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Artificial Intelligence in Crop Protection: Current Advances

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Abstract- Crop damage caused by animals is a significant threat to crop production reduction. Encroachment of farmland into previously uninhabited areas has intensified the contentious issue of crop raiding. Indian farmers face considerable risks from pests, natural disasters, and animal-related losses, leading to decreased productivity. Traditional methods employed by farmers to mitigate these challenges have proven ineffective, while hiring guards to protect crops from animals is impractical. Balancing the safety of both animals and humans is crucial, necessitating the protection of crops without causing harm and diverting the animals. To address these concerns and achieve our objectives, we utilize deep learning, a branch of computer vision, specifically employing the concept of deep neural networks to recognize animals visiting our farm. This project involves installing a camera that continuously records the farm, allowing us to identify when animals enter the premises using the deep learning model. To deter them an Secure Digital (SD) card is utilized and speaker to play appropriate sounds.

Keywords- AI, Crop raiding, SD Card, Camera.

I. Introduction

Agriculture serves the dual purpose of meeting the food needs of the population and providing raw materials for various industries. However, animal interference in agricultural areas poses a significant threat to crop production. Crop damage caused by animals, including destructive ones like buffaloes, cows, and goats, has been increasing in recent years and has led to substantial losses. This issue particularly affects small farmers who often lose a significant portion of their crops, up to 40 to 50 percent, due to animal raiding [8, 9]. Stringent rules and regulations make it difficult for farmers to take drastic measures to protect their crops. In India, conflicts with animals, particularly elephants, have become a common occurrence, exacerbating the human-animal conflict [5]. Therefore, there is a need for a mechanism to assist farmers in promptly driving away animals when they intrude on agricultural lands. Farmers who wish to employ such a technique do not need to incur substantial expenses, as the current trend is towards achieving strong crop returns with minimal investment. However, natural disasters like cyclones, floods, and droughts, as well as unexpected pest attacks and crop damage from domestic animals during the harvest season, continue to threaten farmers' yields [1, 7]. In an attempt to address this problem, government representatives and farmers have resorted to methods such as beating drums and exploding firecrackers to drive animals back into forested areas. However, these approaches have not proven to be effective, prompting researchers and planners worldwide to seek alternative solutions [2]. Farmers residing near forests or mountainous regions are particularly concerned about ensuring sufficient crop production to feed their families. While methods like wire fences and electric fences exist to protect crops from animals, their costs can be significant and depend on the size of the area. Additionally, legal restrictions often limit the protection to species that are at risk of extinction. Electric fences, although effective, can also pose risks to human life and are often

positioned far from potential human contact. Therefore, it is crucial to employ environmentally safe and non-hazardous automation methods that prioritize the well-being of all living beings. In this study, we employ Artificial Intelligence (AI) to detect animal encroachment in agricultural regions. To divert animals from agricultural land without endangering them or humans, we utilize sound waves. This project involves the use of an Arduino Uno microcontroller, an SD card, and an amplifier to play sounds that would scare away animals. If an animal is detected by the camera, the microcontroller receives the data and compares it to the sound patterns. If a match is found, the corresponding audio is played, and the data can be displayed on an LCD screen. To enhance the range of animal detection, we position a Passive Infrared (PIR) sensor strategically. The hardware configuration of our system is described following an overview of an existing system [11]. The objectives and scope of our project are discussed, highlighting the rationale behind implementing various components.

The objective of this study is to explore image processing techniques and implement an algorithm for a convolutional neural network (CNN). Image processing involves manipulating digital images to extract meaningful information or enhance their visual quality. CNNs are a type of deep learning model widely used in computer vision tasks, including image classification, object detection, and image segmentation.

II. Related Works

There have been various approaches and related work aimed at protecting crops from animals. Here are some examples [10]:

1. *Physical Barriers*: One common method is to establish physical barriers around crop fields to prevent animal intrusion. This can include constructing fences, installing netting, or using scare devices like scarecrows or reflective materials to deter animals from approaching the crops.
2. *Crop Rotation and Intercropping*: Implementing crop rotation and intercropping strategies can help reduce the attractiveness of crops to specific animals. By alternating different crop types or mixing crops together, it becomes more challenging for animals to locate and target specific crops.
3. *Repellents and Deterrents:* Some studies have explored the use of repellents and deterrents to keep animals away from crops. This can involve using natural substances like predator urine, strong scents, or taste aversions to discourage animal feeding.
4. *Acoustic Devices:* Utilizing sound-based devices that emit noises or specific animal distress calls can startle or scare away animals, discouraging them from approaching the crops. These devices can be automated or triggered manually.
5. *Visual Deterrents:* Visual deterrents such as reflective tape, motion-activated lights, or hanging objects that move in the wind can create visual disturbances that animals find unsettling. This can help deter them from entering crop fields.
6. *Intelligent Pest Monitoring Systems:* Advancements in technology have led to the development of intelligent pest monitoring systems. These systems utilize sensors, cameras, and machine learning algorithms to detect and identify animal intrusions. Once detected, appropriate actions can be taken, such as triggering alarms or deploying deterrent mechanisms.
7. *Community and Government Initiatives:* Collaborative efforts involving farmers, local communities, and government agencies are crucial for effective animal damage control. These initiatives may include implementing wildlife management plans, conducting awareness campaigns, or providing financial assistance for implementing protective measures.

