International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 02 | Feb - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

"Forest Sound Monitoring System to Detect Illegal Activities Using Machine Learning"

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Abstract:-
This project aims at creating an apparatus that utilizes machine learning to create a real-time sound monitoring and analysis apparatus. The ultimate objective is to identify relevant or abnormal sound occurrences and automatically issue warnings. Coming to the present-day, the necessity in intelligent systems that are able to compute the environment such as forests, industries, or limited zones without a human operator on duty at all times is increasing. Under this system, a microphone records the audio data which is then processed to obtain significant features. A trained machine learning model is provided with these features and it is able to classify various kinds of sounds. The system will be programmed to identify high profile events like chainsaw sounds or gun shots, the unusual noise of the machine, or any other suspicious activities. In order to ensure the system is efficient and secure, the system is implemented on a low-power edge device. This guarantees quicker response time and more privacy on the data. The system triggers an alert in the monitoring platform when a certain sound is detected and one can view additional information like the time and the location. On the whole, the project can be useful in following the entire workflow of machine learning, including data collection and model training and deploying it to a real-time process. The end product is a prototype that can be used in providing security, forest safeguarding and industrial safety through intelligent sound monitoring.

Keywords:-
Audio Analysis, Machine Learning, Sound Event Detection, Edge Computing, Alert System, Real- Time Processing.

Introduction :-
Forests play a big role in ensuring the ecological balance, safeguarding biodiversity and also in mitigating the impact of climatic change. They offer habitats to wildlife, assist the local people, and assist in keeping the air and water clean. But now forests are under severe threat because of illegal logging, poaching and human interference

which is unauthorized. These sports not only destroy the environment, they also disrupt the natural ecosystem. Forest areas are usually safeguarded using traditional methods of monitoring such as manual patrol and camera traps. Nevertheless, these ways involve a massive amount of workforce, and they are costly to maintain in addition to lacking the ability to give real-time warnings, especially when it comes to the illegal activities. Due to the large and remote size of forests, it is hard to have continuous monitoring. In such environments sound can be an effective source of information. The rare sounds such as chainsaw, gunshots or disturbed animal calls may show signs of illegal or dangerous activities. With the help of the tools of Machine Learning (ML), one can create a smart system that can listen to the sounds of the forest continuously and automatically recognize any suspicious activities. This project will seek to design and deploy a Forest Sound Monitoring System that records the sounds of the environment with the help of sensors and processes the sound to get useful features and classifies the sound in real time with trained ML models. In case illegal activities are reported, the system will automatically notify the forest officials via a web or mobile application. This is a cost-effective solution, which can be scaled and offers a proactive solution to protect the forests, wildlife and prevent disasters.

Literature Survey:-

1. Gunshot Detection Systems

Many researchers have worked on detecting gunshots using sound sensors in both urban and rural areas. One well-known example is **ShotSpotter**, which uses multiple distributed microphones to detect and locate gunfire in cities. These systems show that sound-based monitoring is highly effective for identifying critical events. However, such systems are expensive and usually require a large number of sensors, which makes them less suitable for remote forest environments.

2. Chainsaw Sound Monitoring for Illegal Logging

Several studies have focused on detecting chainsaw sounds to prevent illegal logging. For example, research by Nguyen et al. (2018) used low-cost microphones and machine learning models to identify chainsaw noises in tropical forests. Their work proved that audio-based systems can successfully detect logging activities even in noisy natural surroundings. This shows that forest monitoring using sound is practical and can be implemented at a larger scale with proper optimization.

3. Bioacoustic Monitoring for Wildlife

In the field of ecoacoustics, researchers use sound recordings to study animal behavior and biodiversity. Bird calls, frog croaks, and other animal sounds are recorded and analyzed to identify species and monitor environmental changes. These studies confirm that acoustic monitoring is a reliable method for observing real- time changes in natural ecosystems. The same approach can be extended to detect unusual or illegal activities in forest areas.

4. Edge Computing in Smart Surveillance Recent research has also explored deploying sound classification models on edge devices such as the **Raspberry Pi**. Running machine learning models directly on such devices reduces delay, lowers bandwidth usage, and improves data privacy. This approach is especially useful in remote forest locations where internet connectivity may be limited. Edge computing makes the system faster, more energy-efficient, and reliable.

5. Machine Learning for Audio Classification Machine learning techniques such as Convolutional Neural Networks (CNNs) and Long Short-Term Memory (LSTM) networks are widely used for sound event detection. Previous research shows that these models achieve high accuracy in classifying environmental sounds. They are capable of detecting specific events like chainsaw sounds, gunshots, or distressed animal calls, making them suitable for forest monitoring applications.

6. Problem Definition :-

Forests are facing increasing threats due to illegal activities such as unauthorized logging, poaching, and human intrusion. These activities often take place in remote areas where regular monitoring is difficult. Traditional methods like manual patrolling and camera surveillance are not always effective because they require high manpower, are

expensive to maintain, and do not provide instant alerts.

In many cases, illegal activities are detected only after significant damage has already been done. Since forests cover large geographical areas, continuous human monitoring is practically impossible. There is a need for a smart and automated system that can monitor forest environments in real time and immediately detect suspicious activities.

Sound is one of the most reliable indicators of illegal actions. Noises such as chainsaws, gunshots, or unusual disturbances can signal potential threats. However, manually analyzing continuous audio data is not feasible. Therefore, the problem is to develop an intelligent, cost-effective, and energy- efficient system that can automatically capture forest sounds, identify suspicious events using machine learning, and generate real-time alerts to the concerned authorities.

The main challenge is to ensure accurate sound classification while operating on low-power devices in remote forest locations. The system must be reliable, scalable, and capable of working with minimal internet connectivity.

7.Project Concept and Proposed Working:

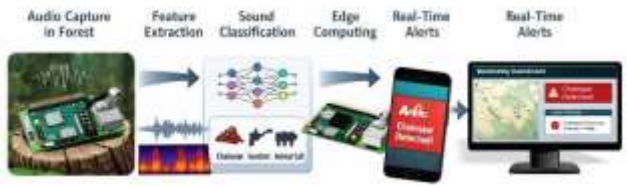

Fig 1: System Live Dashboard Screen

Fig 2: Troop Deployment

Fig 3:Alert Management

The system uses a sound sensor connected to a Raspberry Pi to continuously monitor audio in forest areas.

Goal:

- The primary goal is to build a low-latency, energy-efficient audio analysis system. Objectives include:
- Developing a data acquisition module to capture audio from a microphone.
- Implementing a robust data preprocessing and feature extraction pipeline.
- Training a machine learning model to classify specific sound events.
- Deploying the trained model on an edge computing device.
- Developing a real-time alert system to notify users upon event detection.

8. Results:-

The developed Forest Sound Monitoring System was successfully implemented and tested using recorded and real-time environmental audio data. The machine learning model was trained to classify different sound events such as chainsaw noise, gunshots, and normal forest background sounds.

During testing, the system was able to accurately detect suspicious sounds and differentiate them from regular environmental noise. The trained

model achieved satisfactory classification accuracy, demonstrating its ability to identify illegal activity-related sounds with reliable performance.

The system was deployed on a low-power edge device, and real-time audio processing was successfully performed without significant delay. When a predefined suspicious sound was detected, the system generated instant alerts, which were displayed on the monitoring dashboard along with the time and event details.

The results show that the proposed solution is capable of continuous monitoring, real-time sound classification, and automatic alert generation. This confirms that the system can be effectively used for forest protection and environmental monitoring applications.

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