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Review Article

AI-Driven Farm-Guard Protection System from Offensive Entry of Nilgai

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A B S T R A C T

Agriculture is the backbone of any country's growth, and it is the utmost duty of every citizen in that country to save it and help in cultivating, but farmers have no such technology to save the crops from being destroyed by animals. Animal intrusion is a major threat to the productivity of the crops; it becomes a major concern for farmers and a threat to the crop fields. To protect their crops from animals like wild boars, goats, monkeys, nilgai (Boselaphus tragocamelus), etc., farmers are led to take preventive measures such as installing fences, which becomes a danger for animals too. The proposed system has been developed to create a defensive framework for the crop fields without causing harm to the animals using a deep learning model and IoT sensors. Upon detecting a wild animal, the system triggers multiple deterrent mechanisms, including the activation of a buzzer, water sprinkler and flashing of light. The proposed system helps the farmer to protect their crops from damage due to wild animals without any harm to them, which also helps in preserving biodiversity.

Keywords: Animal Intrusion Detection, Crop Protection, Farm-Guard System, Deep Learning, Real-Time Object Detection, Model, YOLOv8, Raspberry Pi, IoT Sensors

Introduction

Agriculture is the main source of income for millions of people in India; however, one of the biggest problems farmers face today is the destruction of crops by animals. These incidents happen across many regions: elephants often attack farms in Andhra Pradesh and Tamil Nadu, resulting in thousands of crop-raiding incidents annually.[1] In Jammu, the monkey menace severely impacts farm produce, causing losses worth crores of rupees.[2] Similarly, Nilgai destroy crops in large herds across Bihar and nearby states.[3,4] Other animals like wild boars, goats, buffaloes, bulls, squirrels, and deer also cause serious losses. Because of this, many farmers lose both their hard work and income every season.

Traditional methods like building fences, using electric wires, or scarecrows are not always effective, as these methods are unable to protect crops as well as harm animals.

In this study, we propose an AI-driven Farm-Guard Protection System that detects animals using a deep learning model integrated with IoT sensors to protect crops from animal intrusions. The proposed system architecture integrates cameras and sensors with a Raspberry Pi for image

processing, designed to trigger deterrent mechanisms including buzzers, sprinklers, and lights upon animal detection. This framework provides a blueprint for practical implementation in agricultural settings.

Our proposed system aims to provide farmers with a smart, low-cost, and non-harmful way to protect their crops. It also helps reduce human–animal conflict and promotes coexistence between farmers and wildlife.

Figure 1 describes the sequence diagram for the proposed.

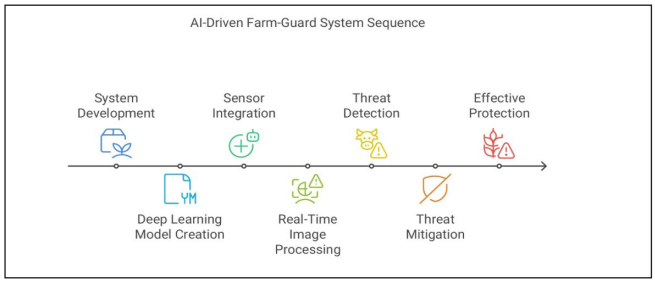

Figure 1.Outline of the workflow

Literature Review

Recent advancements in artificial intelligence and the Internet of Things (IoT) have provided effective tools for addressing the recurring challenge of animal intrusion in agricultural lands. Several studies have explored diverse frameworks that integrate these technologies for real-time crop protection and sustainable farm management.

Reddy et al.[5] proposed an Edge-AI framework that combines deep learning with IoT-enabled devices to detect wildlife threats to crops. Their lightweight model, EvoNet, processes image data directly on an edge camera and collaborates with an autonomous rover for real-time detection and deterrence. The framework achieved a classification accuracy of 96.7%, demonstrating the efficiency of decentralised AI in field-level protection.

