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Real Time AI-based Wildlife Detection and Deterrent System for Farmland Protection

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Abstract— Using real-time detection, identification, and deterrent, the automated agricultural land security system is a smart AI-supported solution that aims to halt animal encroachment and safeguard crops. The proximity of the crops and their agent may be continuously monitored by the distance-based sensors. The farmer is alerted by an alert bell the moment the animal is detected. The AI system will then activate the YOLO object detection algorithm to determine the animal's species and trigger the transmission of a deterrent frequency tailored to that species in order to ward off any unwanted visitors. Through GSM communication signals, the farmer is alerted in the event of a tampering occurrence or the animal's persistence. As an added layer of defense against intruders, a perimeter-mounted electric shock pulse device will be installed. The microcontroller's sense modes, deterrents, and communication modules work together to guarantee that processing choices based on sensor data are immediately implemented with everlasting alarm feedback. This technology eliminates the need for human monitoring by effectively deterring animals in an automated and least disruptive way. As a result, crop damage should be reduced. It offers a better long-term solution to the problem of wildlife management than the traditional approaches by using AI and intelligent deterrents to increase agricultural security and production. Agricultural practices, crop preservation, farmers, GSM, wildlife prevention, and live and let die

I. INTRODUCTION

The danger that wildlife poses to crop productivity and the enormous financial losses that farmers suffer when they invade agricultural fields has long been a big worry for farmers. This is why farmers used antiquated forms of deterrence, such physical barriers or fear techniques, to manage animals. These procedures may be time-consuming, costly, and sometimes ineffectual. Furthermore, these treatments lose part of their efficacy over time since many animals develop immunity to them. Therefore, depending on the various behaviors of wildlife ontologies, there is a need for an automated, scalable, enhanced solution [1-2]. Integrating distance-based sensors, artificial intelligence (AI) using the YOLO object identification framework, and an active electric deterrent mechanism, this article presents an enhanced animal repulsion system. Using real-time detection and classification, the system can determine which kinds of animals are approaching farms and then respond with an appropriate deterrent. It applies automated reactions to animals in pastures and employs AI to handle the problem of species identification. In order to modernize the battle against wildlife infiltration, this technology offers a compassionate and effective way to secure crops. It is scalable, requires less human participation, and improves the overall security of agricultural fields.

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II. LITERATURE REVIEW

A method for preventing animals from getting into crops is presented by Balakrishna et al., and it uses machine learning and the Internet of Things. Raspberry Pi, linked to various sensors and components including the Pi Camera and ESP8266 module, serves as the system's brain in this concept. Using two image detection models—SSD and Region-Based Convolutional Neural Networks—the detection part allows animals access to cropland. Since SSD is both the quickest and most accurate of the two models, it may be used as a real-time animal detection system. The system offers a scalable and affordable way to protect crops against animal infiltration [3]. It can also interact with Twilio API to deliver SMS notifications to help farmers.

To lessen the human-wildlife conflict that occurs in agriculture, Sabina and Haseena propose an animal repellant system that is based on deep learning. Using MobileNet SSD, animals may be detected and classified. Once this is done, an alarm can be triggered to scare away nearby wildlife while also notifying the appropriate authorities. The goal is to provide a way to deter animals without hurting them too much, in a compassionate way. In rural locations, real-time work is crucial for crop protection, and this approach achieves the right balance between speed and precision [4]. A camera vision-based system that uses machine learning approaches to identify and repel animals in agriculture is presented by Sudhakar et al. Ultrasound uses high-frequency sound waves to ward off animals, while faster R-CNN is used for real-time detection. Use of a confusion matrix, which shows how well the model detects and classifies different animals, allows us to evaluate the detection model's performance. Timely notifications are sent to farmers by the system to ensure the protection of crops and wildlife. The techniques used to repel animals are non-destructive, making them compassionate [5]. When it comes to protecting agricultural areas from wildlife infiltration, there is an intelligent system for animal identification that uses AI and deep learning, according to Sivasubramanian et al. When animals are seen, ultrasonic signals are sent out to gently scare them away. This helps to reduce the amount of damage they may do to crops and the need for humans to intervene physically. Data from this study supports the idea that artificial intelligence (AI) systems might one day improve crop protection [6]. A real-time animal-repelling system that uses edge AI to keep ungulates away from crops is described in the work of Adami et al. In order to identify which animals are damaging crops and to activate ultrasonic repellent devices, this system makes use of object identification algorithms that are based on the YOLO principle (you only look once) and embedded hardware such as Raspberry Pi and NVIDIA Jetson Nano. In order to shed light on practical agricultural uses, the suggested system's performance assessment took into account factors including cost, energy efficiency, and the feasibility of such AI-powered systems for crop protection [7].

