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Animal Intrusion Detection Model based on Temporal Convolutional Network for Smart Farming

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***Abstract*—** Our project revolves around integration of image processing and AI for preventing animals from approaching the crops and ensuring the protection of crops. It incorporates two key features: detecting live animal through a live camera feed and predicting unseen animals image uploads in-off assistance. The system involves advance image processing software techniques like edge detection and object recognition to identify animals and categorize them base on their species, and triggers timely alarms or deterrents that help to minimize the loss. Furthermore, the customers can upload images for artificial intelligence-based analysis so that they can get insights into animal behavioral patterns and extract the best remedial measures The program's integrated approach seeks to improve food security and ensure crop protection methods are not only humane but also technology-driven for sustainable farming.

Keywords — Animal Intrusion Detection, smart farming, wildlife, Computer vision.

I. INTRODUCTION

The practice of agriculture has indeed seen a lot of refinements throughout the millennia. Nowadays, most people make their own domesticated species of animals and plants grow on people's farms. In the past few hundred years, for example, agronomist tried to make crops more productive through efficient techniques of rotations and keeping a good record on their farm. Also, not too long ago people used systematic breeding and adopted

The agricultural sector is in the fourths revolution process which is based on exponential growth of using information and communicational technology (ICT) in Agriculture. Robotic and self-driving vehicles have in fact been also developed for agricultural purposes, i.e. weed removal, fertilizing, and crops harvesting. Autonomous UAVs with flight controllers have become reality. Also the new snapshot cameras which are small and powerful enough to make applications like variety detection, as well as crop and fertilizer status measurement possible, have opened up the way to the sophisticated farm management advising. The modern decision tree models are also availed that helps to empirically make a diagnosis between the plant diseases with the optical information. Unlike traditional fence technology, virtual fence technologies are based on remote sensing signals that monitor the livestock by fitted actuators or sensors to the cows.

All these technical advances together make a complete revolution in the field of agronomy which will unexpectedly transform crop farming. It can be said that this trend not only comes in developed countries, but in a way also in developing countries, where existing ICT applications (e.g., phone apps, Internet access) are being adopted at a fast rate and could become the game-changers in the future (e.g. as seasonal droughts predictions, climate-smart agriculture).

The Agri technology and the environmental conservation are key issues that agriculturalists need to address to cope with the challenges farmers are facing in the modern world. Needless to mention the challenge in agriculture is to decrease the negative impact of wild life on crop yields. Farmers usually face vandalization either by animals like deer and birds or by rodents and insects. These live beings destroy crops and this is quite costly to the

farmers. The practice of pest management using traditional methods of chemical interventions is one that has negative consequences on the environment as well as it affects people's health. In line with this, it is crucial to adopt sustainable and technology-driven techniques to ensure the crops keep off pest while the environment still thrives.

To a large extent, this project provides a solution to the animal intrusion problem in the agricultural fields with the use of an AI system which uses the image processing techniques to detect and limit the animals' entry on the fields. Through the use of live cameras and post-target image analysis, our system may achieve a strong efficiency in crop safeguarding. The animal detection with real-time feature makes use of advanced image processing algorithms and controls the field 24/7 as part of it monitoring. It is through this step that the system uses animal features, behaviors, and movement pattern recognition to identify and classify animals.

Also, the system interface is user-friendly so that the farmers can get at any time of history, real time information, and configure preventive measures. The assembly of AI and machine learning models brings about the eyes of the system through which species of animals are predicted with accuracy, allowing for precise actions or reactions. Another major feature of the system is the alarm systems and deterrents, made autonomous such as flashing lights or sound emitters, that would repel animals in the event they detect their presence. In such a way, the farmers can have the data-driven insights to make right decisions for implementing the best protection strategies for their crops.

Utilizing AI, image processing and data analytics capabilities, the project hopes to move the agricultural sector to a new level in the field of crop protection. Utilizing technology-driven techniques for reduction of crop loss as well as lowering the input of harmful chemicals fosters in the concept of "go green" farming methods which are sustainable and environmentally-sound. Ultimately, the project pursues to equip farmers with the essential devices and skills to protect their crops from being harmed by wildlife while fostering the peaceful living within nature.

