EAI Endorsed Transactions
on Internet of Things
Research Article EAI.EU

SMART REPELLER: A Smart system to prevent Rhesus Macaque Trespassing in Human Settlements and Agricultural Areas

Radha R[1*], Balaji G[1], Anita X[1] and Mridhula N[1]

[1]School of Computer Science and Engineering, Vellore Institute of Technology, Chennai

Abstract

Rhesus macaque trespassing is a widespread problem where wild Rhesus macaque monkeys enter human settlements and agricultural areas, causing various issues such as property damage, food theft, and health risks to humans. These primates also cause significant economic losses by raiding crops, damaging plants, and disrupting the natural balance of the ecosystem. To address this problem, a research paper proposes a technology-based solution called Smart Repeller, which uses ultrasonic sound waves and Calcium Carbide Cannon, along with computer vision technology and artificial intelligence to detect the presence of monkeys and activate repelling mechanisms automatically. The proposed device eliminates the need for human intervention, making it efficient and cost-effective. Our paper aims to demonstrate the feasibility and effectiveness of the proposed device through experimental studies and simulations, with the ultimate goal of providing a practical and scalable solution to mitigate the problem of Rhesus macaque trespassing in human settlements and agricultural areas.

Keywords: Rhesus macaque, IoT, Calcium Carbide Cannon, ultrasonic sound

Received on 12 November 2023, accepted on 02 January 2024, published on 10 January 2024

doi: 10.4108/eetiot.4809

*Corresponding author. Email: radhu.mithu@gmail.com

1. Introduction

Rhesus macaque trespassing is a problem where wild monkeys enter human settlements and agricultural areas, causing various issues such as property damage, food theft, and human safety concerns (Alexander et al., 2015; Das & Mandal, 2015). The monkeys can spread diseases such as herpes B, which can be fatal to humans, and cause significant economic losses by raiding crops and damaging agricultural infrastructure (Li et al., 2013; Gupta, 2019).The proposed Smart Repeller device aims to mitigate the problem of Rhesus macaque trespassing by using ultrasonic sound waves and Calcium Carbide Cannon, along with computer vision technology to detect the presence of the monkeys and activate the repelling mechanisms automatically (Stefano et al., 2018). The research paper aims to demonstrate the feasibility and effectiveness of the proposed device through experimental studies and simulations, with the ultimate goal of providing a practical and scalable solution to the problem of Rhesus macaque trespassing (Artelle et al., 2016; Mateo-Tomás et al., 2012).

The negative impact of Rhesus macaque trespassing on daily life and agriculture can be significant and widespread, and addressing this issue is crucial to reduce economic losses, health risks, and ecological imbalances caused by these primates (Bencin et al., 2016; Mojo et al., 2014; Campbell et al., 2010).The proposed Smart Repeller device aims to mitigate the issue of Rhesus macaque trespassing by using ultrasonic sound waves and Calcium Carbide Cannon, which are known to be effective in repelling these primates. The device incorporates computer vision technology to detect the presence of the monkeys and activate the repelling mechanisms automatically, eliminating the need for human intervention, making the solution more efficient and cost-effective. The research paper aims to demonstrate the feasibility and effectiveness of the proposed Smart Repeller device through experimental studies and simulations. The ultimate goal is to provide a practical and scalable solution to the problem of Rhesus macaque trespassing, which can benefit both human settlements and agricultural areas by reducing economic losses, health risks, and ecological imbalances caused by these primates. The process is shown in fig 1.

2. Literature Survey

Expansion of human habitat due to increase in population majorly leads to human-wildlife interaction [1][3]. These interactions lead to severe damage to wildlife and as well humans [2][10]. The human-wildlife conflict is more intense in agricultural land where the livelihood of people is dependent [7][9]. Due to the heavy loss, farmers involve in unethical practices like poisoning [8] the wildlife to reduce the impact. In India, huge impact is due to the human-monkey conflict and it creates huge threat because of increasing monkey population [5]. Due to their flexible food habits, monkeys can survive in urban areas and they survive by feeding on whatever human eat [4] .

The traditional way to scare monkeys are using catapult to through stones and making monkey repelling noise like drum beating and firecrackers etc. which remains ineffective as it needs physical monitoring. As reported by economic times[13] (2020), to overcome monkey menace, the Ahmedabad airport staffs were directed by their official to dress up like bear and to scare away monkeys. In order to runaway monkeys, [6] proposed innovative monkey repelling sound that mimics baboon barking which need to be operated manually. [11] proposed an IoT based repeller that emits ultrasonic sound in the wide band of 20kHz-40kHz. The ultrasonic sound generator was activated by Passive Infrared (PIR) Sensor. [12] proposed a Smart Animal Intrusion Detection System that monitors the movement of wild animals by integrating camera, PIR and motion sensor. If any one of the sensor detects animal, the intimation regarding the presence of animal will be sent to the farmer. According to Times of India [14] (Oct 29, 2019), Telangana State Agricultural University introduced Agri-Cannon (Calcium Carbide cannon) to protect agricultural crops/farms from monkeys. They claimed that the damage made by monkeys has reduced by 60 percent with the help of calcium carbide cannon used by farmers in their physical presence. Still these approaches are executed manually by the farmers on seeing or detecting monkeys. Automating the detection and repelling is very much required for the farmers to keep them stress free and their crops safe. Several methods have been proposed for animal detection using wireless sensor nodes. For instance, Kozo Ohtani et al. [15] proposed using ultrasonic array sensors to detect the presence of animals and humans. Alternatively, detector circuits placed on both sides of a road can detect the entry or presence of wildlife animals, as proposed in [16]. However, this method is limited to a narrow range of the road width. Another effective method involves using data collection technology to analyze animal movement and generate spatio-temporal data, as proposed in [17]. G. Sasikumar et al. [18] analyzed the use of various wireless sensor networks for animal detection. They proposed a method for positioning and detecting elephants using the spectral energy magnitude and highest pitch frequency produced during communication, aimed at avoiding human-animal conflict. Furthermore, Pankaj Kumar et al. employed deep convolutional neural networks to detect native monkeys from live video. They trained a YOLO model using Google image sets. K.K. Sharma et al. [21] have identified several indigenous traditional methods developed and practiced by farmers to repel monkeys. Among them are sound devices, ultrasonic repellents, and artificial intelligence.

A sound device developed by scientists at SKUAST-Jammu was successfully used in villages Ramkot and Bhool in Kathua district, producing an innovative repelling sound that mimics baboon barking. Farmers commonly use monkey repellents domestically, but high-powered ultrasonic repellents using special "Multiplex Modulated Sweeping Ultrasonic Sounds" can be more effective. These waves, out of the range of human and pet hearing, penetrate the monkeys' brains and nervous systems, making them uneasy and uncomfortable and forcing them to leave the area. "Microsoft AI for Earth" is using AI, machine learning, and cloud computing to track monkey movements and identify them, allowing for a humane solution to the monkey problem. The team is also developing a mobile app that allows people to capture monkey photos, tag their location, and upload them to the project's database for identification and sterilization.

