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Literature Review on Detection Systems for Wild Animal Intrusions

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Abstract

Agriculture is a crucial contributor to the economy, and farmers aim to increase their crop yields annually. However, with the increasing deforestation and destruction of wildlife habitats, wild animals are venturing out of the forest in search of food and often end up in nearby agricultural fields, leading to conflicts between farmers and wildlife. To address this issue, technology can be used to detect animal intrusions. Wireless sensors and animal intrusion detection systems, equipped with object detection and segmentation, can alert farmers regarding any animal incursions on their fields even when they are not present. When an animal enters the field, cameras at various locations capture images and send them to processors for analysis. The system then sends automatic notifications with images to landowners and foresters, thus providing an early warning so that appropriate action depending on the type of intruder can be taken. The system uses feature extraction and image matching techniques, along with regression algorithms, to identify and classify the intruding animal. This survey focuses on exploring the various steps, tools, and experimental setups that can be used to prevent human-wildlife conflicts and protect lives.

Keywords: IoT (Internet of Things), Sensors, Image processing, Microcontroller, GSM module

1. Introduction

In recent times, wildlife has become a growing concern for human life globally. Wild animals like wild boars, elephants, and tigers often cause significant damage to crop, as they traverse fields. This not only causes financial losses for farmers but also increases the risk to human life. Deforestation, lack of natural prey, and habitat loss have forced these animals to reside near human settlements, leading to conflicts. Elephants, in particular, pose a significant threat in India, causing loss of life due to their extreme conflict behavior. Human activities

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such as rapid industrialization and population growth are leading to deforestation and causing animals to encroach nearby villages. Drought and loss of livelihoods are driving animals to attack crops, livestock, and sometimes even humans. Electric fences are used by farmers to protect their fields, but they can be dangerous to both animals and humans.

This review work focuses on various wired and wireless applications used to alert people of animal intrusions. Image processing and IoT (Internet of Things) are the two key areas that are being researched to improve the detection of animal intrusions. Wireless applications have the potential to enhance the quality of everyday activities in many fields and environments, such as emergency response, intelligent control, and military purposes. This study discusses various methods and algorithms developed to enhance security measures against animal intrusions and presents a review of animal detection methods using digital images. Sensor-based applications are widely used in real-world applications, offering cost-effectiveness, robustness, reliability, ease of use for farmers, and remote monitoring with low energy consumption. The table presented below shows the methods used to detect animal intrusions.

Table I. Animal intrusion methods

Methods	Detection techniques
Electric Fences	The circuit setup of the Wheatstone bridge is utilized for the detection principle in electric fences.
Artificial Repellents	Electronic repellents that repel animal intrusion by emitting odors and colors.
Acoustic System	Deter animals by emitting sounds that resemble predator calls.
Microcontroller based system	When an intrusion is detected, a message alert will be sent to the farmers and a buzzer will be activated.
Intrusion detection system using Raspberry PI	This method of detection is automatic and characterized by high efficiency.

2. Overview of Existing Animal Intrusion Alert System

The examination of existing studies and materials on a particular topic is crucial to any research endeavor. In this case, the term “review” pertains to the investigation of systems for detecting animal intrusions and the analysis of Internet of Things-based solutions. These works provide valuable insights and information on the various methods used for observing, keeping track of, and identifying wildlife in various surroundings.

In a study by A. Sathesh et al. 2022 [1], a concept for an animal intrusion detection system proposed using object detection was presented. This system includes storage of pre-existing images and attributes of various animals within an image processor. As animals enter the area, cameras capture their images and transmit them to the processor for further analysis. Then, a Yolo (You Only Look Once)-based regression algorithm performs feature extraction and comparison between the stored image and the new image, resulting in an SMS alert being sent to the landowner. This proposed system can greatly benefit agriculture by increasing yields.

D. Ranparia et al. 2021 [2] proposed the creation of an acoustic repelling system that utilizes a Convolutional Neural Network (CNN) machine learning model and an infrared camera. The system was designed to identify specific animals like wild boar, nilgai, and deer, and utilize a Raspberry Pi module that integrates with a camera and frequency generator to detect the animals and produce frequencies to deter them from the targeted farm.

Mohit Korche et al. 2021 [3] presented an IoT-based solution for animal intrusion detection. The system utilizes an LDR sensor placed vertically to measure the size of the animal, while a PIR sensor detects the animal’s location. In response, the APR board activates and emits a sound to discourage the animal. During nighttime, a flashing light is turned on and a message is sent to the farmer through a GSM module. The system also has an LCD display that shows the presence of animals and LDR readings.

