Forest Auditory Surveillance System to Mitigate Deforestation

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Problem Statement

Deforestation is a serious problem worldwide, with an estimated 10 million hectares of forests lost each year[1].

500,000+ estimated acres of forests are cut annually throughout Uganda, this is equivalent to deforesting 43 football fields every hour. 62.5% of Uganda's forest land has been logged in the last 3 decades, and it is estimated that by 2050, there will be no forests outside of protected areas remaining[2].

Figure 1. Deforested land

The loss of forests can significantly impact the environment, including climate change, loss of biodiversity, and soil erosion[3]. Illegal logging often carried out using chainsaws, is a major contributor to deforestation in many areas. Early detection of chainsaw activity in forests can help authorities take action to prevent further damage. Existing methods for detecting illegal logging in forests have limitations, including the high cost of satellite monitoring and not having near real-time information about when a tree is being cut down. As a result, there is a need for more effective and efficient methods for detecting illegal logging in forests.

Scope and Objectives

The scope of this project is to design and develop a system that can detect and alert authorities to instances of illegal logging in natural forests using sound data. It consists of hardware and software components to collect, process, and analyze audio data. The system includes sound capture devices placed at strategic locations in the forest, a web server, a mobile application, and a web portal. The system uses machine learning algorithms to analyze acoustic data collected from forest areas and identify the specific sounds associated with chainsaw use. This project is to help mitigate deforestation and promote sustainable forest management practices by providing a more effective means of monitoring and detecting illegal logging activity. The primary goal of the FASS is to provide organizations like the National Forest Authority (NFA) and forest rangers with a tool that can help them monitor and protect the biodiversity of forests. By using near real-time audio monitoring, forest rangers, and other authorities can detect and respond to threats quickly, helping to prevent illegal logging.

- To design and develop a system for collecting sound data from natural forests and storing it in a database.
- To develop a model for analyzing sound data to identify and classify sounds associated with illegal logging activities like the sound of a chainsaw machine.
- To integrate the algorithm with the database to enable near real-time detection and alerting of logging activities.
- To design a user interface for the system that enables forest managers to view and monitor detected logging activities.

Benefits

- More efficient and effective management of forest resources, helping to prevent damage and illegal logging.
- Enhanced collaboration between conservationists, forest rangers, and other stakeholders in the effort to protect forests.

System Architecture

The Forest Auditory Surveillance System consists of five major components i.e., a mobile application, an edge sound monitor, a web server, and a Database Management System.