The proposed model is different from these methods in that it is location-specific and involves automatic detection of monkeys without human intervention. Once detected, the model produces sound to restrict the entry of monkeys into the restricted area.

Anson Wong et al. [22] have introduced an animal deterrent device that uses a canister containing compressed gas connected to a valve system to create a deterring sound. However, the proposed model uses calcium carbonate cannon to produce sound instead of compressed gas, making it different from the above-mentioned model.

A Sharanjah et al. [23] proposed two CNN classification models developed using transfer learning with VGG-16 as a pretrained model to detect elephants, wild boars, and buffalos. Their proposed mechanism uses loud noise to scare away animals, but our scheme uses dual approaches - an ultrasonic sound generator and calcium carbide cannon - to scare away monkeys, increasing the mechanism's efficiency.

3. Proposed Work

Our proposed method for detecting Indian monkeys in video streams consists of two main components: motion analysis and deep learning. The motion analysis component detects motion in each sub frame of the video stream separately using a background subtraction algorithm. If motion is detected, the deep learning component uses a pre-trained deep learning model in ONNX/Pytorch format to detect Indian monkeys in the sub frame. The deep learning model was trained on a dataset of Indian monkey images using the YOLOv5 algorithm. The system also computes the direction of monkey movement by comparing the position of the detected monkey in each subframe with the position of the monkey in the previous subframe. The direction of monkey movement is displayed in a window along with the detected monkey images.

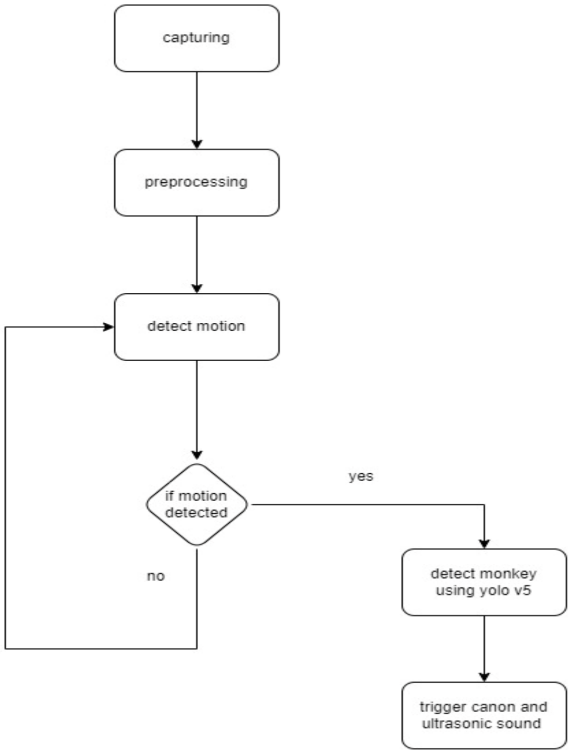

Fig. 1. Working flow diagram of smart repeller

3.1. System Design

System design refers to the process of defining, designing, and developing a system, which includes hardware, software, and other components that work together to achieve specific goals. In the context of the Smart Repeller project, the system design involves designing and developing the hardware and software components that make up the Smart Repeller device. The hardware components of the Smart Repeller device include the ultrasonic sound wave generator, Calcium Carbide Cannon, and computer vision system. The ultrasonic sound wave generator produces high-frequency sound waves that are audible to Rhesus macaque monkeys but not to humans. The Calcium Carbide Cannon releases a burst of acetylene gas, which produces a loud noise and bright flash, both of which are effective in scaring away monkeys. The computer vision system uses image processing algorithms to detect the presence of monkeys and activate the repelling mechanisms.

The software components of the Smart Repeller device include the control software, image processing algorithms, and user interface. The control software controls the operation of the ultrasonic sound wave generator and Calcium Carbide Cannon, and it communicates with the computer vision system to detect the presence of monkeys. The image processing algorithms analyze the images captured by the camera and detect the presence of monkeys in real-time. The user interface allows the user to configure and control the device and view its status. Overall, the system design of the Smart Repeller project involves integrating the hardware and software components to create a smart device that can detect the presence of monkeys and automatically activate the repelling mechanisms, thus mitigating the problem of Rhesus macaque trespassing in human settlements and agricultural areas.

3.2. Software Design

The program starts by importing the necessary libraries, including OpenCV for video capture and processing, NumPy for numerical operations, and yolov5 for running the pre-trained DL model in ONNX/pytorch format. The program defines a function to split each frame into 16 subframes using parallel processing. The subframes are then resized to 640x640. The program defines a function to detect motion in each subframe using OpenCV's background subtraction algorithm. If motion is detected, the subframe is passed to the next step. The program defines a function to detect Indian monkeys in each subframe using the pre-trained DL model in ONNX/pytorch format. If a monkey is detected, the subframe is passed to the next step. The program defines a function to find the direction the monkey is moving in each subframe using OpenCV's optical flow algorithm. The direction is then used to draw an arrow on the subframe. The program combines the subframes with detected monkeys and their direction of movement into a single window with spaces. The program continuously captures video from the camera and repeats the above steps for each frame. Overall, the program captures video from the camera and processes it using a combination of OpenCV's built-in functions and the pre-trained DL model to detect Indian monkeys and their direction of movement in real-time.

4. Dataset

We created a custom dataset created for detecting Indian monkeys in images. The dataset consists of images of Indian monkeys collected from various sources, including open-source image repositories and custom image captures. The images are annotated with bounding boxes around the Indian monkeys present in the images. The dataset contains over 1,500 images with approximately 2,000 annotated objects. The images are in JPEG format, and the annotations are in the COCO format. The dataset can be used to train machine learning models for object detection tasks related to Indian monkeys, such as counting the number of monkeys in an image or detecting the presence of monkeys in a video stream.

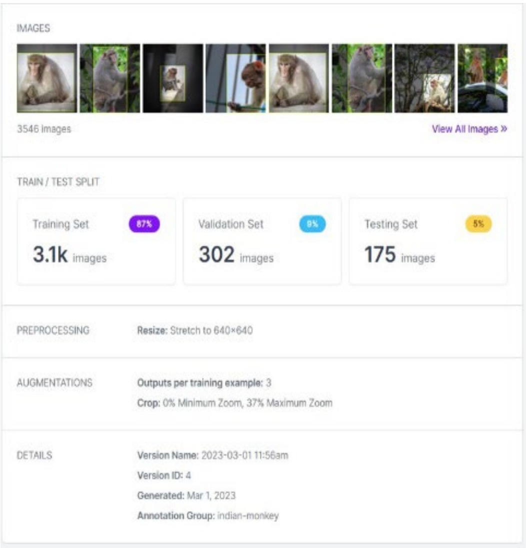

Fig. 2. Roboflow.com

The dataset can also be used to evaluate the performance of existing machine learning models for monkey detection. The dataset is made available through the Roboflow platform, which provides tools for data pre-processing, data augmentation, and integration with machine learning frameworks such as TensorFlow and PyTorch. The platform also provides a REST API for easy integration with other applications. In Fig.2 and Fig.3 you can see some screenshots of the site and datasets.