An agricultural crop security system that can identify and repel animals from fields has reportedly been developed using machine learning algorithms and analysis (Marichamy et al., 2018). Using MobileNet SSD, the Wildlife Detector can identify animals in real-time and notify users of any potentially harmful ones. Aiming for quick detection and, by extension, a compassionate means of discouraging animals from damaging crops, this system makes use of IoT and AI technology. How these machine learning methods contribute to conflict avoidance and food supply safety is outlined in this paper's implications [8].

There is a proposal for an AI-powered monitoring system that would use deep learning techniques to keep animals off farms. The system has a built-in camera, image processing, and a deep learning model to identify animals in real-time. An image processing technique is set to quickly repel and identify any intruding animals once they are spotted. The model continues by creating a picture of itself using AI and image processing; this aids in crop protection and decreases the unit application of work. For small-scale farmers, this is a practical and economical solution [9]. This research paper presents a combination of deep learning and artificial intelligence to address the issue of crop damage caused by animals. It details the problem of animal raids experienced by farmers in India and suggests a more humane solution than traditional methods of crop protection, such as electric fencing and human guarding, by suggesting an animal detection system that uses PIR sensors and sound alarms to alert for intrusion [10].

Members of the Kommineni group. To safeguard agricultural crops from animals, propose a new paradigm that uses

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computer vision and machine learning approaches....The technology uses image processing to identify and detect animals on farms, then sounds an alert to keep the animals away from the crops. The goal of this inexpensive and scalable AI-based animal identification and warning systems method is to decrease agricultural damage without harming the animals [11]. Jyothi et al. presented an AI-based crop security system that uses YOLOv3 for object identification and real-time field monitoring to detect animal invasions. Surveillance cameras installed around the farm record footage that may deter unwanted animals with the use of audible alarms. By eliminating the need for expensive and time-consuming human monitoring and conventional fencing, the suggested solution not only notifies farmers instantly via email and mobile notifications, but it also protects their crops from harm while reducing labor expenses [12].

III. METHODOLOGY

To safeguard crops from pests, the system employs cutting-edge sensors, artificial intelligence, and auto-deterrent techniques. In order to detect any approaching wild animals, it employs distance-based sensors that are spread out throughout the perimeter walls of the farm. The farmer is alerted with a loud alarm the moment an animal is spotted. The YOLO AI system will identify the species as the animal gets closer, and then set the deterrent's frequency accordingly. It notifies the farmer via GSM connection if an animal refuses to leave or if the system is being tampered with, allowing for prompt action. Along with the perimeter, an electric shock pulse device is also installed to deter illegal individuals from entering the field. For features like real-time detection and categorization, as well as feature activation, a microcontroller unifies all components into one. Figure 1 shows the system's operational flow, including detection, categorization, the deterrent mechanism, and alarms. This concept proposes a novel way to prevent animals that is clever, eco-friendly, and the simplest way to get things done. Traditional wildlife control measures include environmentally harmful chemical repellents, ineffective scare tactics, and labor-intensive manual monitoring. Through using the system's AI and automation features, agricultural output is improved while crop losses are minimized. Additionally, sustainable farm management is achieved. A greater possibility to address difficulties in modern farming exists in the design's scalability, which allows it to be adapted to various agricultural situations. nstantaneous monitoring, intelligence-based decision-making, and automatic deterrent make up the system, giving farmers a real-time weapon against wildlife that may harm their crops and farms. Safeguarding crops against animal invasion might be achieved by the systematic integration of distance-based sensors, object identification powered by artificial intelligence, and automated deterrent responses.

