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Security Measures for Crops and Domestic Animals using CNN

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Abstract:- India is mainly an agriculture based country. Security of agricultural farm is of utmost importance for protecting the produce. Not being able to make the grown crops to the market is another side of the problem. Valuable investments and efforts can be ruined in minutes intentionally or unintentionally by persons or by animals. Introducing machine learning to this problem paves a way to smart agriculture. The proposed system employs Raspberry Pi board to detect any malicious activities or motion in the farm land and triggers the thermal camera to take picture of the scene image. The captured image is fed into the trained CNN (Convolutional Neural Network) model of deep learning. And after detecting the class of the animal, a sound file mapped to that class is played at little higher frequency, so as to scare away the animal. The result shows that the system is 80-95% accurate and 100% consistent for detecting any suspicious movement and to act accordingly.

Keywords:- *Deep Learning, Convolutional Neural Network, Thermal Cameras, Tensor flow, Fastai, Raspberry Pi, PIR sensor etc.*

I. INTRODUCTION

Agriculture is the backbone of our country. Agriculture provides food, raw materials and also occupation to a large portion of the Indian population. It plays vital role in the growth of country's economy. The true purpose of education is served only when the products of education (we the students) are able to address the problem of the nation through their specialization stream. We have tried to tackle the problem faced by the farmers (confined to areas near the forests) through the little knowledge we have.

Ever since humanity started farming and taming animals, the concept of perimeter protection has always been the use of hazardous objects placed as physical fencing apparatus to protect the interiors. These mainly serve as "hindrance" objects which do not act/communicate intelligently in cases of perimeter breach. Over the years, many advanced surveillance technologies have aided in monitoring regions of concern. But these are deployed primarily for high end security purposes in critical areas. And majority of the time farmers are not as skilled as it requires to operate these things. In this regard making agriculture smart, important contributions can be made by using emerging technologies like IoT, ML and DL which inculcates image processing techniques. Hence we aim to come up with a user friendly and simple yet an effective system to monitor farmlands and protect them from animal intrusions. Crop is not the only thing in danger, but domestic animals too. The model that we have proposed also makes sure that domestic animals are safe too. Because in many areas, domestic animals like sheep, goat, hen etc. are eaten away by the wild animals that trespass the boundary and even other domestic animals that are higher in the hierarchy.

II. LITERATURESURVEY

To build an intelligent security system using IoT and image processing: database management systems, sensor networks and Open CV modules are the foundation.

Most of the existing solutions to this problem primarily involve using CCTV footages to alert the owner about the intrusion. Researchers have developed various IoT-based security devices, but very little work relating to agricultural land security is reported. The methods defined in the papers referred have methods such as detection of vibration when the fence is touched, ultrasonic sensors for sensing movement or the use of simple cameras with automated algorithms to detect a change in image and hence the intrusion of the person. In Ronnel Kylon A et.al, (2016), a smart security system built using image processing and Arduino microcontroller is described. The system captures the image when any motion is detected in the farm and then the image is sent to a server for processing using matlab which is again sent back to the Arduino for appropriate action to be taken. There is no provision for processing the image the source and hence this process is very much time consuming. In Jo˜ao Natividade et.al, (2017), a fully automated system is designed using a raspberry pi and it is used to control and unmanned aerial vehicle (UAV) which has a camera with filters. The output is given to the ground station through Wi-Fi to the raspberry pi in real time. In Vinita Tyagi et.al, (2017), a survey is presented with applications of image processing techniques applied to the field of agriculture for detecting weeds and grading fruit. This method was less time-consuming and precise than many conventional approaches used. Image processing helps enhance decision making for vegetation measurement, crop sorting and irrigation. We can also classify the different types of weeds using image processing techniques. In Zhanjie Wang, et.al, (2010), a system is described in which a crop destroying animal or intruder is identified. The farm is monitored closely using Closed-circuit television (CCTV) which also provides the recorded video for security. Motion is detected using Arduino microcontroller and a snapshot of the video is taken and displayed on the Graphical User Interface (GUI) which is programmed. It is further processed to identify the intruder and alarm system is turned on through an opto-isolator. This alarm can be turned off by the respondents. These methods are usually effective during the day, and ineffective at night. Moreover, mere alerts about intrusions do not solve the problem of animals destroying crops. The reaction towards the intrusion by humans might be delayed by several minutes which is at most times useless. One more solution is we can deploy electric fences. But the problem that lies with deploying electric fences is that they are dangerous to animals as well.

