A Review on Animal Encroachment Detection in Crop Fields Using Deep Learning and Iot

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Abstract: *Agriculture is a crucial component in the advancement of human civilization. There are a number of traditional farming practises that are inefficient. Many agricultural challenges that farmers experience can be considerably minimised and crop yields can be increased by utilising contemporary technology. Animal encroachment in grain fields is one such issue that farmers are dealing with. Traditional tactics such as scarecrows, cracker bursting, and agricultural fencing are still utilised in agricultural fields to keep animals out of agricultural operations. Farmers suffer significant losses as a result of this, and in the worst-case scenario, the animals may even kill humans. Why these animals are intruding into crop fields is that because of destruction of natural resources. So, in search of food, water and other needs animals will be entering humans' territory. As a result, both animal and human life are in grave danger. To address this issue, smart animal encroachment systems have been developed to detect the presence of animals, issue a warning, and redirect the animal by reflex action. The system is set up to check for any animals that may enter the field on a regular basis. Animal movement is detected using a variety of sensors, including infrared and ultrasonic sensors, which provide a signal to the controller. The controller performs a reactive action, such as making loud noises, to divert the animals' attention. By doing so, animals are kept out of crop fields. A warning message is also sent to the farmer, alerting him to the presence of the animal.*
Keywords – *Animal encroachment, Artificial intelligence, IOT, Convolution Neural Network, Sensors*

I. Introduction

The Indian economy is driven by agriculture, a sector on which more than 70% of the country's population is dependent either directly or indirectly. Fields adjacent to forest areas are especially vulnerable to animal intrusion. Farmers and government are affected equally by the problem. They lose their crops, which are their main source of income to support their families during the non-monsoon months. The government is responsible for compensating the farmers. Providing effective way to prevent human-animal conflict is now one of the most substantial demanding situations in most of the countries. A common method implemented by people is to lay electrical fences outside the crop fields on the limitations of human settlement. This method affects animals and causes its death. Around 1300 animals were killed because of electrocution in the last decade.

Intrusion detection is basically tracking the moving target in the surrounding area with the help of sensors. The sensor will alert and remind the relevant workforce as and when the intrusion occurs to take up certain action in order to repel the animals from that area. There are many strategies and structures involved in solving the conflict between human and animals, which include motion capturing, image capturing, ultrasonic sounds etc. But in realistic applications, those technology have a few defects. For example, while video is used for intrusion detection, there may be blind spots because of the place of the camera. The sensor may not differentiate between animals and human being and produce a reflex action right after detecting motion.

Machine Learning is the science of artificial intelligence (AI) used for statistics evaluation, which automates the decision-making process for identifying the sample and tools used in making decisions. Convolution Neural Network (CNN) is one of the ML algorithms which is mainly used to analyse visual images. A deep system, studying set of rules for item detection and type version is trained and tested. By analysing and extracting the capabilities, the use of convolutional neural network (CNN), the intrusion detection of goal gadgetscan be realized. By making use of this algorithm, a model can be developed by training it with various animal images. This outputs the type of animal that is trying to intrude. Based on the output of the model the IoT (Internetof things) based controller takes up certain action to drive the animals away from that area. IoT is an upcoming concept in which various IoT devices communicates and are interconnected facilitating various advantages in forming computing devices. IoT controls the things which are linked to it and transfers the statistics over the network. The use of IoT applications enables the gathering of real-time statistics from the farm area by using sensors and a variety of digital components.

II. Literature Survey

According to Nikhil R et al. [1] They have developed a system using CNN Algorithm, few cameras and sensors. The dataset they have considered is images of elephant, horse and hen. This model helps in crop protection which in turn results in helping the farmers in preventing wild animals from entering the field, to grow suitable crops depending on the soil parameters, water conservation by supplying only required amount of water automatically to do that soil moisture sensors are used and this irrigation status will be updated to the farmer wirelessly by emails and SMS.

According to Stefano Giordano et al. [2] They have developed an IoT Application. Here they have used open-source systems and low power devices like microprocessor Cortex ARM M0+ and RIOT OS where one thread is used for detection of animals and another thread is used for detection of movement of animals. In addition to providing farmers with real-time knowledge about the weather conditions, the ultrasound system repels animals, with this weather monitoring system, various sensors are connected to an Arduino ESP-8266 board.