Undoubtedly, the project pays particular attention to the aspect of partnership and knowledge exchange among the agricultural entities. Taking collaboration with agricultural extension offices, research institutes, and governmental bodies, our goal is to share our developments with more farmers by means of our technology and practices. Through the implementation of workshops, training, and knowledge exchange programs, we strive to provide farmers with a wide range of skills and the needed knowledge to help them utilise the latest technologies for their crop protection. The collaborative approach does not only generate innovations and promote the adoption of such methods, but also it contributes in creating strong and flexible agricultural systems that are able to withstand future challenges for instance, climate change and biodiversity conservation.

II. EXISTING SYSTEM

It is important to discuss the shortcomings of the traditional solutions used by farmers prior to introducing our innovative AI-based animal intrusion detection and crops protection system.The main mechanisms of conventional crop protection often consist of physical obstacles like fences and nets, chemical pesticides, scarecrows and patrols. Undefined

- Limited Effectiveness: Physical deterrents such as fences or nets can easily be bypassed by crafty wildlife, leading to crops yield loss. Scarecrows may be ineffective in a season as animals can get accustomed to them.
- Environmental Impact: In addition to the effects of chemical pesticides on soil health, water quality and non-target organisms such as beneficial insects and wildlife, they can also be detrimental to the environment. This can also lead to the development of pesticide tolerance in

the pest populations.

- Labor Intensive: Human monitoring and interventions methods are labor-intensive, time-consuming, and require resources in great quantity, especially in extensive agriculture. This can be a bit costly and does not guarantee all-day protection.
- Limited Data Insights: Traditional monitoring systems are not capable of collecting and analyzing data on wildlife about behavior patterns, trends and hotspot areas. This stalls the growth of tailored and data-oriented crop protection solutions.
- Lack of Real-Time Monitoring: Most working systems do not have the feature of real-time monitoring, which makes the quick response to animal intrusions very difficult.
- Scalability Challenges: Application of traditional methods to larger farms or remote areas can be complicated and expensive.

The major drawbacks of the existing animal intrusion protection systems for crops are in the aspects of effectiveness, environmental sustainability, data insights, scalability, and real-time monitoring.

III. METHODOLOGY

Data Collection and Preprocessing:

Collect an extensive dataset of pictures containing diverse representations of different family species that may raid the crops. Clean the pictures to improve clarity, allude the noise, and make all the materials to have a standardized format for the model training.

AI Model Training for Animal Detection:

Be encompass either TCN or WildNet architectures for deep learning models training with. Label the pre-processed images with species annotations utilizing supervised learning which would help the identification of animals accurately and precisely. Transfer learning refers to the process of repurposing well-trained models to fit a new problem layer by layer, which in turn increases the efficiency of the training process.

Species-Specific Ultrasound Deterrents:

Develop a database of particular call patterns that deter the specific animals in order to protect marked out areas from them with ultrasonic receivers. Tightly integrate ultrasound emitters belonging to the system with the capacity of sending ultrasound frequencies at the targets that are found during the scanning time.

Real-time Alert System Integration:

Develop an online monitoring system with real-time captured images and image processing algorithms that work to keep 24/7 surveillance of the farmers' fields. Set the system to alert farmers with SMS immediately when animals' intrusion is discovered, for instance, the content should show species classification and location.

Field Testing and Validation:

Perform comprehensive, in-field testing in order to assess the accuracy and true value of AI detection tools using ultrasound decoy system. Validate this system by creating real-world scenarios, taking into account all the behaviour variations of animals, different environmental and farming conditions, and types of crops.

Optimization and Fine-tuning:

Study results of field tests that include feedback and performance measures and to identify the aspects that need to be optimized and improved. Perform fine-tuning of AI models, ultra-low frequency (ULF) emission parameters, and warning mechanisms on the basis of outcomes observed and received feedback from user trials.

