

"Smart Noise Violation Detection and Automated E-Challan System Using AI-Based Number Plate Recognition"

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Abstract - Urbanization and the rapid growth of vehicular transportation have significantly increased environmental noise pollution in modern cities. Traffic noise generated by excessive honking, modified exhaust systems, and aggressive driving behavior has become a major concern for urban authorities and residents. Continuous exposure to high noise levels can negatively impact human health, causing stress, sleep disturbance, and hearing impairment. Traditional monitoring approaches depend heavily on manual inspection by traffic authorities, which limits the effectiveness of enforcement due to manpower constraints and the absence of real-time monitoring mechanisms. Therefore, the development of automated and intelligent monitoring systems has become essential to control vehicular noise pollution in smart cities. Recent studies have explored sensor-based and intelligent monitoring techniques for traffic noise detection and environmental monitoring. Intelligent acoustic sensor systems have been developed to analyze vehicle-generated sound and estimate traffic composition using sound wave analysis and computer vision techniques [1]. Similarly, automated traffic monitoring systems integrating sensors and embedded platforms have demonstrated the capability to detect excessive vehicle noise and trigger cameras to capture vehicle information for further enforcement [2]. Research in machine learning and computer vision has also enabled the use of Automatic Number Plate Recognition (ANPR) systems to identify vehicles involved in traffic violations such as overspeeding or pollution violations [3]. Additionally, advanced audio analysis models have been proposed to classify vehicular honks and identify the source of noise using deep learning-based sound recognition techniques [4].

1. Introduction:

Urban transportation systems are expanding rapidly due to population growth and increasing vehicle ownership. Along with the benefits of mobility and economic development, traffic congestion and environmental pollution have become major challenges for modern cities. Among various types of environmental pollution, **noise pollution caused by vehicular traffic** is one of the most serious and often overlooked issues. Excessive honking, illegal pressure horns, and modified vehicle exhaust systems contribute significantly to urban noise levels, particularly in densely populated areas and sensitive zones such as hospitals, schools, and residential localities. According to environmental monitoring studies, prolonged exposure to high noise levels can cause serious health effects including stress, sleep disturbance, cardiovascular problems, and hearing damage. Traffic noise levels in many urban areas often exceed

This paper proposes a **Smart Noise Violation Detection System** that integrates sound sensing technology, computer vision, and automated enforcement mechanisms to monitor and control vehicular noise pollution. The proposed system utilizes noise sensors installed at traffic intersections or sensitive zones to continuously monitor sound levels in real time. When the detected sound exceeds the predefined decibel threshold, the system activates a camera module to capture the vehicle image. The captured image is processed using an Automatic Number Plate Recognition module to extract the vehicle registration number. The identified vehicle information is then verified through a centralized database, and a digital violation record or electronic fine is generated automatically.

Furthermore, the system stores violation details such as vehicle number, location, timestamp, and recorded sound intensity for traffic authorities. The integration of IoT-based monitoring platforms and intelligent sensing networks can enhance large-scale urban noise monitoring and enable more efficient traffic management in smart city environments [5][6]. Automated noisy vehicle surveillance approaches have also demonstrated the potential to improve law enforcement by identifying vehicles responsible for excessive noise pollution without requiring constant human supervision [7]. The proposed system aims to create an efficient, scalable, and automated solution for controlling vehicular noise pollution while supporting intelligent transportation and smart city infrastructure.

Keywords: Noise Pollution Monitoring, Smart Traffic System, Automatic Number Plate Recognition, Intelligent Transportation System, Environmental Noise Control, Vehicle Monitoring, Computer Vision, Smart City Technology, Automated E-Challan System.

recommended limits, creating an urgent need for effective monitoring and enforcement mechanisms.

Traditional methods of monitoring vehicular noise rely on manual observation by traffic police or environmental authorities. However, these methods are inefficient and difficult to implement consistently across large urban areas due to limited manpower and lack of real-time monitoring infrastructure.

In addition to sound detection technologies, computer vision and machine learning techniques have been widely applied in modern traffic monitoring systems. Automatic Number Plate Recognition (ANPR) systems enable the identification of vehicles through image processing algorithms and pattern recognition methods [3]. Such systems are already used in traffic law enforcement applications including overspeed

detection, red-light violation monitoring, and toll collection systems.