According to Sanku Kumar Roy et al. [3] IoT based IoT system utilizes Advanced Virtual RISC (AVR) micro controller based wireless sensor boards that have two different types of sensors: passive infrared (PIR) and ultrasonic. AVR detects an event and transmits data to the sink using a single- or multi-hop connection. This sink alerts the farmer by sending a SMS along with that the alarm is generated which is fixed in the farmer's house. Here ZigBee functions are used as the wireless transmitter units.

According to K S P. Premarathna et al. [4] They have built a model considering the dataset containing images of Elephant, Deer, Bear, Hen, Tiger, Fox. This system is used to prevent the elephants from entering the human territory by distinguishing almost all the species of elephants in every angle among other animals using image processing, Convolutional Neural Network and Sliding Window Algorithm to find the region of interest and they have achieved the accuracy of 94 percent in this work.

According to Harish S et al. [5] They developed a system where the dataset they have taken is images of most of the carnivores and the herbivore animals and used the PIR sensors with the camera which helps in detecting the movement or the intrusion using PIR sensors and images can be captured using camera and that image can be further processed using Content Based Image Classification (CBIC) algorithm. According to the classification the repellent techniques can be used like if its herbivores then ultrasound can be produced and bright light repels few animals, and huge noise scares away few animals. Farmers and forest officials will also be informed about this situation.

According to Wenling Xue et al. [6] In this methodology they have prepared a dataset of size 1200 x 350, where 1200 represents 3 scenes, (a)null, (b)human-being, (c)animal and here they used a WSN based on Ultra-Wide Band technology, UWB signals will be different when distinct objects enter wireless network. The characteristics of these UWB signals is analysed by Convolutional Neural Network and automatic feature extraction is used to differentiate between different species. This method has accuracy of detection by 16 percentmore than the traditional extraction.

According to Kuei-Chung et al. [7] They have mainly focused on monkeys so the dataset used here is images of monkeys. Hybrid Recognition Mechanisms are used in this system. IP Cameras are used to capture the images of monkeys. That image will undergo the image recognition algorithm. Image recognition algorithm has 3 modules: (a)preprocessing module (b)feature mapping module (c)verification module. After this process the image will be classified whether it is a monkey or not. If it is a monkey then system will take few warning actions like huge noice to scare the monkeys and also this model will notify farmers. This experimental model has 91 percent of accuracy.

According to R. Radha et al. [8], they proposed a system which consists of WSN with ultrasonic sound generator. A measure of the range of transmission of ultrasonic waves is used to divide agricultural land into clusters. When sensor node experiences the movement of monkeys into the fields then an alarm tone is transmitted to all the nodes in every cluster. As a result, the sink will activate the ultrasonic sound generator, generating waves at a frequency that will irritate the monkeys, causing them to flee.

According to Varsha Bapat et al. [9] This is a WSN application which is used to the protection of the crop lands from intruding animals. This system uses PIR Sensors, RF Module, sound generating devices, flashlights. Wireless sensors are mounted in the crop field boundaries. Using laser assisted perimeter guarding sensors, these sensors will detect intruders. When animal intrusion is detected, it will divert the animal by sound and flashlights. In any case, if the animal does enter the crop field, the PIR Sensors will sense it and activate the deterrent devices to force it out.

According to Seug You Na et al. [10], Their main focus is on wild animals and birds. USN devices are used here where the USN nodes have been equipped with microphone circuit to receive sound information and the USN nodes have also been upgraded to include camera modules which are in the radial direction to cover the direction area of the sky to watch out the birds which are approaching the field. If the animal or a bird appeared

the field already then warning text will be sent to the farmer and also few traditional repelling devices will be activated.

According to K Balakrishna et al. [11], It is based on the IoT and Machine Learning algorithms such as region-based Convolutional Neural Networks (CNNs) and Single Shot Detection Technology (SSDT). In this experiment they figured out that Single shot detection is better compared to R-CNN. For this work they considered 300 datasets of animals' images which includes 5 different types of animals like Horse, Cow, Cheetah, Zebra, Elephant. R-CNN algorithm generates around 2000 regions in each image so it takes high computation time. SSD algorithm includes pre-trained image classification networks where 4 x 4 grid rows and columns are used to detect objects. This is where SSD outperforms than R-CNN. The accuracy using SSD is 89.32 percent and using R-CNN is 85.22 percent.

