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Non-Lethal Protection of Farmlands Against Wild Animals and Crop Estimation

Anvith Shankar B.[1,*], Dheeraj Kumar Swamy B.[1], Guru[1], Abhiram D.[1]

Abstract

This study is an integrated smart system that aims to enhance productivity related to agriculture along with agricultural safety through modern technology. The crop estimation system uses Internet of Things (IoT) sensors and machine learning algorithms for the analysis of real-time environmental data in terms of soil moisture, temperature, pH levels, and humidity. This data will further be used to provide the optimal crop for cultivation and appropriate fertilizer requirements for the prediction of requirements. This will ensure that farmers can make data-informed decisions that will help maximize yield while using minimal resources. In addition to crop estimation, this study addresses the problem of wild animals threatening farmland by deploying a non-lethal animal detection and deterrence system. The system uses an object detection algorithm named YOLOv5 to detect approaching animals, and the system identifies the species approaching then buzzes a buzzer, sprinkles water or turns on high-intensity lights and non-lethal electric shocks. The system is effective at keeping wild animals without harming them as it provides the best solutions to secure farmland with ecological balance and is humane. An integrated system results in higher farm security, maximum crop productivity, and sustainable agricultural practices. The invasion of farmlands by wild animals is a serious risk to agricultural output, resulting in monetary losses and disputes between people and wildlife. Sustainable ways to safeguard crops while maintaining ecological balance are provided by non-lethal techniques. This article discusses methods for precise crop prediction as well as cutting-edge non-lethal ways to protect farmlands from wild animals. These solutions combine technology like artificial intelligence (AI), sensor networks, and remote sensing to reduce conflict between humans and wildlife, increase agricultural productivity, and foster coexistence. The conversation focuses on realistic implementation techniques and how they could transform contemporary agriculture.

Keywords: Raspberry Pi, sensors, machine learning, object detection, crop estimation, remote sensing

INTRODUCTION

Recently, agricultural practices have undergone a revolutionary transformation by incorporating technology into farming. One area of thought is the protection of crops from wild animals, which often incur severe damage to farmlands. Most traditional methods of deterring animals from crops are harmful or disruptive. Advances in technology have the potential to lead to non-lethal approaches. This study has addressed the challenge of innovation in crop management and humane techniques for wildlife deterrence. The crop estimation system used in this study is also sophisticated, making use of the connected IoT sensors. Equipped with Raspberry Pi technology, the sensors collect critical environmental information, such as soil moisture and temperature, pH levels, and humidity. This information is analyzed using machine learning algorithms to recommend suitable crops for that condition and to predict the exact amount of fertilizer required. The real-time information being implemented by the system enables farmers to maximize crop choices

***Author for Correspondence**
Anvith Shankar B.
E-mail: anvtihshankarb@gmail.com

[1]Student, Department of Electronics and Communication Engineering, Dayananda Sagar College of Engineering, Bengaluru, Karnataka, India

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and resource allocation, thus increasing productivity and sustainability. Simultaneously, the problem of interference from wild animals was addressed using a non-lethal detection and deterrence system. As this is an object detection system, it employs the YOLOv5 algorithm to identify incoming animals, distinguish species, and decide what kind of reaction should be performed afterward. Deterrents such as buzzers, water sprinkles, or mild electric shocks can then be tailored to effectively drive away animals without killing them. This will protect farmland with ethical considerations while simultaneously creating an ecological balance. Overall, this study is forward-thinking when it comes to solving two problems in farming–crop management and wildlife protection–by employing modern technology. The system offers a holistic approach toward improving farm security and productivity through machine learning in crop estimation and non-lethal animal deterrence. This innovative use of technology not only enhances agricultural practices but also contributes toward a more humane and sustainable approach to managing wildlife interactions.

