Snake Detection in Agricultural Fields using IoT

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Abstract - *Snakebites have been a major problem among the farmers, especially in rural areas. According to a recent survey, 58,000 Indians die from snake bites annually, which is more than 50% of the world's total snake bite deaths. Almost 1.2 million Indians have lost their lives since 2000 in this manner. "Time" is the most valuable asset in these types of cases. We can save the people if they can get quick medical help. If there is a delay in this, the snake bite may cause serious damage to the organs, or in the worst cases, the person may die. Today, the IoT technology using different sensors in the field and deep learning techniques using convolutional neural networks allow us to detect these snakes, particularly in the agricultural fields, so that the farmers can be alerted using a buzzer and take precautionary measures against these dangerous reptiles. Identification of the species of the snake can also be accomplished with this system, ensuring the anti-venom is found as quickly as possible. This system also indirectly helps to conserve snakes in the area.*

Key Words: Agriculture, Convolutional neural networks, Deep Learning, IoT sensors.

1. INTRODUCTION

India is a very diverse country and home to many snake species. Of all those species, some are very poisonous and deadly. India is a land that depends a lot on agriculture for economic growth. Farmers are always in grave danger because they spend most of their time in the field, where the snake may be present. Thus, snake bites become a major problem that must be solved as human lives are in danger.

According to the World Health Organization (WHO), although the precise count of snake bites is unclear, it is believed that 5.4 million individuals are bitten every year, with close to 2.7 million of those bites resulting in poison. Every year, between 81,000 and 138,000 individuals pass away due to snake bites. In India, it is estimated that 58,000 people are dying due to snake bites annually, which is higher than any other country in the world. Venomous snake bites can result in a variety of medical conditions, including breathing difficulties, bleeding abnormalities that can result in tissue injury and deadly haemorrhage, and irreparable kidney failure that can cause long-term incapacity and loss of limbs. The most impacted groups are kids and farm laborers. Due to their smaller body mass than adults, children frequently have more severe impacts.

Sometimes, farmers do not actually recognize the snake species, and if they are lucky enough, they will kill them right away so that they do not get hurt. The fact that snakes are a crucial component of the food chain and that their widespread extinction might upset the balance makes this a potential issue as well. If snakes are killed in large numbers, this could disrupt the food chain. Therefore, we must reduce the harm humans do to them to protect them as well.

For this reason, there must be a system where the sensors placed on the borders of the field can detect the snake movements and capture an image, which is then analysed and processed by various deep learning techniques to find out if it's a venomous snake or not. If it's venomous, the farmers are alerted immediately with the help of an alarm so that he will take some precautionary measures to quickly get out of trouble. The alerts will also be sent to members near the farm.

2. RELATED WORK

In this section we discuss the work done previously by other authors/people all over the world.

As per the paper [1], to accomplish the stated goal, the authors suggested a system that makes use of image analysis, CNN-based networks, and deep learning strategies. The automated image categorization system heavily utilizes CNN. Typically, characteristics are extracted and used for categorization. The researchers employed a database of 3050 RGB photos, divided into 28 species and of varied sizes. Images are subjected to the GrabCut method for pre-processing data, and data augmentation is carried out and trained using DenseNet 161.

In the paper [2], the growing monkey threat on Indian farming fields is causing a huge problem for farmers. The enormous fruit and vegetable harvests, worth tens of thousands of rupees, were completely ravaged and ruined by the monkeys. Infrasound, seismic interaction, and light and photo options are just a few of the present detection methods that are both extremely costly and ineffective. So, they suggested a detection system consisting of wireless sensor nodes connected to a noise producer that emits ultrasonic waves to scare away monkeys. The wireless nodes consist of sink nodes and sensor nodes. The sensor nodes are installed along agricultural fields' borders, where they are used for the detection of monkey movement. When a detection is made, the sensor sends an alert, which is subsequently sent from the sensor nodes to the sink node. The ultrasonic sound producer is then activated by the sink node, producing ultrasonic sounds at a rate of 20 kHz that annoy the monkeys and finally cause them to leave the field.

