iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** IV **Month of publication:** April 2026

DOI: https://doi.org/10.22214/ijraset.2026.80058

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue IV Apr 2026- Available at www.ijraset.com

Hush-Traffic: *IoT- Based Smart Traffic Noise Monitoring and Violation Detection System*

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Abstract: ***Rapid urbanization has led to a significant increase in traffic congestion and noise pollution in metropolitan areas. Excessive honking and traffic signal violations are common issues at busy intersections, contributing to unsafe road conditions and environmental noise. This paper presents Hush-Traffic, an IoT-based smart traffic monitoring system designed to detect excessive honking and monitor traffic rule violations in real time. The proposed system integrates a sound sensor, an Arduino-based traffic controller, and an ESP32-CAM module to create an intelligent monitoring platform. The sound sensor continuously measures environmental noise levels near traffic signals, and when the detected noise exceeds a predefined threshold, the system identifies it as a potential violation. The microcontroller then triggers the ESP32-CAM module to capture images and stream live video through a localhost-based web interface.***

The traffic signal operates with predefined timing sequences while the monitoring system records abnormal events for analysis. A web-based dashboard provides real-time visualization of signal status and camera output. Experimental results demonstrate that the proposed system effectively detects excessive honking and enables efficient monitoring of traffic behavior. The system offers a low-cost, scalable, and practical solution for improving traffic discipline and reducing noise pollution in smart city environments.

.Index Terms: Embedded systems, ESP32-CAM, Internet of Things (IoT), noise detection, smart traffic monitoring, traffic violation detection.

I. INTRODUCTION

The rapid growth of urbanization and the increasing number of vehicles on roads have led to significant challenges in traffic management and environmental noise pollution. Traffic congestion, signal violations, and excessive honking are common issues in busy city intersections, which negatively affect road safety and urban living conditions. Traditional traffic signal systems typically operate using fixed timing mechanisms and rely heavily on manual monitoring by traffic authorities. These conventional approaches are often inefficient in detecting traffic rule violations and managing noise pollution in real time.

Excessive honking has become a major contributor to noise pollution in metropolitan areas. Continuous exposure to high noise levels can lead to stress, reduced concentration, and other health-related problems for both drivers and pedestrians. In many cases, drivers tend to honk unnecessarily at traffic signals, especially during red light phases, which increases noise levels and creates chaotic road environments.

Modern traffic monitoring solutions have introduced camera-based surveillance systems and automated traffic management technologies to address these issues. However, many of these systems require expensive infrastructure, complex image processing algorithms, and high computational resources. As a result, implementing such systems in all traffic intersections can be costly and impractical for many developing regions.

Recent advancements in the Internet of Things (IoT) and embedded systems provide new opportunities for developing intelligent and cost-effective traffic monitoring solutions. By integrating sensors, microcontrollers, and camera modules, it is possible to monitor traffic conditions and detect abnormal events in real time.

To address these challenges, this paper proposes Hush-Traffic, a smart traffic monitoring system designed to detect excessive honking and traffic violations using IoT technologies. The system integrates a sound sensor, an Arduino-based traffic signal controller, and an ESP32-CAM module to monitor environmental noise levels and capture visual evidence of potential violations. When the detected noise exceeds a predefined threshold, the system triggers the camera module to stream live video through a localhost-based web interface. By combining noise detection and real-time visual monitoring, the proposed system aims to improve traffic discipline, reduce noise pollution, and support the development of smarter and more sustainable urban transportation systems.

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A. *Literature Survey*

Several research studies have been conducted in the domain of traffic management and noise monitoring using advanced technologies such as Internet of Things (IoT), embedded systems, and artificial intelligence. These systems aim to improve traffic discipline, detect violations, and reduce environmental noise pollution. Many researchers have focused on developing smart solutions for honk detection, traffic congestion analysis, and automated monitoring using sensors and camera-based systems. However, most of the existing approaches either focus only on noise detection or only on traffic monitoring, lacking an integrated and cost-effective real-time solution. A comparative analysis of the existing systems is presented in Table 1.1.

