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An Intelligent Animal Repelling System For Crop Protection

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Abstract: The fusion of rotating cameras and ultrasonic sound technology in agriculture constitutes a noteworthy leap forward, carrying significant socio-environmental implications. Positioned as a beacon of eco-friendly practices, this innovative system addresses vital challenges in agriculture by not only safeguarding farmers against crop losses but also fostering a symbiotic relationship with wildlife. It stands out from prevalent protection methods, such as wire and electric fences, through its utilization of image processing to identify specific threats. Specialized ultrasonic sound emitting devices are then strategically deployed, offering a targeted and efficient solution. Despite its potential, the implementation faces challenges. High initial costs, potential false alarms, and ethical concerns regarding the impact of ultrasonic sound on animals are considerations that necessitate attention. However, these challenges open avenues for further development and improvement. Looking ahead, the project holds immense promise for the future of agriculture. Integrating more sophisticated sensors, including cameras and infrared sensors, along with advancements in AI and machine learning, could enhance the system's efficacy over time. Customizing the system to specific crop types, geographical regions, weather conditions, and animal threats could amplify its impact. Achieving energy efficiency and economic viability across different farming scales could have profound global implications. In summary, this innovative system not only tackles pressing agricultural issues but also lays the groundwork for a more sustainable, technology-driven future in farming. It represents a paradigm shift towards responsible and efficient agricultural practices, contributing to both food security and wildlife conservation on a global scale.

Keywords: Object detection, Raspberry Pi 4B, SSD MobileNetV3, Ultrasonic frequency.

I. INTRODUCTION

In the modern world, where humans and animals conflicts are arising and cities are growing all the time, our project initiative is to fight back against these hardships. At its heart, this new system uses high-tech tools to find and stop animals. It gives a simple local answer that involves using technology tosolve the problem of disagreements or fights between people. This way of doing things is great because it involves people from the community. These people become very important in stopping fights and making peace with animals that livenear them. More than just stopping fights, this shared way of handling things is a bright example for protecting different kinds of life. Using new ways, it shows that local work can bring big changes. This plan not only deals with the quick worries of trouble between people and animals, butalso helps a lot to protect different types of living thingsin our always changing world. As people fully support this technology approach, it shows what small local attempts can do to create long-lasting and peaceful connections between humans and nature.

The system departs from the traditional ways of settling conflict which were always fatal, and theyalso always damage the environment. Nonetheless, it directsits intelligence in an ethical way of selectively and precisely deploying resources to manage the management of wild game.For example, the image processing feature allows other speciesto be identified and selectively excluded without doing harm. It is a way of affirming biodiversity's intrinsic value andalso promoting harmonious coexistence. It avoids the tension generated through conventional conflict resolution and leads us toward life together on earth.

In fact, the project's importance in conflict resolution is secondary to its overall significance forsustainable wildlife management. As human activities damaging ecosystems carry on, the intelligent animal detection and repelling system is in fact a glorious example of how cutting- edge technology can help protect biodiversity. It demonstratesthe path to a new age of conservation in wildlife management,and is a beam of light for mankind living harmoniously with nature. Globalization, water accommodation alongside aninflux of technological advances and conservation work hand in glove.

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This project adopts a holistic strategy to resolve the intricate problems of human-wildlife conflicts and wildlife intrusionin raising crops. Furthermore, the project aims to developan intelligent animal defense and repellent system able toaccurately identify sources of damage. This requires advanced technology, including sensors, rotating cameras and ultrasonicsound generators. Non-lethal deterrents form the ethical as- pect, while image processing limits targets to specific species as needed. What's more, this project involves building a systemthat is nimble enough to be designed for each country's different geographical regions and varieties of crops. It can thus be used in many types of agricultural vision. In reality,the purpose is to secure a long-term solution which will tie agriculture with wildlife conservation projects and allow people and nature to co-exist in more harmony. This project's motive is the increasing tension between human activities and wildlife, particularly in agriculture. The frequent cases of wildlife invasion are a great danger to global food security and the sustainable development of agriculture. Crop damage by wildlife causes tremendous economic losses to farmers, so we must find a new and effective method. In addition, our concernfor wildlife certainly forces us to first choose those animal repellents that are not cruel and thus advantageous both to manand beast. The project also is a part of the larger ecological objective of maintaining variety in species. A balance mustbe struck between human activity and nature. Ultimately, the objective is to create a robust and versatile system that notonly resolves current agricultural problems but can also be applied across the broader effort to bring sustainable farming and wildlife management techniques into practice.

