IMPLEMENTATION OF AGRICULTURE BASED ANIMAL REPELLENT SYSTEM USING DEEP LEARNING

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ABSTRACT

Abstract— Crop raiding by animals has become one of the most common human animal disputes as a result of human encroachment of wildlife habitats and deforestation. Wild animals can cause significant damage to agricultural crops and attack farmers working in the field. Farmers suffer huge crop loss due to crop raiding by wild animal like elephants, wild boar and deer. One of the main concerns of today's farmers is protecting crops from wild animals' attacks. There are different traditional approaches to address this problem which can be lethal (e.g., shooting, trapping) and non-lethal (e.g., scarecrow, chemical repellents, organic substances, mesh, or electric fences).Farmers has tried many ways for preventing animals raid from lighting fire crackers to maintain a watch on the field through the night but none of these were effective. Nevertheless, some of the traditional methods have environmental pollution effects on both humans and ungulates, while others are very expensive with high maintenance costs, with limited reliability and limited effectiveness. In this project, we develop a system, that combines Computer Vision using DCNN for detecting and recognizing animal species, and specific ultrasound emission (i.e., different for each species) for repelling them. The edge computing device activates the camera, and then executes its DCNN software to identify the target, and if an animal is detected, it sends back message to the Animal Repelling Module including the type of ultrasound to be generated according to the category of the animal.

Keywords: Animal Recognition, Repellent, Artificial Intelligence, Edge Computing, Animal Detection, Deep Learning, DCNN.

I. INTRODUCTION

1.1 Overview

Agriculture has seen many revolutions, whether the domestication of animals and plants a few thousand years ago, the systematic use of crop rotations and other improvements in farming practice a few hundred years ago, or the "green revolution" with systematic breeding and the widespread use of man-made fertilizers and pesticides a few decades ago.

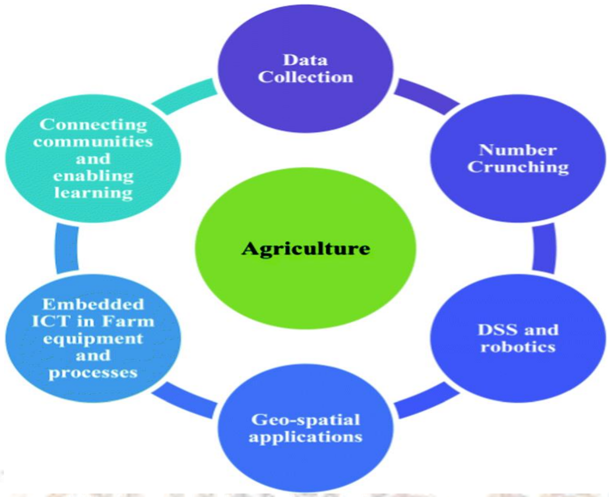


Figure 1.1. Agriculture and ICT innovation

Agriculture is undergoing a fourth revolution triggered by the exponentially increasing use of information and communication technology (ICT) in agriculture. Autonomous, robotic vehicles have been developed for farming purposes, such as mechanical weeding, application of fertilizer, or harvesting of fruits. The development of unmanned aerial vehicles with autonomous flight control, together with the development of lightweight and powerful hyperspectral snapshot cameras that can be used to calculate biomass development and fertilization status of crops, opens the field for sophisticated farm management advice. Moreover, decision-tree models are available now that allow farmers to differentiate between plant diseases based on optical information. Virtual fence technologies allow cattle herd management based on remote-sensing signals and sensors or actuators attached to the livestock.

Taken together, these technical improvements constitute a technical revolution that will generate disruptive changes in agricultural practices. This trend holds for farming not only in developed countries but also in developing countries, where deployments in ICT (e.g., use of mobile phones, access to the Internet) are being adopted at a rapid pace and could become the game-changers in the future (e.g., in the form of seasonal drought forecasts, climate-smart agriculture).

1.2 Smart Farming

Smart farming is a management concept focused on providing the agricultural industry with the infrastructure to leverage advanced technology – including big data, the cloud and the internet of things (IoT) – for tracking, monitoring, automating and analyzing operations.

Also known as precision agriculture, smart farming is software-managed and sensor-monitored. Smart farming is growing in importance due to the combination of the expanding global population, the increasing demand for higher crop yield, the need to use natural resources efficiently, the rising use and sophistication of information and communication technology and the increasing need for climate-smart agriculture.

