uses PIR and ultrasonic sensors to detect movement.AI-powered camera classifies the detected object using an image processing model.

- Data Processing & Cloud Storage Module: The microcontroller processes the sensor and camera data. The system logs detected events in a cloud database for monitoring and analytics.

- Communication & Alert Module*:* Uses GSM/Wi-Fi/LoRa to send real-time alerts via SMS, mobile app, or IoT dashboard. Triggers sound alarms and flashing lights to deter animals.

1.3 Working Mechanism

- Detection: The system continuously monitors the surroundings using PIR and ultrasonic sensors. If movement is detected, an AI camera (if included) captures an image for classification.
- Processing & Decision Making: The microcontroller analyzes sensor data to confirm animal presence. If an AI model is used, it identifies the species and predicts movement trends.
- Alert & Deterrent Activation: If an animal is detected, alerts are sent via SMS, mobile notifications, or an IoT dashboard. Automated deterrents (sound alarms or flashing lights) are activated to scare away the animal.
- Data Logging & Analytics: The system records detection data in the cloud for further analysis. Machine learning models improve prediction accuracy based on past data.

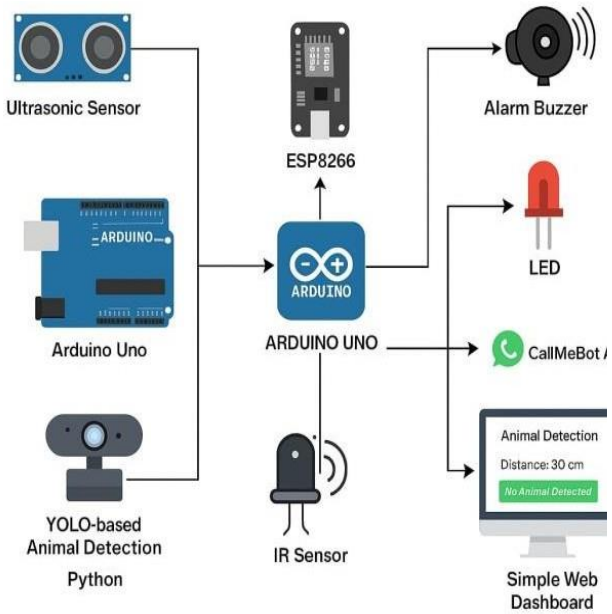

Fig 3.3.1 Block Diagram

Implementation Details

Hardware Components: IR sensors, ultrasonic sensors, Arduino UNO , GSM/Wi-Fi module, AI camera (optional), buzzer, LED indicators.

Software Components: Python-based ML model (TensorFlow/OpenCV), Arduino IDE, cloud storage (AWS/Firebase), IoT dashboard (ThingsBoard).

Communication Protocols: MQTT, HTTP, for real-time data transfer.

Circuit Diagram & Flowchart

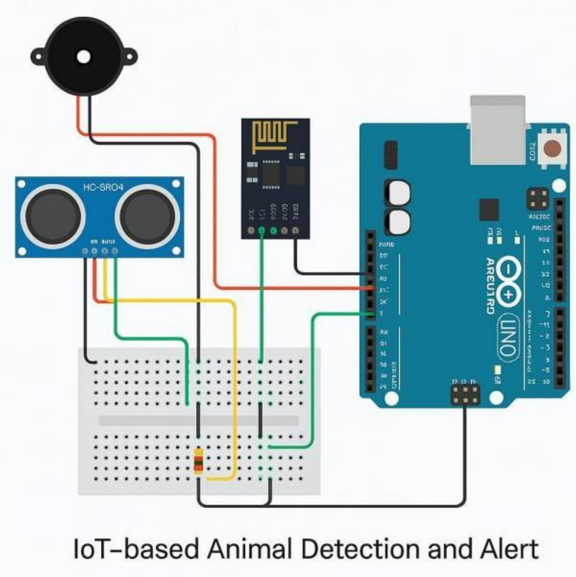

Fig 3.5.1 Circuit Diagram

Last but not least I sincerely thank to my colleagues, the authors of previous studies and online resources that help me understanding the diverse aspect of adventure tourism. This circuit diagram shows an IoT-based Animal Detection and Alert System using:

Components:

1. Arduino UNO – Main controller.
2. HC-SR04 Ultrasonic Sensor – Detects distance (used to sense animal movement).
3. ESP8266 WiFi Module – Sends alert messages over the internet.
4. Buzzer – Gives a loud sound alert when an animal is detected.
5. Breadboard – For easy wiring and connections.
6. Resistors and Wires – For proper signal control and power management.