Besides protecting crops and domestic animals from the attack of wild animals, it is our utmost duty to make sure that no harm is done to those animals. We intend to solve these problems of delay in reaction time and night-time monitoring with our proposed system. Thus after looking into these aspects and the shortcomings of the papers described (linked in the reference section below) we propose a novel system for smartsurveillance.

III. PROPOSED SYSTEM

The need for smart solutions lead us to design this solution which uses an efficient system to alert the owner in real-time indicating "what" has breached the perimeter. The system also tries to intimidate the intruder by producing "customized" sounds for each class of intrusion detected (for example Dog's bark for scaring away cattle). This would decrease the damage caused by the breach and would alert and enable the owner to take immediate action. Even if the owner couldn't make it to his farmland due to some unavoidable reasons, the produced sound is enough to protect the crops on its own. The system primarily uses Deep Learning technique, i.e. Convolutional Neural Network. Proposed model detects not only motion but also the class of object by means of a Machine learning model or an embedded digital image processing software in the microprocessor. This "class" knowledge would be used as the input to a software that would interface with a speaker to play the custom catered sound for each class of intruder. This can be extended by using embedded systems. Thermal cameras are used to capture the images in that case. The choice of using a thermal camera was after due consideration of various other sensors and their day and night, range and visualization capabilities. From the economic perspective a thermal camera mounted on a rotating platform would eliminate the need for multiple cameras required for covering the needed area, also allowing a single centralized monitoring system to cover the entire area without any blind-spots [6]. The conventional night vision cameras detect images only in the presence of at least little amount of light. And these cameras fail to recognize the things (in our case animals) in the complete dark. The proposed system can easily be scaled up with the use of more precise thermal cameras and the Amazon cloud services if there is a need for multi- sensor networking. In such models, multiple microcontrollers can be deployed as slaves and controlled by a master computer on the cloud. In our proposed system we have used Raspberry Pi as the heart of our project i.e. all the image processing and decision making code is run in the Piitself.

A. Thermal Camera

Unlike normal cameras, thermal cameras don't use light to capture the image. Thermal cameras detect temperature by recognizing and capturing different levels of infrared light [1]. This light isn't visible to the naked eye, but can be felt as heat if the intensity is high. All the objects (including humans) emit some kind of infrared radiation, and it's one of the ways that heat is transferred. A shade of green, blue or purple is coated to the region of colder temperatures whereas colors like red, yellow or orange are given to the relatively warmer temperatures. Since the infrared radiation emitted by the animals is way different from that of the background (in this case the environment), differentiating the animal even amidst the full darkness and other obstacles becomes efficient.

IV. SYSTEM DESIGN

First of all, images of animals required (elephant, lion, tiger, leopard, cat, dog and fox) are collected and stored in different folders with respective names as the names of the folder. Using these images, a dataset is created consisting of images as one column and labels as another column. Our model is trained using these datasets; this makes use of many python libraries like OpenCV, NumPy, tensor flow etc. CNN (Convolutional Neural Network) of Deep Learning really carries out training steps efficiently. Training is carried out through three main layers of keras (tensor flow). The first layer being the Convolutional layer, where in the input image, which is represented by a matrix containing pixels. 2-D matrix in case of grey images and 3-D matrix in case of coloured images (For computing it is better to have images in grey format as it doesn't require additional resources like coloured ones.) is multiplied by feature detectors. At the end of this layer, many convolutional layers are formed [3]. It is difficult to go through each convolutional layer individually. This is where the second layer, MaxPooling Layer helps us. This layer converts each convolutional layer into 2-D matrix of smaller sizes like 2*2 0r 4*4. Hence in this layer bigger matrices are being converted into matrices of lower order [4]. This 2-D vector is then converted into a single vector with the help of the third layer, i.e. Flattening layer. This layer takes each pooled layer one by one and converts them into one dimensional vector. This one dimensional vector is the final vector, which will be used to match the different characteristics. At last all the vectors are formatted using the Dense Layer of CNN. After the model undergoes the training phase, it is ready to be tested. The inputs are the images of the animals that have to be detected.