II. PROPOSED METHODOLOGY

The focus of our project is a system for integrated wildlife management, making use of cutting-edge animal detection andharassment technologies. Figure 1 shows the block diagram of the proposed methodology. The system starts with a cam- era, which takes pictures of the monitored area. The major component for image processing also uses the MobileNet-SSDalgorithm, a newer object detection model noted for both its speed and accuracy. This system, which has been implemented on the Raspberry Pi 4 can process a camera's visual data in real-time. As a result it is able to quickly and precisely take note of animals in the monitored area.

As for the repulsion mechanism, we add ultrasound technology, a non-invasive deterrent that keeps animals at a safer distance. When Raspberry Pi 4 detects the presence of animals,it regulates when to activate ultrasound devices and thus realizes a responsive, automated mode for reducing human- wildlife conflict.

This system has the potential to use LoRaWAN technology to make data communication more efficient. With LoRaWAN (long-range, low-power wireless communication),data is sent easily between the Raspberry Pi 4 processing unit and a central monitoring station. This feature not only improves system scalability, but also allows for deployment of monitoring nodes in widely separated geographical areas. The combination of camera, MobileNet-SSD, Raspberry Pi4, ultrasound and LoRaWAN not only increases the accuracy and real time capability of wildlife detection and dispersion,it also allows for a distributed network with interconnected monitoring units. Our networked approach means that we can capture real-time data on animal presence and repulsionactivities to analyze and use in our wildlife management work.