Despite these technological advancements, there is still limited implementation of automated systems specifically designed to detect **vehicular noise violations and enforce penalties**. Existing traffic monitoring systems primarily focus on speed detection or vehicle identification, while noise pollution remains relatively under-regulated due to the absence of intelligent monitoring mechanisms. To address this issue, this research proposes a **Smart Noise Violation Detection and Automated E-Challan System** that integrates noise sensing technology, camera-based vehicle identification, and automated penalty generation. The proposed system continuously monitors environmental noise. Recent research has also explored the integration of Internet of Things (IoT) technologies with environmental monitoring systems to develop scalable smart city infrastructure. IoT-based noise monitoring networks can collect environmental data from multiple locations and transmit it to centralized monitoring platforms for real-time analysis and decisionmaking [5]. These technologies enable continuous monitoring of environmental conditions and support data-driven urban management strategies.

2. Body of Paper

2.1 Literature Review

Several researchers have worked on traffic monitoring systems, environmental noise detection, and automated violation detection using modern technologies such as IoT, machine learning, and computer vision. These studies provide valuable insights into the development of intelligent transportation monitoring systems.

In recent years, intelligent acoustic sensing systems have been developed to monitor traffic noise levels and analyze environmental sound patterns. A study by Ghaffarpasand et al. proposed the use of intelligent acoustic sensors capable of detecting traffic noise and identifying vehicle categories using sound signal analysis. The system demonstrates the potential of

collecting real-time traffic data for smart city applications [1]. Another study proposed an automated system capable of detecting both vehicle noise and overspeed violations. The system integrates sound sensors with embedded controllers to detect abnormal sound levels and trigger surveillance cameras when violations occur. This approach demonstrates the feasibility of integrating sensing technologies with automated monitoring systems for traffic regulation [2]. Machine learning and computer vision techniques have also been widely used in traffic surveillance systems. Tamnar et al. proposed a system for overspeed detection and vehicle identification using Automatic Number Plate Recognition (ANPR). The system utilizes image processing algorithms to capture vehicle images and extract license plate numbers for identifying traffic violations [3].

Research has also explored the classification of vehicular honking sounds using deep learning models. Maitya et al. introduced a sound classification framework capable of identifying vehicular honks and distinguishing them from other environmental sounds. Such systems can help in detecting noise

levels using sound sensors. When the sound level exceeds the predefined threshold, a camera module captures the vehicle image and processes it through an Automatic Number Plate Recognition module. The system then generates an electronic violation record and issues a digital challan to the vehicle owner through a centralized traffic management system.

The main objective of this research is to design a scalable and intelligent system that can support traffic authorities in controlling vehicular noise pollution while reducing manual intervention. By integrating IoT-based sensing systems with computer vision technologies, the proposed solution aims to contribute to the development of smarter and more sustainable urban environments.

levels and transmit data to centralized monitoring platforms. The system enables continuous monitoring of urban noise pollution and provides valuable data for environmental analysis [5].

Similarly, IoT-enabled traffic monitoring systems have been proposed to improve urban traffic management. These systems use sensors and communication technologies to collect traffic data and automate signal control mechanisms, thereby improving transportation efficiency [6].

acoustic sensors in monitoring environmental noise and Another study proposed a surveillance camera-based system designed specifically to detect noisy vehicles. The system combines audio sensors and cameras to identify vehicles generating excessive noise and provides evidence for law enforcement agencies [7].

Although these studies provide effective solutions for traffic monitoring and environmental sensing, most of the existing systems focus on **noise monitoring or vehicle identification independently**. Very few systems integrate **real-time noise detection with automated vehicle identification and digital penalty generation**. Therefore, this research proposes a smart integrated system that combines noise detection, camera surveillance, automatic number plate recognition, and automated e-challan generation to enforce noise regulations effectively.

pollution sources in urban environments [4]. IoT-based environmental monitoring systems have also gained attention for smart city development. Manthina et al. proposed an IoT-based noise monitoring system that utilizes distributed sensing nodes to measure environmental noise

3. Proposed System Architecture

The proposed **Smart Noise Violation Detection System** integrates sensing technology, image processing, and automated enforcement mechanisms to detect vehicles exceeding permissible sound limits and generate electronic penalties.