Deployment and User Training:

Push for large scale implementation of efficient technology on famers through streamlining the system's integration with the existing infrastructure and being the farmer' logics. Offer end-to-end training and user service to farmers related to the use, data interpretation and making response strategies for smoothing crop protection.

Monitoring and Maintenance:

Set up a monitoring system to make sure that system functions correctly, detect anomalies, symptoms and perform necessary updates and changes.Carry out regular quality inspection, software upgrades and data backups in order to ensure a long-term functionality and system stability of the system.

Continuous Improvement and Adaptation:

Develop a culture of continuous improvement by incorporating the users' feedback, monitoring the systems performance metrics and leading-edge technologies to evolve this integrated system to respond to market changes. Adopting this approach, we will eventually launch a cross-breed animal detection technique that relies on AI, combined with species-specific ultrasound as a deterrent and on-the-spot alarms, thus making it possible for farmers to detect animals and crops and to protect crops and to give farmers access to high technologies.

IV. PROPOSED WORK

Our project brings about a plan for an innovative method that serves the role of solving agricultural issues related to wildlife. We propose the use of the newest AI technologies together with ultrasound emissions and real-time alert mechanisms to create reliable devices that farmers will use for crop protection.

Key components of the proposed system:

Advanced AI Technologies: To this end, we utilize advanced AI models such as Temporal Convolutional Network (TCN) and WildNet that can distinguish and categorize different animals. This makes it possible to carry out field-specific inspection and identify animals that could be harmful to the crops.

Species-Specific Ultrasound Emissions: The system has to be aimed at the harmful animals upon their detection and they are to be pushed away by species-specific ultrasound as a non-invasive deterrent. This strategy makes certain that the species other than those which are targeted and the environment, are not compromised.

Real-time Alert Mechanisms: Integrated SMS messages will send alarms as soon as animal intrusion is detected, thus, by catching it immediately it will reduce harvest damage in crop production.

Integration and Compatibility: This system is able to integrate smoothly with the existing agricultural infrastructure, such as CCTV cameras, IoT (Internet of Things) devices, and farm management systems which makes the adoption and implementation easy.

Data-driven Insights: Our system is able to obtain and analyze data on what animals are doing at certain hours, how often they are trespassing, and how effective different deterrents can be, which gives farmers the ability to see exactly what areas need protecting and how best to do so.

Scalability and Flexibility: Based on the smaller and larger farms and different locations, the system is able to be modified to suit all farmer’s specific requirements and problems, making it possible to increase the degree of scalability and flexibility in implementation.

Environmental Sustainability: Through the use of low chemical pesticides and ecosystem-friendly practices the system keeps the environmental sustainability that is best suited for the safe keeping of the crops.

Such a well-thought-out system incorporating numerous technologies represents a new collective approach to wildlife management in agriculture that is comprehensive and innovative. Merging AI technologies and precise ultrasonic emissions with live alerts leads to an increase in the crop defense level, a decrease in environmental pressure, and the empowerment of farmers with technology-driven resolutions.