We manually annotated the images of monkeys using the tool provided in roboflow.com and exported in our required format. Fig.4 shows the annotation tool.

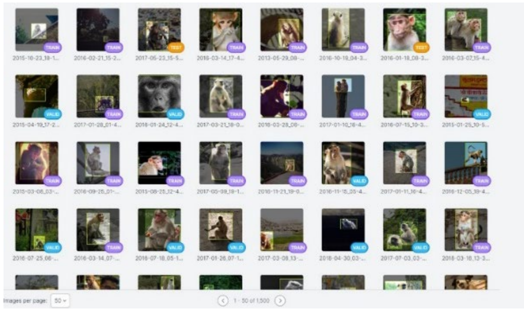

Fig. 3. Dataset

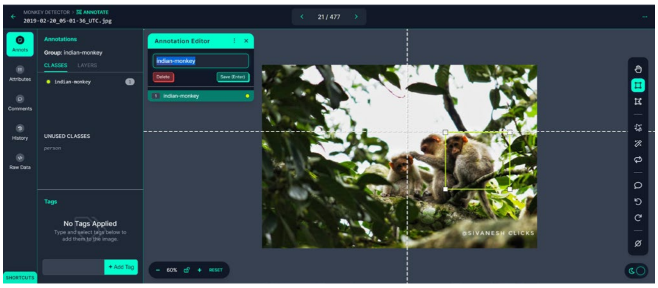

Fig. 4. Annotation tool

5. Deep Learning Model

Here we are going to use a deep learning model named YOLO. YOLO (You Only Look Once) is a popular real-time object detection algorithm that was first introduced in 2016 by Joseph Redmon, Santosh Divvala, Ross Girshick, and Ali Farhadi. The main advantage of YOLO is that it can detect objects in an image in just one forward pass through a neural network, making it significantly faster than other object detection algorithms that require multiple passes through the network. YOLO uses a single convolutional neural network (CNN) to predict bounding boxes and class probabilities directly from full images, rather than selecting a set of regions-of-interest (ROIs) as in other object detection algorithms. The network divides the image into a grid of cells, and for each cell, it predicts bounding boxes, class probabilities, and a confidence score indicating the accuracy of the detection.

The YOLO algorithm has undergone several improvements over the years, including YOLOv2, YOLOv3, and the latest version YOLOv4. These improvements have resulted in better detection accuracy, increased speed, and the ability to detect smaller objects. YOLO has many practical applications, including object tracking, autonomous vehicles, security systems, and more. Its speed and accuracy make it an attractive option for real-time applications where detecting and tracking objects in real-time is essential. Overall, YOLO is a powerful and widely used object detection algorithm that has revolutionized the field of computer vision by providing a fast and accurate solution to object detection.

6. Project Architecture

To detect Indian monkeys in a video feed using Python, we can follow the following steps. First, we need to get video frames from the camera and split each frame into 16 subframes using parallel processing. Next, we resize each subframe to 640x640 pixels and detect motion in each subframe separately. If motion is detected in a subframe, we then use a pre-trained DL model in ONNX/ PT format to detect if there is an Indian monkey in the subframe. If a monkey is detected, we also determine the direction that the monkey is moving in the video feed. Finally, we display all the subframes in one window, with spaces in between them. This algorithm makes use of computer vision techniques such as object detection and motion detection to detect Indian monkeys in the video feed. The use of parallel processing helps to improve the efficiency of the program, enabling it to process video feeds in real-time.

The pre-trained DL model in ONNX format helps to accurately identify Indian monkeys in the video feed, and the determination of the direction of movement can be useful in tracking the movement of the monkeys over time. Overall, this algorithm can be a useful tool for researchers and conservationists working with Indian monkey populations. Removing greens from an image can be useful in identifying specific objects of interest, such as monkeys in agriculture areas.

By removing green color from the image, the algorithm can focus on identifying the monkey in the agricultural area, which can be useful in monitoring their presence and behavior. This can help farmers and wildlife conservationists make more informed decisions about managing monkey population in areas where they may cause crop damage or pose a threat to human safety. Fig.5 shows architecture of monkey detection.

The following algorithm outlines the steps involved in removing green color from an image to help identify Indian monkeys in agricultural areas.

1. Convert the image to the HSV color space.
2. Define the lower and upper bounds for the green color range in HSV.
3. Create a mask to filter out the green pixels in the image.
4. Apply the mask to the image to remove the green color.
5. Convert the resulting image to the RGB color space for further processing.
6. Detect motion in each subframe of the video stream.
7. If motion is detected, apply the green color removal algorithm to the subframe.
8. Use a pre-trained Deep Learning model in ONNX format to detect Indian monkeys in the subframe.
9. Determine the direction of the monkey's movement in the subframe.
10. Display the subframe with the monkey and the direction of movement in the output window.

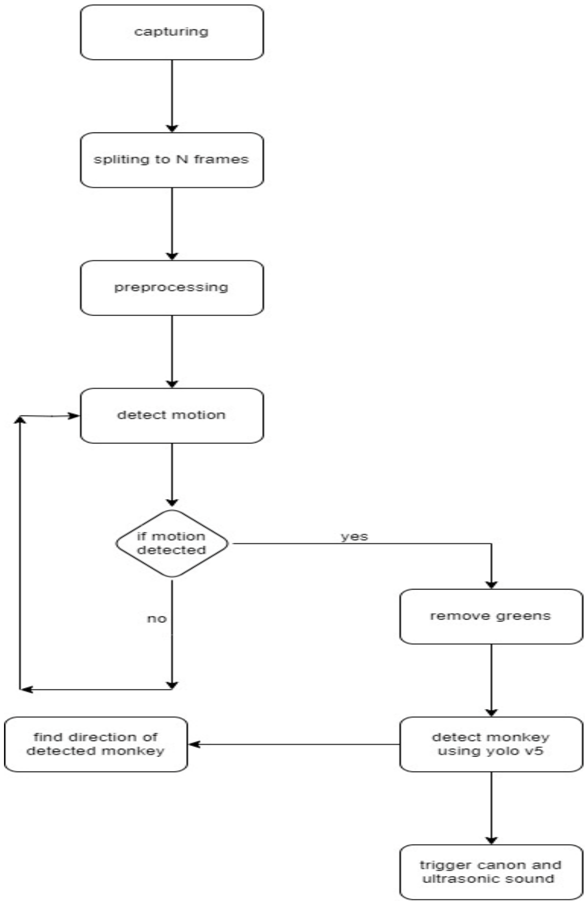

Fig. 5. Monkey detection

6.1. Splitting Frames

Our program starts from splitting the frames for better result and reduced work load. Split frames that takes a frame as input and splits it into multiple sub-frames. The frame is split into H_SPLIT number of horizontal and V_SPLIT number of vertical sub-frames.

