# Land Encroachment: Mitigating Human- Wildlife Conflict Through Edge AI Solutions

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**Abstract** - ***In India, wild animals have been reported to invade cities, towns, and urban clusters. This phenomenon is occurring globally, with elephants, leopards, deer, spotted deer, and sambar deer crossing into towns. Humans occupy 45-50% of the world's 510 million square km land, with 30% desert and 24% mountainous. Since 17,000 years ago, humans have built cities and urban clusters, turning wild land into civilized land. Despite this, some tribes and Adivasi still live in the wild. In everyone's daily lives, technology plays a major role. This paper focuses on mitigating human-wildlife conflict through AI solutions using Nano Edge AI Studio which is an AI tool that simplifies the integration of AI into embedded systems, enabling developers to find the best model for their needs. It generates machine learning libraries for event detection, classification, or regression, So that we can easily detect the entering of wild animals into villages by using the audio detection of the wild animals, while it sounds, it immediately shows the message of which animal has been entered, and people can wisely catch the animals and leave them in the forest and thereby easily both people and animals can be protected using the edge AI techniques.***

***Key Words*: Edge AI techniques, Nano edge AI, Machine Learning model, classification of signals, Audio detection.**

## 1.INTRODUCTION

Biodiversity has significantly decreased as a result of human activity's devastation of wildlife habitats. Therefore, in recent years, conservation initiatives have grown in significance. Animal attacks on crops reduce yield, and the expansion of cultivated land into wildlife habitats is causing conflicts that threaten human-wildlife relationships, as the tiger habitat diminishes due to deforestation and human encroachment, these big cats are forced to seek new territories outside protected areas.Nano edge AI aims to analyze the wild animal's sound to detect the arrival of the particular animal, and also to monitor the arrival of wild animals into villages. This Edge AI is an automated machine learning-based advanced technique used to detect and analyze, and it also has an automated trained model to separate the new data that are used to train. Recognizing and detecting animals is essential for studying ecosystem function and behavior, analyzing growth and development, understanding population dynamics, and identifying variables influencing animal migrations. STM32CubeIDE is an Integrated Development Environment (IDE) designed for STM32 microcontrollers and microprocessors. This IDE uses a GNU based C/C++ compiler for ARM embedded processorsDevelopment may be made easier with the help of STM32CubeIDE, a complete cross-platform development tool. It provides peripheral configuration, code generation, code compilation, and debugging features. In this paper, STM32CubeIDE software tool used to interface the Nucleo board and the microphone sensor, which collects the acoustic data of the wild animals to easily detect and analyze the animals which entered into the village. Based on the trained model in the Nano edge AI software, it automatically detects the animals by its frequency. Based on accuracy score, The model is defined, whether it is a RF, SVM or MLP Model. The Nano edge AI has N classification of audio signals. N number of signals can be added to detect the various species of animals when it enters into the human habitat. Nucleo boards have markedly superior performance, quality, input/output, and debugging capabilities when juxtaposed with the Arduino UNO.

## 2. LITERATURE SURVEY

1] Intrusion Detection and Repellent System For Wild Animals Using Artificial Intelligence of Things.

Dr. Namrata Farooq Ansari and Hardiki Deepak Patil (2022), As they proposed, The growing tension between India's wildlife and its expanding population has led to several serious consequences, including harm, death, destruction of human habitats, crop damage, and property loss, among others. While temporary measures such as electric fences, trenches, manual surveillance, and guard dogs offer some protection, they are not cost-effective and can pose risks to both humans and animals. The aim of the proposed system is to protect human settlements and livestock on the periphery of fields and forested areas by developing an automated solution that can detect wild animals and safely guide them back into the forest.

[2] Human Wildlife Conflict Mitigation Using Yolo Algorithm

TT Leonid, H Kanna, CC VJ, AS Hamritha, C Lokesh (2023), As they Proposed, The goal is to detect wild animals and prevent them from entering human habitats, thereby reducing human-wildlife conflicts. This will be accomplished using machine learning to identify various endangered species. The dataset includes over 10,000 images, with 7,000 designated for training and 3,000 for testing. Our proposed solution utilizes the You Only Look Once (YOLO) algorithm, a type of Convolutional Neural Network (CNN), to detect and identify wild animals. The method achieves 94% accuracy in detecting endangered species using computer vision algorithms. This accuracy is notably higher compared to existing models, thanks to the YOLO V4 model.