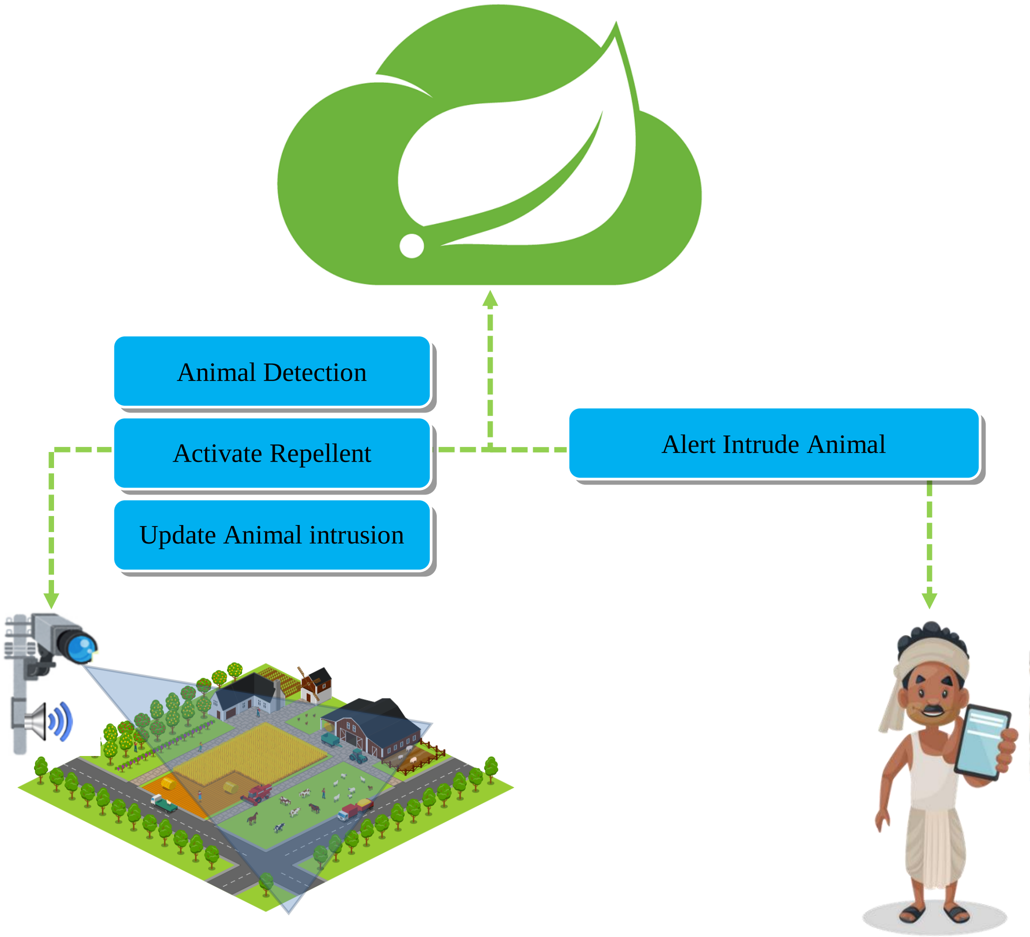
1.1.1. Smart farming technologies

The intelligent farm includes the use of technology such as:

- Sensors for soil scanning and water, light, humidity and temperature management.
- Telecommunications technologies such as advanced networking and GPS.
- Hardware and software for specialized applications and for enabling IoT-based solutions, robotics and automation.
- Data analytics tools for decision making and prediction. Data collection is a significant part of smart farming as the quantity of data available from crop yields, soil-mapping, climate change, fertilizer applications, weather data, machinery and animal health continues to escalate.

Satellites and drones for gathering data around the clock for an entire field. This information is forwarded to IT systems for tracking and analysis to give an "eye in the field" or "eye in the barn" that makes remote monitoring possible.

The combination of these technologies facilitates machine-to-machine (M2M) derived data. This data feeds into a decision support system so that farmers can see what is happening at a more granular level than in the past. For example, by precisely measuring variations within a field and adapting the strategy accordingly, farmers can greatly increase the effectiveness of pesticides and fertilizers and use them more judiciously. Similarly, smart farming techniques, help farmers better monitor the needs of individual animals and adjust their nutrition to prevent disease and enhance herd health.