It's important to note that the effectiveness of these methods can vary depending on the specific context, the types of animals involved, and local environmental factors. A combination of approaches tailored to the specific challenges faced by farmers is often the most effective strategy for protecting crops from animal damage.

Utilizing two key algorithms: an algorithm for object recognition using artificial neural networks and an algorithm for motion detection using sensors. Animal movement near highways can be detected using a PIR sensor, and objects can be with the aid of ANN [4]. When a motion is discovered, the object identification system determines if it was caused by a moving animal or by some other element. Following the detection of the motion,

the object identification algorithm examines it to determine if the motion was brought on by an animal movement or by any other factors. If this happens as a result of an animal movement, alerts are sent over MQTT to an Android application that uses Google Maps to display them on the relevant area [3]. In a farm, an algorithm is utilized to identify the animals. The variety of animals makes it challenging to manually identify each one. In order to better effectively monitor animals, this system categorizes them based on their photographs. Animal tracing, theft prevention, and animal-vehicle accident prevention can all be aided by animal detection and classification. Applying efficient deep learning techniques can help with this. In order to find animals in a given image, an algorithm is employed. A more accurate feature vector with gradients oriented toward the histogram is called WCoHOG [6]. Co-occurrence Histograms of Oriented Gradients is an extension of this (CoHOG). For high dimensional data, LIBLINEAR classifier is employed in order to improve accuracy. Two benchmark datasetsthe animal and Camera Trap datasetswere used for tests. Experimental results demonstrate that W-CoHOG outperforms current state-of-the-art techniques. Authors in [11] utilized a PIC microcontroller to safeguard the crops in the farm field against animals like buffaloes, cows, goats, and birds. The implemented system employs a motion sensor to identify animals in close proximity to the field, enabling the sensor to send signals to the microcontroller, prompting the farmers to take suitable measures. The motion sensor, which operates on the principle of passive infrared (PIR) detection, is responsible for recognizing the presence of animals, while the microcontroller guides the buzzer to alert the farmers as per its instructions. The authors of this model assert that it eliminates the need for farmers to constantly remain in the farm field for 24 hours and construct physical barriers around their crops. The focus of the author's work in [12] was to safeguard crops from animals while ensuring the well-being of both animals and humans in the conflict. To achieve this goal, the author employed deep machine learning and a Convolutional Neural Network (CNN) algorithm. The developed model aimed to divert animals away from the crop fields. By leveraging the concept of neural networks and computer vision techniques, a machine learning algorithm was created to detect animals approaching the farm field. A camera placed at the field captured images at regular intervals, and the algorithm analyzed these frames using various library functions and neural network concepts. When animal movement was detected, the model played appropriate sounds to divert the animals and prevent them from entering the farm field. The authors in [13] undertook a project to safeguard crops from insects and small animals while also implementing IoT technologies to control irrigation. The central component of their proposed model was the Arduino UNO microcontroller, which played a vital role in managing irrigation and crop protection. The irrigation system operated automatically, turning water siphons on or off based on the moisture levels of the farm field. To protect the crops from insects and animals, deliberate sensors were deployed throughout the field. These sensors detected the motion of insects and animals in close proximity to the crops and transmitted signals to the Arduino Uno microcontroller. The microcontroller then calculated the distance and performed necessary actions. Based on the calculated distance values, the microcontroller triggered high-frequency sounds as a deterrent for the pests. In [14], authors dedicated their efforts to develop a prototype that utilizes IoT and machine learning technologies to monitor crops and issue warnings to wild animals. The IoT components employed in this prototype include a PTZ (Pan-Tilt-Zoom) camera, GSM module, sensors, and an Arduino UNO microcontroller. To classify the animals, the authors employed machine learning algorithms such as K-Nearest Neighbor (KNN), Logistic Regression, and Support Vector Machine (SVM). The dataset used for training and testing the models consisted of 605 images encompassing various animals such as elephants, horses, and zebras. Upon evaluation, the SVM algorithm demonstrated an accuracy of 89.6%, outperforming both the KNN and Logistic Regression models when the regularization parameter was set to C=100.