Table 1 Generalised Review

Year	Paper	Objective	Classifier/ Sensors &Micro-controller	Dataset	Accuracy
2020	[1]	Crop prediction, prevention of animal intrusion, water conservation	CNN algorithm, Infrared sensors, USB camera	Images ofElephant, Horse and Hen.	-
2018	[2]	Animal and weather conditions monitoringsystem	ARM MO+ microprocessor, PIR sensor	-	-
2015	[3]	Intrusion detection andalarming	RISC, ZigBee, LCD,EEPROM	-	95%
2021	[4]	Identification and Tracking of animals	CNN, Gaussian Pyramid, Sliding Window Algorithm	Images of Elephant,Deer, Bear, Hen, Tiger,Fox.	94%
2019	[5]	Detection and classification of animals into herbivore and carnivore and repelling action(flash light and loudnoise)	PIR sensor, Background Separation Algorithm, Content Based Image Classification Algorithm	Images of Most of the carnivore and herbivore animals	-
2017	[6]	Human and animal intrusion detection	CNN, Back propagationalgorithm, Softmax Classifier	The datasets are null, human beings and animal and size is 1200x79	Improved accuracy by 16%
2018	[7]	Detection of monkey intrusion and repelling thesame	IP cameras, FAST algorithm, LBP cascadeclassifier	Images ofMonekys	Detection rate-91% Miss rate-9%

|					False detection rate- 15%
2017	[8]	Animal intrusion detection and deterring system	PIR sensors, RF module, WSN, laser diodes	-	60-70%
2010	[9]	Animal Intrusion detection and warning	Ubiquitous sensornetwork, Infrared Motion sensors	Images ofWildBirds and Animals.	-
2021	[10]	Detection and prevention of intrusion of animals	R-CNN model, Voltage regulator, PI camera, LED, SSD	A total of 60 images were collected for horses, cheetahs,zebras, cows, and elephants	89.32%
2018	[11]	Image classifier	Watershed algorithm, Gabor Filters, SVM	Images of nilgai and dog	54.32%

III. Analysis
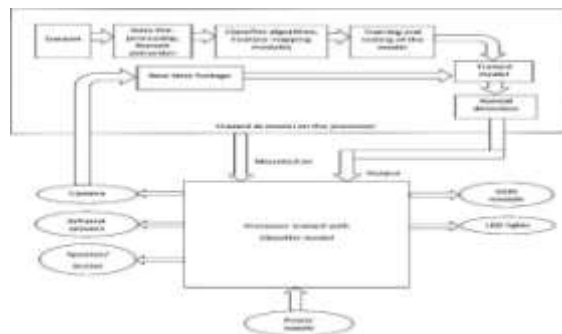
Fig 1. System Architecture inferred from the survey

The project's goal is to incorporate the finest of Artificial Intelligence into the appropriate hardware in order to achieve the goal of a Smart Animal Encroachment System. This provides a complete solution to the issue at hand. A GPU Engine can be used to build and train the AI model. The optimised model will then be installed on the Processor. The processor, which will be outfitted with a variety of sensors, peripheral devices, and modules, will be able to collect data from the outside and provide it to the trained AI model as input. The processor will then perform certain actions based on the output, depending on the situation.

The implementation consists of two stages:

- Model Development
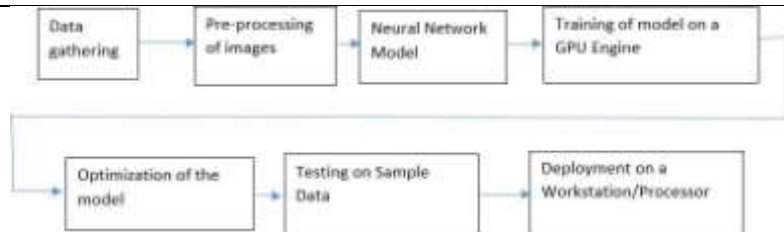- Hardware Integration