In the paper [3], the authors state that in today's society, surveillance serves as one of the most crucial security systems since it shields homes from robberies, killings, and other crimes that have become common in major cities. Governments and police departments use surveillance to preserve social order and look into illegal activity. Conventional monitoring systems use more electricity since they cannot be shut off in the event of an attacker and also require more space for storing the captured images. To resolve this issue, a PIR-based embedded home monitoring system has been created. These sensors are usually installed at residential windows and doors to prevent intrusion. For the purpose of recognizing human body movement, PIR sensors employ infrared radiation. Hardware requirements of this system are a PIR (pyroelectric infrared sensor), an ATMEGA328 microcontroller, RS-232, GSM (global system for mobile communication), and a webcam. PIR sensors, which are used to identify human bodies, can detect movement up to 6 meters away and generate a pulse that is read by the MCU (microcontroller unit). Therefore, embedded monitoring systems evaluate the sensor's data and decide whether to activate the webcam to capture a picture. When an invader is present, the sensor alerts a resting MCU to start powering an interior sensor and transmitting a signal to the GPIO network. The system activates an alarm and delivers an SMS when it determines that an unauthorized person or invader is present. Following this MCU's transmission of sensor signals to embedded systems, a camera is used to take a picture.

As per the paper [4], the authors of this research examined the primary issues that arise from human-animal conflict in the agricultural sector, such as resource loss and the threat to human life. As a result, people lose their property, livestock, crops, and frequently even their lives. Therefore, to stop the entry of wild animals, the boundaries of the farm fields must be regularly maintained. To prevent these problems, the authors designed a system that consists of PIR (passive infrared sensors), a microcontroller, and a webcam. PIR and a camera serve as the initial layer of security. The camera captures photographs of the triggered moving objects and sends those images to the microcontroller once the PIR identifies the movements of the wild animals. The microcontroller categorizes the photographs according to whether or not an animal is wild. It yields 1 if the animal is wild and 0 otherwise. If the animal is classified as wild, the PC will transmit a signal to an animal repellent system that makes a loud noise, produces brilliant light, and sends an SMS message to the landowners.

In the paper [5], dangerous animals entering the vicinity of neighborhoods or populated places has become very common now-a-days. In this paper, they have proposed a system that alerts people if a wild animal steps out of the forest. Cheap motion sensors and computers with less computing power are utilized to achieve this. A control center is set up for computations. We also suggest a repellent that can stop wild creatures from fleeing the forest, such as producing a lot of noise via speakers. The fundamental tenet of IOT is to link various sensors, facilitate contact, and offer services. In this paper, we develop an alarm system using a number of IOT devices placed around a nature reserve. Smugglers as well as other people breaking the law by entering the forest can also be caught using this approach. The place is surrounded by many sensor towers, and some of them are connected to the control center. They are placed at the boundaries to detect animal movement. The Raspberry Pi is used. Cameras are also connected to it. It uses very little power. The computations performed here are transmitted to the service center. PIR sensors are used to detect motion. Additionally, the sensor tower incorporates a GPRS/3G module for communication with the control room. Since they are nearer to people, the forest's borders have GPRS connectivity. This facilitates communication and makes it easier. The PIR sensor detects motion; when it does, we snap a photo of the area and transfer it back to the control center. We sent a further SMS to the relevant official. In order to prevent wildlife from entering the forest border, the control center may transmit a signal to the relevant tower to generate a loud noise. Each tower has a defined position, so we are aware of it. The authorities can promptly travel to the area if necessary and take additional action. Solar power is widely used at sensor modules to cut down on costs. As mentioned earlier, the main computing power, which is the Raspberry Pi, is connected to a camera, which is going to take photos whenever it detects some movement and then transmit them to the main server over the internet. In future work, much more efficient and high-performing sensors will need to be used because they perform better in movement recognition. Night vision-capable cameras make a perfect fit. Electrical fences may be replaced with something safer.

The paper [6] presents several examples of how dangerous animals pose a threat to farmers in agricultural fields. In particular, it focuses on the harmful impact of snakes, which cause the deaths of many farmers in the age range of 20 to 50 every year. Additionally, these animals also cause significant losses in productivity for farmers. To address these issues, the authors propose a solution involving the use of an algorithm and IoT systems to detect the presence of dangerous animals in agricultural fields. The algorithm employs feature extraction and classification techniques to identify the unique characteristics of snakes and other harmful insects. It then generates a buzzer to alert farmers of the animal's location, which is determined using GPS. The Raspberry Pi is used (for computation and processing) as the main platform for the system. The existing system only detects the presence of animals but does not provide any preventive measures. Therefore, the authors propose a new system that not only detects snakes but also alerts farmers through a buzzer to protect themselves and their land. The paper suggests using a feature extraction method to identify moving objects and creating a database of unique features belonging to each snake and dangerous insect to train the classifier. Different technologies, such as ultrasonic sensors, light-dependent resistors, GPS, and buzzers, are used to achieve this goal.