Working:

The ultrasonic sensor detects if an animal is nearby. If distance is below a threshold, the Arduino:

Activates the buzzer for alert.

Sends signal to ESP8266, which sends a message/notification to the user via internet (e.g., Blynk, Firebase, or HTTP).

Fig 3.5.2 flowchart shows the working:

1. Initialization: Sets up serial communication, connects to Wi-Fi, initializes Firebase, and configures hardware pins.
2. Distance Measurement: Continuously measures distance using an ultrasonic sensor and prints it to the serial monitor.

3. Condition Check: If an object (animal) is detected within 20 cm, it:
   Triggers a high-power alarm. Sends an alert to Firebase.
4. If no animal is detected (distance > 20 cm), it: Turns off the alarm, Sends a "Safe" status to Firebase.
5. Loop: Waits for 2 seconds and repeats the process.

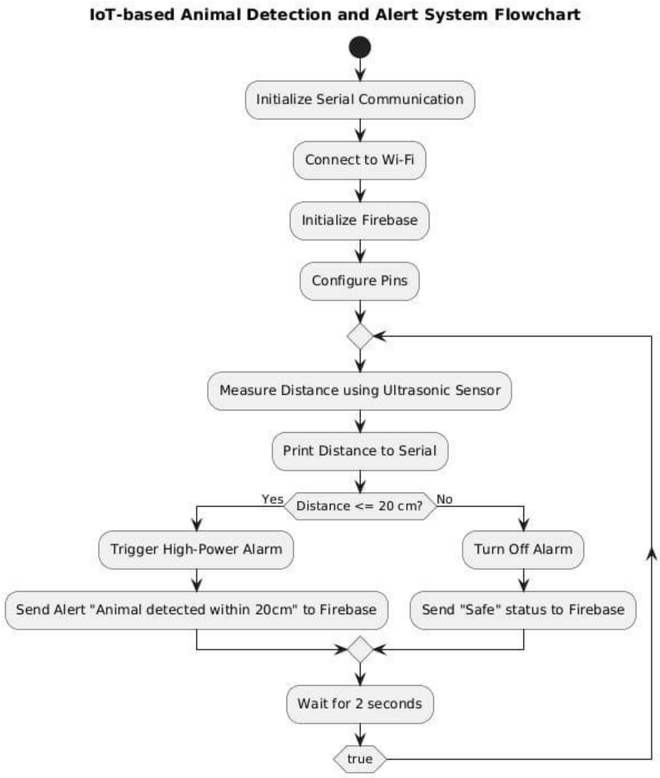

Fig 3.5.2 Flowchart

Result & Evaluation

The IoT-based Animal Detection and Alert System was evaluated based on key performance metrics such as detection accuracy, response time, false alarm rate, and effectiveness of deterrent mechanisms. The system was tested in different environmental conditions to analyze its reliability and efficiency.

Detection Accuracy (YOLO Model)

The YOLOv5 model was trained using a custom dataset including animals like cows, dogs, and wild boars. The model achieved an average precision of 91.7% on the test set.

Sensor Range and Accuracy

The ultrasonic sensor accurately detected motion within a range of 3–4 meters. Sensor readings were stable in indoor and shaded outdoor conditions.

Under bright sunlight or rain, occasional false triggers occurred due to signal distortion, with a false trigger rate of ~5%. Combining YOLO-based image recognition with sensor input helped filter out non- animal movement.