Shashank H N et al. 2020 [4] introduced a novel animal intrusion detection system that utilizes image processing techniques. This system detects unauthorized animal intrusions into agricultural fields using a camera system, captures images, classifies them through image processing, identifies the type of intruder, and takes necessary action. The farm owner and forest manager are also notified via message.

K. Mohana et al. 2020 [5] proposed an innovative solution for animal intrusion detection using GSM technology. A virtual fence system that operates similar to physical fences to keep wildlife restricted to a designated area was introduced. This system allows farmers to monitor their farms remotely from any location. It consists of a microcontroller-based monitoring system in combination with infrared sensors. In the event of unauthorized intrusion, automatic SMS alerts/calls are sent to the farm or field owners, and warning sounds such as buzzers in prototypes and sirens in real-time applications are triggered.

Penchalaiah et al. 2020 [6] designed a system that aims to conserve water and protect crops by detecting wildlife around the farm boundaries. The system utilizes infrared sensors to detect the presence of wildlife, soil moisture sensors to monitor the soil's moisture levels, and speakers to emit frightening sounds to keep animals away from the farm. The system collects sensor data with a microcontroller, which then evaluates the data and sends signals to the speakers to produce sounds to repel animals and sends an alert to the nearest residents and farmers for safety purposes. Additionally, the microcontroller sends instructions to the forest office and signals to turn the engine on or off based on the soil moisture levels detected by the soil moisture sensor.

M. Jaya Prabha et al. 2020 [7] proposed a wildlife intrusion detection system that can identify the presence of animals and alert farmers while distracting the animals in a humane way. The system employs the use of infrared and ultrasonic sensors to monitor the movements of animals and sends signals to a controller. This triggers the generation of noise and signals to deter the animals without causing harm. The signals are then transmitted to GSM to promptly inform the farmers of any intrusions. This allows the farmers to be aware of the situation and take necessary measures to ensure the safety of the animals.

In a study published by Yang et al. 2020 [8], a blockchain- based framework was suggested to enhance livestock monitoring systems. The architecture incorporates the use of Radio Frequency Identification (RFID) sensors, along with physical tracking utilizing RFID tags, throughout the entire production process. The system is connected to a network of decentralized cloud servers, allowing for secure collection and protection of all monitoring data.

Srikanth N et al. 2019 [9] proposed a system for automatic crop protection from animals and fire. The system uses an Arduino Uno microcontroller and motion sensors to detect the approach of wild animals and smoke sensors to detect fires. Upon detection, the sensors trigger

the microcontroller to activate an alarm and alert the farmer through SMS and a phone call. The farmer is then able to come to the site and shoo the animal away, or if there is a fire, the engine is automatically started to put it out. This system offers a comprehensive solution for protecting crops from damage caused by wild animals and fires, ensuring that farmers do not suffer losses.

Vidhya S et al. 2019 [10] suggested a system that employs Raspberry Pi to protect agricultural fields from animal intrusions. PIR sensors detect any animal entry, and the Pi camera captures images for further analysis. The images are then classified as either local or wild animals with the help of a CNN. This architecture of artificial neural networks specializes in image classification and is used to determine the type of animal. Once classified, the system emits an appropriate sound to repel the animal and notifies the owner via SMS. The data of these intrusions is sent to the cloud for further analysis and management. In this way, farmers can easily obtain information about intruders and take necessary actions.

Sourav R. V et al. 2020 [11] presented a system with live video surveillance cameras placed at specific locations. The system operates in three steps to detect the presence of elephant. First, video frames are used to create an image. Second, machine learning techniques are utilized to identify the elephant. Lastly, a pre-trained CNN model is used to verify the appearance of the elephant. The proposed method showed a 98.7 % accuracy rate.

Shubham Mishra et al. 2022 [12] aimed to develop a surveillance system that incorporates motion detection using OpenCV and notifies the user of any intrusions. The system also uses a camera module to capture video footage and a GSM module to send SMS notifications to the user’s mobile phone.

Paramasivam et al. 2020 [13] proposed a convolutional neural network-based animal detection algorithm that runs on a Raspberry Pi control platform. The algorithm operates in two phases, training and testing. During the training phase, a large dataset of 13412 photos is used, which is classified into 6 different animal cases. Webcam-captured images are then evaluated for animal features in the training dataset. Upon detection, the system will then classify the animals and calculate the accuracy percentage based on the number of matching objects. When the accuracy of detected animals surpasses 45%, an alarm signal is sent to registered users via the BLYNK APP. The current situation is displayed on a mobile device, captured by the camera, and inputted into the Raspberry board. For example, while the elephant image in the dataset is fully visible, only a portion of it is captured and processed due to the

camera's focus. Nonetheless, 80% of the elephant's features were still able to be matched, confirming that it was indeed an elephant.