In our proposed model, we plan to incorporate advanced IoT components such as high-resolution cameras, motion sensors, and environmental sensors. These components will provide real-time monitoring of the farm field, enabling us to detect and respond to animal intrusions promptly. Additionally, we will integrate a robust machine learning algorithm, such as a deep neural network, to accurately classify and identify different animal species. To train the model, we will gather a diverse and extensive dataset consisting of images and data related to various animals encountered in farm fields. By utilizing transfer learning techniques and leveraging pre-trained models, we aim to achieve higher accuracy and faster inference times. The model will be deployed on a powerful microcontroller or edge device capable of processing data in real-time. This will allow for quick decision-making and immediate response actions to prevent damage to the crops. The system will be designed to send alerts to farmers or farm management personnel through mobile applications or SMS notifications, ensuring that timely action can be taken. Through the integration of IoT and machine learning technologies, we envision a comprehensive and efficient solution that can effectively protect farm fields from animal threats. By continuously

improving and refining this model, we aim to provide farmers with a reliable and scalable solution that can be deployed in real-world agricultural settings.

III. Proposed Methodology

Our initiative has two main goals: preventing animals from damaging crops and safely diverting them. We have developed a system that detects the presence of animals and alerts users accordingly. By utilizing a PIR sensor, we can track the movement of animals. Additionally, we plan to install cameras across the entire farm to monitor the surroundings continuously. Through the implementation of a deep learning model, we can detect animals and play specific sounds to frighten them away. The research paper discusses various frameworks and Convolutional Neural Network concepts employed to develop this model. To transmit information to the microcontroller in an agricultural area, the PC will utilize a USB to UART converter once an animal is detected using the CNN method. The microcontroller will then access the file from the SD card, activate the speaker, and guide the animal away from the agricultural field based on the data received from the PC.
Here's a high-level algorithm for crop protection using AI:

1. *Data Collection:* Gather relevant data about the crop, environmental conditions, and potential threats such as pests, diseases, or animals.
2. *Data Preprocessing:* Clean and preprocess the collected data to remove noise, handle missing values, and normalize the data if necessary.
3. *Feature Extraction:* Extract meaningful features from the preprocessed data that can be used to identify and classify threats to the crops.
4. *Model Development:* Train an artificial intelligence model, such as a machine learning or deep learning model, using the labeled data to recognize different types of threats based on the extracted features.
5. *Real-time Monitoring:* Deploy sensors or monitoring devices in the agricultural field to collect real-time data about environmental conditions and potential threats.
6. *Data Integration:* Integrate the real-time data with the trained AI model to continuously analyze and monitor the crop's health and detect any signs of threats.
7. *Threat Detection:* Apply the trained AI model to the integrated data to identify and classify potential threats to the crops, such as pests, diseases, or environmental stress.
8. *Alert Generation:* If a threat is detected, generate alerts or notifications to inform the farmer or relevant stakeholders about the specific threat and its severity.
9. *Intervention Recommendation:* Provide recommendations or actionable insights to the farmer on appropriate interventions or mitigation strategies based on the detected threat.
10. *Decision Support:* Assist the farmer in making informed decisions by providing historical data, trends, and predictive analysis regarding crop health and potential threats.
11. *Continuous Learning:* Continuously update and retrain the AI model using new data to improve its accuracy and effectiveness in threat detection and intervention recommendation.

It's important to note that the actual implementation and specific algorithms used may vary depending on the crop, region, available data, and the specific threats being addressed.

