Forest Auditory Surveillance System (FASS)

Halimah B.*
Department of Networks
Deep Learning IndabaX Uganda
Kampala, Uganda
halimahbukirwa24@gmail.com

Abstract

Deforestation is a serious problem worldwide, with an estimated 10 million hectares of forests lost each year [1]. The loss of forests can have a significant impact on the environment, including climate change, loss of biodiversity, and soil erosion [2]. Illegal logging often carried out using chainsaws, is a major contributor to deforestation in many areas. FASS takes in sound data as input and produces notifications and analytics as output. The development of FASS involved the utilization of various tools and technologies like Arduino Nano RP2040 Connect for the edge device, Angular and TypeScript for the web portal, Tensorflow for the Machine Learning model, and React Native Expo framework for the Mobile Application. The system was able to undergo different types of testing to make sure it works as intended including functional testing, performance testing, integration testing, and regression testing. In terms of service and maintenance for FASS, a comprehensive user manual to guide users in effectively utilizing the system will be provided. The responsibility for maintaining the system rests on the development team to ensure that the system is operating smoothly and that any issues that may arise, are addressed. The development of the Forest Auditory Surveillance System for detecting illegal logging activities but the successful implementation of such a system requires collaboration among various stakeholders, including the National Forestry Authority (NFA), researchers, forest management organizations, and local communities.

1 Introduction

1.1 Background of the project

Deforestation is a serious problem worldwide, with an estimated 10 million hectares of forests lost each year [1]. The loss of forests can have a significant impact on the environment, including climate change, loss of biodiversity, and soil erosion [2]. 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 to 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 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. The Forest Auditory Surveillance System aims to address this issue by providing a cost-effective and efficient way to detect illegal logging in forests.

*We are a team of four and this was our final year project as students at Makerere University (https://sites.google.com/view/forestmonitoringsystembse23-22)

5th Deep Learning Indaba Conference (DLI 2023).

1.2 Scope of the project

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 analyse 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 analyse 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 organisations like: National Forest Authority (NFA) and forest rangers with a tool that can help them monitor and protect the biodiversity of forests. By using real-time audio monitoring, forest rangers and other authorities can detect and respond to threats quickly, helping to prevent illegal logging. The objectives of the project include:

- To design and develop a system for collecting sound data from natural forests and storing it in a database.
- To develop an algorithm for analysing sound data to identify and classify sounds associated with illegal logging activities like the sound of a chain saw machine.
- To integrate the algorithm with the database to enable 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.

The benefits of the Forest Auditory Surveillance System include:

- 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.

2 System Specifications

2.1 Input

Sound data: This is the major input to the system. It contains environmental sounds captured by audio devices put in forests. It is this data that the machine learning model uses to identify the specific sounds associated with chainsaw use. When the sound associated with chainsaw use is detected, a notification is sent to the authorities in charge.

2.2 Output

Notifications: A notification is sent to the authorities in charge, notifying them about an illegal activity currently happening in the forest via the mobile application. This data contains the approximate location where the illegal activity is taking place. Analytics: The web portal will be used to display information about analytics and the trends in deforestation, it will also enable viewing of past events.

2.3 Functionality

The sound capture devices collect audio data from the forest using a microphone. This sound is then processed in the sound preprocessor to convert it into a format that can be classified and checked for any sound of a chainsaw. All the processing and classification of the sound collected from the environment is done on the sound capture device. If a chainsaw sound is detected, an event is dispatched to the web server informing it about a tree cutting activity. This information has the approximate location of where deforestation is taking place. The web server then forwards this information as a notification to the mobile application, this process takes less than 15 seconds. The mobile application then displays the approximate location of deforestation activity so that the patrol team can take action to prevent further damage to the environment. The web portal is used to display information about analytics and the trends in deforestation, it also enables viewing of past events.

2.4 Limitations and safety

The system requires an active internet connection. If there is no internet connection, events will not be sent to the web server to be logged and a notification will not be sent to the user via a mobile application. The user too needs to have an active internet connection in order to receive the notification once sent via the mobile application. The edge device needs to be continually powered so that it can keep monitoring the sound in the forests for any illegal activity.

2.5 Default settings

By default, when the system is powered, the audio sensor starts capturing the sound in the forest and analyses it on the edge device.

2.6 Special requirements

Strict access controls are in place to ensure that only authorised personnel can access the system, its data, and configuration settings. Sensitive data like passwords is encrypted to prevent unauthorised access or tampering. Regular backups of all system data, including detection results and system configurations are performed, to prevent data loss in the event of hardware failures or other unforeseen circumstances. The code repositories to store and manage the system's source code are secure and access is restricted to authorised developers and version history is maintained.

2.7 Errors and alarms

The system may incorrectly identify normal forest sounds as indicators of illegal logging (false positive) or fail to detect actual illegal logging activities (false negative). This would be handled by continuously refining and updating the AI algorithms through iterative training and validation processes. Regular performance evaluations should also be conducted, and the detection thresholds fine-tuned to reduce false positives and negatives.

Acknowledgments and Disclosure of Funding

First and foremost, we would like to thank God for blessing us with life and for His continuous financial provision throughout all the four years of this course. We also deeply acknowledge the support of our supervisor Dr. Mary Nsabagwa who has tirelessly and consistently guided us throughout the conception, realisation, design, and completion of this project. Your intellectual support has been a great asset to us. She has been very supportive and present to offer all the necessary guidance whenever we needed her. We also thank the team at National Forestry Authority who allowed us to make an appointment with them, took the time to speak with us and provided valuable information about the efforts being taken to detect and combat illegal logging. Their insights and perspectives were invaluable in our understanding of the issue of illegal logging.

References

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