This proposed CNN model is trained under 5 epochs. Since epoch cannot be applied to a very large dataset, it is divided into batches and each batch is processed. A forward pass and a backward pass of every training sample is obtained in each epoch. In each epoch the accuracy of the model increases. More epochs can be applied to increase the model's efficiency.

Epoch	Loss	Accuracy	Val_loss	Val_acc
0	0.6523	0.5997	0.8054	0.5663
1	0.5374	0.7320	0.5038	0.7516
2	0.4065	0.8163	0.4603	0.7821
3	0.2696	0.8841	0.5502	0.7766
4	0.1284	0.9527	0.6952	0.7789

Table 1: Accuracy of Cnn Model

Alternative to using this CNN, we have one more powerful library in python called Fastai. This library is built on pytorch framework, which has several models inbuilt that have been trained on Image net samples. Image net is an annual competition where there are 1000 classes to classify into with 1lakh samples for each. We build our image classification model using any of these in-built models [8]. Example -if you use resnet34, a 34-layer neural net. Since it is already trained we don't need to update parameters of initial layers. We only train the last 2 layers According to the sample and classes we have. Since it has already been trained on imagenet a high probability that our class is already included so we can get high accuracy with very few epochs and samples. When we used Fastai library the accuracy was increased to 98 % from 95 %. Fastai based CNN model is recommended when the training data sample size is less. Though the accuracy obtained using the Fastai library is more than that of the accuracy obtained from previous CNN, Former Convolutional Neural Network is good enough for our proposed system. And it is proven to be efficient in detecting the classes of animals that we have taken to be more important for our model.

Epoch	Loss	Accuracy	Val_loss	Val_acc
0	0.070390	0.958333	0.070921	0.952564
1	0.044929	0.969167	0.036075	0.968325
2	0.044649	0.977584	0.045687	0.972456
3	0.031912	0.979167	0.032845	0.975687
4	0.022775	0.981235	0.025647	0.912564

Table 2: Accuracy of the Model Using Fastai.

There are totally four audio files, which are mapped to the index of respective animal class.

Animal	Sounds
Elephant	Buzzing sound of honey bees
Fox	Whistling
Lion	Sound of gun shooting
Tiger	Sound of gun shooting
Leopard	Sound of gun shooting
Cat	Sound of dog barking
Dog	Sound of gun shooting

Table 3: Animals With The Sound They Scared Of

Raspberry pi Model 3 contains 40 pins which include 5v, GND, 3.3v and 26 GPIO pins and 2 ID EEPROM pins to provide I/O connectivity [2]. Servo motor is connected to Raspberry Pi. Servo motor state (ON/OFF) is controlled by program running in RaspberryPi.

The PIR sensor and the thermal camera module are connected to Raspberry Pi [7] and housed on the shaft of servo motor. Servo motor shaft rotation makes both PIR sensor and thermal camera module rotate. The infrared light radiating from an object is measured by a PIR sensor [9]. Speaker is connected to Raspberry pi either through USB cable or Wi-Fi [5]. The CNN deep learning model is dumped into Raspberry where the image processing is carried out.