In the paper [7], the authors cite "Sri Lanka" as an example for implementing the project of identification of particular species occurring most frequently there. The paper highlights the problem of snake bite deaths among Sri Lankan farmers, specifically how the current system is inadequate and leads to delays in treatment. The authors propose a solution using a convolutional neural network with 2000 images of the six predominant snake species found in Sri Lanka. Five models were developed, including one from scratch, and the best model in terms of accuracy was determined for automatic snake identification. The authors collected images and videos of snakes using Google Images. These videos were augmented to create a large number of images to work with, and the backgrounds were removed. Of the 2,000 images collected, 1,200 were used for training neural network models, 400 for validation, and 400 for testing. Batches of size 32 were created for input. Adjustments were automatically made to the weights before the next iteration of the convolutional neural network (CNN) began. Models like InceptionV3, VGG16, ResNet50, MobileNet with ImageNet, and a new model were trained using TensorFlow as the backend and Keras as the front end. Various measures were taken to improve accuracy, such as inputting cropped images of different dimensions and trying raw images. This training was performed on a Core i7 machine. After training, a testing dataset was used to evaluate the models.

In paper (8), the authors discuss the difficulty of identifying snakes and the use of computer vision technology to improve accuracy. It illustrates that extraction of features and classification are the two steps involved in machine learning-based image categorization. The classes are pre-set, and the procedure comprises categorizing the test data using the trained model after a training stage that uses the training data. They point out that snakes' flexible and elongated bodies cause fluctuations in their posture and deformation, making it challenging to identify characteristics from dorsal body arrangements. Additionally, they note that a lack of specialized image datasets for snakes makes it difficult to train deep convolutional neural networks for this task. Additionally, they suggest that museum samples, which lack original color and position, are useless for including in full body image collections. This study aims to compare the accuracy of several machine learning methods in the classification of snake images. Out of 594 photographs, six different snake species could be distinguished; only those showing at least 50% of the snake's body were used. A method for extracting features was combined with conventional classification methods, and transfer learning was used to improve the performance of a deep neural network model on the small dataset. The results of this study will help identify the most effective machine learning methods for snake image classification.

As per the paper [9], researchers developed a computer method to recognize several snake species from pictures. The system performed noticeably better than arbitrary guessing when it was compared with human performance. Some species were easily identified by both the algorithm and humans, while others were more difficult to distinguish. The researchers discovered that when detecting photographs with visual artifacts or of low quality, human beings had an edge over the software. Future research on snakebite epidemiology may benefit from computer vision technologies, particularly when paired with location data and expert advice. The development of a computer vision method for classifying snake species was indeed the aim of this project. The algorithm was tested and compared with human performance in identifying snake species. The algorithm was found to be better than randomly guessing but had difficulty identifying certain groups of species. The algorithm could potentially be used by healthcare providers to quickly identify snakes involved in snakebite cases. The algorithm was developed using a collaborative approach with input from data science experts and enthusiasts. For picture categorization, it used massive, deep CNNs (convolutional neural networks).

The paper [10] provides a summary of the most recent methods for locating moving objects in footage shot by moving cameras. Model-based background subtraction, trajectory classification, decomposition of low-rank and sparse matrices, and object decomposition are the four categories into which the approaches may be classified. This study provides a thorough analysis of the available approaches for moving cameras, despite the fact that there have been several research studies and reviews on object recognition and background reduction for stationary cameras. Computer vision can detect moving objects and is used in various applications such as action recognition, traffic control, industrial inspection, human behavior identification, and intelligent video surveillance. But it might be difficult to identify a moving item in a video series because of things like occlusion and changing lighting.