LITERATURE REVIEW

Mohamed Bouni et al. [1] provided a clear description of precision agriculture while underlining the role of IoT and machine learning in agriculture today. It highlights various technologies with IoT sensors and their applications in monitoring soil and environmental conditions. These roles confer crop estimation and fertilizer prediction, making it possible to implement real-time agricultural practices based on precise and accurate data. Machine learning algorithms are also considered for their part in analyzing these data to optimize crop selection and resource allocation, with a general view toward improving total farm productivity. Mingyu Zhang et al. [2] presented an elaborate discussion of the different methods and technologies applied to manage livestock and wildlife conflicts in agricultural settings. Such measures include audio deterrents, water sprays, and electric fences, and their effectiveness is considered in terms of the prevention of damage caused by wildlife to crops. A block diagram of the working mechanism of the sensing system is shown in Figure 1. Specific discussions on how improvements of these methods can be enhanced through technological innovation outline humane methods targeted at the reduction of harm within animal populations while farmland continues to be protected. Benos et al. [3] reviewed machine learning techniques applied to agriculture for crop management and yield estimation. Different algorithms have been used for the analysis of agricultural data to make informed decisions on choosing a crop and managing its resources. Recent breakthroughs and cases with the successful use of machine learning to enhance crop estimation and fertilizer prediction are provided, emphasizing the potential benefits and challenges associated with these technologies. Ma et al. [4] reported recent progress in object detection technologies, with particular emphasis on their applications in wildlife management. Hence, this study discusses various object detection models, such as YOLOv5, and how they may detect and track wildlife in agricultural setups. The idea is to discuss how such technologies may be developed towards building autonomous systems that can monitor and manage wildlife interactions, offering insight into benefits and limitations. Malika Kulyal [5] explored the integration of IoT sensors and machine learning in smart agriculture. It specifically discusses how IoT devices collect environmental and soil data, which are then examined using machine learning algorithms to provide actionable insights into the management of crops and resources. This study includes case studies and real-world applications to highlight the massive improvements that this interaction has brought about in agricultural practices. It highlights technological advancements but also presents challenges in such interactions.

GAPS IDENTIFIED

The available studies only include the IoT and machine learning aspects; they lack the real-time integration of data and their impact on decision-making. Real-time integration increases the accuracy of crop estimation models [6]. There is very limited research on effective methods for non-lethal prevention techniques in animals. There are many studies on different forms of deterrence, yet determination of their long-term effectiveness and performance in different species of wildlife and under different environmental conditions is lacking. Long-term performance and performance in different contexts need to be studied. Real-time object detection is also something new in this aspect, as detection is performed using GPS and other methods. The object detection model implementation is new and has much scope for research.

METHODOLOGY

The methodology of the "Non-Lethal Protection of Farmlands against Wild Animals & Crop Estimation" primarily attempts to develop a system that protects farmlands from damage to wild animals or animals without harming them. Additionally, crop estimation is performed based on the IoT sensor values [7]. Compared to scratch, this system is initiated by incorporating important elements in the design system: a Raspberry Pi microprocessor, relays, a camera, a pH sensor, a temperature, and humidity sensor, a soil moisture sensor, and deterrents such as buzzers, water sprinkles, or non-lethal electric shocks. These elements represent the core of the system; hence, they would monitor farmland. Upon detection, the system activates tailored deterrents, such as buzzers, water sprinkles, or non-lethal electric shocks, to effectively discourage animals without causing harm. Crop estimation is also performed using machine learning models and IoT sensors. The methodology places software writing through coding, using Raspberry Pi and its development tools. The programming is mainly Python, which makes it easy to communicate with hardware components. A camera was placed to monitor the farmland, and the YOLOv5 object detection algorithm was used to detect and identify any animals approaching the farmland [8]. Upon detection, the system activates tailored deterrents, such as buzzers, water sprinklers, bright high-intensity lights, or non-lethal electrical shocks. YOLOv5, an open source object detection algorithm, uses a variety of algorithms and techniques, including convolutional neural network (CNN) models, dynamic anchor boxes, spatial pyramid pooling (SPP), cross-stage partial networks (CSP), test-time augmentation (TTA), PANet, Decision Trees. The datasets are also taken from open sources such as the common objects in context (COCO) Animal Set and Wildlife Datasets. Relays were used to switch between the four methods of stopping an animal from entering farmland. The DHT11 temperature and humidity sensor, pH meter, and soil moisture sensor were used to read real-time soil data. The data read by the pH meter were used to calculate the phosphorous and nitrogen levels of the soil. The data read by the sensors with some external data, such as rainfall, are fed to a machine learning algorithm, which gives us the most suitable crop that can be grown for given conditions. The integration of the system is a significant aspect of this methodology. The Raspberry Pi acts as the central processor, reading incoming data from the sensors and camera and making commands to control the relay, which operates different methods to scare away the animals. The sensor data read by the microprocessor will be updated directly to a webpage where we will have to enter some external data to obtain crop estimation [9]. The webpage was created using HTML programming language. Wide-range testing to verify functionality under various conditions also falls within the scope of the methodology. Testing the accuracy of detection and identification of animals, switching speeds of the relays, and reliability in non-lethal methods would also be part of the evaluation. An efficient, real-time monitoring solution should be provided to consumers and utility providers through the final system, such that farmland is protected while maintaining ethical considerations and promoting ecological balance. Crop estimation is also accurate and provides the best yield.