[3] An Automated Vision - Based Method To Detect Elephants For Mitigation Of Human – Elephant Conflicts

G Ramesh, S Mathi, SR Pulari, V Krishnamoorthy (2017) As they proposed, Implementing a vision-based surveillance system in real-time environments can be highly effective in providing early warnings and thus reducing human-elephant conflicts. This paper proposes a method for identifying elephants as objects through image processing. The approach dynamically learns from training images with varying backgrounds and lighting conditions. It classifies input images based on color and texture features. The results show that the proposed method successfully detects elephants at both close and distant ranges, even in cluttered or occluded environments.

[4] Audio Classification method based on machine learning

Feng Rong (2016) In this paper, We introduce a new audio classification method utilizing machine learning techniques. First, we outline the hierarchical structure of audio data, which consists of four levels: 1) Audio frame, 2) Audio clip, 3) Audio shot, and 4) High-level semantic unit. Next, we extract three types of audio features to create a feature vector: 1) Short-time energy, 2) Zero-crossing rate, and 3) Mel-Frequency cepstral coefficients. We then explain how to classify audio data using an SVM classifier with a Gaussian kernel. Finally, experimental results show that our proposed method achieves improved accuracy in audio classification.

[5] Audio Classification Using Braided Convolutional Neural Networks

Harsh Sinha, Vinayak Awasthi, Pawan K. Ajmera (2020), This work focusses on audio categorisation using a CNN-based architecture and audio representation as spectrogram pictures. It presents a new neural architecture based on CNN that learns a sparse representation similar to that of receptive neurones seen in the primary auditory cortex of mammals. Using common benchmark datasets, such as the UrbanSound8K dataset (US8K) and the Google Speech Commands datasets (GSCv1 and GSCv2), the efficacy of this CNN-based architecture is assessed. Overcoming previous deep learning architectures, the suggested CNN model, dubbed the braided convolutional neural network, obtains average recognition accuracies of 97.15%, 95%, and 91.9% on the GSCv1, GSCv2, and US8K datasets, respectively.

## 3.PROPOSED WORK

The goal of the suggested system is to lessen conflict between humans and wildlife by utilising AI solutions. Nano Edge AI Studio is an AI tool that makes it easier to integrate AI into embedded systems and enables developers to choose the best model for their requirements. To find, examine, and separate fresh data for training, this Edge AI uses a sophisticated automated machine learning method. It produces machine learning libraries for regression, classification, and event detection. We can readily identify wild animals entering settlements by employing audio detection; the technology instantly identifies the animal that has arrived when the microphone sensor detects its sound.

By using cutting-edge AI algorithms, this makes it possible for people to securely capture the animals and release them back into the forest, saving both people and animals.

3.1 BLOCK DIAGRAM

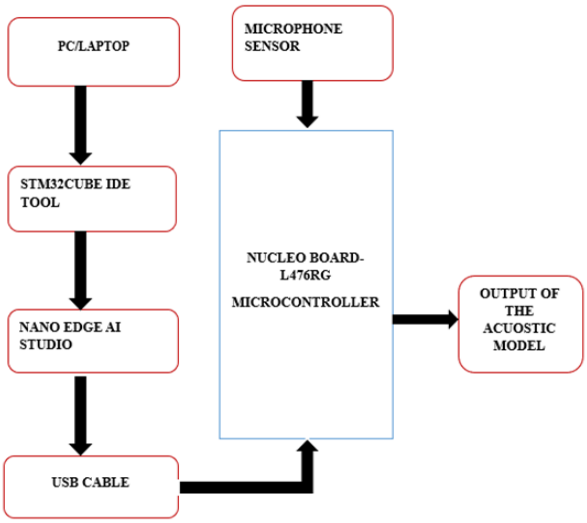


Fig. 1: The proposed system's block diagram

3.2 WORKING OF PROPOSED SYSTEM

In this proposed system, the generated code in the STM32cubeIDE is fetch to the Nucleo-l476RG microcontroller board using the USB cable which interface the STM32cubeIDE and microphone sensor. Connections are made in the board, as in the circuit diagram. Next, generate the code for the audio detection, debug the code and console it to the board. When, noise signals are generated, it starts to obtain the voice signals and it observe the signals and analyze the acoustic waves based on the trained model. The audio data is trained in the nano edge software tool then the model is calibrated using the benchmark for more accuracy. It shows the score of the model based on the accuracy level, whether it is RF, SVM Or MLP model . The nano edge AI shows the graph of the trained model and the signal is added and validated. In the emulator part, the detection of the data is made which is accurately matches the data trained. finally in the STM32cubeIDE tool shows the output in the console part. Additionally, it provides the trained model's high accuracy data. For training purposes, real-time audio can also be utilised.

