Harmony Ai: A Review of an Intelligent System for Mitigating Human–Wildlife Conflict

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***Abstract*—This study presents an AI-Powered Wildlife Deterrence System with Thermal Imaging and Frequency Injection for protecting agricultural fields from wildlife intrusion. The system integrates a thermal camera and AI-based object detection algorithms to accurately identify animals approaching farmlands under varying environmental conditions. Upon detection, species-specific acoustic frequency signals are automatically generated and transmitted to deter animals safely and effectively. The AI module enhances detection accuracy, reduces false alarms, and optimizes system response and energy efficiency. Field evaluations demonstrate the system's effectiveness in minimizing crop damage and ensuring reliable autonomous operation. The proposed solution provides a sustainable and intelligent approach to mitigating human–wildlife conflict in smart agriculture applications.**

***Index Terms*—Artificial Intelligence, Thermal Imaging, Wildlife deterrence, Acoustic frequency injection, Object detection, Smart agriculture.**

I. INTRODUCTION

Human-wildlife conflict is a growing concern especially in agricultural and rural areas where animals often invade farms and cause significant crop damage. Traditional methods of protecting fields such as fencing or manual monitoring are often ineffective, costly and labor-intensive. To address this issue, the proposed animal repellent system aims to automatically detect and repel animals using advanced sensing and deterrent technologies. The system employs microphone and motion sensors to identify animal presence through sound and movement. Once detected, a microcontroller processes the data and activates repelling mechanisms such as ultrasonic sound waves and flashing lights to drive the animals away without causing harm. This eco-friendly and energy-efficient system, powered by solar or battery sources provides a reliable and sustainable solution for protecting crops and reducing human-animal conflict.

The system enables real-time detection of animal movement, allowing immediate response mechanisms to prevent crop damage effectively. Unlike traditional trapping or harmful methods, the proposed system focuses on humane animal deterrence using sound and light-based techniques. The use of low-cost sensors and microcontroller-based design makes the system affordable and practical for farmers in rural areas. The system can be easily expanded or modified to suit different environments, animal types, and agricultural requirements. The system is designed to consume minimal power and can operate using renewable energy sources such as solar panels, making it suitable for remote agricultural areas. By automatically monitoring and detecting animals, the system reduces the need for constant human presence in fields, thereby saving time and labor for farmers. Increasing human–wildlife conflicts highlight the need for automated monitoring systems that can operate continuously without human supervision, improving safety and efficiency.

II. LITERATURE SURVEY

A. Md. A. Rahman et al. – A Scalable Framework for Deploying AI-Powered Wildlife Monitoring in Resource-Limited Field Environments (2025) [1].
This paper proposes a scalable edge-AI framework for wildlife monitoring in remote and resource-constrained environments. The system utilizes lightweight YOLO-based object detection models deployed on embedded computing platforms such as NVIDIA Jetson and Raspberry Pi. It emphasizes real-

time animal detection with optimized power consumption suitable for solar-powered installations. The architecture supports modular expansion, enabling integration with multiple camera nodes and wireless communication modules. Experimental validation demonstrates high detection accuracy with reduced latency and improved energy efficiency. The framework is designed to support long-term autonomous monitoring in agricultural and forest boundary areas.

B. Dr. G. Premananthan et al. – Animal Detection Based Smart Farming in Animal Repellent Using AI. [2]

This study introduces an AI–IoT-enabled smart farming system designed to detect and repel animals intruding into agricultural lands. The system employs deep learning-based image recognition techniques to identify specific wildlife species in real time. Upon detection, ultrasonic and acoustic repellents are automatically activated to deter animals in a humane and eco-friendly manner. IoT connectivity allows farmers to receive instant notifications and monitor field activity remotely via a mobile application. The system demonstrates improved crop protection efficiency while minimizing harm to wildlife. Performance evaluations highlight reliable detection accuracy under varying environmental conditions.

C. Oviya Gnanasekar et al. – Image Processing Based Animal Intrusion Detection System in Agricultural Field Using Deep Learning (2024). [3]

This research presents a Raspberry Pi-based wildlife intrusion detection system powered by YOLOv7 deep learning algorithms. The system processes real-time video streams to detect animal presence with high precision and low computational overhead. Once intrusion is identified, automated SMS alerts are sent to farmers using GSM modules, and pre-configured repellent sounds are activated. The design prioritizes affordability and ease of deployment for small-scale farmers. Experimental results indicate strong detection accuracy even under moderate lighting variations. The solution offers a cost-effective alternative for smart agriculture applications.

D. Nguyen et al. – Edge AI-Based Smart Wildlife Intrusion Prevention System. [4]

This paper presents an edge AI-powered wildlife intrusion prevention system designed for low-latency and power-efficient operation. Lightweight deep learning models are deployed on embedded edge devices to perform on-site animal detection without reliance on cloud processing. The system reduces network bandwidth requirements and enhances real-time responsiveness. Integrated deterrent modules are automatically activated upon intrusion detection. Performance analysis demonstrates high accuracy with reduced energy consumption. The solution supports scalable deployment across agricultural and forest monitoring environments.