1.3 Problem Identified

Most farmers have challenges related to crop damage due to wildlife pests. Animal intrusion is a major threat to the productivity of the crops, which affects food security and reduces the profit to the farmers. Organic farmers have additional challenges because they cannot use chemical controls which are sometimes the most effective and efficient options. A need has been identified for alternative pest control appropriate for traditional and organic farmers. Three types of animal intrusion you might find include animal tracks, crop damage and animal scat or faces. In the case of animal tracks, only one instance of tracks in the field carries a relatively low risk. On the other hand, sporadic or widespread animal tracks carry a moderate risk, and a no-harvest buffer zone may need to be created around nearby crops. Crop damage, such as bite marks or trampled plants, is riskier than animal tracks. Sporadic evidence, such as a few observations of trampled plants throughout the field, is moderately risky. Widespread crop damage is a high risk and indicates significant evidence of contamination. Marking and avoiding harvest around high-risk areas of crop damage is a good strategy to reduce the potential for contamination. Risks associated with faucal matter in the field are the highest. For even just one instance of faucal matter, the risk of contamination is moderate. Widespread evidence of faucal contamination is very high risk and would justify marking the contaminated area and creating a no-harvest buffer zone around the area where significant faces was found. Animal activity on the farm can be a huge risk to food safety when growing fruits and vegetables, which is why prearrest wildlife scouting is so important. Existing methods like fencing can be an effective deterrent, but it may not be practical for larger farms; however, small portions of fencing may direct animals around high value or sensitive crops to other areas and electric fences are no longer efficient in solving such conflicts, to protect their crops from getting damaged because of animal intrusions, farmers have been using electric fences around their fields and areas where the fencing don't prove efficient, farmers prefer to stay up all night and guard their fields from animal intrusions. Nuisance permits may be another option, but check with local Department of Environmental Conservation (DEC) or the National Resources Conservation Service (NRCS) before choosing this method. Practices like these have done more harm than good for us and in extreme cases; it has even costed lives of both man and animals. So, we decided to come up with a smarter solution that could protect the crops from animal intrusions without causing any harm to the wildlife. To solve this conflict by using technology such as IoT and Deep learning, which is called AIoT (Artificial Intelligence for the Infrastructure of Internet of Things)?

1.2. Scope of the Project

The product has been iterated over a period of time. Some of the innovative ways in which this product stands out are:

1. Usage of a combination of Camera Vision to detect intrusion of any animal entering the farm
2. Usage of the electrical signal to trigger an alarm that repels the detected animal away.

3. Solar-powered set-up

4. Since animals tend to get acquainted to the recurring sounds and lights in their surroundings, ordinary alarming systems will work in the beginning but its effectiveness will decrease sharply with time. To overcome this shortcoming, AniRep uses permutations and combinations of Vision and sound patterns those changes every time an intrusion is detected. This delays habituation in animals. As our system is deployed in rural areas, where energy efficiency is essential, we evaluated some HW and SW architectural alternatives for the design and implementation of the AI embedded Edge computing components to be added to our system.

II. SYSTEM ANALYSIS

3.1. Existing System

Wild animals are a special challenge for farmers throughout the world. Animals such as deer, wild boars, rabbits, moles, elephants, monkeys, and many others may cause serious damage to crops. They can damage the plants by feeding on plant parts or simply by running over the field and trampling over the crops. Therefore, wild animals may easily cause significant yield losses and provoke additional financial problems. Another aspect to consider is that wild animal crop protection requires a particularly cautious approach. In other words, while utilizing his crop production, every farmer should be aware and take into consideration the fact that animals are living beings and need to be protected from any potential suffering.

Farmers Traditional Approach

There are different existing approaches to address this problem which can be lethal (e.g., shooting, trapping) and non-lethal (e.g., scarecrow, chemical repellents, organic substances, mesh, or electric fences), firecrackers, bright lights, fire, beating drums, and dogs. Non-chemical control of pocket gophers. 22 rim fire rifle or a shotgun can be used to dispatch woodchucks. Some motion-activated water sprayers have been developed that spray birds when they break the motion-detecting

1. Agricultural fences

Fencing is a popular wild animal protection practice for that can last for many years. Agricultural fences are quite an effective wild animal protection technology. However, utilizing fences as a practice is often regulated. Some local and state entities may restrict or prevent the use of certain types of fences. Therefore, before deciding on a suitable fence, it's important to check local law regulations. The quality of fencing depends on the material and structure. Depending on how it is made and what it is made of, some permanent fences can last up to 30 years. Farmers usually use one of the following types of fences:

- **Wire fences**

Constructed of metal wires woven together forming a physical barrier. The fences are effective, long lasting, and require relatively little maintenance. However, they are expensive and recommended only for the protection of high-value crops.