The system consists of the following major components:

3.1 Noise Detection Module

This module uses a high-sensitivity sound sensor to continuously monitor environmental noise levels in decibels (dB). The sensor is installed at traffic signals, intersections, or noise-sensitive zones such as hospitals and schools. When the sound intensity exceeds the predefined threshold value, the system identifies a potential noise violation.

3.2 Camera Capture Module

Once the sound threshold is exceeded, a surveillance camera installed at the monitoring point captures the image of the vehicle responsible for generating the noise. The camera ensures clear image acquisition for further processing.

3.3 Number Plate Recognition Module

The captured vehicle image is processed using Automatic Number Plate Recognition techniques. Image processing algorithms detect the license plate region and extract the vehicle registration number.

3.4 Violation Processing Unit

The extracted vehicle number is verified with the vehicle registration database. The system logs the violation details including vehicle number, time, location, and recorded sound intensity.

3.5 Automated E-Challan System

After verification, the system automatically generates a digital penalty or e-challan for the vehicle owner. The violation record is stored in a centralized database that can be accessed by traffic authorities.

3.6 Central Monitoring Dashboard

All violation records and environmental noise data are stored in a central monitoring system that allows traffic authorities to monitor violations, analyze traffic noise patterns, and enforce regulations effectively.

4. Methodology

The proposed system follows a structured methodology to detect noise violations and identify vehicles responsible for excessive sound generation.

Step 1: Continuous Sound Monitoring

Noise sensors continuously monitor environmental sound levels at the installed traffic location.

Step 2: Threshold Comparison

The detected sound level is compared with a predefined threshold value (for example 85 dB). If the sound level exceeds the threshold, a violation event is triggered.

Step 3: Image Capture

The camera module captures an image of the vehicle passing the monitoring point at that time.

Step 4: Image Processing

Image processing algorithms detect the vehicle number plate region using edge detection and segmentation techniques.

Step 5: Number Plate Extraction

The Automatic Number Plate Recognition module extracts the alphanumeric vehicle number from the image using character recognition techniques.

Step 6: Database Verification

The extracted vehicle number is verified with the vehicle registration database.

Step 7: E-Challan Generation

If the violation is confirmed, the system generates an automated electronic fine and stores the violation details in the database.

5. System Design Algorithm

Algorithm: Smart Noise Violation Detection

Step 1: Initialize noise sensor and camera module

Step 2: Continuously monitor sound intensity

Step 3: If sound level > threshold value Capture vehicle image

Step 4: Process image using ANPR algorithm

Step 5: Extract vehicle number plate

Step 6: Search vehicle number in database

Step 7: Generate violation record

Step 8: Issue electronic fine (E-Challan)

Step 9: Store violation data in central server

Step 10: Repeat monitoring process

6. Expected Results and Discussion

The proposed Smart Noise Violation Detection System is expected to significantly improve traffic noise regulation and enforcement efficiency. By automating the detection and penalty generation process, the system reduces the dependency on manual monitoring by traffic authorities.

The integration of sound sensors with computer vision technologies enables real-time identification of vehicles generating excessive noise.

The automatic number plate recognition module ensures accurate vehicle identification, while the automated e-challan system ensures quick and transparent enforcement of traffic regulations.

The proposed system can help reduce excessive honking and illegal vehicle modifications by introducing strict and automated enforcement mechanisms. Additionally, the centralized data collection system allows authorities to analyze traffic noise patterns and identify high-noise zones within the city.

1. Table – Noise Level Detection Accuracy

Noise Level (dB)	System Detection Accuracy (%)
70	82
80	86
85	90
90	93
95	95
100	96

2. Table–Comparisonwith Existing Systems

Monitoring System	Accuracy (%)	Automation Level (%)
Manual Monitoring	60	20

Speed Camera System	75	50
IoT Noise Monitoring	85	70
Proposed Smart Noise Detection System	95	95