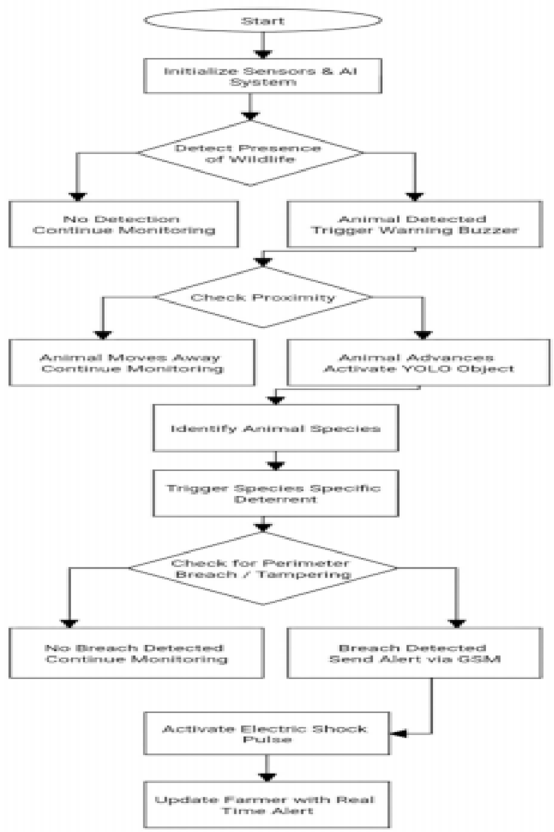

Fig. 1. Flowchart of the proposed system

In order to detect approaching animals that move within a predetermined range, distance sensors constantly monitor the dispersed perimeter.
The farmer is notified when the warning bell goes off in the case of any first discovery. A YOLO object detection system that is powered by artificial intelligence can instantly identify the species of an approaching animal and set off a deterrent frequency that is particular to that species to keep it at arm's length. The technology employs GSM communication to promptly alert the farmer in the event of persistent infiltration or any kind of manipulation. To further dissuade animals from crossing the boundary, a nonlethal electric shock pulse device is activated all around the property.
The system's reading of sensors, programming of alarms, and timely activation of deterrents are all controlled by a microprocessor. An efficient and automated solution is provided by the system, which incorporates real-time monitoring, AI-based identification, and targeted deterrent mechanisms, to protect agricultural lands from wild animals. This ultimately reduces the need for constant human vigilance and limits possible damages to crops. Figure 2 shows the system's block diagram, which shows how the different parts, including sensors, AI processing, and the microcontroller-controlled deterrent mechanisms, are integrated. The system provides its end-user with several

benefits. First, it minimizes the need for human intervention by automatically detecting, identifying, and discouraging animals without continual human oversight. Farmers may save money, time, and effort because of this. Second, it improves precision and efficiency by reducing the number of false alarms caused by the detection of species-specific deterrents to ward off invaders. In contrast to chemical repellents or harmful barriers, the system offers non-lethal deterrents and smart alert signals to keep crops in good condition. It also provides formal eco-friendly and sustainable protection, which is great for wildlife conservation and ecological balance.

In the end, the system offers a lot of benefits to the user. First, it minimizes the need for human intervention by automatically detecting, identifying, and discouraging animals without continual human oversight. The farmers may save on labor, operational expenses, and time thanks to this. Secondly, it improves precision and productivity: False alarms are minimized by the use of artificial intelligence (AOI) to recognize species-specific deterrents. Third, it offers long-term, environmentally friendly security: unlike chemical repellents or harmful barriers, this system uses smart alert signals and non-lethal deterrents to keep crops healthy. It also helps to preserve wildlife and keep the ecological balance in check. After the identification and detection procedure is complete, the Alert and Deterrence