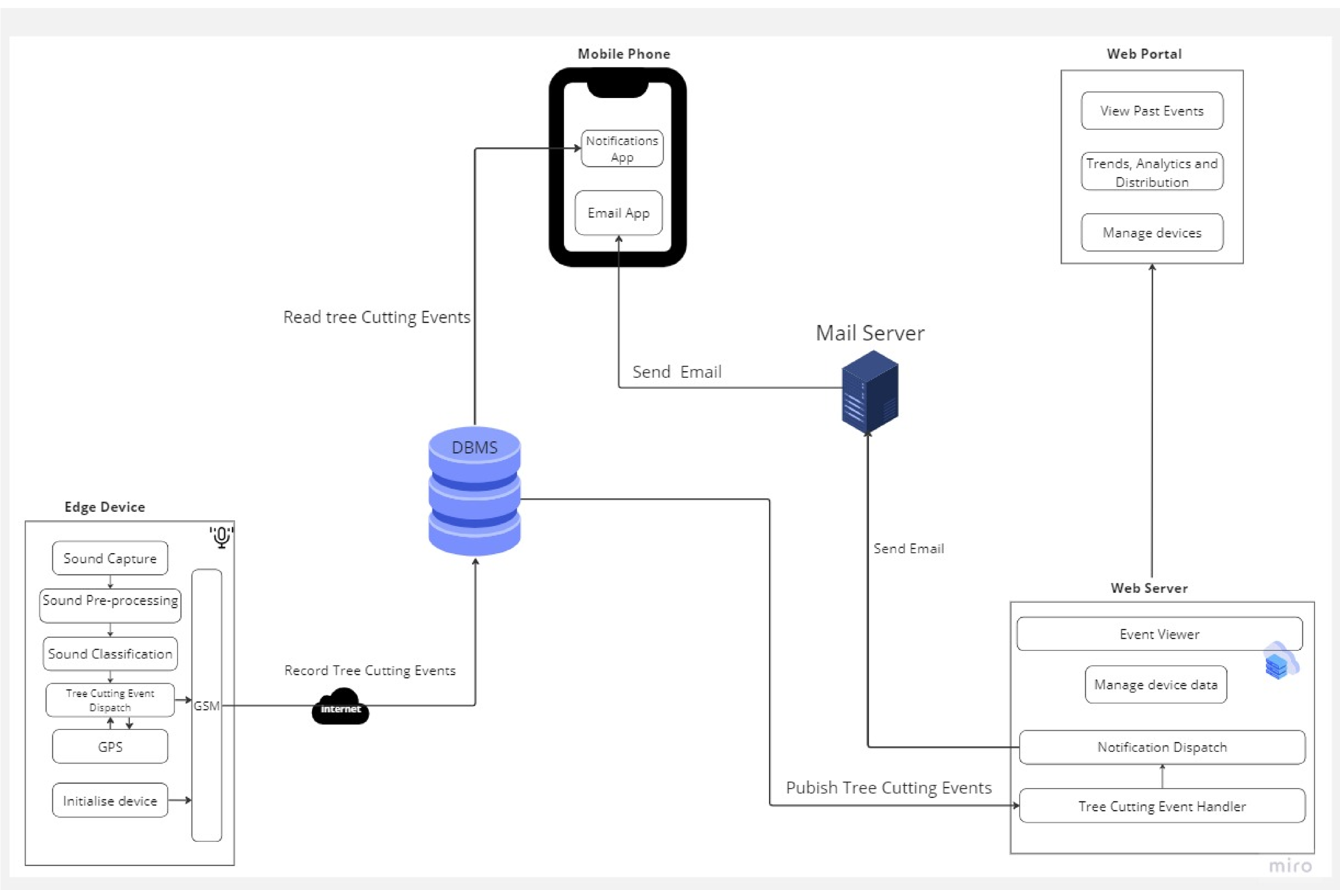

Figure 2. FASS architecture

The Edge Device contains a sound capture module that records sound from the environment. It then passes it to the Sound Pre-processing module which prepares the recorded sound for analysis and classification. After preprocessing is done, the sound is passed on to the Sound Classification Module which detects whether there is a chainsaw sound or not. If the sound of a chainsaw is detected, the Tree Cutting Event Dispatch module is invoked to handle the event. The notification mobile app running on the user's phone also reads the event from the database and displays a map that shows the location of the detected tree cutting. The user can later then visit the Web Portal to see the trends in deforestation cases.

Implementation

The development of the Forest Auditory Surveillance System involved the utilization of various tools and technologies. We used different technologies to implement each of the modules as follows:

1. **Web portal:** Angular, TypeScript, IntelliJ IDEA as our integrated development environment (IDE) and Jest testing framework for thorough testing and validation.
2. **Edge Device:**Arduino Nano RP2040 Connect. CMSIS DSP library. The Arduino IDE and CLion were employed for the development and deployment of the edge device.
3. **Model:** TensorFlow, Keras, librosa, matplotlib, pandas, and NumPy.The model was built using a Convolutional Neural Network (CNN) on Google Colab, and Edge Impulse, an AI tool used to optimize models to be deployed to any edge device with ease.
4. **Mobile Application:**Visual Studio Code as the IDE and the React Native Expo framework.
5. **Web Server:** Django using pycharm as the development environment and hosted on google cloud. Postgres and hosting it on crane cloud.

The data was gathered from different online sources like Kaggle (Environmental Sound Classification), freesound and urbansound datasets.The current model accuracy is 73.26%.

%

ACCURACY

73.26%

	CHAINSAW	NOISE	UNCERTAIN
CHAINSAW	53.4%	41.8%	4.8%
NOISE	1.3%	95.3%	3.4%
F1 SCORE	0.69	0.79	

Feature explorer ?