Sr No.	Author & Year	Method Used	Key Contribution	Limitation
1.	Madke et al. (2024)	Adaptive Honking System	Detects unnecessary horn usage	No real-time monitoring
2.	Maity et al. (2024)	AI-based Sound Detection	Accurate honk detection using AI techniques	High computational cost
3.	Chaudhary & Panchal (2023)	Smart Sensor-Based System	Controls honking in residential areas	Limited automation
4.	Middya & Roy (2023)	IoT-Cloud Monitoring	Enables remote monitoring of traffic noise	Requires continuous internet
5.	Ahire & Sakhare (2021)	IoT-Based Noise Control	Implements noise restriction in smart cities	No visual evidence
6.	Shahid et al. (2025)	ESP32-Based Traffic Monitoring	Detects congestion using wireless signals	Does not consider noise pollution
7.	Fatema et al. (2022)	IoT Noise Monitoring	Measures environmental noise levels	Limited real-time violation detection
8.	Manthina et al. (2025)	Mobile Sensor-Based Monitoring	Uses mobile nodes for smart city noise tracking	Complex deployment
9.	Glasl et al. (2008)	Video-Based Traffic Analysis	Predicts congestion using camera systems	No sound detection
10.	Chen et al. (2021)	Deep Learning Sound Detection	Advances sound event recognition	Requires high processing power
11.	Zhang et al. (2024)	IoT Traffic Management	Smart traffic monitoring system	Does not address honking
12.	Barral Vales et al. (2024)	ESP32 IoT System	Efficient IoT-based communication	Not specific to traffic applications

Table 1.1 - Literature Survey Table

From the above analysis, it is observed that most of the existing systems focus on either traffic monitoring or noise detection independently. While some approaches use IoT and cloud technologies for monitoring, they often lack integration with real-time violation detection and visual evidence collection. Additionally. Many systems require high computational resources or complex infrastructure, making them less suitable for cost-effective implementation. To overcome these limitations, the proposed Hush-Traffic system integrates sound sensing with ESP32-CAM-based visual monitoring to detect excessive honking and capture real-time traffic violations. This approach provides an efficient, low-cost, and scalable solution for improving traffic discipline and reducing noise pollution in urban environments.

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1) Limitation / Existing System / Research Gap

The limitations of traditional traffic monitoring systems become particularly evident in modern urban environments where traffic congestion and noise pollution are increasing rapidly. Traffic systems require:

- Continuous monitoring of vehicle movement
- Efficient traffic rule enforcement
- Real-time traffic condition analysis
- Noise pollution control in sensitive areas

Drivers frequently exhibit behaviors that negatively affect the traffic environment, including:

- Excessive honking in traffic congestion
- Ignoring traffic signals
- Lack of awareness of noise pollution
- Traffic rule violations during peak hours
- Increased noise levels near hospitals and schools

Research in smart city and traffic management studies indicates that uncontrolled honking and poor traffic discipline contribute significantly to urban noise pollution and traffic inefficiency. Therefore, developing an intelligent traffic monitoring solution is essential to improve traffic discipline and reduce unnecessary honking.

2) Objectives

The primary objective of the Hush-Traffic system is to design and develop an intelligent traffic monitoring solution capable of detecting excessive honking and traffic rule violations in urban environments using IoT and embedded technologies. The system aims to reduce noise pollution and improve traffic discipline by implementing automated monitoring and real-time detection mechanisms.

Specific objectives include

- Develop a smart traffic monitoring system using embedded hardware and IoT technologies.
- Detect excessive honking in traffic areas using sound sensing modules.
- Capture vehicle images using the ESP32-CAM module for monitoring traffic violations.
- Monitor traffic conditions in real time to improve traffic management.
- Identify areas with high noise levels caused by unnecessary horn usage.
- Provide automated monitoring to reduce dependence on mutual traffic supervision.
- Implement a low-cost and efficient solution suitable for smart city applications.
- Improve road discipline by encouraging drivers to reduce unnecessary honking.
- Reduce noise pollution near sensitive zones such as hospitals and schools.
- Enhance urban traffic environments through intelligent monitoring systems.

II. PROPOSED SYSTEM

A. Analysis/ Framework/ Algorithm

1) The Hush-Traffic system analyses traffic conditions and noise levels in urban areas by integrating sounds detection sensors and camera-based monitoring to identify excessive honking and traffic violations.

2) The system begins by initializing the sound sensor and ESP32-CAM module, which continuously monitor the surrounding traffic environment and capture real-time audio and visual data from the road.

3) The sound sensor continuously measures environmental noise levels and detects sound intensity generated by vehicle horns during traffic movement.

4) When the detected sound level exceeds a predefined threshold, the system identifies it as excessive honking and triggers the monitoring mechanism.

5) Simultaneously, the ESP32-CAM module captures images of vehicles in the monitored area to observe traffic activity and identify potential violations.

6) The captured images are processed and analysed to detect vehicle presence and traffic behaviour within the monitored zone.