- **Plastic fences**

Polypropylene fences are generally less expensive and easier to install and repair than other types. Additionally, these fences are widely acceptable and meet various regulations. Their disadvantage includes their short lifespan (up to 10 years) and questionable effectiveness in areas with a higher possibility of wild animal crop damage.

Figure 3.1. Wire and Plastic Fence

- **Electric fences**

These are constructed to inflict an electric shock to animals that come in contact with the fence, thus preventing animals from crossing the fence. These fences are long lasting and an effective crop protection measure. Costs vary depending on specific type and size of an area. Before purchasing electric fences, it's very important to make sure they are allowed for use in the specific area, and for protection against endangered animal species. Additionally, it's recommended that electric fences are marked with a warning sign to prevent any possible human contact.

Figure 3.2. Electric Fences

2. Natural Repellents

Some farmers prefer using natural protection measures instead of mechanical or chemical protective practices. There are various ways to protect crops from wild animals, including:

- **Smoke**

In some areas farmers burn elephant dung or other materials that smolder and create heavy smoke

- Fish or garlic natural emulsion; repels rabbits and deer

Figure 3.3. Beehive fence

3. Chemical repellents; active substances such as Anthraquinonoid, Butane thiol, and Methyl Anthranilate can be used to keep wild animals away from crops

4. Electronic repellents; effective, long lasting, and eco-friendly method for crop protection that repels animals without harming them. Farmers use one of the following two types of electronic repellents:

Figure 3.4. Ultrasonic Electric Animal Repellent

- **Ultrasonic electronic repellent -** silent to humans, high-frequency sound waves repel wild animals
- **Sonic electronic repellent -**audible noise that scares animals
- **Hog**

Weighted Co- occurrence Histograms of Oriented Gradients (W-Coho) feature vector to recognize animal. Histogram equalization is performed to reduce noise, distortions and to enhance the highlighted region of interest. The gradients are calculated in magnitude and direction is represents to convert into eight orientations. Sliding window techniques identify animals in different sizes with zoom level of the camera.

- **LBP and SIFT**

Automated species recognition method using local cell-structured LBP (Local Binary Pattern) feature and global dense SIFT (Scale- invariant Feature Transform) descriptor for feature extraction and improvise (Scup) sparse coding spatial pyramid matching to extract dense SIFT descriptor and cell-structured LBP as a local feature. Global features generate max pooling and weighted sparse coding using multi-scale pyramid kernel.

- **SVM**

Animal intrusion detection system based on image processing and machine learning approach. The image of an animal is segmented using a watershed algorithm to extract various objects in the image and to examine that if any threat animal is found in segmentation. This algorithm is to create a barrier which is the contour only when the marked region meets different markers. Gabor filter is extensively used in extracting a region with text to recognize facial expression in various frequencies. Linear SVM is a supervised learning algorithm to train the dataset and to classify text and hypertext.

Disadvantages

- Its disadvantages include the potential for the entire fence to be disabled due to a break in the conducting wire, shorting out if the conducting wire contacts any non-electrified component that may make up the rest of the fence, power failure, or forced disconnection due to the risk of fires starting by dry vegetation touching an electrified wire.
- Bee fence disadvantages are that it is only restricted to elephants and humans can also become targets of the bees
- Percentage of all intrusions in the detection area that was detected was relatively low
- Sensor Failure
- Expensive

III. MODELING AND ANALYSIS

AI Computer Vision based DCNN for detecting animal species, and specific ultrasound emission (i.e., different for each species) for repelling them. Design, deployment and assessment of an intelligent smart agriculture repelling and monitoring IoT system based on embedded edge AI, to detect and recognize the different kinds of animal, as well as generate ultrasonic signals tailored to each species of the animal. This combined technology used can help farmers and agronomists in their decision making and management process.

Deep learning in the form of Convolutional Neural Networks (CNNs) to perform the animal recognition.