Abed et al.[6] presented an AI- and IoT-based solution designed to reduce human–wildlife conflicts in agricultural zones. Their approach uses ultrasonic sensors to capture motion data, which triggers a camera supported by a customised YOLOv8 deep learning model. With a 99% recognition accuracy, the system provides rapid identification and response to potential intrusions, reinforcing both crop safety and biodiversity preservation.

A study by Raiaan et al.[7] introduced an object-detection mechanism integrating ESP32-CAM modules with a YOLOv8 architecture. Their dataset was curated and annotated for improved precision, achieving a mean average precision (mAP) of 92.44%. The system transmits alerts through a cloud interface, enabling remote monitoring and prompt farmer notifications.

Senthil et al.[8] explored a hybrid deep learning model for animal detection in residential and farming environments. By combining DenseNet201, ResNet50, and the YOLO algorithm, their system improved prediction accuracy, with YOLO achieving 98%, outperforming the other models. The research emphasises the effectiveness of hybrid AI solutions for real-time animal prediction.

Kutugata et al.[9] developed a specialised deep learning model trained on 120,000 camera-trap images to identify the Nilgai (Boselaphus tragocamelus) and other animal groups. Their system obtained 97% accuracy for Nilgai detection and 89% for multi-class animal classification. This research underlines the importance of deep learning in automating wildlife monitoring and conservation efforts.

Muthuraju et al.[10] proposed a Raspberry Pi-based surveillance framework that integrates cameras, OpenCV modules, and IoT sensors for real-time monitoring. The YOLO-based model detects animals entering agricultural land and instantly shares images with farmers via a smartphone application, promoting rapid responses to field threats.

Uma et al.[11] introduced a deep learning-based IoT system that employs cameras, drones, IR sensors, and GSM modules to detect and classify animals such as elephants, cows, goats, and pigs. The model uses transfer learning with convolutional neural networks (CNNs) for precise species identification, while automated alerts and deterrent devices protect farmlands without harming animals.

Geerthik and Vishal[12] designed an IoT-enabled platform for humane wildlife deterrence using motion sensors and machine learning algorithms. Their field trials demonstrated a 97% reduction in crop damage. The use of CNN and Support Vector Machine (SVM) classifiers yielded accuracies of 96% and 90%, respectively, highlighting the potential of AI-driven eco-friendly protection systems.

Bharathan and Suganthi[13] proposed a deep learning and industrial IoT-based model that leverages sensors and buzzers to deter animal intrusions. Their system uses the YOLOv3 algorithm integrated with a Raspberry Pi to detect animal movements and trigger species-specific sound alerts, thereby preventing damage to farmlands.

Nandhini and Hi-Tech[14] implemented an acoustic repellent mechanism using infrared cameras and a CNN-based detection model. The system distinguishes between animals such as deer, wild boars, and Nilgai and generates frequency-based deterrent sounds through a microcontroller. Their approach demonstrates a non-invasive and intelligent method to protect crops while maintaining ecological balance.

Balakrishna et al.[15] examined the use of IoT and machine learning to safeguard crops through a distributed sensor network. Their setup employed motion and image sensors to monitor farm activity and notify farmers instantly, showcasing the efficiency of IoT-driven communication for rural automation.

Sannakashappanavar et al.[16] developed an intelligent surveillance model combining AI-powered cameras with IoT-based sensory nodes to monitor multiple animal species. The proposed system improved detection accuracy and reduced false alarms by applying neural network–based animal–human differentiation.

Preethi et al.[17] recently introduced an AI-driven wildlife detection and management system for farm protection. Using the YOLOv8 object detection model integrated with IoT sensors, the system efficiently classified and tracked animals, achieving high accuracy during field trials. The study emphasised scalability, real-time adaptability, and multi-species recognition as key features of future smart farming systems.

Collectively, these studies demonstrate how the integration of AI and IoT technologies can create effective, humane, and sustainable systems for crop protection. However, our work is distinct from the cited literature in its specific application and focus.