Fig. 6 shows the subframes after the image being split vertically and horizontally.

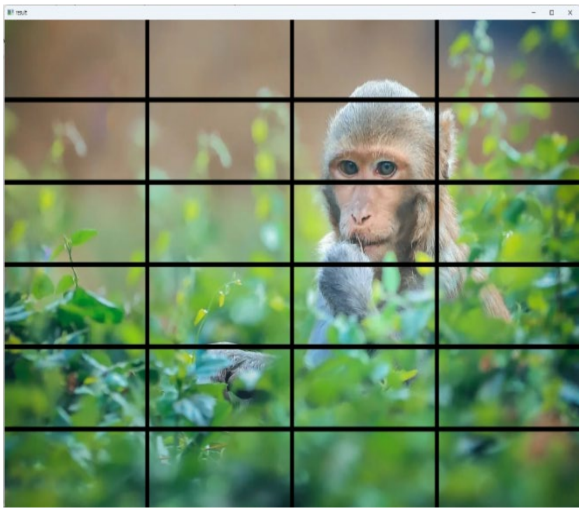

Fig. 6. Subframes

The algorithm of the code can be described as follows:

1. Obtain the height and width of the input frame.
2. Calculate the height and width of each sub-frame by dividing the height and width of the input frame by the H_SPLIT and V_SPLIT values respectively.
3. Initialize an empty list named frames to store the sub-frames.
4. Loop through each horizontal sub-frame and each vertical sub-frame and slice the input frame accordingly to obtain the sub-frame. Append the sub-frame to the frames list.
5. And finally returns the list of sub-frames.

The flowchart for the algorithm is represented in Fig. 7

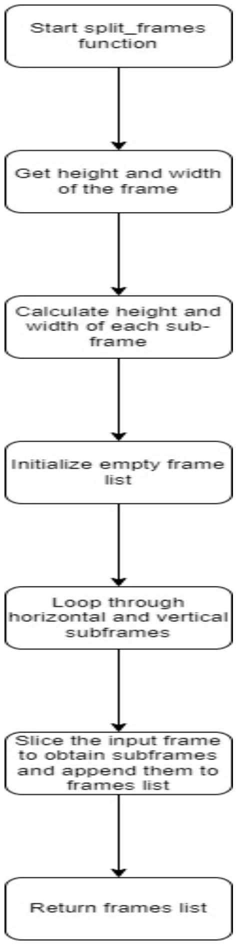

Fig. 7. Split frame

6.2. Motion Detection

Next comes motion detection in each subframes. The algorithm takes a single frame as input and applies background subtraction to it using a pre-trained background subtractor (fgbg). It then identifies the contours in the resulting foreground mask and checks if their area is above a specified threshold. If there is at least one contour with an area above the threshold, it indicates that there is motion in the frame and returns True. Otherwise, it returns False. Fig. 8 represents the algorithm of detecting motion.

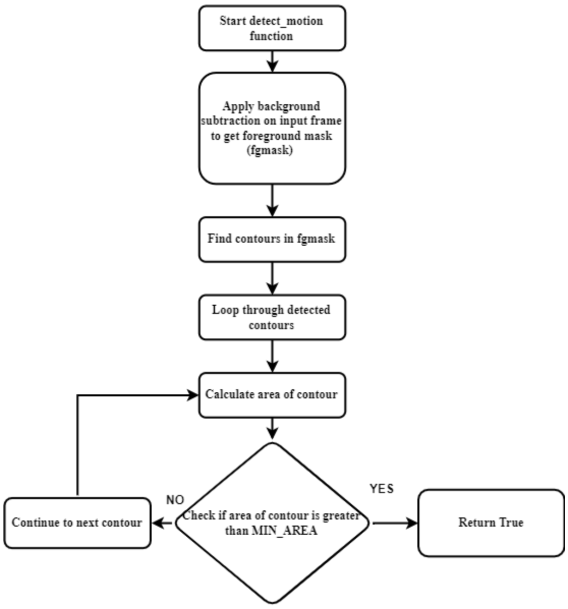

Fig. 8. Motion detection.

After that comes the preprocessing or the masking. The pre-process function is used to pre-process a given frame in order to detect green colors in the image. First, the frame is converted to the HSV color space. Then, a threshold range is defined for the green color. Next, the image is thresholded using the defined range to obtain only the green colors. Finally, the original image is masked using the obtained green color mask. Fig.9 shows the flow of preprocess function.

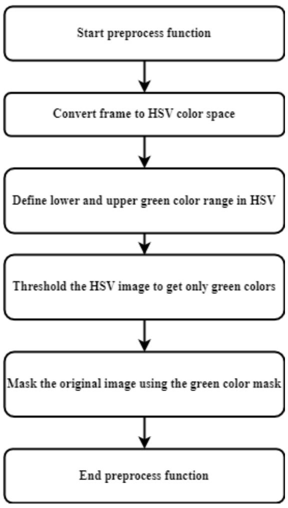

Fig. 9. Preprocess

6.3. Preprocessing

This function can be useful in agricultural areas for detecting monkeys as they often cause damage to crops and are difficult to detect in the fields. By pre-processing the image to detect green colors (which are indicative of the crops), it becomes easier to detect monkeys in the field as they stand out in the green color. Fig. 10 shows before and after preprocessing.

Fig. 10. Preprocessed image.

6.4. Monkey Detection

Once after the preprocessing is done we move on to monkey detection. The designed system uses computer vision and machine learning techniques to detect monkeys in a given video frame. The function takes a video frame as input and returns the same frame with bounding boxes drawn around any detected monkeys, along with their labels and confidence scores.

The first step in the code is to preprocess the input frame. This involves converting the frame to a format that can be used by the machine learning model. In this case, the model expects the frame to be in the RGB format, so the code converts it to RGB using the preprocess () function.

Next, the model is applied to the preprocessed frame using the model () function. The model used in this code is a pre-trained object detection model that can detect various objects, including monkeys. The output of the model is a list of detected objects, along with their confidence scores and bounding box coordinates. It then checks if any monkeys were detected by checking the length of the output list. If the list is not empty, the code determines the maximum confidence score for all detected objects. This is used later to calculate the confidence score of each individual object relative to the maximum confidence score.

It then iterates over each detected object and draws a bounding box around it using the cv2.rectangle() function. The label and confidence score of each object are also displayed next to the bounding box using the cv2.putText() function. The label and confidence score are obtained from the output of the model, and the confidence score is adjusted based on the maximum confidence score calculated earlier. The code also calculates the center of each bounding box and checks if it is the same as the previous center. If it is, the code starts a timer and checks if the duration exceeds a certain threshold. If the threshold is exceeded, a node_start() function is called, indicating that a monkey has been detected in the area for a prolonged period. Finally, the preprocessed frame with bounding boxes is displayed using the cv2.imshow() function.