As per the paper [11], it has become a crucial tool for wildlife protection and management worldwide to eradicate invading vertebrate species from ever-larger islands. Past mainland exclusion attempts have frequently failed as a result of weak or shoddy barriers against pest reintroduction. In order to create technology that effectively excludes pests, they have carried out extensive trials over the past ten years. A large number of problematic vertebrate species that can be discovered in New Zealand and some other areas of the world have had their behavior and physical capabilities identified. They have tested different pest species against different defense systems in order to develop a 100% effective defense system. The design excluded almost all the vertebrates that are found on the island. In regions up to 3,400 hectares in size, more than 20 exclusion fence structures have been built, enabling efforts at multispecies eradication. Many initiatives are currently carrying out extensive restoration efforts, including the return of vulnerable species and habitats to mainland areas as a result of the effective eradication of vertebrate pests.

As per the paper [12], incorrect snake identification is the major cause of human deaths resulting from snake bites. For the two main types of snakes, Elapidae and Viperidae, no automated classification approach has yet been presented to classify snakes by understanding the taxonomic aspects of snakes. So, they provided an automated categorization system for many snakes that is based on inter-feature product similarity fusion and identified 31 various elements from snake photos that are taxonomically significant for automatic detection research. Through a GPU-enabled parallel computing system, the classifier's adaptability and real-time development are examined. The designed systems are used in snake count management, bite analysis, and investigations of wild animals.

In their paper [13], the authors proposed a system whose goal is to determine the species of these dangerous reptiles using their unusual traits so that the appropriate course of action may be taken to prevent deaths from snake bites. The authors of this system employed deep learning techniques like CNN and image analysis to obtain the same results. CNN was heavily utilized for picture classification by machine. Feature extraction, a technique used for classification, is used to extract the significant and distinctive aspects of snakes. In order for necessary follow-up steps to be performed, it is expected that this system will accurately categorize snakes and report their species. Due to the similarity in the species' traits, including texture, color, and head form, automated snake species detection is a difficult undertaking. Rapid snake species identification can be aided by deep learning and transfer learning. One of the writers has suggested a method in which MobileNetv2 is used for identification. The categorization of snakes is based on a pre-trained fish classification model that was utilized by another author. Over 3000 images of different snake species are included in the suggested technique. They are divided into 28 distinct types. Only a few of these factors are very helpful and are used to increase accuracy. Pre-processing, training, classification, testing and verification, and accuracy check are the five main aspects of this system. For augmentation, a program named GrabCut is employed. The most crucial stage of this process is testing, when random photos of the snakes are taken to confirm and then determine their correctness. Additionally, the system's overall algorithm is explained. Firstly, the snake dataset, which already includes 3000 images, is divided into two sections, one for training and the other for validation. This is done as it was with all previous datasets. The GrabCut method was employed for feature extraction, as was previously indicated. Enhancement aids in minimizing or preventing overfitting. DenseNet 161 is used during training. There were 28 classifications of snake species created as a result. The accuracy is examined, as it is with every machine learning activity, to determine whether it can be made more accurate. The document thoroughly illustrates the architecture and flowchart of the entire procedure. Each step is well explained, along with particular algorithmic information. The authors concluded that the transfer learning approach is particularly advantageous since it gives great performance while saving time. They assert that this approach is easily adaptable to new species that are found in the future. They advise creating and using larger datasets with a variety of species for future studies. Additionally, this huge dataset should make use of more effective machine learning methods.

As per the paper [14], the authors introduced a number of methods for seismic activity, ultrasonic, and acoustic data-based person detection. Footstep recognition and formant analysis are performed on the auditory data. When human audio is not available, auditory data are also utilized to distinguish between humans and animals and to determine the walking rhythm of animals. Human and animal categorization is done using seismic analysis. They classified the objects and estimated their presence using ultrasonic data. Using all three system methods, the authors got a high proportion of accurate categorization. Each algorithm tried to identify and categorize individuals using the specific phenomenology of the detector. The given methods are computationally effective, use less energy, and are therefore suitable for implementation on sensor nodes like networked UGS.