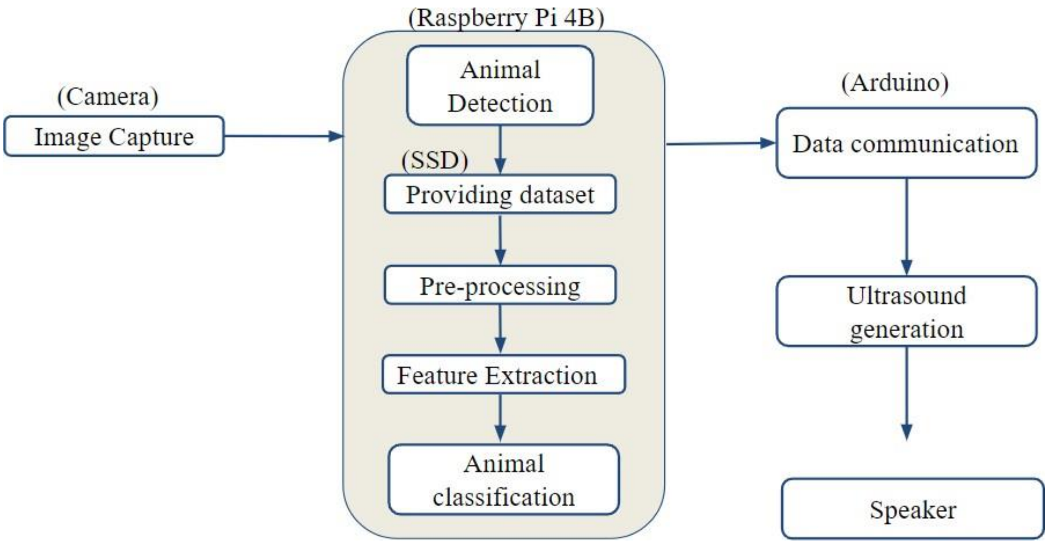

Figure 1. Proposed work methodology

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A. Image Capture

The object capturing technology relies on the cameras in- stalled at strategic places to facilitate the constant surveillance of the area. Being the primary sensors, these cameras use highresolution maps to monitor the area and other parameters. It is the first source of raw materials for our system, therefore the camera system to a commendable extent is investigated andpositioned to assure wide angle view to provide a complete coverage with no dead zones on the very object of the surveillance or on the whole landscape. Factors including the parameters of age resolution, frame rate and sensitivity are tuned to raise the capture accuracy of the complex regulatory framework images and identifying wildlife. These captures are then analyzed later, with the animals detected and positioned on the frames in the images. From the real-time analysis onsite,the origin of the defensive measures or central notification process is the designed for the sentry actions of the future. They call for imaging tools that are capable of infrared cameras or low light equipment for example used to monitor even in very dark nights or bad weather. The basis of our monitoring is a camera system that turns into the main typeof obtained information. The ongoing imaging technique, in other words, allows to track behaviors of animals in real-time.

B. Object Detection

Our system uses the latest image processing methods. We systematically placed cameras throughout the field to provide live images to the Raspberry Pi 4B. This helps ensure accurateidentification when photographing wildlife. The Raspberry Pi 4B uses its processing capabilities toinspect the photos taken. Raspberry Pi 4 serves as a real-time processing and data processing tool for accurate animal identification. Animals in collected photos can be accurately and individually identified. This real-time analysis influences decision-making and response approaches in wildlife management environments. The improved algorithm of SSD MobileNetV3 can be effortlessly accommodated into the object detection image pipeline. Through this Raspberry Pi 4, the images of the objectsare transmitted to the SSD MobileNetV3 for recognition and identification. The system's effectiveness is also enabled byits abilities to identify moving objects thus, fast and accurate animal identification can also be achieved. Combining the cameras, Raspberry Pi 4B and SSD MobileNetV3, an efficient platform was formed, which is a prerequisite for such actions as taking caution measures and transferring information to central monitoring stations. This hybrid method helps to increase the efficiency and precision of the tool as a remedy for the human-wildlife conflicts and wildlife conservation management.

C. Ultrasound Generation

High-frequency sound waves, while undetectable by thehuman ear, are necessary for our system to operate. This skill revolves around the ultrasonic transducer, a critical componentof our system. Our system is dependent on the transducer to emit sound. Thus, it acts as a trigger for the production of ultrasonic waves through the careful conversion of electric datainto mechanical vibrations. It is vital because the transducer type factors into the operational frequency range. For the sake of accuracy, we select transducers whose frequency surpasses 20 kHz . The reason behind this measure is to ensure that we strike a delicate balance between guaranteeing that the waves deter wildlife and ensuring that ultrasonic frequencies releasedare undetectable by human perception.

The fact is that these frequencies are easily perceived by many animals. With the help of natural sensitivity, these ultrasonic sounds can be used as a good deterrent for animals. The sources of sounds if you want to generate ultrasonic waves can be a speaker or a tweeter. Such devices can playan electrically processed signal, produce high-frequency noise,and ultrasonic waves. A tweeter, transducer, or speaker is the source of the choice of which to perform weighs, which is based on efficiency, the ability to direct, the frequency range. Once the animal is detected by the Raspberry Pi 4 throughthe advanced object detection algorithms, it responds urgently demanding the transducer, the tweeter, or simply the speaker be activated to produce ultrasonic waves. The monitored regionis entirely cleared of unwanted intruders in real-time by not requiring lethal methods . The selected animals hearing range is as shown in Table 1.