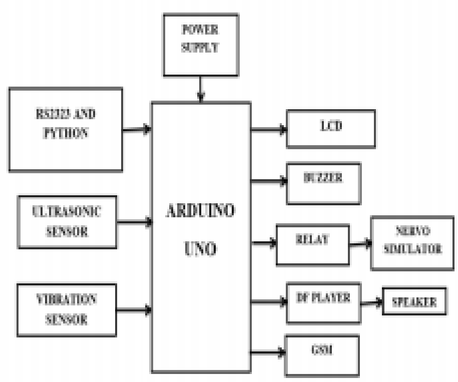

Fig. 2. Block diagram of the proposed system

Module is activated. It scares off the invader at first, then alerts the farmer by sounding a buzzer to sound a warning. Consistently moving closer to it will cause it to release frequencies that are known to be toxic to some animals. If the intrusion or tampering continues, it immediately alerts the farmer using GSM network to deliver an electric shock pulse mechanism for safety. It is designed to adapt to animal hazards with little human intervention, thanks to its active and automated nature. This module connects all other parts via the microcontroller and acts as the central processing unit (CPU). Data from sensors, processing of AI identifications, and deterrent control are all under its control.

Additionally, it handles GSM communications, providing the farmer with immediate notifications in the event of an intruder. It does its job so well, with little effort required for detection, categorization, and the deployment of deterrents. When it comes to automated decision-making, ongoing farm protection, and system stability, this module is essential.

To summarize, the proposed solution for agricultural land security is an all-inclusive automated product that combines cutting-edge AI technology with real-time monitoring and non-lethal deterrence tactics. Thanks to the sensors and the YOLO-powered AI detection model, the system helps keep the environment under check, which is important for agricultural security. Modern farmers now have a viable, efficient, and environmentally friendly option for crop security because to the solution's adaptability and scalable architecture.

IV. RESULTS AND DISCUSSION

The results obtained by the monitoring systems for animal identification and deterrent after their deployment, installation, and testing are detailed in this section. For real-time animal monitoring and detection, the detection and deterrent detection system use a combination of YOLO-based object identification and the Arduino-based sensor network. Next, we'll go at the outcomes in terms of system performance, overall effectiveness, reaction time, and detection accuracy. Chapter One: Performance and Accuracy in Detection Images from an animal dataset and live video stream were used to train and test the YOLO-based object recognition algorithm. The system can detect, categorize, and identify a wide variety of animals in a variety of settings, including zebras, elephants, rhinos, and buffalo. The model demonstrated excellent performance in both bright and dim lighting, as shown in Figure 3. As a result, its reliable operation was assured throughout the clock,

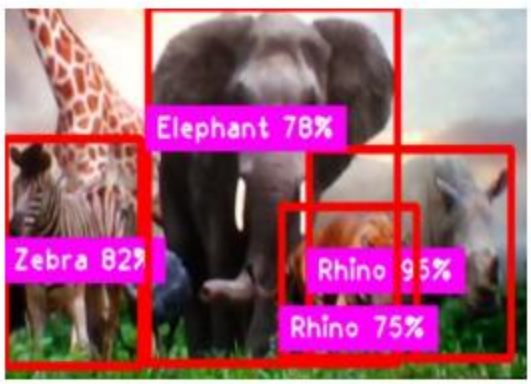

Fig 3 Object detection on wildlife with bounding boxes

In order to train and test the model that could recognize data from live video feeds and animals, the YOLO framework was used. Detecting and classifying buffalo, elephants, rhinos, and zebras in different settings was a breeze with our animal identification system. It is immune to variations in lighting conditions and works admirably in both bright and low light, as seen in Figure 3.
Table I displays the results of YOLO's confidence-based assessment of detection efficiency for each species. Rhinos and zebras, for example, had detection confidence ratings between 75% and 95% in this instance. Confidence ratings for buffalo and elephants were somewhat lower than 50, suggesting they may still be fairly well-categorized, but to a lesser extent.