APPLICATIONS

Non-lethal protection of farmlands and crop estimation have various applications in agriculture and farming. This system helps farmers by providing an ethical and non-lethal way to prevent wild animals from entering their farmlands and damaging crops. This will reduce human-wildlife conflicts. This system maintains ecological balance by preventing the use of harmful wildlife controls such as shooting, poisoning, or the use of an electric fence [10]. Farmers do not want to use these harmful methods but are forced to use them to save their crops and protect themselves. Despite being harmful, these methods are expensive. The major problem is monitoring a large farmland, which requires multiple cameras and a greater number of sprinklers, buzzers, etc. This system could also be used to protect livestock from wild animals. Crop estimation promotes precision agriculture. A prototype is illustrated in Figure 2. The data collected from the sensors can be used to improve the machine learning algorithm. The more data we used to train and test the model, the more accurate it became. This system provides real-time data monitoring, thus reducing the need for frequent manual checks and allowing farmers to monitor the fields remotely.

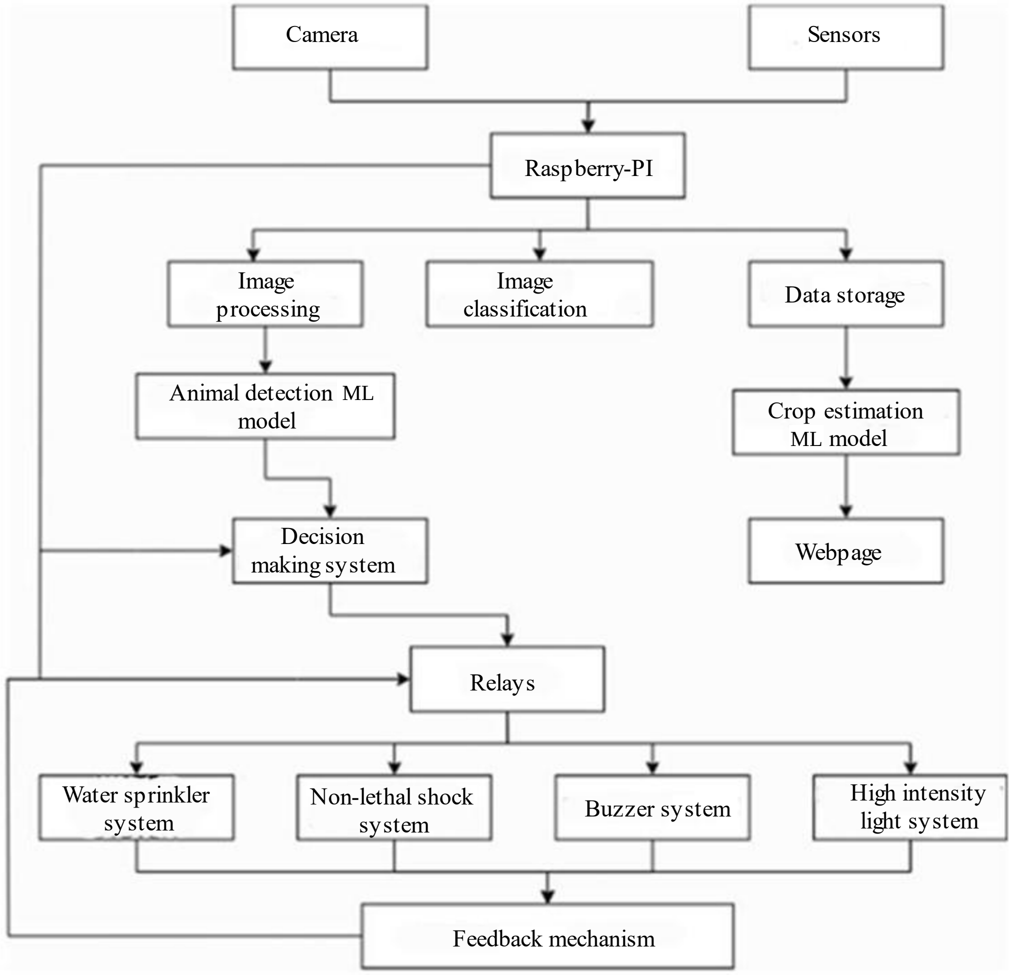

Figure 1. Block diagram of the sensing system.

Figure 2. Prototype of the proposed system.