This code can be very useful in agricultural areas where monkeys are known to cause damage to crops. By detecting and tracking monkeys in real-time, farmers can take appropriate measures to deter or remove them before they cause too much damage. The code can be integrated into a larger system that includes cameras and sensors to create a complete monkey detection and deterrence system. This can help farmers save time and money by preventing crop damage and reducing the need for manual monitoring and intervention.

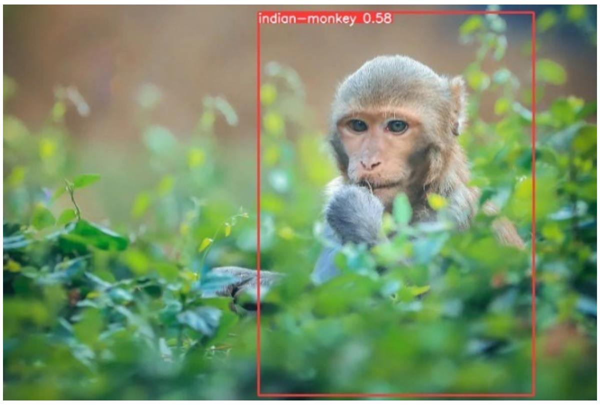

Fig. 11. Monkey detection.

The algorithm for detecting monkeys in agricultural areas using computer vision consists of the following steps:

Pre-processing: The first step is to pre-process the input image frame. This includes resizing the frame to a standard size, normalizing the pixel values, and applying any necessary filters to improve the quality of the image.

Object detection: The pre-processed image frame is then passed to an object detection model. The model identifies regions in the image that contain objects, and classifies the objects into different categories. In this case, the model is trained to detect monkeys.

Bounding box visualization: Once the objects are detected, the algorithm draws bounding boxes around the identified regions to indicate where the objects are located in the frame. It also labels each bounding box with the class of the object and its confidence score.

The algorithm then tracks the center of each bounding box over time to determine whether the detected object is moving or stationary. To do this, it compares the current center of the bounding box with the previous center, and measures the elapsed time between each update. If the object is stationary for a specified duration, the algorithm triggers an alert.

Alert generation: When the algorithm detects a stationary object, it generates a sound to scare away the monkey. Overall, the algorithm uses computer vision and machine learning techniques to detect and track monkeys in agricultural areas, and generates sounds when stationary monkeys are detected. This can help farmers to prevent crop damage and minimize losses caused by monkey raids. Fig. 12 represents flow diagram of monkey detection.

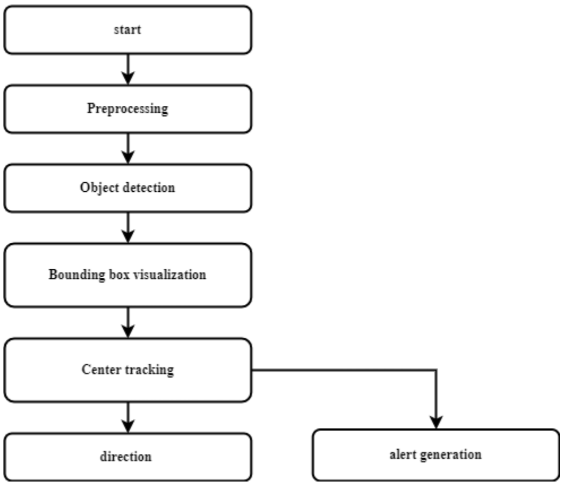

Fig. 12. Algorithm of monkey detection

6.5. Direction

After detection of monkeys we move on to finding their direction of motion. To find the direction of a monkey, we first need to detect the monkey's position in a frame captured from a camera. This can be done using computer vision techniques such as object detection. Object detection is a computer vision technique that involves identifying objects of interest in an image or video frame.

Once the monkey's position has been detected, we can calculate the direction of its motion by comparing its position in the current frame to its position in the previous frame. By calculating the difference between the two positions, we can determine the direction of the monkey's motion. This can be done using simple mathematical operations such as subtraction.

To calculate the center of the monkey's bounding box, we can use the coordinates of the top-left and bottom-right corners of the box. By taking the average of the x-coordinates and y-coordinates of these two points, we can find the center of the bounding box.

Once we have the center of the bounding box for the current frame, we can compare it to the center of the bounding box in the previous frame to calculate the difference in x and y coordinates. If the difference in x is positive, the monkey is moving to the right. If the difference in x is negative, the monkey is moving to the left. If the difference in y is positive, the monkey is moving downwards. If the difference in y is negative, the monkey is moving upwards.

To improve the accuracy of the direction finding, we can use multiple frames to calculate the direction of motion. By using multiple frames, we can reduce the effect of noise and jitter in the tracking data, leading to more accurate results. We can also use more advanced algorithms such as Kalman filters to improve the accuracy of the direction finding.

7. Hardware

Calcium Carbide Cannon is a device that produces a loud noise to scare off wildlife such as monkeys, birds, and other animals. The device works by mixing calcium carbide with water to produce acetylene gas, which is then ignited to create a loud explosion that can reach up to 120 decibels. This loud noise is effective in repelling animals as it mimics the sound of a predator, causing them to flee from the area. According to Sharma et al. (2021), the Calcium Carbide Cannon was used as a repelling mechanism in the proposed Smart Repeller device to prevent Rhesus macaque trespassing. The device used a solenoid valve to regulate the release of acetylene gas and an electric spark to ignite the gas, producing a loud noise that can scare off the monkeys. Ultrasonic sound waves are high-frequency sound waves that are not audible to the human ear but can be detected by animals such as monkeys, rats, and bats. These waves are effective in repelling animals as they cause discomfort and irritation to the animals, causing them to leave the area. The proposed Smart Repeller device also incorporated ultrasonic sound waves as a repelling mechanism. The device used an ultrasonic sound producer that emitted high-frequency sound waves to repel Rhesus macaque monkeys, as reported by Sharma et al. (2021).

In summary, Calcium Carbide Cannon and Ultrasonic Sound Producer were used as repelling mechanisms in the proposed Smart Repeller device to prevent Rhesus macaque trespassing in human settlements and agricultural areas. The Calcium Carbide Cannon produced a loud noise that mimics the sound of a predator, while the Ultrasonic Sound Producer emitted high-frequency sound waves that caused discomfort and irritation to the monkeys. These mechanisms were effective in repelling the monkeys and mitigating the negative impact of Rhesus macaque trespassing.

7.1. Calcium Carbide Canon

Carbide cannons, also known as "banglore torpedoes," are devices that produce a loud bang by igniting a mixture of carbide and water. These devices have been used for many years as signaling devices in mining and other industrial applications. In recent times, carbide cannons have also been used to scare away monkeys and other animals that cause damage to crops and property. Carbide is a chemical compound made up of calcium and carbon. When it is mixed with water, it produces acetylene gas, which is highly flammable. Carbide cannons work by igniting this mixture of carbide and water, which produces a loud bang that can be heard over a long distance.