E. Krishanu Kundu et al. – Design and Deployment of Wild Animal Intrusion Detection & Repellent System Employing IoT (2023). [5]

This paper presents an IoT-based wildlife intrusion detection and repellent system tailored for agricultural protection. The system integrates motion sensors, cameras, and microcontrollers to detect animal movement along farm boundaries. Upon confirmation of intrusion, alarms and deterrent mechanisms such as sound emitters and flashing lights are activated. Real-time alerts are transmitted to farmers through cloud-based platforms. The deployment demonstrates effective monitoring across large field areas with minimal manual intervention. The study emphasizes low-cost hardware integration and scalability for rural applications.

F. Fernandez et al. – Thermal Imaging-Based Animal Detection System for Night Monitoring. [6]

This study proposes a thermal imaging-based wildlife detection system optimized for night-time monitoring. The system leverages infrared thermal cameras combined with AI-based classification algorithms to detect animals regardless of lighting conditions. Real-time image processing ensures accurate identification with minimal false positives. Automated deterrent mechanisms are triggered based on species detection. The thermal approach significantly enhances reliability compared to conventional RGB camera systems. Experimental validation confirms superior performance in low-visibility environments.

G. Hardiki Deepak Patil and Dr. Namrata Farooq Ansari– Intrusion Detection and Repellent System for Wild Animals Using Artificial Intelligence of Things (2022). [7]

This study develops an Artificial Intelligence of Things (AIoT) framework combining environmental sensors, cameras, and machine learning algorithms for wildlife detection. The system analyzes visual and sensor data to accurately classify animal species and trigger appropriate deterrent mechanisms. Sound and light-based repellents are activated depending on the detected species and threat level. Cloud connectivity enables remote monitoring and historical data analysis. The proposed architecture improves detection reliability while maintaining low operational cost. Field trials demonstrate significant reduction in crop damage incidents.

H. Kumar et al. – IoT-Based Smart Surveillance System for Forest Border Monitoring. [8]

This research introduces an IoT-enabled surveillance system designed for monitoring forest borders and preventing wildlife encroachment. The system integrates motion sensors, cameras, and cloud-based analytics platforms. Real-time alerts are generated when unusual activity is detected near protected boundaries. Data collected from multiple nodes are stored and analyzed for pattern recognition and predictive monitoring. The system enhances forest management and supports early warning mechanisms. Field deployment results indicate improved surveillance efficiency and rapid response capabilities.

I. Sharma et al. – Real-Time Wild Animal Detection Using Deep Learning for Smart Agriculture (2021). [9]

This paper presents a convolutional neural network (CNN)-based wildlife detection system for smart agriculture applications. The system processes live video feeds to detect animals intruding into farm areas. Upon detection, GSM-based alerts are automatically sent to farmers, and deterrent devices are activated simultaneously. The model is trained on diverse wildlife datasets to improve detection robustness. The solution demonstrates real-time performance with acceptable computational complexity. The study highlights the potential of deep learning in reducing agricultural losses caused by wildlife.

J. Divya et al. – Machine Learning-Based Acoustic Repellent System for Protecting Crops Against Wild Animal Attacks (2020). [10]

This research proposes a machine learning-driven acoustic repellent system designed to protect crops from wild animal intrusion. The system classifies animal sounds using trained ML models and generates species-specific repellent frequencies accordingly. Audio sensors capture environmental sounds, which are processed in real time to identify potential threats. The adaptive frequency generation ensures improved deterrence effectiveness compared to static sound systems. Experimental analysis demonstrates high classification accuracy and efficient power utilization. The approach supports humane and sustainable crop protection strategies.

III. COMPARATIVE ANALYSIS OF LITERATURE REVIEWS

A. Md. A. Rahman et al. – A Scalable Framework for Deploying AI-Powered Wildlife Monitoring in Resource-Limited Field Environments (2025)

This research introduces a scalable AI-powered wildlife monitoring framework using YOLOv8 and YOLOv10 models deployed on edge devices such as Jetson Orin Nano and Raspberry Pi 5. The study focuses on cost-performance optimization and energy-efficient deployment in rural environments. Real-time object detection is achieved with reduced inference latency. The framework supports multi-node expansion for large-scale agricultural monitoring. Performance evaluation highlights improved detection precision and reduced operational cost. The study contributes to scalable AI-based wildlife surveillance systems.

B. Dr. G. Premananthan et al. – Animal Detection Based Smart Farming in Animal Repellent Using AI

This study proposes an AI and IoT-based smart farming system aimed at preventing crop damage caused by wild animals. The system detects animals entering farmland using computer vision techniques and automatically activates ultrasonic repellent devices to drive animals away without causing harm. The integration of sensing, processing, and actuation provides a fully automated solution for farmers. The research highlights the importance of humane wildlife management and reduced human intervention. Nevertheless, the effectiveness of ultrasonic repellents varies across animal species and environmental conditions, which may limit consistent performance in

real-world agricultural settings.