- **DCNN**

CNNs are a category of Neural Networks that have proven very effective in areas such as image recognition and classification. CNNs are a type of feed-forward neural networks made up of many layers. CNNs consist of filters or kernels or neurons that have learnable weights or parameters and biases. Each filter takes some inputs, performs convolution and optionally follows it with a non-linearity. A typical CNN architecture can be seen as shown in Fig.3.1. The structure of CNN contains Convolutional, pooling, Rectified Linear Unit (ReLU), and Fully Connected layers.

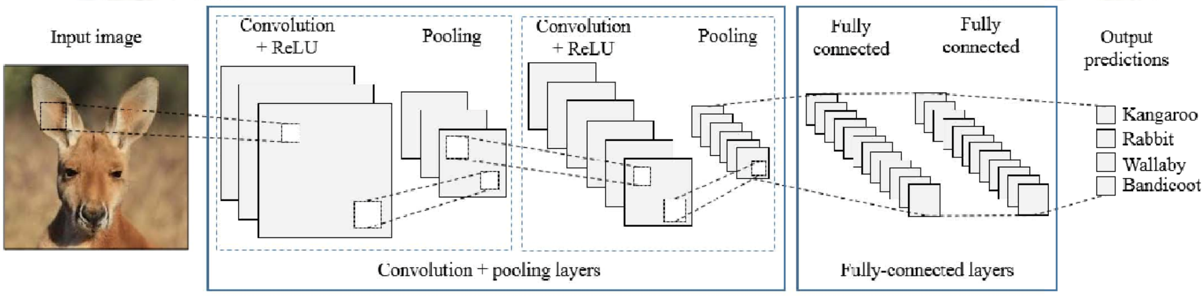


Figure 3.5. CNN

A. Convolutional Layer: Convolutional layer performs the core building block of a Convolutional Network that does most of the computational heavy lifting. The primary purpose of Convolution layer is to extract features from the input data which is an image. Convolution preserves the spatial relationship between pixels by learning image features using small squares of input image. The input image is convoluted by employing a set of learnable neurons. This produces a feature map or activation map in the output image and after that the feature maps are fed as input data to the next convolutional layer.

B. Pooling Layer: Pooling layer reduces the dimensionality of each activation map but continues to have the most important information. The input images are divided into a set of non-overlapping rectangles. Each region is down-sampled by a non-linear operation such as average or maximum. This layer achieves better generalization, faster convergence, robust to translation and distortion and is usually placed between convolutional layers.

C. ReLU Layer: ReLU is a non-linear operation and includes units employing the rectifier. It is an element wise operation that means it is applied per pixel and reconstitutes all negative values in the feature map by zero. In order to understand how the ReLU operates, we assume that there is a neuron input given as x and from that the rectifier is defined as f(x) = max (0, x) in the literature for neural networks.

D. Fully Connected Layer: Fully Connected Layer (FCL) term refers to that every filter in the previous layer is connected to every filter in the next layer. The output from the convolutional, pooling, and ReLU layers are embodiments of high-level features of the input image. The goal of employing the FCL is to employ these features for classifying the input image into various classes based on the training dataset. FCL is regarded as final pooling layer feeding the features to a classifier that uses SoftMax activation function. The sum of output probabilities from the Fully Connected Layer is 1. This is ensured by using the SoftMax as the activation function. The SoftMax function takes a vector of arbitrary real-valued scores and squashes it to a vector of values between zero and one that sum to one.

- **Generation of Repelling Ultrasound**

Animals generally have a sound sensitive threshold that is far higher than humans. They can hear sounds having lower frequencies with respect to the human ear. For instance, while the audible range for humans is from 64Hz - 23KHz, the corresponding range of goats, sheep, domestic pigs, dogs and cats is 78Hz - 37KHz, 10Hz - 30KHz, 42Hz - 40.5KHz 67Hz - 45KHz and 45Hz - 64KHz.Generating ultrasounds within the critical perceptible range causes animals to be disturbed, thus making them move away from the sound source. At the same time, these ultrasounds are not problems to the human ear even when the frequency range is beyond the human ear. The human eardrum has a far lower specific resonant frequency than animals and cannot vibrate at ultrasound frequency. In addition, such solution is non-lethal and has no effect of environmental pollution, no impact on the landscape.

- **Notification System**

The detection system recorded the date and time of each detection. In addition, there were cameras and a video recording system that recorded all animal movements within the enclosure. The detection log was compared to the images from the cameras, which also had a date and time stamp, to investigate the reliability of the system. A message alert is sent to the registered mobile number.