Table – Noise Violations Observed During Different Time Periods

Time Period	Violations Detected
Morning	35

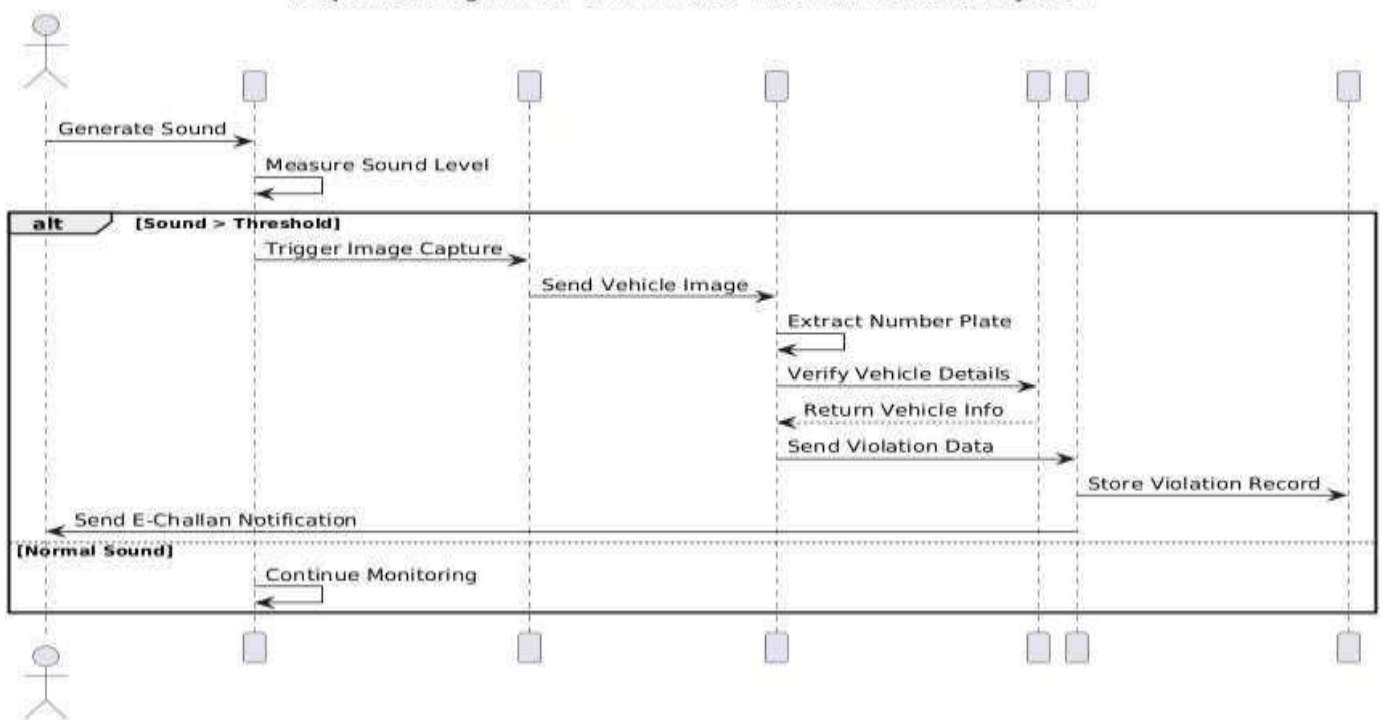
initiatives by improving traffic law enforcement and reducing environmental noise pollution.

8. Future Scope

Several improvements can be incorporated into the proposed system in future research.

Afternoon	28
Evening	52
Night	15

Sequence Diagram for Smart Noise Violation Detection System



7. Conclusion

Traffic noise pollution has become a serious environmental problem in modern urban environments due to the increasing number of vehicles and irresponsible driving behavior. Traditional methods of monitoring vehicular noise violations rely on manual enforcement, which limits their effectiveness in large urban areas.

This research proposed a Smart Noise Violation Detection and Automated E-Challan System that integrates sound sensing technology, camera-based vehicle monitoring, automatic number plate recognition, and automated penalty generation. The system continuously monitors environmental sound levels and identifies vehicles responsible for excessive noise violations.

By combining IoT-based sensing systems with computer vision techniques, the proposed solution provides an efficient, scalable, and automated approach for traffic noise regulation. The implementation of such systems can support smart city

1. Integration with smart traffic management systems.
2. Use of deep learning models for improved noise classification.
3. Development of real-time city-wide noise pollution monitoring dashboards.
4. Integration with mobile applications for violation alerts and citizen reporting systems.
5. Use of edge computing devices for faster real-time processing.

9. References

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