RESULTS

Non-lethal protection of farmlands against wild animals and crop estimation are models used to safeguard the interests of farmers. As shown in Figures 3 and 4, the deterrence system automatically activated the detection of an animal. It is user-friendly and simple to use. There are some initial investments to be made, but these investments are cheaper compared to conventional methods. This system offers continuous monitoring and does not require manual supervision. The accuracy of identification is also shown next to the name of the animal.

The crop estimator is sufficiently accurate and trusted, although the decision is in the hands of the farmer. Ecological balance was also maintained with this system. Multiple methods of non-lethal protection can also be used against domestic animals or livestock, which usually damage crops. As can be seen in the above photos, crop rice is recommended based on the values entered. The model can also provide fertilizer recommendations to farmers based on the sensor values and the crops to be grown on that soil. This system provides the type of fertilizer, but the brand or producer of the fertilizer should be determined by the farmer. This model helps the farmer trust the technology and makes his work easier. Figure 5 shows the homepage of the open source website. Figure 6 shows the page where we have to enter the annual rainfall and sensor values or the sensor values can be directly updated through thing speak. Figure 7 shows the crop predicted from our model for some soil samples.

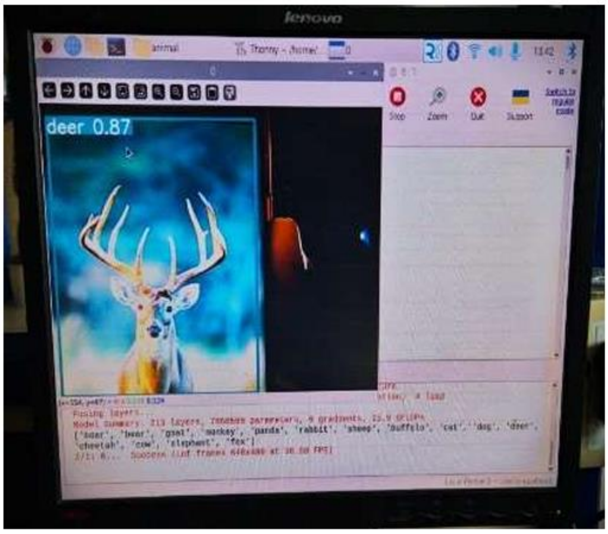

Figure 3. Identification of deer.

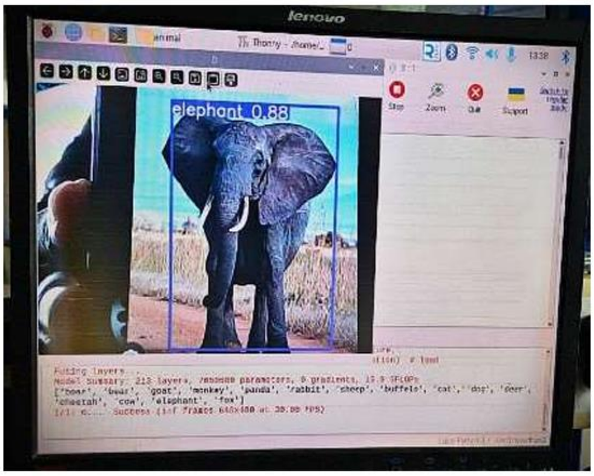

Figure 4. Identification of elephant.

Figure 5. Homepage.

Figure 6. Crop predictor.

Figure 7. Crop prediction.

Some constraints are not addressed in this study, which are left for future developments or interpretations that include the possibility of this prototype having reduced accuracy under night or light conditions. To address this, a thermal camera can be incorporated, allowing it to function effectively even in the absence of light. The crop prediction model can also be improved using some more parameters like the current market scenario, demand, and supply of the market, etc.

CONCLUSION

The proposed Non-Lethal Protection of Farmlands Against Wild Animals and Crop Estimation system is capable of monitoring farmlands and preventing animals from entering farmlands with non-harmful ways of deterrence and estimates the crop that is suitable to grow in that farmland. The system uses a YOLOv5 object detection algorithm to detect and identify an animal entering farmland. It uses relays to switch among multiple deterrence methods for different animals. Thus, some energy can be saved. This system makes farmers' lives easier and less risky. The system collects real-time data from multiple sensors connected through the Raspberry Pi to predict the most suitable crop. The machine learning algorithm was also trained and tested using large amounts of data. The webpage makes it easier to read and understand estimations. Although some challenges are difficult to overcome with this system, most of the problems will be solved without harming any species or suffering any loss. Therefore, this project introduces a scalable, sustainable, and farmer-friendly approach towards changing the face of agricultural productivity and effective wildlife management by providing a holistic system that merges crop estimation, fertilizer prediction, and wildlife deterrence.

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