Gap Analysis

The study by Kutugata et al.[5] provides a valuable deep learning model for the automatic classification of Nilgai from static, pre-collected camera-trap images, achieving high accuracy. Our work builds on this concept by moving from offline classification to a real-time, active protection system.

While the study by Muthuraju et al.[6] also proposes an IoT-based surveillance framework for detection and farmer notification, our proposed study is different. Our main motivation is to provide a non-harmful and sustainable solution specifically for the Nilgai problem in the Bihar region, where current methods like electric fencing or government-sanctioned culling harm wildlife.

Therefore, our proposed framework is not just a detection-and-alert system. It is an integrated and automated deterrent framework. It is designed to actively protect the crops by triggering multiple non-harmful deterrents, specifically a buzzer, water sprinkler, and flashing lights to repel the animals without causing them any harm, thereby also preserving biodiversity.

Motivation

In rural regions of Bihar, such as Siwan, East Champaran, Vaishali, Samastipur, Buxar and other districts, they face major losses of their crop production; agricultural lands face significant challenges due to wild animals like Nilgai invading and destroying crops. This causes economic impact, agricultural loss, and environmental and ethical imbalance.

The monkey menace is severely impacting agriculture in Jammu & Kashmir, especially in the Jammu division (districts like Jammu, Kathua, Udhampur, and Reasi).

- Crops affected include maize, wheat, rice, and fruit trees like mango, guava, citrus fruits.
- Farmers in over 250 villages in Jammu report losses of farm produce worth crores of rupees due to monkey attacks, according to the Director of Agriculture Jammu.
- Monkey menace making farmers switchover to lemongrass, lavender cultivation

Tamil Nadu reports numerous incidents of crop raiding by wild animals, particularly elephants. The state also faces challenges with human-animal conflict in areas bordering forests.

- Major crops raided by elephants – banana, sorghum, areca nut and coconut.
- Tamil Nadu reported a total of 7,562 incidents of crop-raiding by wild animals in the last three years. According to the Union Minister of Agriculture and Farmers Welfare Narendra Singh Tomar.
- While Andhra Pradesh recorded 7,589 incidents, in which crops on 5,543 acres of land were damaged. Source: The New Indian Express

Due to which farmers practise violent methods such as electric fencing or tools to protect their crops from animals, which harm those animals and impact the wildlife.

Government in Bihar have allowed farmers to abolish nilgai to get rid of them.

In order to control this destruction caused by Nilgai, government of Bihar declares to kill them. Here are some references of news articles in which Bihar government to launch drive to kill Nilgai and wild boars.

https://www.thehindu.com/news/national/bihar/bihar-government-to-launch-drive-to-kill-nilgai-and-wild-boars/article68679079.ece

https://www.livehindustan.com/bihar/hajipur/story-farmers-in-sahdehi-struggle-against-wild-boars-and-nilgai-destroying-crops-201737226081333.html

Our main motivation is not only to protect the crop but also the animals should be safe.

Developing an AI driven farm guard protection system can effectively address this issue by offering a smart, automated and efficient solution

Figure 2.shows the farmers of the Bihar region whose crop fields have been destroyed by a herd of nilgai
Source: Live Hindustan https://www.livehindustan.com/bihar/ara/story-bhojpur-farmers-struggle-against-increasing-nilgai-damage-to-rabi-crops-201740935610837.html

Figure 3.Real-time image of a farm destroyed by a herd of invading nilgai
Source: Source: Collected by project team [Aman, Sumit, Ankit Sachin]

Figure 4.shows some of the real time images of nilgai entering in the farmers field in Bihar region. Images captured by the members of the project team

For the last many years, it has been noticed that Indian farmers have suffered from crop loss to a great extent due to destruction caused by wild animals. Karnataka, Kerala and Tamil Nadu are well-known regions where farmers faced crop loss due to wild animals. Similarly, the undiscovered story of farmers belongs to Bihar, where the protection

of crops from Nilgai is a big challenge for them. Acres of cropland are being destroyed because of them. And the majority of the farmers from districts such as Siwan, East Champaran, Vaishali, Samastipur, Buxar and other districts are faced with major losses of their crop production.