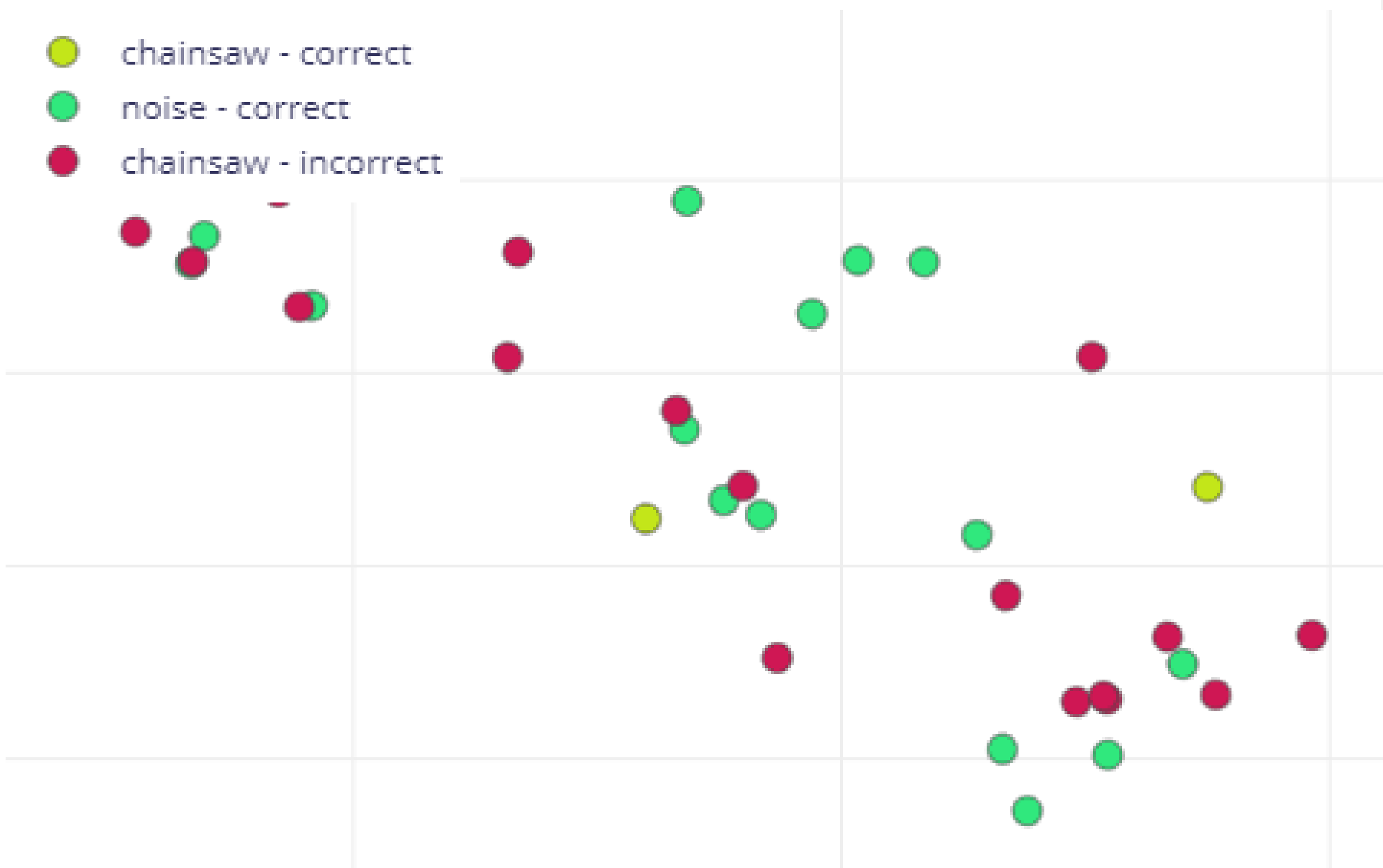

Figure 3. Confusion matrix on test set

Limitations

- One key issue was the size limitation of the microcontroller's memory space. The trained machine learning model we had initially was too large to fit within this constrained memory.
- Many of the chainsaw sound datasets we sourced were contaminated with significant levels of background noise, which caused confusion and hindered the model's ability to accurately predict chainsaw sounds.
- One of the challenges faced during the development of the mobile application was choosing the map provider.

Conclusion

The successful implementation of such a system requires collaboration among various stakeholders. As technology continues to advance and our understanding of AI and forest monitoring deepens, further research and development are needed to refine and expand the capabilities of the system. With continued dedication and innovation, FASS can become a powerful tool in preserving our forests, mitigating climate change, and fostering a sustainable future for generations to come.

BLOG - https://sites.google.com/view/forestmonitoringsystembse23-22/

References

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