3.3 SOFTWARE REQUIREMENTS

- STM32Cube IDE
- Nano Edge AI studio

3.3.1 STM32cubeIDE

The STM32CubeIDE is a comprehensive development environment for writing code for nearly all of ST Microelectronics' STM32-based microcontrollers. As the name implies, it's an Integrated Development Environment (IDE) that basically comes with a full compiler and the STM Cube Mx GUI HW setup tool. It may be used as a development platform for any STM32 MCU, regardless of whether it is installed on a specially made board or one from ST's Nucleo or Discovery line of development boards.

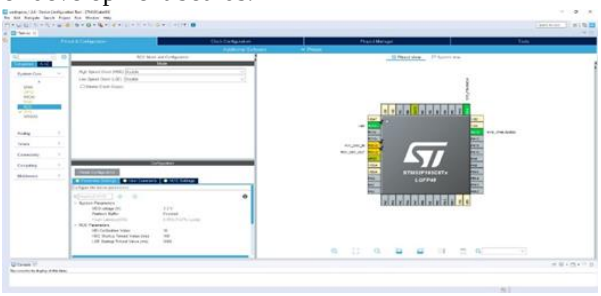

Fig 2: STM32cube IDE Software tool

3.3.2 Nano Edge AI Studio

The model, its preprocessing, and features for simple integration into new or old embedded systems are all included in the Nano Edge AI library that is created by this program using input data. The benchmark that will examine hundreds of possible combinations of preprocessing, models, and parameters is Nano Edge AI Studio's primary strength. Using the user's data as a basis, this iterative procedure determines the best appropriate algorithm. An artificial intelligence (AI) static library called Nano Edge TM AI Library was first created by Cartesian for embedded C applications running on Arm® Cortex® microcontrollers (MCUs).

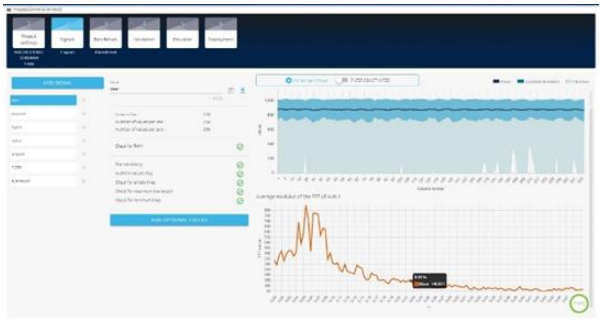

Fig 3: Nano Edge AI Studio

4.HARDWARE SETUP

The Experimental results obtained in this proposed work are discussed here.

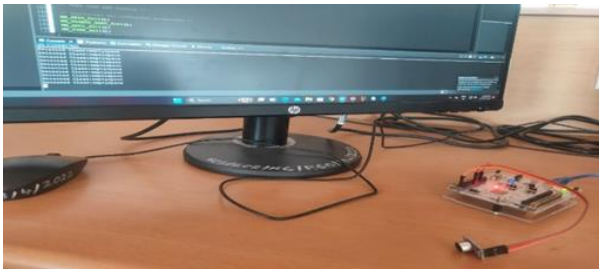

Fig 4: Hardware setup

4.1 RECORDED AUDIO SIGNAL OF ANIMALS
EMPTY SPACE

Fig 5: Recorded audio of empty space

DEER

Fig 6: Recorded audio of deer

ELEPHANT

Fig 8: Recorded audio of elephant

LEOPARD

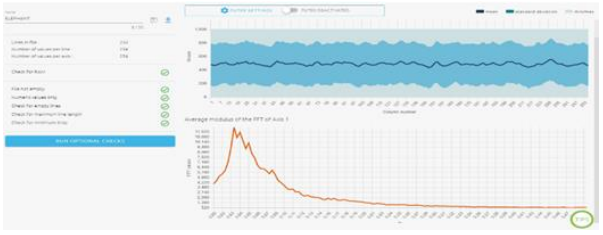

Fig 9: Recorded audio of Leopard

4.2 VALIDATION OF RECORDED AUDIO SIGNALS

Fig 10: Validation score of recorded audio signals

In this validation part, the modelled signals are validated using the benchmark.