Carbide cannons have several advantages over other methods of scaring away monkeys. They are relatively cheap to operate, and can be set up quickly and easily. They are also very effective, as the loud bang they produce can startle monkeys and cause them to flee the area. This can help prevent damage to crops and property, and can also reduce the risk of human-monkey conflict. **Fig. 17 shows a DIY calcium carbide canon made using pvc pipe and gas lighter.**

Carbide cannons were first invented in the late 19th century and were primarily used as signalling devices in mining operations. The loud bang produced by the carbide and water mixture could be heard over long distances and was used to signal miners working deep underground. Over time, carbide cannons were also used in other industrial applications, such as construction and demolition. They were also used as part of military operations, particularly in World War I, where they were used to destroy enemy barbed wire and other obstacles.

In recent times, carbide cannons have also been used to scare away monkeys and other animals that cause damage to crops and property. The loud bang produced by the carbide and water mixture can startle monkeys and cause them to flee the area, thus reducing the risk of damage and conflict.

The canon uses the chemical reaction between calcium carbide and water to produce acetylene gas, which is then ignited to create a loud bang. This loud bang is used to scare away animals like monkeys, birds, and other wildlife. The cannon itself is relatively simple, consisting of a metal tube with a small chamber at one end for holding the calcium carbide pellets, and a second chamber at the other end for holding water.

$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2 \quad (1)$$

A plunger is used to force the water into the calcium carbide chamber, where it reacts with the pellets to produce acetylene gas. The acetylene gas then travels back through the tube to the open end, where it is ignited by a spark or flame to create a loud bang. The chemical reaction between calcium carbide and water is a exothermic reaction, meaning that it produces heat as a by-product. When calcium carbide is mixed with water, the following chemical reaction occurs:

In this reaction, the calcium carbide (CaC2) reacts with water (H2O) to produce acetylene gas (C2H2) and calcium hydroxide (Ca(OH)2).

The acetylene gas produced by the reaction is highly flammable and explosive when mixed with air, making it ideal for creating a loud bang. To ignite the gas, a small spark or flame is introduced at the open end of the cannon. When the spark or flame reaches the acetylene gas, it ignites, producing a loud report that can be heard for several hundred feet.

In order to use a calcium carbide cannon to scare away animals like monkeys, it is important to follow proper safety precautions. The cannon should be placed in a secure location away from people and structures, and should only be operated by someone who is familiar with its use. It is also important to wear appropriate hearing protection when using a calcium carbide cannon, as the loud bang produced by the cannon can be extremely loud and can cause hearing damage.

Overall, a calcium carbide cannon can be an effective and relatively inexpensive way to scare away animals like monkeys. However, it is important to use caution and follow proper safety procedures to ensure that the cannon is used safely and responsibly.

There are several advantages to using carbide cannons for monkey control. These include:

Cost-effective: Carbide cannons are relatively cheap to operate and maintain, making them an affordable option for farmers and other landowners.

Easy to use: Carbide cannons are simple to set up and use, and do not require any special skills or training.

Effective: The loud bang produced by the carbide and water mixture is highly effective at scaring away monkeys and other animals.

Non-lethal: Carbide cannons do not harm the monkeys in any way, making them a humane option for monkey control

Carbide cannons are known to be quite effective in scaring monkeys away from agricultural fields, orchards, and other areas where they cause damage. The loud noise produced by the explosion of acetylene gas is unpleasant for monkeys and causes them to flee the area. Carbide cannons are particularly effective in scaring monkeys away because they produce a loud and sudden noise that startles the animals, making it difficult for them to adjust to the sound.

Studies have shown that the use of carbide cannons can significantly reduce the damage caused by monkeys to crops and other agricultural products. For example, a study conducted in India showed that the use of carbide cannons reduced crop losses due to monkey damage by up to 90%. Similarly, a study conducted in South Africa found that the use of carbide cannons reduced the number of monkeys in the area by up to 50%.

There are several factors that can affect the effectiveness of carbide cannons in scaring monkeys away. One of the most important factors is the placement of the cannons. Carbide cannons should be placed strategically in areas where monkeys are known to cause damage. The cannons should also be placed in such a way that they cover the entire area where the damage is occurring.

Another important factor is the timing of the explosions. Carbide cannons should be set to explode at random intervals so that monkeys cannot predict when the next explosion will occur. This makes it difficult for them to become accustomed to the sound and reduces the chances of habituation.

Finally, the use of carbide cannons should be combined with other methods of monkey control, such as the use of visual deterrents and physical barriers. This can help to make the use of carbide cannons more effective in scaring monkeys away.

While carbide cannons are an effective way to scare monkeys away, there are also some potential drawbacks associated with their use. One of the main drawbacks is that the loud noise produced by the explosions can be disturbing to nearby residents, particularly at night. This can lead to complaints and even legal action in some cases.

Another potential drawback is that the use of carbide cannons can be expensive. The cost of the cannons themselves, as well as the cost of the acetylene gas needed to operate them, can be significant. This can make it difficult for some farmers and landowners to afford to use carbide cannons on a regular basis.

Finally, the use of carbide cannons can also be harmful to other wildlife in the area. The loud explosions can startle and disorient other animals, potentially causing them to flee into dangerous situations. Additionally, the use of acetylene gas can be harmful to the environment and contribute to air pollution.

Overall, carbide cannons can be an effective way to scare monkeys away from agricultural fields, orchards, and other areas where they cause damage. However, their use should be combined with other methods of monkey control, and they should be used with caution to avoid potential drawbacks. By using carbide cannons strategically and in conjunction with other deterrents, farmers and landowners can reduce the damage caused by monkeys and protect their crops and other resources

7.2. Ultrasonic sound repeller

Ultrasonic sound repellers are devices that emit high-frequency sound waves to repel animals such as monkeys, rodents, and birds. These devices are commonly used in agriculture, forestry, and urban areas to prevent animals from damaging crops, trees, and buildings. In this note, we will focus on how ultrasonic sound repellers can be useful to scare monkeys away.

The working principle of ultrasonic sound repellers is relatively simple. These devices emit high-frequency sounds that are above the range of human hearing but are audible to animals such as monkeys. The high-frequency sounds are created by an electronic oscillator that produces a signal at a specific frequency. This signal is then amplified and sent to a transducer, which converts the electrical signal into an acoustic signal.

The transducer emits the acoustic signal in the form of ultrasonic sound waves. These sound waves are directional and can be focused in a particular direction or area, depending on the design of the device. The ultrasonic sound waves are then transmitted through the air and reach the target animals. When the animals hear these sounds, they may become agitated, scared, or uncomfortable, causing them to leave the area.

Ultrasonic sound repellers offer several benefits for monkey control, including:

- Non-Lethal: Ultrasonic sound repellers are a non-lethal way to control monkeys and other animals. They do not harm the animals or pose any danger to humans.
- Environmentally Friendly: Ultrasonic sound repellers do not use any harmful chemicals or toxins, making them environmentally friendly.
- Easy to Install: Ultrasonic sound repellers are easy to install and require little maintenance. They can be placed in strategic locations to target specific areas and can be adjusted as needed.
- Cost-Effective: Ultrasonic sound repellers are a cost-effective solution for monkey control. They are relatively inexpensive to purchase and do not require any ongoing costs or maintenance.