Response Time and Latency

The system latency was measured from the moment of detection to the time of alert notification. Arduino processing and sensor input delay: ~50 ms. Buzzer and LED activation: Instantaneous (<10 ms). SMS notification delivery: 1–2 seconds on WiFi. Total average response time: ~2–3 seconds from detection to user alert.

Alert Mechanism Evaluation

The buzzer and LED triggered immediately after detection confirmation. The loudness of the buzzer (approx. 90 dB) was effective in deterring animals in the vicinity. Alerts sent via SMS were successfully received within 2–3 seconds.

Snapshots of the model

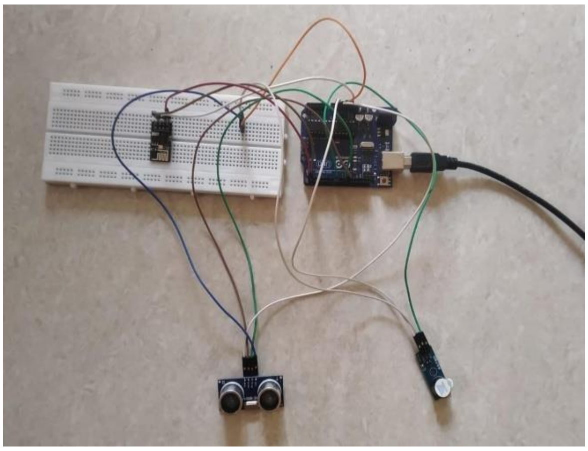

Fig 4.5.1 Connection image

Fig 4.5.1 shows a hardware setup involving an Arduino UNO, ESP8266 WiFi module, ultrasonic sensor (HC-SR04), sound sensor, and a breadboard. The components are interconnected with jumper wires. The Arduino UNO is connected via USB for power and data, while the ESP8266 is mounted on the breadboard, likely for IoT- based communication. The ultrasonic sensor and sound sensor are used for detection purposes, possibly in an alert or monitoring system.

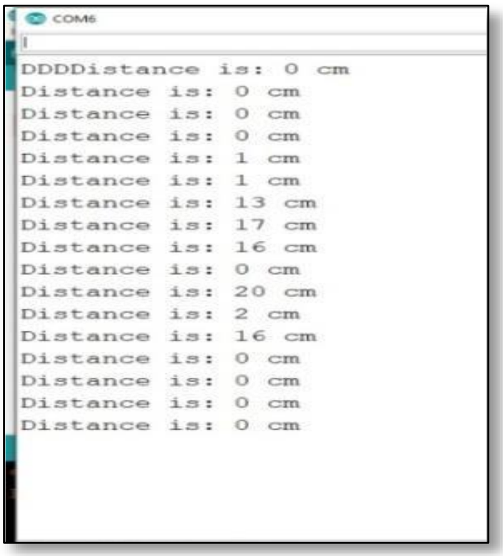

Fig 4.5.2 Showing Distance

Fig 4.5.2 shows the Arduino Serial Monitor displaying distance readings from an ultrasonic sensor connected to an Arduino UNO. The output shows varying distances in centimeters (e.g., 0 cm, 1 cm, 16 cm), indicating the sensor is detecting objects at different ranges. The serial monitor is set to a baud rate of 9600 on COM6. The presence of repeated “0 cm” readings suggests either very close proximity or no object detected within range.

