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INTERNATIONAL ACADEMIC RESEARCH COMPETITION

RESEARCH PROPOSAL
ON

FORESEE: A CONVOLUTIONAL NEURAL NETWORK APPROACH FOR SPECTOGRAM-BASED CHAINSAW SOUND DETECTION WITH LORA-GSM COMMUNICATION AND MOBILE APPLICATION INTEGRATION FOR IOT-ENABLED FOREST MONITORING

FORESEE

Camarines Norte Senior High School

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PROPONENT:

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Forests are essential to climate stability, carbon storage, water filtration, and biodiversity conservation [1]. In the Philippines roughly seven million hectares of forest remain, including important areas such as the Sierra Madre, Bicol Natural Park, and Mount Labo, yet these landscapes face rising pressure from tourism, agricultural expansion, and weak enforcement that accelerate forest loss [2][3][4][5][6]. Illegal logging — frequently carried out with chainsaws — is a primary immediate threat to these ecosystems and to local livelihoods [8][9]. Recent technological work demonstrates that IoT acoustic devices, combined with deep learning classifiers, can detect chainsaw activity and report incidents over long-range networks [10][11][20]; however, prototype systems still face practical constraints in the field, including false positives, limited connectivity in remote areas, and operational costs that hinder scale-up [16][18].

To address these gaps, this study develops **FORESEE**: a spectrogram-based, CNN-powered IoT system that performs on-device chainsaw detection and transmits geolocated alerts using LoRa–GSM to a mobile application for timely ranger response and improved forest monitoring.

Research Questions

This study aims to develop FORESEE, an IoT-based system that detects chainsaw sounds and transmits alerts to a mobile app to enhance forest monitoring and response. Specifically, this study intends to answer the following questions:

1. How effective is the Foresee device in terms of: a. Range of Area Coverage using LoRa-GSM b. Speed and Accuracy of CNN-based sound detection c. Tracking Exact Location d. Sending of Alert Signals

2. How effective is the Foresee app in terms of:
a. Receiving Alert Signals **b.** GPS tracking and mapping **c.** Generating Field Reports **d.** Alert and Report Management

3. Is there a significant difference in the Foresee device in terms of:
a. Speed of sound detection **b.** Tracking of exact location **c.** Time relay of sending of alert signals

4. Is there a significant difference in the Foresee app in terms of:
a. Receiving Alert Signals **b.** GPS tracking and mapping **c.** Generating Field Reports and Managing Alerts

5. What is the rate of acceptability of Foresee in terms of:
a. Functionality **b.** Durability **c.** Accessibility

Literature Review

Global forest loss remains severe: since 1990 hundreds of millions of hectares have been permanently converted, driven by agriculture, infrastructure, and both legal and illegal logging [7]. Illegal timber extraction is estimated to account for a substantial share of international timber flows, and it imposes broad socio-environmental harms including habitat loss, soil erosion, and governance problems in affected regions [8][9].

Researchers have responded with sensing and algorithmic approaches. Fieldable acoustic monitors that capture chainsaw signatures and forward alerts via LoRa or similar links have been demonstrated in large forests, showing feasibility for remote detection [10]. Convolutional Neural Networks and spectrogram-based features are widely used to classify environmental audio and have proven effective across tasks from biodiversity monitoring to targeted sound-event detection, making them a natural choice for chainsaw recognition on the edge [11][20][21]. Community reporting platforms and apps (e.g., ForestLink, TIMBY) complement automated sensing by enabling citizen or ranger reports to reach authorities even when conventional connectivity is limited [12][13].

In the Philippine context, deforestation remains critical and localized losses are well documented [14][15]. Low-cost pilot efforts — such as repurposing mobile phones into solar-powered listening nodes (Rainforest Guardians) — have already detected and helped stop illegal incursions, demonstrating how simple acoustic approaches can produce actionable alerts in practice [16]. Local research also shows deep learning can deliver high accuracy for forest mapping and remote sensing tasks, indicating transferability of CNN methods to local audio monitoring needs [17]. Meanwhile, DENR's Lawin platform and recent apps like Sumbong illustrate how mobile reporting and patrol data can inform spatial risk models and community enforcement, but these systems still rely largely on manual input and can be delayed by coverage and staffing limitations [18][19].