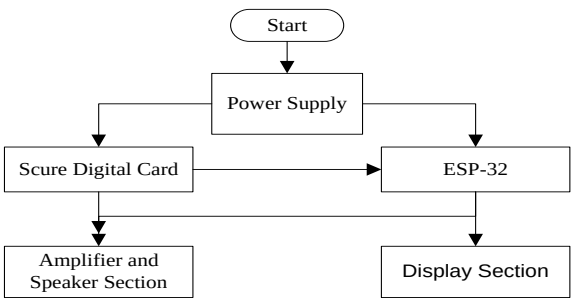


Fig.1. Proposed Method

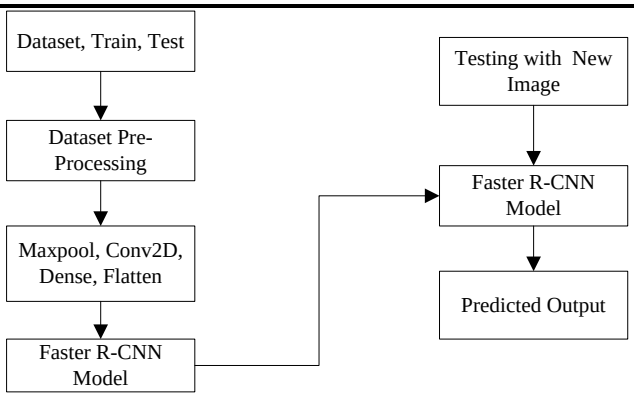


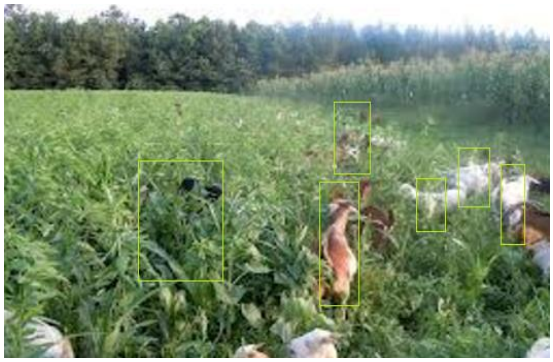
Fig.2. Flowchart of Testing and Training Process

For this assignment, our primary task is to gather images of buffaloes, cows, and goats that clearly depict animals. This is a crucial phase of the project, and we will be sourcing these images from recent or archived CCTV footage. Once we have obtained the data, we can proceed with the following steps. The first step involves pre-processing the collected images. Not all visuals effectively convey the necessary information, so we need to identify, rename, and prepare the photos by resizing them. This ensures that the images are in a suitable format for further processing. Once the pre-processing is complete, we can train our deep learning model using these images. To accomplish this, we need to import the required library files. Library files contain collections of functions and short execution codes that assist us in performing object detection and image processing tasks. In this project, essential library files such as TensorFlow, OpenCV, Keras, and others are utilized. These libraries enhance the effectiveness and adaptability of our deep learning model for processing real-time photos or videos. To train the deep learning model, we need a comprehensive dataset of labeled images, where each image is assigned the appropriate class label. This dataset is inputted into a Convolutional Neural Network (CNN) during the training phase. The CNN network processes each image, assigns random values, and then compares the results with the original image's class label.

By following these steps, we can build an effective deep learning model capable of accurately detecting and classifying buffaloes, cows, and goats based on the provided images.

IV. Results and Discussion

In various agricultural landscapes worldwide, particularly those adjacent to forests and mountainous areas, animals such as buffaloes, cows, and goats pose a significant threat to crops. These animals are responsible for causing approximately 50% to 60%, and in some cases even 100%, of crop damage. We conducted experiments by modifying the training datasets to improve the detection and classification of animals for our research purposes. The proposed algorithm's testing model is illustrated in Figure 3.



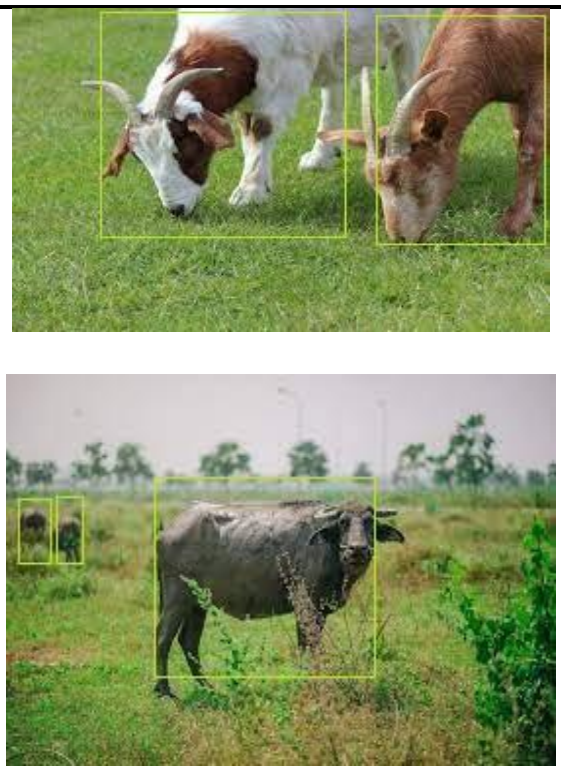


Fig. 3. Proposed Method's Testing Model

V. Conclusion

As a result, villagers who heavily rely on their crops for income and sustenance have faced considerable challenges. In their quest to protect their fields, they have sought alternatives to deter animals from encroaching on their crop areas. To address this issue, the implementation of acoustic devices powered by Arduino technology has proven to be effective. Installing this equipment in crop fields has not only bolstered farmers' financial gains but also ensured the safety of both crops and people without posing any harm to the animals themselves. Currently, agricultural vandalism caused by animals and fires has become a significant societal problem, with no efficient solution available thus far. Consequently, the proposed design holds substantial social relevance as it aims to tackle this issue head-on. By safeguarding fields and orchards, this design will assist farmers in preserving their lands and avoiding substantial financial losses. Moreover, it will contribute to increased crop yields, subsequently enhancing their profitability.

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