TABLE I: DETECTION ACCURACY FOR DIFFERENT ANIMAL CLASSES

Animal Class	*Detection Accuracy (%)*	*Confidence Range (%)*
Buffalo	89.9	50-95
Elephant	78.0	50-90
Rhino	95.0	75-99
Zebra	82.0	75-88

The average inference time, which is crucial for real-time detection, was determined to be 90 to 105 ms, as shown in Figure 4. Given that this inference time is sufficient to enable real-time monitoring, with swift identification and response to approaching animals, this discovery shows that the system strikes a good balance between precision and speed, enabling efficient detection of animals without sacrificing performance.

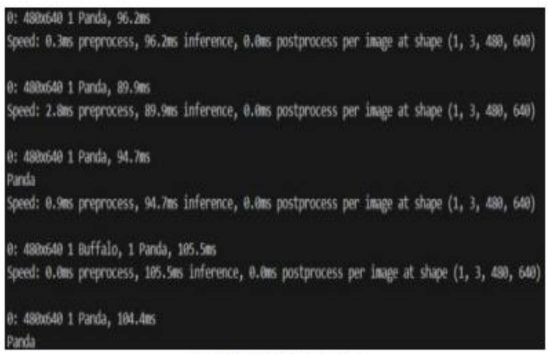

Fig 4 Inference log

B. System Integration and Response

In order to create a robust and reactive deterrent system, the detector model was integrated with a hard device. This was made feasible by a combination of an Arduino microcontroller, vibration sensors, ultrasonic sensors, and a GSM module. These components allow for real-time detection and action when the animal is within the specified distance.

The ultrasonic sensors in the detection system showed the distance in kilometers on an LCD interface once animals crossed the perceived radius of 100 meters. A DF Player module subsequently activated the audio deterrent. As shown in Figure 6, the vibration sensor is set to display a value of 1 when an animal attempts to harm the kit, and a value of 0 otherwise, in order to make noise and frighten away animals at a maximum distance.

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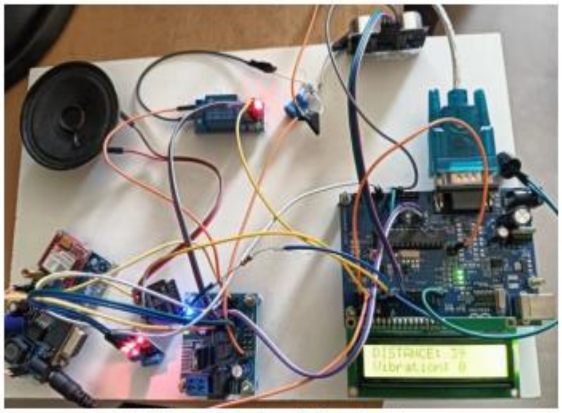

Fig 5 Photograph of the circuit setup

However, the operator may activate a third line of defense using a nerve stimulator to provide an electric shock if the animal still didn't stop after 50 meters. The animal would be maintained at a safe distance from the monitored area's boundary in this fashion, like a farm. Whenever the animals got close to the user's property, the GSM module would send them a real-time notice. Because of this, users were able to take preventative actions, such as contacting the police or using additional manual deterrents.

Fig 6 Illustration of distance and vibration detection

V. CONCLUSION

We are currently developing an automated system to defend farms against animals. It will include cutting-edge sensor technology, AI, and automated deterrent mechanisms. A beneficial, open-scale, and sustainable method to reduce crop devastation by animals is the use of AI-backed YOLO object identification, distance-based sensors, and species-specific deterrent reactions. A non-lethal electric shock pulse system may be used to deter attackers and increase strength around perimeters, while a notice can be sent out to farmers using GSM standard architecture to notify them. Overall, this technique is much more efficient than traditional deterrent tactics, requires far less human interaction, and is more environmentally friendly. It offers a solution to the current, difficult problems in farming with its modular and adjustable architecture, which should make it easier to integrate in any agricultural environment. Potential future improvements include integrating solar panels to make it a more efficient energy consumer, adding other kinds of deterrent mechanisms to make it more specific-oriented repelled, and enhancing the AI model filtering by fine-grain to make detection more accurate. Resolving the long-standing problem of wildlife infiltrating farmlands increases agricultural output and food security by providing farmers with more tools for efficient crop protection.

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