3.1. Model Development:

Fig 2. Software Development Phase

A large amount of raw data can be considered to construct an AI model for picture recognition. This can be done via a web scraper or by any open-source picture repository (Like, Kaggle or GitHub). The photos must be pre-processed and thoroughly categorized. Following image pre-processing, an AI model must be created utilizing TensorFlow, Keras/Pytorch framework and CNN/ RNN/ MaskRCNN/ YOLOR, among other techniques. Then the model must be trained. Following training, the model may need to be optimized based on the results, which necessitates model adjustments. The model will be tested on Test data set once the results are good. The model will then be installed on Workstation.
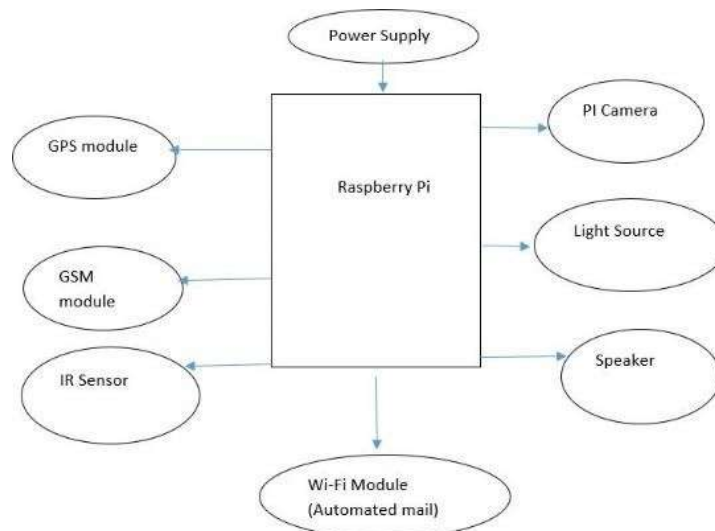
3.2 Hardware Integration:

Fig 3. Processor Strip

Raspberry Pi can be used as a processor, as it is capable of running software as well as host many sensors and modules at the same time. The deployed model will run in the background on the Raspberry Pi. Modules such as GPS, GSM, and an infrared sensor will be connected. It will also be connected to auxiliary devices such as a speaker, a light, and a PI camera. The photos from the camera are sent into the model as input. The model then analyses the data and provides us with the result. The type of animal recognised will be the output. Following the

detection of the output, the deployed speaker and light source will take prompt action to prevent the animal from entering the farm. Simultaneously, the farmer will receive an automated call alerting him to the possibility of an animal attack on his property. Additionally, the precise GPS coordinates will be given through text message. Meanwhile, photographs of the incident will be sent to the adjacent forest authority via e-mail, along with GPS coordinates.

IV. Drawbacks

- The existing papers discuss as to how to detect animals, differentiate them and implement a reflex action to drive them away. But few animals may not react to the same kind of sound. There are specific sounds that specific animals are scared off. For example, elephants are scared of bee sounds, pigs are afraid of barking of dogs etc. Therefore, the reflex actions can be modified to be specific for different animals. As shown in fig.2, at the phase of training the model, it is ensured that it is trained with different noises for different animal input, thereby improving the probability of the model working against animals

- In case of carnivores, there is a high chance that they do not react to the reflex sound or light and even if it does, when driven away, there is a high risk of that animal entering the residential area and harm people. Even if the forest department receives an alert-message, by the time they arrive the animal may have fled and it may be impossible to find it. In order to prevent this, GPS trackers can be installed along with sensors so that the message received form nearest sensor will be recorded and sent to the department. This makes it easier for the department people to track the animal movement. In fig.3, there is a GPS model connected to the processor (raspberry pi), which performs the above explained task.

- Another point to be considered is to ensure that the camera should be able to capture the image even during night time. Most of the currently existing works only talk about day time image capturing. But the animals can enter the fields even during night time and cause damage. This problem can be addressed either by implementing grayscale conversion in the algorithm which may affect the accuracy rate of the algorithm. Another way is to capture the image of animal in the presence of artificial source of light.

V. Conclusion

It is our first responsibility to safeguard the agricultural sector, which is the backbone of the Indian economy. Our initiative proposes a practical approach for farmers to protect themselves from animal assaults, which result in significant crop losses. The animals are also not injured in any manner because the processor's reaction action is to scare them away rather than hurt them in any way. When wild animals, such as wild cats, pose a threat to human life, the forest department receives detailed information on the animal and its location, ensuring human safety.

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