7) To improve monitoring reliability, the system continuously analyses multiple sound readings and image captures to confirm the occurrence of repeated honking or abnormal traffic conditions.

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8) Finally, the collected data is transmitted to the monitoring system where it can be analysed for traffic management purposes, helping authorities identify areas with high noise pollution and promote better traffic discipline.

B. Tools and Technologies

Layer	Technology
Microcontroller	Arduino UNO
IoT Module	ESP32-CAM (Image / Video Streaming)
Sensors	Sound Sensor / Horn Detection Module
Traffic Signal System	Red, Yellow, Green LEDs
Display Modules	16×2 LCD Display, 7-Segment Display
Alert System	Buzzer
Programming Environment	Arduino IDE
Programming Language	Embedded C / C++
Communication	Serial Communication / Wi-Fi (ESP32-CAM)
Monitoring Interface	Web Browser (Live Video Stream via IP Address)

Table 1.2 - Tools and Technologies

C. Methodology

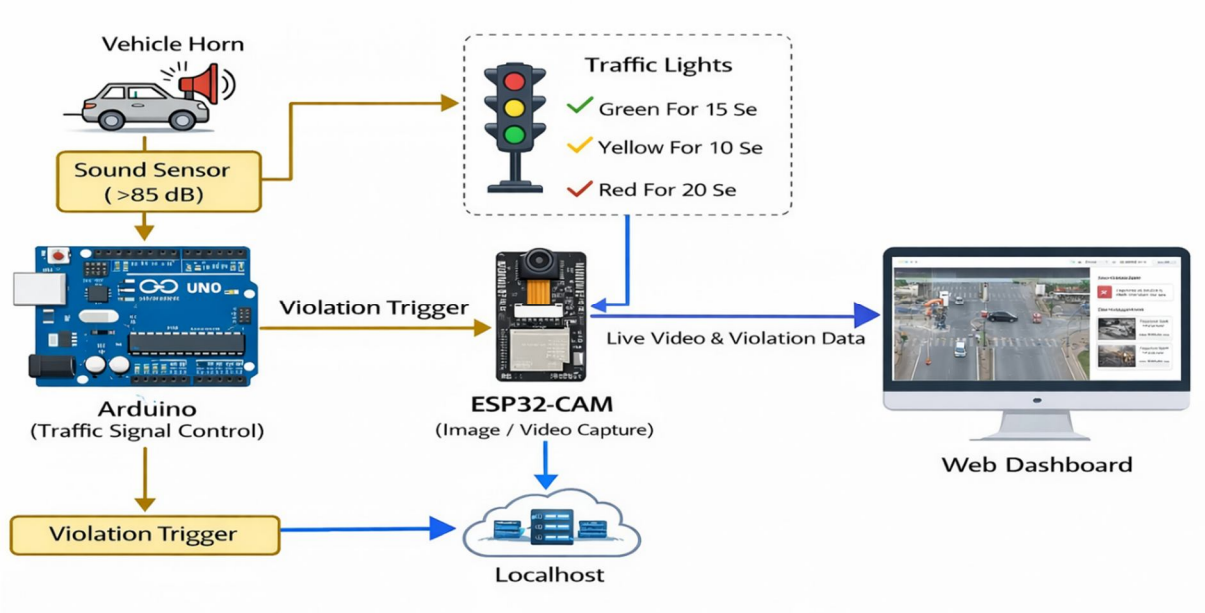


Figure 1.1 – Methodology/ Project Lifecycle

1) Project Initiation & Planning : In this phase, the concept of the Hush-Traffic system is proposed to monitor excessive vehicle honking and traffic violations at signal junctions. The project objectives, scope, and required hardware components such as sound sensor, Arduino UNO, ESP32-CAM module, traffic signal controller, and web dashboard are identified. The system workflow is planned to detect horn noise levels, trigger violation detection, capture vehicle images, and send data to a monitoring interface.

2) System Design : The system architecture is designed to integrate a sound sensor with an Arduino UNO for traffic signal control and noise detection. When the sound level exceeds 85 dB, the Arduino identifies it as excessive honking and triggers a violation event. The ESP32-CAM module is connected to capture live images or video of the traffic area. The captured data is transmitted to a localhost server and displayed on a web dashboard for monitoring and analysis.

3) Implementation : In this phase, the hardware components are assembled and programmed using Arduino IDE and embedded C programming. The sound sensor continuously measures environmental noise levels from vehicle horns. If the noise level crosses the threshold value, the Arduino triggers the violation detection system and activates the ESP32-CAM. The camera captures images or video footage of the vehicles present at the signal during the violation event.

