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# Cyber-Driven Surveillance and Alert System for Illegal Logging Detection in Protected Forest Areas

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**Abstract:** Illegal logging poses a significant threat to biodiversity, forest ecosystems, and climate stability. In this paper, we propose a cyber-driven surveillance and alert system designed to detect and report illegal logging activities in real time. The system integrates Internet of Things (IoT) sensors, edge computing, and artificial intelligence (AI) to monitor protected forest zones continuously. Acoustic sensors detect chainsaw sounds, while visual sensors capture unauthorized human activity. AI algorithms classify the threats and generate alerts for forest officials via secure communication protocols. Field tests demonstrate high accuracy in detection and timely alert delivery. This work enhances environmental protection efforts through technology-driven monitoring and intervention.

**IndexTerms:** Illegal logging, Cyber-physical systems, Forest surveillance, AI detection, IoT, Edge computing, Environmental monitoring

## I. INTRODUCTION

Illegal logging continues to devastate protected forest ecosystems worldwide. Traditional surveillance mechanisms often lack real-time responsiveness and require significant human intervention. The fusion of IoT, AI, and cyber-physical systems presents an opportunity to automate and enhance the monitoring of vast forest areas with minimal resources. This study introduces a novel cyber-driven system capable of continuous surveillance, real-time detection, and rapid response to illegal logging incidents.

## II. RELATED WORK

Prior studies have explored satellite imagery, drone-based monitoring, and manual patrolling for forest protection. However, these methods often suffer from delays, limited coverage, and high operational costs. Recent advancements in low-power sensors and AI-enabled acoustic detection have opened pathways for more efficient ground-level monitoring. Our system builds on these foundations, leveraging edge computing for low-latency decision-making.

## III. SYSTEM ARCHITECTURE

The proposed system comprises the following components: - **IoT Acoustic and Visual Sensors**: Deployed at strategic forest locations, these sensors detect the presence of chainsaws and human activity.
- **Edge Computing Node**: Processes sensor data locally using AI models trained for sound and object classification.
- **Central Server**: Receives classified data and triggers automated alerts.
- **Mobile Alert System**: Notifies forest officials through SMS and secure app notifications.

A mesh network ensures sensor connectivity even in dense foliage. Data integrity is maintained through encrypted communication.

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## IV. METHODOLOGY

Audio datasets were collected to train a convolutional neural network (CNN) model for chainsaw sound detection. Object detection models (YOLOv5) were trained to recognize unauthorized persons in restricted zones. Field deployment included 10 sensor nodes across a 5 km2 area in a wildlife reserve. Accuracy, precision, and latency were the primary performance metrics.

## V. RESULTS AND DISCUSSION

Experimental results showed a **detection accuracy of 96.2%** for acoustic logging events and **91.5%** for visual detection. Alerts were generated within an average latency of **3.8 seconds**. Compared to manual patrols, the system significantly reduced response times and improved event traceability.
Challenges included sensor weatherproofing and wildlife-triggered false positives. These were mitigated by model refinement and sensor casing improvements.

## VI. CONCLUSION AND FUTURE WORK

This research demonstrates the effectiveness of a cyber-driven surveillance system in detecting and alerting illegal logging activities in real time. Future enhancements will include drone-assisted validation, integration with satellite data, and broader deployment across ecologically sensitive regions.

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