The effectiveness of ultrasonic sound repellers in deterring monkeys from entering an area or encouraging them to leave an area depends on several factors. The frequency of the sound waves emitted by the device, the volume or intensity of the sound, and the design of the device all play a role in its effectiveness.

Monkeys, like many other animals, are sensitive to certain frequencies of sound. The ideal frequency for ultrasonic sound repellers used to scare monkeys away is around 20-30 kHz. However, the effectiveness of the device may decrease if the monkeys become accustomed to the sound or if the sound is not loud enough.

Another factor that affects the effectiveness of ultrasonic sound repellers is the design of the device. Ultrasonic sound repellers can be designed to emit sound waves in a specific direction or area. This can be useful if you want to target a particular area and not affect other animals or humans in the vicinity.

Ultrasonic sound repellers are an effective way to scare monkeys away from an area without harming them or posing any danger to humans. These devices work by emitting high-frequency sounds that are above the range of human hearing but audible to animals such as monkeys. They offer several benefits for monkey control, including being non-lethal, environmentally friendly, easy to install, and cost-effective.

8. Performance

The YOLOv5 model trained on the monkey detection dataset achieved an mAP@0.5 of 0.813 and an mAP@0.5:0.95 of 0.357, with a precision of 0.888. The model was trained for 100 epochs with an image size of 640, using a GPU for computation and a batch size of auto. The training loss and validation loss values were 0.023 and 0.053, respectively, and the object loss values for the training and validation sets were 0.014 and 0.011, respectively. The dataset used for training consisted of 3069 images, with a validation set of 305 images and a test set of 175 images. Overall, an mAP@0.5 of 0.813 and an mAP@0.5:0.95 of 0.357 suggest that the model is able to accurately detect monkey objects in images with relatively high precision. The precision value of 0.888 indicates that the model is able to correctly identify a high proportion of true positive predictions relative to the total number of predicted positives.

The training loss and validation loss values suggest that the model was able to learn from the training data and generalize well to new data. The relatively low object loss values for both the training and validation sets indicate that the model was able to accurately predict the presence of objects in the images.

Fig. 13. Training graph

However, it's important to note that these performance metrics do not provide a complete picture of the model's performance, and additional evaluation may be necessary depending on the specific requirements and constraints of the intended use case. Additionally, it's worth considering the potential impact of false positives or false negatives on the performance of the model, as well as the potential biases in the dataset or evaluation metrics.

Fig. 14. Bounding box loss.

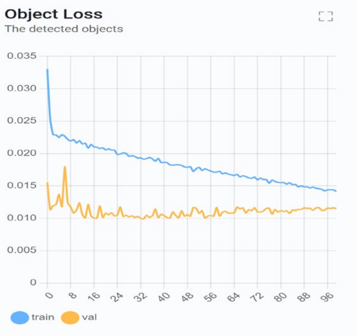

Fig. 15. Object loss

9. Result

The training loss and validation loss values were 0.023 and 0.053, respectively, and the object loss values for the training and validation sets were 0.014 and 0.011, respectively. These low loss values suggest that the model was able to learn from the training data and generalize well to new data. The relatively low object loss values for both the training and validation sets indicate that the model was able to accurately predict the presence of objects in the images. However, it's worth noting that these results are specific to the monkey detection dataset and may not generalize well to other datasets or use cases. We get an accuracy of 100 till 60-70 mts And in long range it can detect a monkey with 15-75% (230-250 mts) Additionally, the performance of the model may be impacted by various factors such as the quality and diversity of the data, the choice of hyperparameters, and the architecture and implementation of the model.

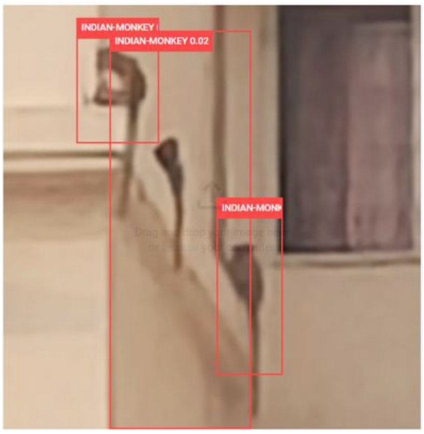

Fig. 16. Monkey detected after zooming

Fig. 17. Original image

Overall, the YOLOv5 model appears to have achieved good performance on the monkey detection dataset, but additional evaluation and validation may be necessary before deploying the model in a real-world application. This could include testing the model on additional datasets, evaluating its performance in various scenarios and conditions, and considering the potential biases and limitations of the model and dataset.

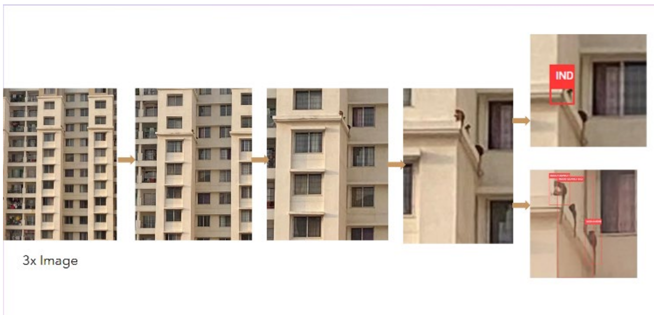

Fig. 18. Flow of identifying

10. Conclusion

In conclusion, Rhesus macaque trespassing is a significant problem that causes various issues in human settlements and agricultural areas. The primates can cause property damage, food theft, and pose health risks to humans. They also cause significant economic losses by raiding crops and disrupting the natural balance of the ecosystem. Therefore, there is a need for an effective and practical solution to mitigate this problem. The proposed solution, Smart Repeller, uses ultrasonic sound waves and Calcium Carbide Cannon, along with computer vision technology to detect the presence of monkeys and activate repelling mechanisms automatically. This solution eliminates the need for human intervention, making it efficient and cost-effective.

The research paper aims to demonstrate the feasibility and effectiveness of the proposed Smart Repeller device through experimental studies and simulations. The results show that the device effectively repels Rhesus macaque monkeys, reducing their presence in human settlements and agricultural areas. Smart Repeller offers several advantages over other methods of Rhesus macaque monkey repelling. Firstly, it is more efficient and cost-effective as it eliminates the need for human intervention. Secondly, it is environmentally friendly, as it does not use harmful chemicals or cause long-term ecological imbalances. Finally, it can be easily scaled up to accommodate larger areas and effectively repel more monkeys. The proposed solution has the potential to significantly reduce the negative impact of Rhesus macaque trespassing on human settlements and agricultural areas. It can also improve the safety and well-being of humans by reducing the risk of injuries and diseases caused by these primates.