Advantages

- Wide area surveillance
- Accurate and Fast prediction
- Cost effectiveness of available Crop protection systems.
- Easy to use and with less maintenance.
- Robust and reliable system.
- Complete security or full proof system.
- Less or no labor requirement.
- Easily adaptable by the farmers
- Remote Monitor

- Low energy consumption
- Warns and tracks
- Fully automated system
- Integra table with third-party cameras

IV. CONCLUSION

Agricultural farm security is widely needed technology nowadays. In order to accomplish this, a vision-based system is proposed and implemented using Python and OpenCL and developed an Animal Repellent System to blow out the animals. The implementation of the application required the design and development of complex system for intelligent animal repulsion, which integrates newly developed software components and allows to recognize the presence and species of animals in real-time and also to avoid crop damages caused by the animals. Based on the category of the animal detected, the edge computing device executes its DCNN Animal Recognition model to identify the target, and if an animal is detected, it sends back a message to the Animal Repelling Module including the type of ultrasound to be generated according to the category of the animal. The proposed CNN was evaluated on the created animal database. The overall performances were obtained using different number of training images and test images. The obtained experimental results of the performed experiments show that the proposedCNN gives the best recognition rate for a greater number of input training images (accuracy of about 98 %). This project presented a real-time monitoring solution based on AI technology to address the problems of crop damages against animals. This technology used can help farmers and agronomists in their decision making and management process.

V. REFERENCES

[1] M. De Clerk, A. Vats, and A. Biel, ``Agriculture 4.0: The future of farming technology," in Proc. World Government Summit, Dubai, UAE, 2018, pp. 11-13.

[2] Y. Liu, X. Ma, L. Shu, G. P. Hacked, and A. M. Abu-Mahfouz, ``From industry 4.0 to agriculture 4.0: Current status, enabling technologies, and research challenges," IEEE Trans. Ind. Informant., vol. 17, no. 6,pp. 4324334, Jun. 2021.

[3] M. S. Farooq, S. Raza, A. Abdi, K. Abdi, and M. A. Nadeem, ``A survey on the role of IoT in agriculture for the implementation of smart farming,"IEEE Access, vol. 7, pp. 156237-156271, 2019.

[4] K. Kirkpatrick, ``Technologizing agriculture," Common. ACM, vol. 62, no. 2, pp. 14-16, Jan. 2019.

[5] A. Farooq, J. Hu, and X. Jian, ``Analysis of spectral bands and spatial resolutions for weed classification via deep convolutional neural network,"IEEE Geosci. Remote Sens. Lett., vol. 16, no. 2, pp. 183-187,Feb. 2018.

[6] M. Apollonio, S. Ciuti, L. Pedrotti, and P. Banti, ``Ungulates and theirmanagement in Italy," in European Ungulates and Their Managementin the 21th Century. Cambridge, U.K.: Cambridge Univ. Press, 2010, pp. 475-505.

[7] A. Amici, F. Serrano, C. M. Rossi, and R. Prime, ``Increase in crop damage caused by wild boar (Sues scrota L.): The `refuge effect,''' Agronomy Sustain. Develop. vol. 32, no. 3, pp. 683-692, Jul. 2012.

[8] S. Giordano, I. Seitanidis, M. Ojo, D. Adami, and F. Vignoli, ``IoT solutionsfor crop protection against wild animal attacks,'' in Proc. IEEE Int.Conf. Environ. Eng. (EE), Mar. 2018, pp. 1-5.

[9] M. O. Ojo, D. Adami, and S. Giordano, ``Network performance evaluationof a LoRa-based IoT system for crop protection against ungulates,'' inProc. IEEE 25th Int.Workshop Compute. Aided Modeling Design Commun.Links Newt. (CAMAD), Sep. 2020, pp. 1-6.

[10] H. E. Heefner and R. S. Heffner, ``auditory perception,'' in Farm Animals and the Environment, C. Phillips and D. Pigging, Eds. Wallingford, U.K.: CAB International, 1992.

[11] https://www.indiatimes.com/news/india/in-the-battle-between-man-vs-wild-highways-railway- lines-emerge-as-new-challenges-375504.html

[12] https://adventuresinmachinelearning.com/neural-networks-tutorial/

[13] https://github.com/tensorflow/models