Figure 4 shows some of the real time images of nilgai entering in the farmers field in Bihar region. Images captured by the members of the project team

Methodology

The proposed framework 'Ai-driven farm guard protection system' is based on advanced AI technology and focused the current need of Agro industries. The major objective of this Proposed framework is to protect the crops from the wild animals such as Elephants, Nilgai (Boselaphus Tragocamelus) and others. The proposed work targets the offensive entries of nilgai in the farms of Bihar region. This region is heavily affected and suffered by the attack of nilgai where lakhs of nilgai in a huge herd entered into farmers field and spoiled the whole cultivated land. In order to protect the lands from these destructive attacks, the proposed model based on real time image analysis with sensors has been designed, which provides the notification about the presence of nilgai to the farmers as well as protective measures has been taken with the help of installation of buzzer sensors, Water sprinkler and light sensors. On the detection of nilgai, buzzer sensor activates and release loud sound, without any harm to animals, with the loud sound the animals run away from the field. This approach helps to protect the crop field form offensive entries of animals. Figure 5 describes the framework of proposed project.

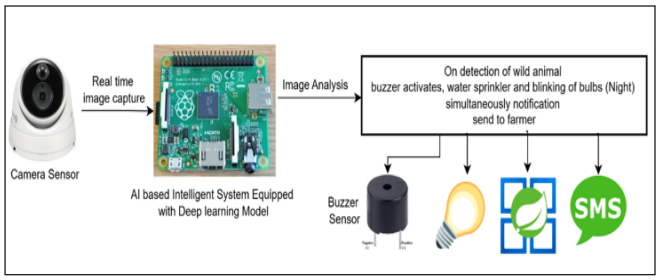

Figure 5.Framework of the Proposed Project

Market Potential

Farmers Need Smart Protection – More farmers want easy, tech-based ways to stop animals like nilgai and wild boars from destroying their crops. AI can help by automatically watching fields and sending alerts, making farming more efficient.

Saves Money & Works Everywhere – Instead of spending on fences or hiring people to guard crops, AI does the job at a lower cost. Plus, it can be used on all types of farms, big or small, making it a great business opportunity.

Conclusion

The AI-driven farm guard protection system represents a significant advancement in protecting agricultural lands from the threats posed by wild animals, particularly nilgai in the Bihar region. By combining real-time image analysis with sensor technology, this framework not only safeguards crops but also promotes coexistence with wildlife through non-harmful deterrent measures. The implementation of this system has the potential to revolutionise farm protection strategies, ensuring the sustainability and productivity of agro-industries in affected regions.