TABLE 1. HEARING RANGE OF DIFFERENT ANIMALS

Animal	Hearing Range (in kHz)
Monkey	43.44
Tiger	57.28
Wild boar	35.260
Rabbit	64
Pig	52.87
Elephant	49.7

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III. OBJECT DETECTION MODEL: SSD MOBILENETV3

SSD MobileNetV3 is one of the most popular machinelearning algorithms. At the cutting edge of object detection frameworks, SSD MobileNetV3 combines the advantages ofMobileNetV3's efficiency and the Single Shot Multibox Detector (SSD) paradigm. The emergence of object detection in realtime on devices limited in resources, such as mobile phones,drones, and embedded systems, has become a revolutionarystage in the development of computer vision. The historyof creating this framework originates from the difficulties,which consisted in the inability of traditional object detectionmethods to combine the maximum possible accuracy withacceptable computational efficiency. This issue was especially relevant for less powerful devices with small amounts of RAM. SSD MobileNetV3 is based on convolutional neural net- works. CNNs play a key function in how computer systemsunderstand pictures. Figure 2 shows the fundamental architecture of a CNN. They divide an image into layers with eachlayer having its own functions. This allows CNN to reliablydiscover objects in images. SSD MobileNetV3 makes use ofCNN to quick and reliably recognize objects in images. Itmakes use of CNN to discover items in actual time, whichrepresents a large improvement in computer imaginative and prescient technology.