Benchmark: In this step, the software uses all the AI libraries to match your normal and abnormal signal and gives you the best learning model. here the learning model is RF model and the Benchmark score is 85.06%.

5.RESULTS AND DISCUSSION

5.1 EMULATOR RESULTS

LEOPARD

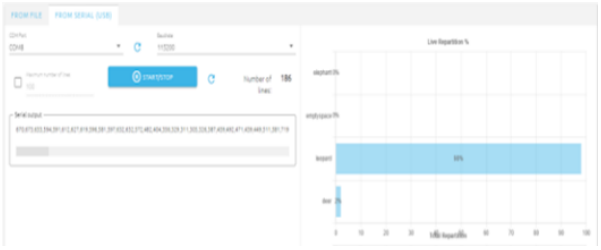

Fig 11: Detection of leopard audio signals

EMPTY SPACE

Fig 12: Detection of empty space audio signals

ELEPHANT

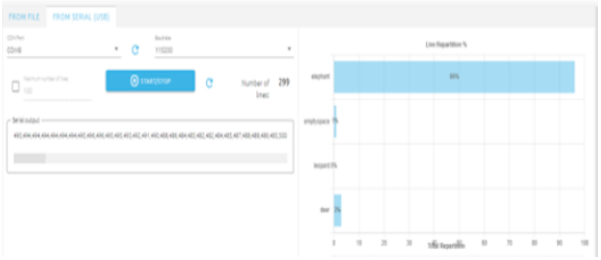

Fig 13: Detection of elephant audio signals

DEER

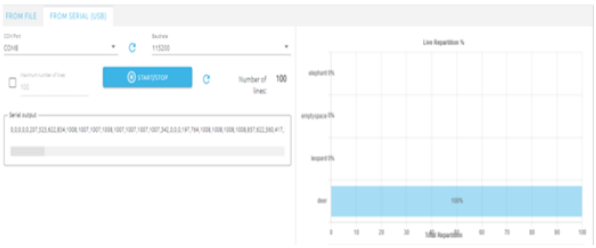

Fig 14: Detection of deer audio signals

When an animal makes noise in close proximity to the sound sensor, the emulation output is acquired. In order to enable us to identify the animals based only on their auditory characteristics, the sensor records acoustic data, classifies sounds based on their frequency, and displays the findings in the emulator.

## 6.RESULTS

Fig 15: Detection of leopard sound

Fig 16: Detection of deer sound

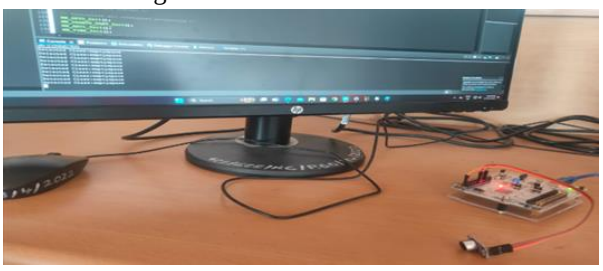

Fig 17: Detection of empty space

With the use of edge AI technologies, this proposed system has successfully created and tested a prototype model to lessen conflicts between people and wildlife. A software application called STM32Cube IDE is used to interface between the Nucleo board and the microphone sensor, which converts the sound waves into the electrical signals. Through the USB serial interface, microphone sensors gather audio data in real time, which they then compare to the learned model in the Nano Edge Studio application. Furthermore, it recognizes the precise animal sound that we have trained it to recognize, making it simple to find the animals and release them into the forest without endangering people. This preserves wildlife and human lives and also protecting farm fields and crops from wild animals without causing harm.

## 7.CONCLUSION

Human-wildlife conflict is a worldwide problem caused by the expansion of human populations into natural habitats. As humans encroach on wilderness areas, wildlife encounters challenges like habitat destruction and obstructed migration paths. These conflicts result in personal injuries, crop damage, and even fatalities. Various technologies, such as electric fences and guard dogs, have been created to alleviate these conflicts, but it's crucial to find a balance that ensures conservation while protecting both wildlife and human communities.

### 7.1 FUTURE SCOPE

In future, there is possibility to send the message to the mobile or any other device regarding the presence of animal using wireless module. So it will be easy to monitor the animals. Also, the repellant system may also be included to safeguard the animals

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