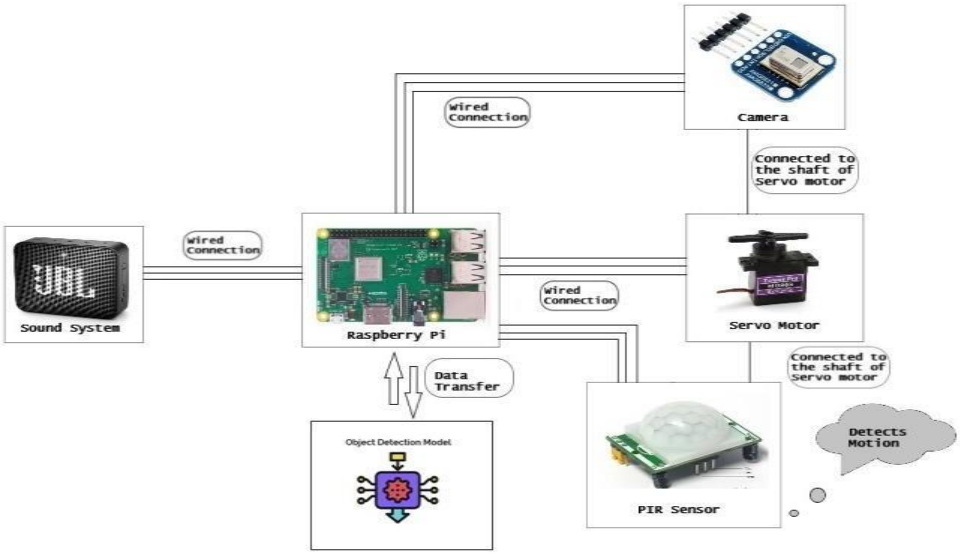

Fig. 1: Virtual Fence System

V. IMPLEMENTATION

Algorithm: Crop Security using Virtual Fence Methodology.

- Step 1: Start
- Step 2: Activate PIR sensor.
- Step 3: Start rotating servo motor shaft connected to PIR sensor and thermal camera module.
- Step 4: If motion detection=YES (PIR sensor output 1), go to Step 5 else, continuerotation
- Step 5: stop servo motor
- Step 6: Activate thermal camera module and capture the image and send it to Raspberry Pi for further processing.
- Step 7: Collect image in Raspberry Pi Media.
- Step 8: Perform image processing on the collected image to identify the class of the animal in the captured image using trained CNN model.
- Step 9: Based on the output of CNN model select an audio file.
- Step 10: Activate speaker and play the audio file to scare away the animal detected for specific amount of time and quickly go back to step 3.