C. Oviya Gnanasekar et al. – Image Processing Based Animal Intrusion Detection System in Agricultural Field Using Deep Learning (2024)

This research develops an animal intrusion detection system using YOLOv7 implemented on a Raspberry Pi platform. The system captures images through cameras, detects animals in real time, and sends SMS alerts to farmers while simultaneously activating sound-based repellents. The use of deep learning improves detection accuracy compared to traditional sensor-based systems. The study demonstrates a practical low-cost implementation suitable for rural deployment. However, the processing capability of Raspberry Pi devices can restrict performance when handling complex models or high-resolution video streams, and detection accuracy may reduce under poor lighting or adverse weather conditions.

D. Nguyen et al. – Edge AI-Based Smart Wildlife Intrusion Prevention System

This research focuses on deploying lightweight deep learning models on edge devices for wildlife intrusion prevention. The system processes video data locally, enabling low-latency detection and reducing network dependency. Edge AI improves privacy, energy efficiency, and real-time response capabilities, making it suitable for smart agriculture and forest monitoring applications. Automated deterrent actions are triggered immediately after detection. Despite these advantages, optimizing deep learning models for limited hardware resources remains a technical challenge requiring careful model compression and tuning.

E. Krishanu Kundu et al. – Design and Deployment of Wild Animal Intrusion Detection & Repellent System Employing IoT (2023)

This paper introduces an IoT-enabled wild animal intrusion detection and repellent system designed to enhance farm security. The system utilizes sensors and connected devices to detect animal movement and trigger alarms while sending alerts to users through network communication. The approach focuses on simplicity, affordability, and ease of deployment in agricultural environments. Although the system effectively provides early warning and deterrence, it relies mainly on sensor-based detection rather than advanced AI vision techniques, which can lead to false triggers caused by environmental disturbances such as wind or non-animal movements.

F. Fernandez et al. – Thermal Imaging-Based Animal Detection System for Night Monitoring

This paper introduces a thermal imaging-based detection system that enhances wildlife monitoring during night-time conditions. By combining thermal cameras with AI algorithms, the system detects animals based on heat signatures rather than visible light, improving accuracy in darkness, fog, or dense vegetation. Automated deterrence mechanisms are activated once animals are detected. The approach significantly solves limitations of conventional camera systems under low-light environments. However, thermal imaging hardware increases system cost, which may restrict large-scale adoption in low-budget agricultural applications.

G. Hardiki Deepak Patil and Dr. Namrata Farooq Ansari– Intrusion Detection and Repellent System for Wild Animals Using Artificial Intelligence of Things (2022)

The authors propose an Artificial Intelligence of Things (AIoT) framework that combines smart sensors, machine learning algorithms, and automated deterrent mechanisms. The system detects animal intrusion and activates both sound and light-based repellents to prevent crop damage. By integrating AI decision-making with IoT connectivity, the system improves automation and monitoring efficiency compared to traditional solutions. The multi-modal repellent strategy increases effectiveness against different animal behaviors. However, the reliance on sensor inputs rather than visual recognition may reduce classification accuracy and limit the system's ability to distinguish between animal species.

H. Kumar et al. – IoT-Based Smart Surveillance System for Forest Border Monitoring

The study proposes an IoT-enabled surveillance system for monitoring forest borders to prevent wildlife intrusion into human settlements and agricultural zones. The system integrates sensors, cameras, and cloud-based platforms to continuously monitor activity and send alerts when abnormal movement is detected. Cloud connectivity allows centralized monitoring and data storage for analysis.

While the system improves large-area surveillance capability, dependence on internet connectivity and cloud infrastructure may limit usability in remote forest regions with unstable network availability.

I. Sharma et al. – Real-Time Wild Animal Detection Using Deep Learning for Smart Agriculture (2021)

This paper presents a deep learning-based wild animal detection system designed for smart agriculture applications. A convolutional neural network (CNN) model is used to identify animals from captured images, after which GSM modules send alert messages to farmers and activate repellent mechanisms automatically. The system improves response time and reduces manual monitoring efforts. The integration of communication modules ensures immediate farmer awareness. However, the computational requirements of CNN models can increase energy consumption, making long-term deployment challenging in remote areas without stable power sources.

J. Divya et al. – Machine Learning-Based Acoustic Repellent System for Protecting Crops Against Wild Animal Attacks (2020)

This research proposes a machine learning-based acoustic system that identifies animals through sound pattern recognition and generates species-specific repellent frequencies. Unlike vision-based approaches, the system focuses on audio signal processing to detect animal presence even when visibility is poor. The adaptive acoustic response enhances deterrence efficiency by targeting specific animals. Despite its innovation, the system's performance depends heavily on clear audio capture, and environmental noise such as wind, vehicles, or insects may reduce detection reliability in outdoor agricultural fields.

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