Taken together, the literature supports an integrated model for forest protection: automated, spectrogram-based audio detection on edge devices; reliable long-range connectivity (LoRa with GSM fallback) for alerts; and mobile interfaces for rangers and communities to act on detections. At the same time, prior work highlights the real-world challenges FORESEE must address — robustness to background noise, communication reliability in complex terrain, and operational cost and power constraints — which informs this study's design and evaluation priorities [10][16][18][20].

Proposed Methodology: The method is a quantitative approach.

1. **Hardware Development:** A BY-MM1 microphone will be installed to collect chainsaw sounds clearly which will then be transported to the Raspberry Pi 5 that is paired with Google Coral TPU to process audio faster for Convolutional Neural Network (CNN) classification. In line with this, Communication of data will be the LoRa and GSM module, managed by an ESP32, that will provide long-range and backup communication to guarantee alerts. Additionally, a solar-powered system with a LiPo battery and charge controller will supply energy to the FORESEE device, the device would be enclosed to a stainless metallic casing that will protect the system outdoors.
2. **Software Development:** Audio recordings of chainsaw and non-chainsaw sounds will be collected and transformed into Mel-spectrograms, which will then be used to train a Convolutional Neural Network (CNN) optimized for deployment on the Google Coral TPU. A Python program running on Raspberry Pi will capture audio and create spectrograms to classify them with the CNN, sounding alerts when chainsaw detected. For signaling, the ESP32 microcontroller will send detection information using Lora or GSM. In a fall-safe mode, detection will trigger Google Cloud Platform (GCP) for logging and advanced

analytics. Additionally, the android based mobile application shows the real-time alerts, GPS coordinates and historical detection data.

3. **Testing and Evaluation:** The FORESEE system will undergo both bench and field testing. Initially, both types of testing will be done to ensure the system is reliable and accurate. For bench testing, first the accuracy of the CNN will be evaluated using various recordings of chainsaw sounds and different background noises, and then the range of the LoRa module and the alert speed of the GSM module. After that, field testing will take place in forest settings and will focus on determining the system's detection accuracy, the false alarm rate, and the transmission lag during different weather and environmental conditions.
4. **Acceptability Rating:** ITs and Forest Rangers will evaluate FORESEE system's functionality, durability and accessibility using ISO-based 4-point Rubrics. Functionality covers detection speed and accuracy, GPS reliability, and responsiveness; durability focuses on the ability to withstand damages over time; and accessibility assesses app usability, instructions, and ease of installation.
5. **Performance Evaluation and Recommendations:** The overall performance of the FORESEE system will be evaluated based on detection accuracy, communication reliability, and user acceptability. The efficiency and effectiveness of the system will be statistically assessed by the use of Arithmetic Mean, ANOVA, Weighted Mean, and the Likert Scale. Detection thresholds, communications, and mobile app usability will be assessed for calibration. The recommendations will center on improving the system reliability for monitoring forests and anti-illegal logging on functionality, durability, and accessibility.

Expected Outcome:

The study is expected to demonstrate the effectiveness of FORESEE as a low-cost, spectrogram-based IoT monitoring system for detecting chainsaw activity in forest areas. It will evaluate the accuracy of the CNN classifier, the stability of LoRa-GSM communication in remote environments, and the usability of the mobile application for real-time alerting and location mapping. Results will guide improvements in forest monitoring systems for enhanced early detection of illegal logging.

Potential Limitation:

Due to varying background noise in natural settings and terrain interference in LoRa-GSM transmission, the system may experience occasional false positives or delayed alerts, especially during harsh weather or in low-signal zones.

Conclusion:

FORESEE offers a practical, scalable solution for real-time detection of illegal logging. By integrating CNN-based audio analysis with long-range transmission and mobile alerts, the system aims to support forest rangers and local communities in protecting vulnerable ecosystems such as those in Camarines Norte and beyond.

Project Practicalities:

The project will span approximately 8 months. The first 2 months will involve device assembly and spectrogram dataset preparation. The next 4 months will be dedicated to training the CNN model, developing the mobile app, and field-testing the device. The final 2 months will be focused on analyzing data, finalizing results, and preparing the full report.

Post-program Plan:

Upon completion, the researchers intend to refine the device through additional field validation and present the findings in academic conferences or publish them in a relevant journal. Partnerships with local government units or DENR are also being considered for potential pilot implementation.

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