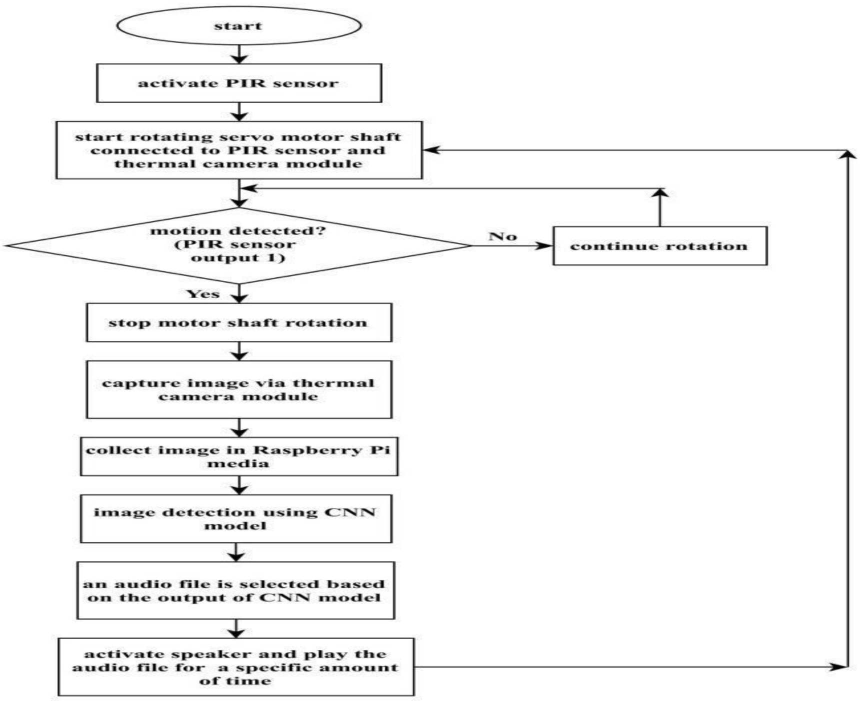

Fig. 2: Flowchart of the Proposed Methodology

The model can be fitted near the farm. Thermal camera can be installed on the rotating platform. Thermal camera is used primarily to capture the image based on PIR sensor readings. And this image is sent to nearby microprocessor, i.e. Raspberry Pi for processing. The model maps the input image to any one of the animals in the list. Labels of animals are stored in the list. And their corresponding sound files are also stored in the lists, maintaining the same indexing order as that of labels. Hence after the detection of any animal, it's index can be made use of, while playing the audio file. Either the thermal camera can be used during both day and night or thermal camera during night and the Rpi camera during the day (the day detection system can be interfaced with the Raspberry board with the Standard camera port and the GPIO ports respectively). The index of the selected animal can be used to play the sound. Bluetooth speakers can be used to play the sound. Upon hearing this, the intruded animal gets scared and flees away. Hence it assures that no harm is done either to the crop or the animal that has trespassed the boundary. All these tasks can be carried out without the concerned farmer noticing the intrusion. Because unlike any other models, our proposed model takes care of everything on its own. If the owner wants to know about when and which animal has breached the perimeter, our system can inculcate the practice of sending an alert message to his/her personal mobile number and this approach stays as an option. Messages can be sent by using the standard python code. Telegram Messenger Service can be used to send messages and files over Telegram to user account, to a group or to achannel.

This proposed system is also economically efficient which means a farmer wanting to save his crops from being destroyed will be able to afford it without facing any problem. Though it seems a bit costly, most of the time it is a onetime investment and multiple similar systems need not be installed in the field. System will be designed in such a way that a single product of this will take care of the entire field, it is installed for.

VI. RESULTS AND EVALUATION

We have considered seven animals, because these are the only animals that farmers come across with problems like this most of the time. Even if the situation demands us to add any extra class of an animal, it can be easily done without affecting the entire setup.

Our model was able to successfully detect the images of animals such as elephants, cats, lions, leopards etc. and play the corresponding audio file. For instance: Elephants are scared of bees and so a buzzing bee sound is played if an elephant's image is inputted to our model. Foxes are frightened by the sound of whistles blowing; hence this sound is played as soon as the fox is detected. As cats are scared of dogs, the sound of dog barking is played when our model is fed with the cat image. Lions, tigers, leopards and dogs are allergic to the sound of a shooting gun; hence the same shooting sound is produced when any of these four animals' images are supplied to our model.

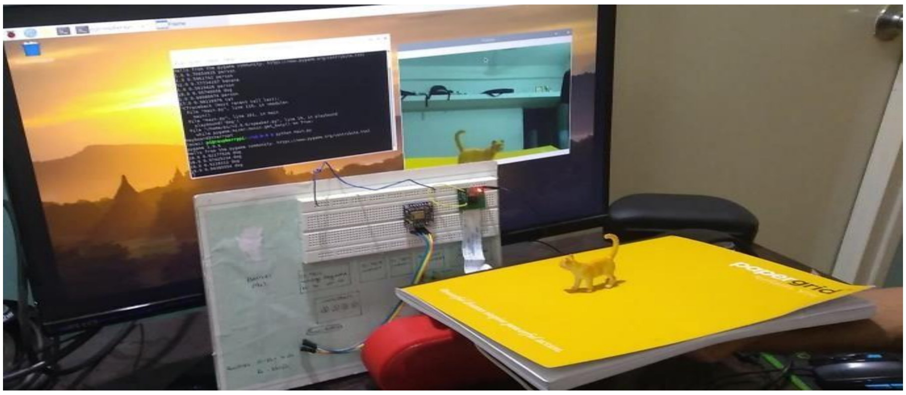

Fig. 3: Demonstration Of The Model

VII. CONCLUSION

Smart agriculture is need of the hour. Virtual fence is widely needed technology nowadays. In order to achieve this vision based smart system is proposed and implemented using raspberry pi and deep learning. The architecture comprises of raspberry pi, which is the heart of the processing unit that takes information from the sensors deployed in the farmland. Different layers of the CNN module provide a systematic way to build the system. Sensor data is processed and the captured image is sent to our trained model where in, the animal responsible for the generated event is identified and corresponding allergic noise is produced to make the respective animals flee. This doesn't even require the owner to be notified. This designed framework can be utilized in smart agricultural applications such as preventing the intrusion of wild animals into the field and detecting any malicious activities being carried out on the farmland. The results show that the system is 80-95% accurate and 100% reliable in detecting the suspicious activities. Thermal imaging has proven to be more effective during both day and night as stated above.

As computer science field is continuously evolving, in particular ML, DL fields are evolving very quickly, hence better algorithms will be discovered which can further increase the accuracy with which the model detects animals. Thermal camera module and PIR sensor combination can be replaced by a long range thermal camera which increases the efficiency and capturing capacity innight.

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