V. IMPLEMENTATION

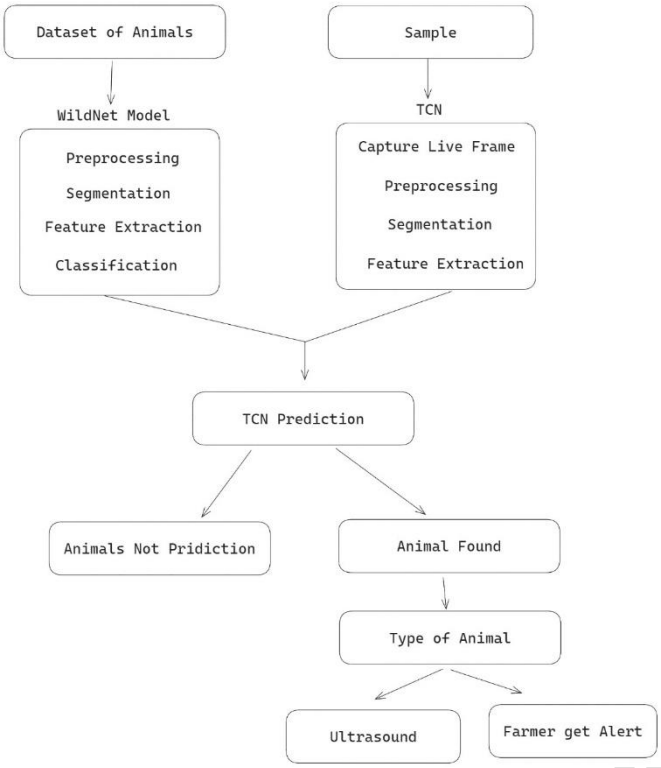

Fig. 1. It represents the work flow of our animal intrusion detection model.

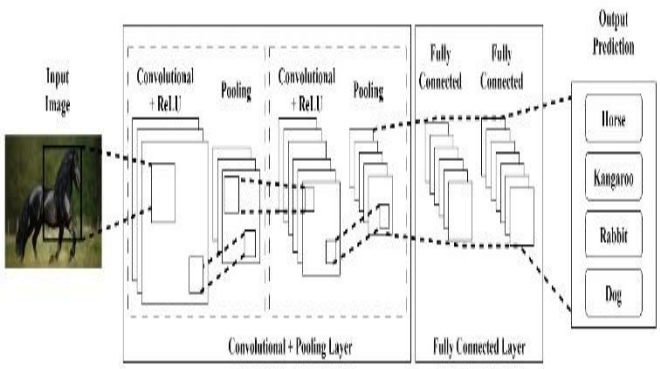

Fig. 2. It represents how neural networks works in prediction animals.

The implementation of our system involves two main functionalities: imaging live animal detection by camera input and animal prediction without online assistance using uploaded photos. Here's a detailed breakdown of how each feature works:

Live Animal Detection

This method rises out with cameras very well developed that are positioned at important points in the fields to monitor the fields alive. The high quality smart cameras with image processing algorithms, like edge detection and object detection to learn in real time, analyze the video stream.AI algorithms are able to detect, label, and interpret animals by examining their visually identifiable traits, conduct, and movement patterns.

Upon detecting potential threats such as wild animals, the system triggers immediate response mechanisms:

- SMS Notification: There is an instant SMS notification for the farmers and a message is displayed alerting them that an animal is in the farm. A sent sentence is that an SMS is made of text ,which indicates the name of the animal and the location on the farm.
- Sound Alert: Moreover, alongside SMS far-away alerts, the system prompts visual site noise alarms here and now, which inform farmers and scare animals at the same time.

Animal Prediction from Uploaded Photos:

Users have an option whereby they are allowed to input digital photographs which contain animals in the system's interface. A neural network-based system which utilizes a trained dataset spanning a wide range of wild species to provide the names of the animals that appear in the uploaded photos. Upon completing the interpretation, the application informs end-users the considered species of animals as well as the warning degree. Upon system installation, the users can access the precise time and place for animal appearance through the system directly, so that they can make deliberate choices in aversion and preventive measures.

This system combines both the data analysis and the advisory functions in helping to manage wild animals in agriculture. This smart technology is endowed with a live animal detection capability which enables round the clock monitoring and instant remedial action at the event of any animal intrusion. Adding to this, the offline animal

prediction module generates stronger insights and models-based recommendations to the farmers as preemptive measures against livestock incursion. This system of multiple approaches, backed up by SMS notifications and sounds alerts, augments farmers' opportunity to employ defence measures and avoid crop destruction by animals.

VI. RESULT

The results of our work is a modern, high-tech and innovative machine which is built for changing a production agriculture into the practice of smart farming. We have managed to achieve such amazing results in the protection of crops, safety of the environment, and granting farmers more cutting-edge instruments for wildlife control as a result of the AI-enabled detection of birds, species-specific ultrasounds diffuser and live alert systems for all types of crop making the most of the technology. The sensor-based system's scalability, adaptability, and green benefits motivate it to a whole new level of modern agriculture that can perfectly help to control the wildlife incursion and to keep the crop damages as less as possible. Following up, such project serves as an example of how advanced technologies are being utilized for further development in crop protection strategies, and are significant in shifting to a more sustainable and stable agricultural sector.