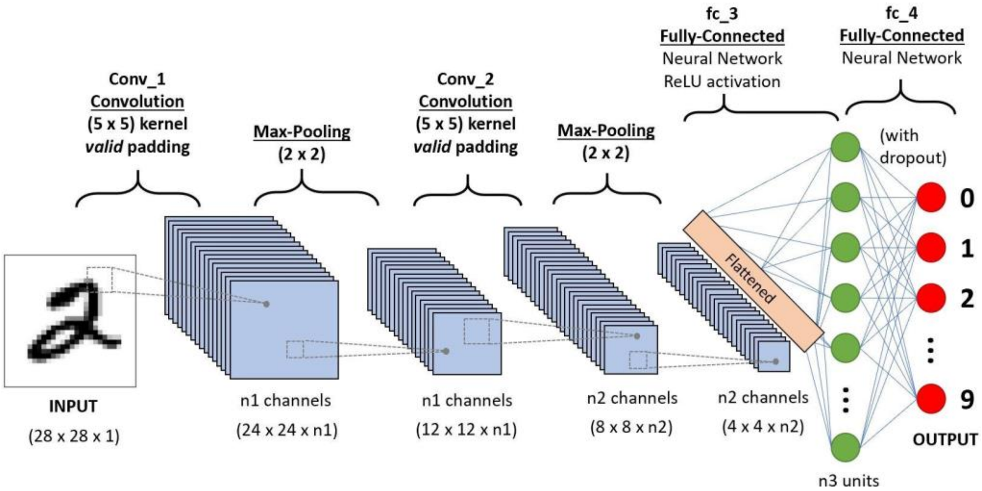

Figure 2. CNN Architecture

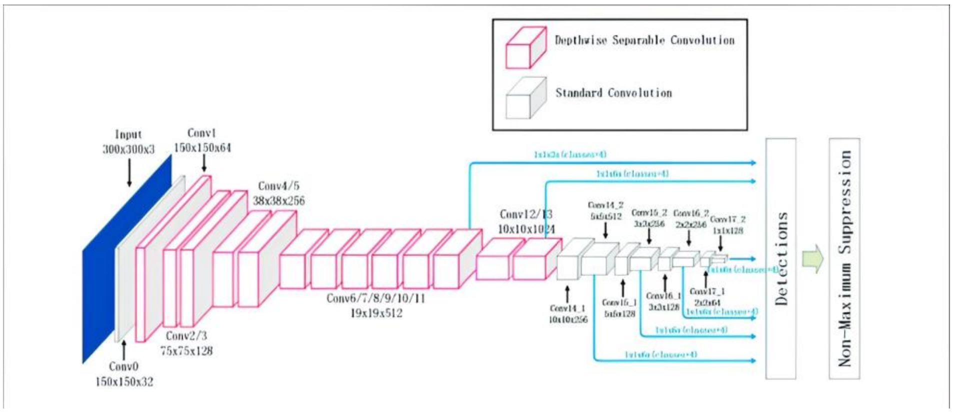

Figure 3. SSD MobileNetV3 network architecture

SSD MobileNetV3is based on extensive use of CNNs. It hasCNNs as its backbone. They enable machines to comprehend pictures. CNNs decompose images into strata of data, ranging from simple forms up to intricate characteristics. Hence, it isa good feature in CNNs that allows them to identify objects from visuals even in the presence of cluttered background. Figure 3 shows the network architecture of SSD MobileNetV3. In addition, SSD MobileNetV3 enjoys the benefits bestowed upon it by CNNs such as fast and accurate object recognition capabilities. Thus, it can run in real time identifying objects, which is a major advancement in computer vision. This systemis a culmination of years' worth of laborious efforts and this testifies on how deep learning has revolutionized human- computer visual perception. SSD MobileNetV3 training occurs in two steps, the pre- training and the fine-tuning. The term pre-training means that we train MobileNetV3 on a big dataset ImageNet, which allows it to learn general features from images.

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After the pre- training, the SSD head is added to the network. The other step is the fine-tuning where the whole model is trained on the dataset that is consistent with the object detection task that you want it to perform. This way, the fine-tuning tweaks the network's parameters obtained during the pre-training, so that the algorithm is able to detect object efficiently. Comparedto its predecessors, SSD MobileNetV3 benefits from the efficiency and effectiveness of the MobileNetV3 architecture, resulting in faster convergence during training and improved performance on resource-constrained devices. During inference, an input image is provided for SSD MobileNetV3 that passes it through MobileNetV3 backbonein order to extract hierarchical features. These will be fed into an SSD head where predictions are made for bounding boxes as well as class probabilities at several spatial scales. When faced with various sizes and aspect ratios of objects withinthe source image, this allows for object detection by the SSD MobileNetV3 model. Predictions are then refined using post- processing techniques including Non-Maximum Suppression (NMS) that yield final set of detected objects. Real time object detection can be done by SSD MobileNetV3 due its efficient architecture and optimized design when used in devices with limited computational resources.

IV. IMPLEMENTATION

A. Camera and rotating system

Raspberry Pi HQ Camera is a camera accessory that integrates to the Raspberry Pi single-board computers. The camera is installed with a 12.3-megapixel Sony IMX477 sensor. This enables the camera to capture more detailed photographs while at the same faster than normal. The cameracan take a variety of photographs due to the numerous lensesit has. The camera comes with dedicated a camera slot, enabling the quick transfer of information. The HQ Camerafit for numerous jobs since it can only handle different image sizes and motion rates. The Raspberry Pi's camera module can handle tasks from image capturing to video creation. Its compact size, adjustable focus, and ability to focus from the back make it suitable for various photography projects. The Raspberry Pi acts as the main controller in a rotating camera system. It oversees the positioning of the camera module.The Raspberry Pi computer processes the live video feed from the camera module. It uses algorithms to analyze the video and determine the optimal camera angle. Based on this analysis, the Raspberry Pi sends instructions to servo motorsto adjust the camera's orientation. This closed-loop system ensures the camera remains pointed in the desired direction even as conditions change.

B. Object Classification

We use the Raspberry Pi for preprocessing of object detection with the camera module and GPU. Known for its small size and convenient versatility, the Raspberry Pi performs mostjobs with captured visuals. It integrates our specialized real- time object detection algorithm called SSD into this setup. Then the Raspberry Pi analyzes each incoming image frame with a pre-trained SSD model capable of recognizing many different things. When we apply our trained SSD system to commercial product data sheets, the system shows what objects it found as shown in Figure 4. We can then discard those objects markedas 'weak'– in order to increase accuracy. And the result isthe original image with the objects we found marked by boxes. This setup is useful in many areas such as surveillance,smart home systems, and robotics, where one needs to quicklyspot objects. With a trained model and OpenCV library, the provided model is a detailed guide for doing object detection. However first we will load the names of objects from a file. Then we create a deep neural network with the trained model and necessary files. We carefully set the parameters, such as size and color. Later on it boxes and labels the objects inthe image. They just seem to be there! The program runscontinuously, capturing frames from a webcam. It analyzes each frame for objects in real-time and uses rectangles to showwhat it finds. This allows us to see how well the algorithmis working as it runs. Making sure that the model and names are correct is crucial for everything to run smoothly. After all, the code provides us with a strong framework for real-time object detection and in a simple and interactive manner, helps us understand that how trained models and computer vision techniques may be of service.