Overall, the Smart Repeller device offers a practical and scalable solution to the problem of Rhesus macaque trespassing, which can benefit both human settlements and agricultural areas. Further research and development can improve the effectiveness and efficiency of the device and expand its application to other areas.
Recommendations for practitioners (strongly recommended in management and business courses and some other areas, so check with your supervisor whether this will be expected); and a final paragraph rounding off your dissertation or thesis

11. Future Works

The proposed Smart Repeller device has the potential to provide a practical and scalable solution to mitigate the problem of Rhesus macaque trespassing in human settlements and agricultural areas. However, there are still some limitations to the current design that need to be addressed in future works. Firstly, the effectiveness of the device should be tested in different environments and under various weather conditions to evaluate its robustness and adaptability. The experiments conducted so far were done in a controlled environment, and it is necessary to evaluate the device's performance in real-world scenarios. Secondly, the device's power consumption needs to be optimized to reduce the device's energy requirements and make it more cost-effective. This can be achieved by improving the design of the ultrasonic sound producer and calcium carbide cannon to reduce power consumption without compromising the repelling effectiveness. Thirdly, the computer vision algorithm needs to be refined to improve the device's accuracy in detecting the presence of Rhesus macaque monkeys. This can be done by incorporating machine learning techniques to enhance the algorithm's ability to differentiate between Rhesus macaque monkeys and other animals or objects. Lastly, it is essential to consider the device's impact on the environment and wildlife. While the Smart Repeller is designed to repel Rhesus macaque monkeys, it is important to ensure that the device does not harm other animals or disrupt the natural balance of the ecosystem.

In conclusion, the proposed Smart Repeller device shows promise as a practical and scalable solution to mitigate the problem of Rhesus macaque trespassing in human settlements and agricultural areas. However, further research and development are needed to optimize the device's performance, energy consumption, accuracy, and impact on the environment.

References

[1] Alexander, J. , Chen, P. , Damerell, P. , Youkui, W. , Hughes, J. , Shi, K. , Riordan, P. , 2015. Human wildlife conflict involving large carnivores in Qilianshan, China and the min- imal paw-print of snow leopards. Biol. Conserv. 187, 1–9 .
[2] Artelle, K.A. , Anderson, S.C. , Reynolds, J.D. , Cooper, A.B. , Paquet, P.C. , Darimont, C.T. , 2016. Ecology of conflict: marine food supply affects human-wildlife interactions on land. Sci. Rep. 6, 25936 .
[3] Bencin, H. , Kioko, J. , Kiffner, C. , 2016. Local people's perceptions of wildlife species in two distinct landscapes of Northern Tanzania. J. Nat. Conserv 34, 82–92 .
[4] Campbell, C.J. , Fuentes, A. , MacKinnon, K.C. , Bearder, S.K. , Stumpf, R. , 2010. Primates in Perspective, 2nd ed. Oxford University Press, New York, NY, USA .
[5] Das, D. , Mandal, S. , 2015. Man-monkey conflict in Khowai district, Tripura, North-east India: a case study. J. Glob. Biosci. 4, 3140–3145 .
[6] Gupta, RK., 2019. Innovative sound device that repel monkeys and its scientific validation in Jammu, Acta Scientific Agriculture 3.7, 182-184.
[7] Li, X. , Buzzard, P. , Chen, Y. , Jiang, X. , 2013. Patterns of livestock predation by carnivores: human–wildlife conflict in Northwest Yunnan, China. Environ. Manag. 52, 1334–1340 .
[8] Mateo-Tomás, P , Olea, P.P. , Sánchez-Barbudo, I.S. , Mateo, R. , 2012. Alleviating human–wildlife conflicts: identifying the causes and mapping the risk of illegal poisoning of wild fauna. J. Appl. Ecol. 49, 376–385 .
[9] Mojo, D. , Rothschuh, J. , Alebachew, M. , 2014. Farmers' perceptions of the impacts of human-wildlife conflict on their livelihood and natural resource management efforts in Cheha Woreda of Guraghe Zone, Ethiopia. Hum.Wildl. Interact. 8, 67.
[10] Nyhus, P.J. , 2016. Human–wildlife conflict and coexistence. Annu. Rev. Environ. Resour. 41, 143–171 .
[11] Stefano, G. et al., 2018. "IoT solutions for crop protection against wild animal attacks", IEEE International Conference on Environmental Engineering (EE), ISBN: 978-1-5386-4182-8.

[12] S Mohandass, S Sridevi, and R Sathyabama, 2021. Animal Health Monitoring and Intrusion Detection System based on LORAWAN, Turkish Journal of Computer and Mathematics Education, Vol.12 No.2,2397-2403.
[13]https://economictimes.indiatimes.com/industry/transportation/airlines-/-aviation/ahmedabad-employs-bears-for-its- airport/grin-and-bear-it/slideshow/74004272.cms
[14]https://timesofindia.indiatimes.com/city/hyderabad/now-special-gun-to-scare-monkeys/articleshow/71797287.cms
[15] Kozo Ohtani and Mitsuru Baba, 2004. Shape Recognition and Position Measurement of an Object Using an Ultrasonic Sensor Array, 2004.
[16] Latha Venkatesan, S.Omar Farooq, J.Faisal Imraan, K.Jegan Kumar, J.Naveen Kumar, 2013. Animals and Vehicle Collision Avoidance Using Wireless Sensor Actuator Network, International Journal of Scientific & Engineering Research, Volume 4, Issue 5.
[17] Mitra Baratchi, Nirvana Meratnia, Paul J. M. Havinga, Andrew K. Skidmore and Bert A. G. Toxopeus, 2013. Sensing Solutions for Collecting Spatio-Temporal Data for Wildlife Monitoring Applications: A Review", Sensors, 6054-6088; doi: 10.3390/s130506054
[18] G. Sasikumar, H. Vignesh Ramamoorthy, S. Natheem Mohamed, 2014. An Analysis on Animal Tracking System using Wireless Sensors", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 4, Issue 9.
[19] J.Nirmal Prince, S.J.Sugumar, 2014. Surveillance And Tracking Of Elephants Using Vocal Spectral Information, International Journal of Research in Engineering and Technology, Vol: 03, Issue: 07.
[20] A Review on Animal Encroachment Detection in Crop Fields Using Deep Learning and Iot, Thanushree Gowda, Sahana, Raksha, Bindushree, Sahana. International Journal of Engineering Science Invention (IJESI) ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726.
[21] Controlling Monkey Menace: K.K.Sharma (Agriculture Economist), Dolly John (Assistant Bio-Chemist), Muneeb Andrabi (Agriculture Extension Assistant)
[22] Animal deterrent device: US20140299071A1, https://patents.google.com/patent/US20140299071A1/en
[23] A Sharanjah at. al. Real-time Animal Detection and Prevention System for Crop Fields, June 2021, 13th International Research Conference General Sir John Kotelawala Defence University.