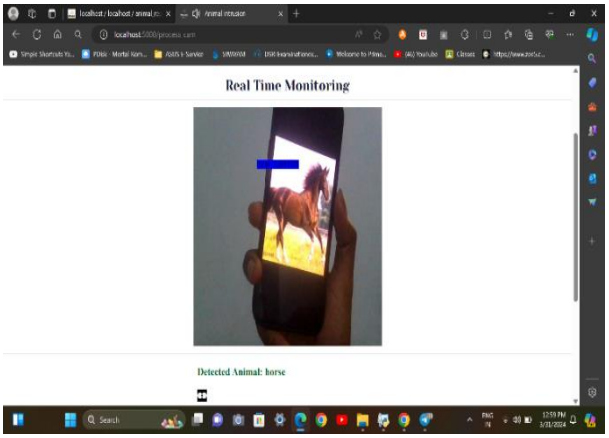

Fig. 3. Real time prediction of animals

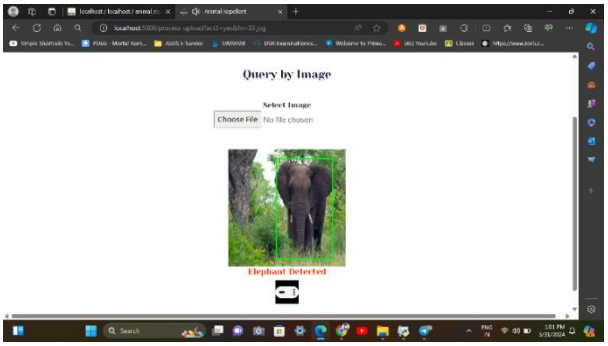

Fig. 4. Photo based animal prediction.

VII. CONCLUSION

Our project is an important innovation in agriculture that has managed to successfully combine state-of-the-art technologies such as the use of AI, focused sonic acoustic signals and real-time notifications for wildlife-related challenges. Essentially, this system aims to equip the farmers with efficient tools to help them track down, scare off, and manage animals that are getting inside their farms, and thus, these farmers will realize great improvement on crop protection and losses that result from unauthorized animal entry.

Through thorough researches and comprehensive development we have wisely designed our AI networks, such as the TCN (Temporal Convolutional Network) and WildNet, that are accurate in detecting and recognizing animals. With the help of such models, our system can be more accurate in identifying different species of animals that are customary around the farms, and this will enable them to differentiate between harmless wildlife and those that could end up damaging their crops.

Also, our AI devices not only enable species-specific detecting but also, as a non-invasive approach radars use bio-acoustic emission of ultrasound. This strategy targets the species without doing any harm to the environment and albeit through successful implementation the fields are protected from the particular targeted species. Adding to that, inbuilt

mechanism of the alert in real time helps the farmers to get immediate messages in SMS whenever animal entry comes up which allows them to take action without delay and implement the damage control measures.

The scalability and adaptability dimension is undoubtedly one of the main factors that contribute to the success of our system. A small-sized farm as well as a large commercial operation can integrate their greenhouse system, meeting the individual needs and issues of each system. Due to this application, we are introducing a solution which is able to be used by most farmers, thus it is making our solution applicable and used by many farmers.

Sustainability of environmental system is a central point of our project. The shift from chemicals pesticides through the ecosystem friendly practices together with non-invasive deterrent does not only respect the environment but also makes farming sustainable. Such an approach is in fact a subpart of numerous international projects that are geared towards more sustainable agriculture and conservation of biodiversity, implying our positive philosophy of innovation.

However, the future of this project withstands the rest for a sustained progress and breakthroughs in wildlife conservation. It is our goal to constantly seek for improvements in our system by listening to what the user have to say, stay up-to-date on the latest development, and enroll in new best practices. Promoting the team-work, the dissemination of knowledge, and process improvements, our efforts should be towards the creation of technologies for improving the resilience and sustainability of agriculture, for the increase of its yields.

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