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As per the paper [15], the least researched group of animals inside the archipelago are indeed the snakes, mostly in the Galápagos. Only 4 of the 9 known species have had their conservation status fully assessed, and early data indicates that most of the species may have totally vanished on a few islands. Moreover, considering that the system of classification of these reptiles in the archipelago has only recently been resolved, practically all claims of Galápagos snakes made by park rangers and resident photographic identifiers of them are false. The idea is to offer park rangers and visitors programs that are simple to use and that can quickly identify different species using automated detection and recognition. They created an artificial intelligence platform—application software—that can identify a species of snake from an uploaded user photograph using deep learning techniques on a database of photos of various snake species. The program for the application functions as follows: after a user uploads a picture of something like a snake into the program, a method processes it, assigns it to one of the nine snake species, provides the category of the expected species, and informs users by giving them details on the dispersion, natural course, preservation, and derivations of the snake. Inception V2, ResNet, and VGG16 were among the R-CNN architectures that were successfully built for the study, with an accuracy rate of 75%.

3. PROPOSED SYSTEM

The primary goal of the “Snake Detection" system is to provide a solution to the problem of deaths caused by snakes in agricultural fields. IoT sensors like PIR sensor, vibration sensor etc., can be used to monitor, sense unusual activity in the farm field and trigger the camera to capture a snapshot and send it to the deep learning model for prediction. These sensors and cameras can be placed in specific positions to cover large areas. Arranging them like this can bring down the costs too. After detection, the farmers can be given a notification in the form of an SMS. This can be easily implemented and operated in isolated places or backward regions, as there is not much of a learning curve. Both the IoT part and the deep learning part of the project need to be integrated for detection without any human intervention. This project focuses on mounting the sensors and cameras in the field, building a deep learning model which classifies snakes, as well as the interaction of the system with the mobile phones of the farmers.

The system consists of many sensors, a microcontroller, and a camera to identify the unique features of snakes in some specific areas (like Telangana and Andhra Pradesh) and send an alert message to the owner of the fields. The Arduino microcontroller is used for computational purposes and CNNs are used for prediction. Images of the different snakes should be collected to train the deep learning model. The images are augmented to increase the accuracy of the model. TensorFlow models such as MobileNetV2 and EfficientNetB7 can be used to train the model. Training and tuning must be done on many models for good results.

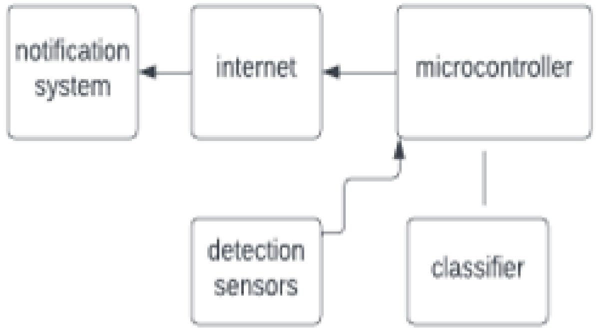

Fig 3.1: System Architecture

This system has three parts:

1. **Movement recognition:** Detection of the snakes' movements in the field using sensors like vibration sensors and passive infrared sensors, etc.
2. **Snake and species detection:** After detecting the movement, an image is captured using a camera, and that image is sent to the classifier. The classifier will detect whether a snake is present in the image or not. The snakes in the image must be classified as venomous or non-venomous. If they are venomous, the snake species are detected using the models we have already trained, and they are used for further operations.
3. **Alarm system and prevention mechanisms:** After detecting whether the snake is venomous or not and finding its species, the farmers in the area are quickly alerted using an alarm so that they can take quick action. Also, an SMS alert is sent detailing the species of snake found, which can be used if the snake causes harm to humans.

4. CONCLUSIONS

In this survey paper, we have done a lot of research on the topic "Detection of snakes using IoT." As a part of this, we have collected numerous previous research papers by various authors in order to understand the existing system and possible future ideas. The ideas proposed in these papers had some limitations, and we hope that some of these can be eliminated using the system we are proposing. We came to know that performance, accuracy, and data sets are the major hurdles for this kind of system. Some of these systems are difficult to install, and others need only high-quality images to work with. A major drawback seems to be the delay in sending the alert to the farmers and other people surrounding the farm. So, major drawbacks like these need to be overcome, which requires a lot of work. We understood that various deep learning techniques needed to be used in a way to improve the performance of the system in classifying the snakes as venomous or not and also reporting the species of them to the farmers. We have studied most of the proposed systems, which will help our system perform tasks as expected.

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