**Project Report**

**NoiseSentinel:** Portable IoT Stick for Detecting Modified Bike Silencers

**By**

**Muhammad Moiz 221073 Ifsan Imran - 221089 Mishkat Fatima - 221336**

***Supervisor***

**Dr. Abdul Hameed**



Table of Contents

1. **Introduction……………………………………………………………………………………3**
   1. **Background of the Problem……………………………………………………………….………..3**
   2. **Motivation…………………………………………………………………………….……………………3**
   3. **Research Gap……………………………………………………………………………………………..4**
2. **Literature Review…………………………………………………………………………..5**
   1. **Manual Inspection by Traffic Police…………………………………………………………….5**
   2. **UK Noise Camera Trials……………………………………………………………………………….5**
   3. **Karachi Safe City Project……………………………………………………………………………..5**
   4. **Research on IoT and Noise Detection………………………………………………………….6**
   5. **Gap Analysis……………………………………………………………………………………………….6**
3. **Requirement Analysis…………………………………………………………………….7**
   1. **Overview……………………………………………………………………………………………………7**
   2. **Functional Requirements……………………………………………………………………………7**
   3. **Non-Functional Requirements……………………………………………………………………8**
   4. **User Requirements…………………………………………………………………………………….9**
   5. **System Requirements………………………………………………………………………………..9**
4. **System Design and Architecture…………………………………………………..10**

**Chapter 1 – Introduction**

**1.1 Background of the Problem**

Noise Pollution is one of the fastest growing environmental issues in urban areas. Motorcycles with illegally modified silencers in Pakistan, are a major contributor to this problem. These bikes produce excessive noise levels that disturb citizens, reduce quality of life, and have negative effects on health such as stress, headaches, sleep disorders, and hearing loss.

Currently traffic police rely on subjective methods to identify such violations. Officers often depend on listening and personal judgement to decide whether a silencer has been modified. These manual checks are inconsistent, lack objectivity, and cannot serve as strong legal proof in court. As a result, many violators escape penalties, which leads to the continuation of noise pollution and public frustration.

**1.2 Motivation**

Urban cities in Pakistan such as Islamabad, Lahore, and Karachi are experiencing a growing traffic population, which amplifies the issue of noise pollution. While initiatives like the Karachi Safe City project and UK noise camera trials have been tested, they either focus on cars or use fixed infrastructure, which is not feasible for motorcycles in densely populated areas.

There is a strong need for a **portable, reliable, and tamper-proof solution** that empowers law enforcement agencies to:

* Detect modified motorcycle silencers quickly.
* Provide court-acceptable evidence (sound recordings, officer identity, timestamps).
* Reduce dependence on subjective judgment and testimonies.
* Improve enforcement efficiency and public trust in traffic police.

This motivation drives the development of **NoiseSentinel**, a portable IoT-enabled stick integrated with a mobile and web system, which offers a technology-based, verifiable, and scalable approach to solving the problem.

**1.3 Research Gap**

Existing solutions have several shortcomings:

* **Manual Inspections**: Police rely on human hearing and judgment, which are prone to errors and not legally verifiable.
* **Fixed Noise Cameras**: Trials in other countries focus on cars and fixed locations, limiting their portability and scope.
* **City Surveillance Systems**: Projects like the Karachi Safe City initiative track speeding and traffic violations but do not address silencer modifications or noise pollution.
* **Lack of Legal Evidence**: Current approaches fail to provide tamper-proof, court-acceptable digital evidence.

Therefore, there is a **research gap** in creating a **portable, IoT-based system** that can detect modified silencers, classify them using machine learning, and generate tamper-proof digital challans with verifiable evidence for legal use.

NoiseSentinel aims to fill this gap by combining IoT hardware, mobile app integration, machine learning classification, and a web-based portal for courts and authorities.

**Chapter 2 – Literature Review**

**2.1 Manual Inspections by Traffic Police**

Traditionally, traffic police rely on manual inspections to identify motorcycles with modified silencers. Officers listen to the sound and make a judgment based on experience. While this method is simple, it is not reliable because sound levels can vary depending on the environment. More importantly, this method does not provide strong evidence in court. Without recordings or digital proof, challans can be challenged and dismissed. This shows that manual checks are not an effective long-term solution.

**2.2 UK Noise Camera Trials**In the United Kingdom, trials have been conducted using noise detection cameras. These cameras are fixed at certain locations and can measure the sound levels of passing vehicles. While this approach works well for cars in developed cities, it has limitations for motorcycles in countries like Pakistan. The system is not portable, requires large infrastructure, and focuses mainly on cars rather than motorcycles. Therefore, while the UK’s system is a step forward, it is not directly applicable to the problem of motorcycle silencers in Pakistan.