Vikas Bavane et al. 2019 [14] developed a system that utilizes a Raspberry Pi as the central component. The system is equipped with various sensors and cameras that are connected to the Raspberry Pi. When the PIR sensor detects movement within a 10-meter radius, the camera will automatically take a picture and start recording a video that lasts for 5-6 minutes. The captured video and images are saved on the board. In the event of an intrusion, the system will use the SIM900A module to send an automatic message to the registered number. The system also records temperature and humidity readings from the DHT11 temperature and humidity sensor. If an authorized person with a motion detection-enabled RFID card enters the area, his presence is recorded. On the other hand, if an unauthorized person is detected, the system will use a cascade classifier based on hair features for object detection to determine if the intruder is an animal or human.

Brain H. Curtin et al. in 2020 [15] proposed a solution that uses a Raspberry Pi-based camera system and deep learning algorithms for wildlife recognition. The team utilized TensorFlow and Keras to construct a convolutional neural network on a Raspberry Pi 3B+ and trained it with 3,600 images from a public database split into three categories. These tests resulted in a detection accuracy of 74% to 97% for snow leopards.

Deivana et al. 2020 [16] presented a new approach that uses CNN to identify wild animals. The model is trained on images of monkeys, wild boars, and elephants and once the training is completed, the model is saved. During live animal detection, the saved model is then run to compare the trained images with the new test images from live capture. In the event that one of the trained animals is detected, a speaker generates a loud noise to scare it away.

Table II. Animal recognition using neural networks

Author	Classifier	Objectives	Advantages
Deivana et al. [16]	CNN	Animal recognition	Scaring away detected animals
A.Sathesh et al. [1]	YOLO	Animal recognition	Scaring away detected animals
Brain H. Curtin et al. [15]	CNN	Animal classification and recognition	74% to 97% accuracy rate for snow leopards
D. Ranparia et al. [2]	CNN	Animal classification and recognition	Can deter specific animals from targeted farms

Table III. Animal intrusion detection using microcontrollers

Author	Microcontroller	Sensors	Objectives	Advantages
SrushtiYadahal li et al. [18]	Arduino Uno	Motion sensor and I.R. sensor	Animal Intrusion detection in farmlands	Affordable option for protecting
K. Mohana et al. [5]	Arduino Uno	IR Sensor, Crystal oscillator	Animal Intrusion Detection	Monitors farms remotely and alerts owners in case of intrusion
Roxanna et al. [19]	Raspberry pi	Soil moisture sensor and a rain sensor.	An IoT-based Intrusion Detection system	Automatic irrigation system managed by IoT
N.Penchalaiah et al. [6]	Arduino Uno	IR Sensor, PIR Soil moisture DHT11 sensor	Animal Intrusion Detection and farm- land monitoring Approach	Conserves water and protects crops from animals
M. Jaya Prabha et al. [7]	Arduino Uno	Ultrasonic sensor, IR sensor	Animal Intrusion Detection	Humane repelling of animals and informs farmers of intrusion

Conclusion

In conclusion, the creation of an animal detection system involves a range of considerations. With increasing destruction of wildlife habitats, wild animals are increasingly seeking food in areas near agricultural fields, leading to conflict between them and farmers. To prevent animal intrusion in these fields, there is a need for specialized detection using wireless sensors and cameras. The system should be able to identify animals based on images captured and compared against a database of endangered species. If a match is found, the system should automatically send a warning to landowners and foresters. Currently, the defense mechanism used against these animal intrusions consists of solid ultrasound. However, animals can eventually become accustomed to the ultrasound, which can limit its effectiveness. There is a need for research to determine the frequency of discomfort for each animal species and to develop defense mechanisms that can change ultrasound frequencies within a certain range to prevent adaptation. Moreover, the limited field of view of normal cameras during nighttime makes it difficult for available systems to identify animals and alter their frequency. As a result, new systems using infrared and night vision cameras should be developed to monitor animal movement effectively. In conclusion, developing an animal intrusion detection system that effectively monitors and prevents wild animals from encroaching agricultural fields, requires careful consideration of various aspects and the implementation of new technologies. This can help protect both wildlife and human life, leading to a more sustainable and harmonious coexistence.

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