References

1. (2024). Data as per Union Minister of Agriculture and Farmers Welfare Narendra Singh Tomar. The New Indian Express. Retrieved from https://www.newindianexpress.com/states/tamil-nadu/2020/Sep/20/7562-cases-of-crop-raiding-by-wild-animals-reported-in-last-threeyears-across-tamil-nadu-2199345.html
2. Mir, G. H. (2013). As cited in: "Out of control: why monkeys are a menace". Down To Earth. Retrieved from https://www.downtoearth.org.in/wildlife-biodiversity/out-of-control-why-monkeys-are-a-menace-50817
3. Bihar government to launch drive to kill nilgai and wild boars. (2025, September 27). The Hindu. Retrieved from https://www.thehindu.com/news/national/bihar/bihar-government-to-launch-drive-to-kill-nilgai-and-wild-boars/article68679079.ece
4. (2025, March 3). Bhojpur farmers struggle against increasing nilgai damage to rabi crops. Live Hindustan. Retrieved from https://www.livehindustan.com/bihar/ara/story-bhojpur-farmers-struggle-against-increasing-nilgai-damage-to-rabi-crops-201740935610837.html
5. Reddy, K. V., Reddy, B. K., Goutham, V., Mahesh, M., Nisha, J. S., Gopinath, P., ... & Varsha, R. (2024). Edge AI in Sustainable Farming: Deep Learning-Driven IoT Framework to Safeguard Crops From Wildlife Threats. IEEE Access.
6. Abed, N., Murgun, R., Deldari, A., Sankarannair, S., & Ramesh, M. V. (2025). IoT and AI-driven solutions for human-wildlife conflict: advancing sustainable agriculture and biodiversity conservation. Smart Agricultural Technology, 100829.
7. Raiaan, M. A. K., Fahad, N. M., Chowdhury, S., Sutradhar, D., Mihad, S. S., & Islam, M. M. (2023). IoT-based object-detection system to safeguard endangered animals and bolster agricultural farm security. Future Internet, 15(12), 372.
8. GA, S., Prabha, R., Aishwarya, N., Asha, R. M., & Prabu, S. (2024). An IoT Integrated Smart Prediction of Wild Animal Intrusion in Residential Areas Using Hybrid Deep Learning with Computer Vision. EAI Endorsed Transactions on Internet of Things, 10.

9. Kutugata, M., Baumgardt, J., Goolsby, J. A., & Racelis, A. E. (2021). Automatic camera-trap classification using wildlife-specific deep learning in Nilgai management. Journal of Fish and Wildlife Management, 12(2), 412-421.
10. Muthuraju, T. S., Likhith, K. S., Rao, P., Monish Kumar, K. M., & Sachin, B. (2023, October). Wildlife Intrusion Detection and Prevention in Farm Fields Using IoT Technology. In International Conference on Robotics, Control, Automation and Artificial Intelligence (pp. 43-54). Singapore: Springer Nature Singapore.
11. Uma, J., Shobana, M., Abhiniti, G., Rahul, R., Kavinkumar, S. P., & Roshan, S. H. (2024, March). IoT-Based Smart Farmland Using Deep Learning. In 2024 2nd International Conference on Artificial Intelligence and Machine Learning Applications Theme: Healthcare and Internet of Things (AIMLA) (pp. 1-6). IEEE.
12. Geerthik, S., & Vishal, B. (2025, February). IoT-Based System for Humane Animal Deterrence and Sustainable Crop Management. In 2025 3rd International Conference on Intelligent Data Communication Technologies and Internet of Things (IDCIoT) (pp. 770-775). IEEE.
13. Bharathan, K., & Suganthi, J. (2022, December). Animal detection and prevention in agri field using IoT. In 2022 Third International Conference on Smart Technologies in Computing, Electrical and Electronics (ICSTCEE) (pp. 1-6). IEEE.
14. Nandhini, G. S., & Hi-Tech, S. V. CROP PROTECTION AND MONITORING FROM ANIMAL ATTACKS USING IOT SOLLUTIONS.
15. Balakrishna, K., Mohammed, F., Ullas, C. R., Hema, C. M., & Sonakshi, S. K. (2021). Application of IOT and machine learning in crop protection against animal intrusion. Global Transitions Proceedings, 2(2), 169-174.
16. Sannakashappanavar, B. S., Kumar, M., & Hegde, G. S. (2024, March). Intelligent Surveillance and Protection System for Farmlands from Animals. In 2024 IEEE International Conference on Contemporary Computing and Communications (InC4) (Vol. 1, pp. 1-6). IEEE.
17. Preethi, K., Vinitha, A., Vinothiga, V., Mahalakshmi, V., & Kumararaja, V. (2025, April). AI-Driven Wildlife Detection and Management System for Agricultural Protection. In 2025 3rd International Conference on Advancements in Electrical, Electronics, Communication, Computing and Automation (ICAECA) (pp. 1-4). IEEE.