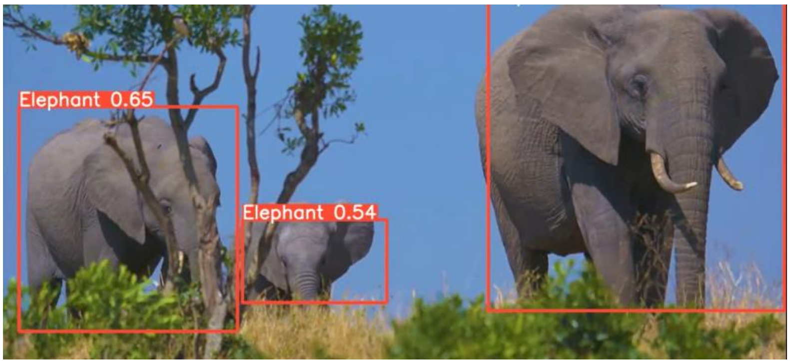

Figure 4. Animal Detection Output

C. Ultrasonic frequency generation using Arduino Mega 2560 Rev3

The chip ATmega2560 is used in the Arduino Mega 2560 R3, a powerful microcontroller board. It has 54 pins for digital input-output and an additional group of 16 pins toaccommodate analog inputs. This gadget operates using a voltage of 5V and includes a crystal oscillator with frequency measurement at 16 MHz.

The connecting to this board, it can be done by using a USB cable. You can power the device eitherthrough jack or reset it by pressing button provided on-board. The enhanced GPIO functions and increased memory of this Mega 2560 R3 make it more capable in handling intricate projects. It has a lot of space to house many sensors andactuators, so it is good for different purposes. To code this Mega 2560 R3, an IDE (integrated development environment)is used. It simplifies the process for any kind of user with basicprogramming knowledge. This board can be powered through a USB or by using an external supply, giving flexibility in its location and setup.

The Arduino is a strong improvement to the usual pulse generator system. This conventional method for generating pulses had decade counters, op-amps and flip-flops as its mainparts. The setup with Arduino greatly improves the systemby changing it into a programmable one that can control ultrasonic frequencies effectively and efficiently using different inputs. Therefore, this advanced configuration increases both programmability and adaptability of our system. Changingfrom a decade counter to an Arduino gives greater flexibility, making it more adaptable; also providing better precision in controlling pulse generation and counting functions on top of everything else. Replacing decade counter with Arduino givesmore versatility making it adaptable plus better precision in controlling pulse generation and counting functions.

Inside the Arduino, the system is programmed to answer commands sent through the serial port. When it gets a command that shows there's an event or trigger happening, systemstarts its action. It creates a tone of certain frequency and at same time changes state on output pin to show occurrence of event. After that, every time we detect an event a timer starts. If no more events happen for a certain length of time, the making of tone stops.

All this has been included in the loop function which takes care of constantly refreshing current timeand checking serial port to receive command inputs related to events. This arrangement makes sure that the system reacts well to incoming commands. It creates tones with frequencies that can be set up, and also manages how long each tone is generated based on the timing between events it detects. Inthis way, the system works in an intelligent manner for best performance under different situations.

D. Amplification Unit

The Power Amplifier, a TPA3118 stereo amplifier featuringAM avoidance capabilities, functions to amplify signal power while offering multiple switching frequency options to mitigate AM interference and synchronize with diverse devices. Engineered to deliver protection against faults like short circuits and thermal issues, it bolsters the system's reliability.