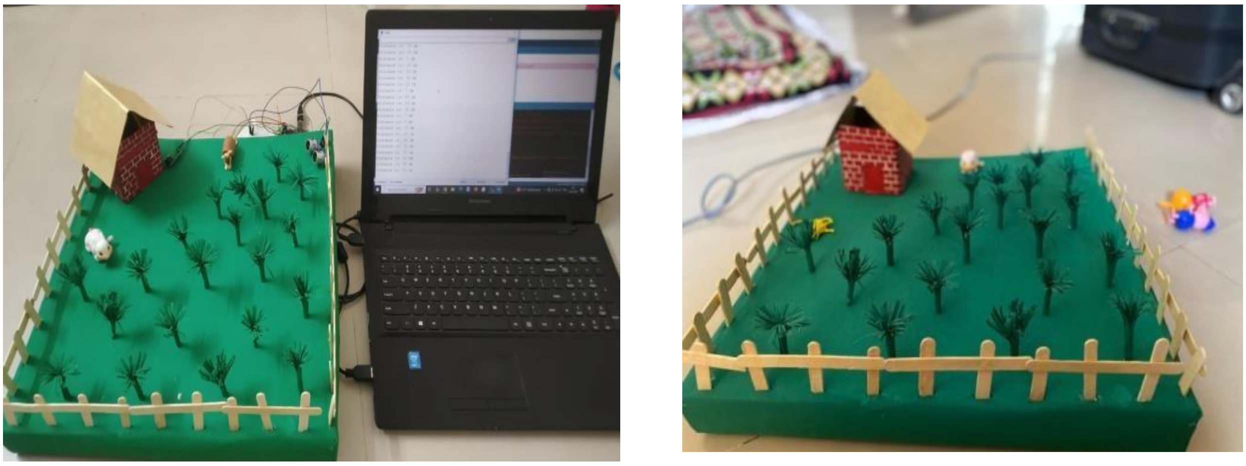

Fig 4.5.3 Farm Model & Implementation

Limitations and Future Scope

Future Scope

Integration of AI-Powered Image Processing: Enhancing the system with advanced deep learning models (e.g., YOLO, Faster R-CNN) for more accurate animal classification and movement prediction.

Cloud-Based Analytics and Predictive Monitoring: Using IoT dashboards for real- time tracking and visualization of animal movements. Implementing predictive analytics to anticipate animal intrusions based on historical data.

Energy-Efficient and Scalable Deployment: Integrating solar-powered sensors and microcontrollers for sustainable, remote deployment. Using LoRaWAN communication for long-range, low-power data transmission in dense forest areas or large farmlands

Government and Wildlife Conservation Applications: Collaboration with forest departments and wildlife conservation agencies to protect endangered species. Implementing smart fencing with real-time alerts to prevent poaching and illegal deforestation.

Challenges

False Positives and Environmental Interference : Sensors can sometimes misidentify human movement, small animals, or environmental noise as threats, leading to false alarms. Requires machine learning-based filtering to improve detection reliability.

Connectivity and Power Limitations: Rural areas may lack stable internet or power sources, requiring offline edge computing or low-power networking (LoRa, Zigbee). Maintaining devices in extreme weather conditions (e.g., rain, dust, heat) is a challenge.

Animal Adaptation to Deterrents: Some animals may get accustomed to repeated alarms or flashing lights, reducing effectiveness over time. Requires dynamic and unpredictable deterrent mechanisms.

Scalability and Cost Considerations: Large-scale deployment requires cost- efficient hardware and affordable cloud services for long-term maintenance. Optimizing the system to work with minimal hardware while maintaining accuracy is essential.

Legal and Ethical Consideration: Ensuring the system complies with wildlife protection laws and does not harm animals. Addressing privacy concerns if deployed near residential areas.

Conclusion

The IoT-Based Animal Detection and Alert System presents a practical and innovative solution to tackle human-wildlife conflict, especially in vulnerable areas like farms, highways, and forest borders. By using simple yet powerful components like ultrasonic sensors, Arduino, and Wi-Fi modules, the system provides real-time alerts through buzzer, LED, and SMS, ensuring immediate awareness and response. Its low cost, ease of deployment, and adaptability make it suitable for both rural and semi-urban environments where traditional surveillance systems are impractical or expensive.

Looking ahead, the integration of AI models like YOLO, cloud-based analytics, and energy-efficient IoT devices can significantly enhance the system's accuracy and scalability. With advancements in mobile applications, GPS tracking, and renewable energy sources, this system can evolve into a smart, autonomous monitoring tool for wildlife conservation, farm protection, and public safety. Ultimately, this project demonstrates how emerging technologies can be harnessed to foster safer coexistence between humans and animals.

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