**2.3 Karachi Safe City Project**

In Karachi, the Safe City project uses cameras for monitoring traffic violations such as speeding, signal breaking, and facial recognition of drivers. This project has improved traffic monitoring, but it does not include noise detection or silencer modification checks. It also depends heavily on fixed infrastructure, which makes it difficult to apply specifically to noise pollution caused by motorcycles. As a result, the system is not addressing the key problem of noisy silencers.

**2.4 Research on IoT and Noise Detection**

Recent research has explored IoT-based devices and machine learning for sound classification. For example, studies have shown that IoT sensors can effectively capture noise data and classify sound levels into categories such as normal, severe, or harmful. Similarly, machine learning algorithms like decision trees and neural networks have been applied for noise source identification. These studies show that it is possible to use IoT and AI together for real-time sound analysis, which forms the foundation for projects like NoiseSentinel.

**2.5 Gap Analysis**

From the above systems, it is clear that there are still important gaps:

* Manual checks are unreliable and cannot be used as legal proof.
* UK noise cameras and Safe City projects depend on fixed infrastructure and mainly target cars, not motorcycles.
* Current systems do not provide tamper-proof, court-ready evidence.
* No existing system offers a portable IoT solution with mobile and web integration for traffic police.

NoiseSentinel fills this gap by introducing a small, portable IoT device that connects with a mobile app and web portal. It not only detects modified silencers but also records tamper-proof sound evidence, generates digital challans, and provides court-accessible data. This ensures the solution is practical, portable, and legally reliable.

**Chapter 3 – Requirement Analysis**

**3.1 Overview**

Our project, **NoiseSentinel**, is an IoT-enabled system designed to detect illegally modified or damaged motorcycle silencers. The solution is composed of three main components: a portable IoT stick, a mobile application, and a web portal. The IoT device captures exhaust sound and emission data, which is then sent to the mobile app used by traffic police. The mobile app forwards this data to a machine learning model for analysis and also communicates with the central web server. If a violation is detected, a digital challan is generated, stored securely, and made accessible to courts and authorities. This system provides tamper-proof, court-ready evidence while reducing reliance on manual inspections.

**3.2 Functional Requirements**

The system must provide the following functions:

1. **IoT Device and Mobile App Connectivity**

* The IoT device connects with the mobile application via Bluetooth or WiFi.

1. **Sound and Emission Capture**

* The IoT device records exhaust noise levels (in dB(A)) and emission values (CO, CO₂, HC, NOx).

1. **Noise Classification Using AI**

* The collected sound is categorized as *Normal, Modified, or Damaged* by a machine learning model.

1. **Data Authenticity and Signatures**

* Each reading must include a digital signature or watermark to prevent tampering and ensure authenticity in legal cases.

1. **Challan Generation**

* The officer enters details such as CNIC, bike make/model, registration number, and photo of the motorcycle.
* The system auto-generates a unique challan number.

1. **Evidence Storage**

* All challan details and audio evidence are stored securely on the server.

1. **Court and Authority Access**

* Courts can log in to review challans and verify tamper-proof data without requiring the officer or motorcycle in person.

1. **Search and Reporting**

* Officers and administrators can search previous challans by registration number, officer ID, or date and generate summary reports.

**3.3 Non- Functional Requirements**

The system should also meet the following quality attributes:

**1.** **Reliability** – The IoT device and software should consistently capture and process data without frequent failures.

**2.** **Performance** – Noise classification and challan generation should occur within a few seconds.

**3.** **Security** – All communications must be encrypted; unauthorized users cannot access data.

**4.** **Scalability** – The system must support multiple officers and devices working at the same time.

**5.** **Usability** – Interfaces must be user-friendly with simple menus and options.

**6.** **Portability** – The IoT stick should be lightweight, battery-operated, and easy to carry.

**7.** **Maintainability** – Updates to mobile and web applications should be easy to apply without affecting existing data.

**3.4 User Requirements**

* **Traffic Police Officer**
  + Connect IoT stick with mobile app.
  + Scan silencers and view instant results.
  + Generate challans with sound evidence.
  + Search and review previous challans.
* **Court / Legal Authority**
* Securely log in to the web portal.
* Review challans with attached audio recordings.
* Verify officer ID and digital signatures.
* Make legal decisions without requiring the officer or bike in person.
* **Administrator**
* Manage officer and court accounts.
* Monitor overall system usage.
* Generate reports for authorities.
* Ensure system security and backups.

**3.5 System Requirements**

* **Hardware Requirements**
* Portable IoT Stick with microphone and emission sensors.
* Microcontroller (e.g., ESP32).
* Smartphone (Android/iOS) for mobile app use.
* Cloud or server system for backend and web portal.
* **Software Requirements**
* **Mobile App:** React Native.
* **Web Portal:** React (frontend), Node.js/Express (backend).
* **Database:** SQL for secure record storage.
* **ML Model:** Decision Tree classifier for silencer detection.
* **Version Control:** Git for collaboration.
* **Hosting:** Cloud server (AWS/Firebase or equivalent).

**Chapter 4 – System Design and Architecture**