Byharnessing a single stereo 60Watt digital amplifier, the device amplifies signal strength and clarity significantly. This amplifier not only enhances the power of the audio signal but also ensures its fidelity by addressing potential interference and safeguarding against operational faults, thereby contributingto an improved overall audio experience.

V. RESULTS AND INFERENCES

In this project rotating camera is used for image captureand with the help of raspberry pi 4B image detection is done. The camera moves with the help of a servo motor, the movement of camera is controlled by the raspberry pi module.

The movement of camera is achieved using a structure called pan tilt hat which is driven using servo motors. After detectionthe raspberry pi gives the signal to the Arduino. The pre-set code in the Arduino will detect the signal and give the corresponding frequency signal as output from the speaker as shown in Figure 5.

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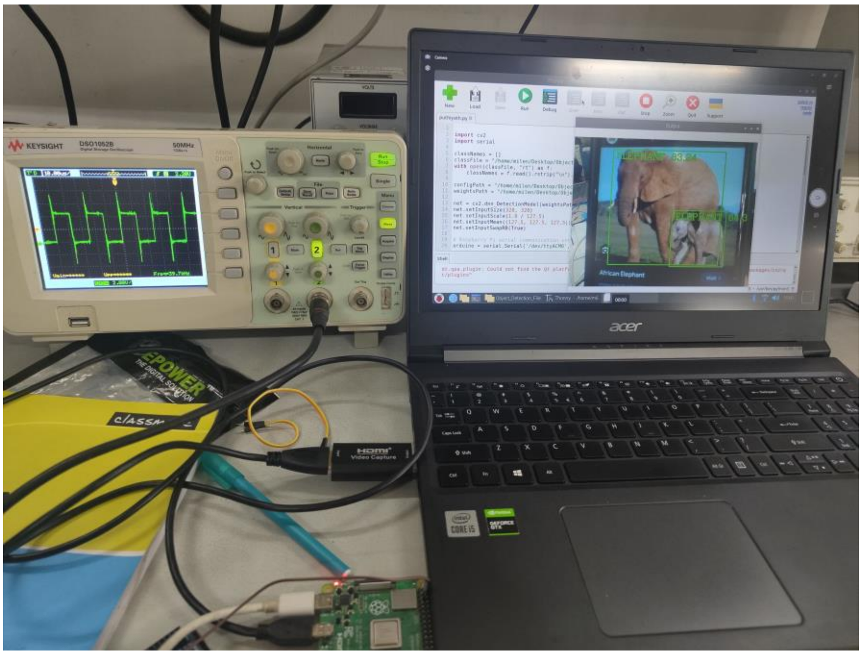

Figure 5. Results obtained

VI. CONCLUSION

The creation of an ultrasonic frequency producing circuit that works correctly is considered as a noteworthy development in agricultural innovation. It shows progress in thearea of preventing animals from eating crops, and promotes harmony between animals and agriculture. Also, implementinganimal recognition and picture processing using Raspberry Pi 4B is very crucial for this project. The device uses high-level methods of picture processing to quickly recognize pests that can damage crops in different settings. The Raspberry Pi is adaptable and can include artificial intelligence into this new technology easily.

The first stage of the project's function is when imageprocessing combines with animal detection. After an animal gets recognized, a signal that matches this specific creature goes to ultrasonic frequency generation circuit. In this circuit, ultrasonic frequencies get made to suit each particular detected animal as they are given their own set frequency based on species type. This specific way boosts the powerof discouraging animals and lessens bothering to non-target kinds. In coming times, there will be a center on making betterthis combined system by including more complicated machine learning rules, improving sensor blending skills and increasinglink with Internet of Things. These adjustments in tactics, theyare not only to improve animal identification and management,but also to establish a comprehensive farming defense system.

In the coming time, this system for keeping wild animals away will improve with technology like better accuracy, flexibility and farming methods that are friendly to environment. These things show a future together when agriculture flourishes without much disturbance caused by wild creatures and uses sustainable farming techniques.

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