4) Testing & Evaluation : The system is tested under different traffic scenarios to verify the accuracy of horn detection and violation triggering. The sound sensor performance is evaluated to ensure it correctly detects noise levels above the threshold. The ESP32-CAM module is tested to confirm that it captures clear images and successfully sends data to the monitoring dashboard.

5) Deployment / Demonstration : After successful testing, the Hush-Traffic prototype is deployed in a simulated traffic signal environment for demonstration. The sound sensor detects excessive honking, the Arduino triggers the violation system, and the ESP32-CAM captures live video or images which are displayed on the web dashboard through localhost.

6) Maintenance & Documentation : In this phase, the complete project documentation, system manual, and IEEE research paper are prepared. Future improvements such as cloud-based data storage, automated number plate recognition, and integration with smart city traffic management systems are planned to enhance the system's functionality.

D. Design Details

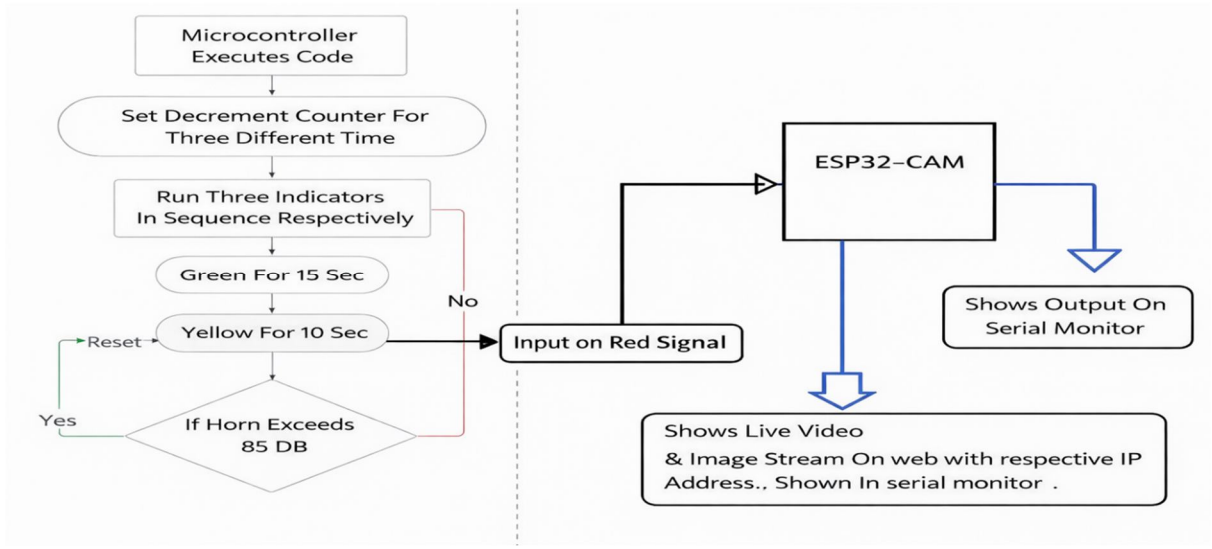


Figure 1.2 – System Design Workflow

1) Microcontroller Initialization & Traffic Signal Control

➢ The system begins when the microcontroller executes the programmed code to control the traffic signal system.
➢ A decrement timer is configured to manage three traffic indicators.
➢ The traffic lights operate sequentially according to predefined timing intervals.

2) Traffic Signal Timing Sequence

➢ The system activates the traffic lights in sequence: Green for 15 seconds, Yellow for 10 seconds, and Red for 20 seconds.
➢ These timings regulate vehicle movement at the intersection and ensure orderly traffic flow.
➢ During this process, the system continuously monitors environmental conditions for horn detection.

3) Horn Detection During Red Signal

➢ When the red signal is active, the system monitors the surrounding sound levels using the sound sensor.
➢ If the horn sound exceeds the predefined threshold of 85 dB, the system identifies it as excessive honking.
➢ This event is considered a traffic violation, and the violation trigger mechanism is activated.

4) Camera Activation and Image Capture

➢ Once the violation is detected, the ESP32-CAM module is triggered automatically.

➢ The camera captures images or live video of vehicles present at the signal during the honking event.

➢ This visual data helps in identifying vehicles responsible for unnecessary honking.

5) Live Monitoring and Output Display

➢ The ESP32-CAM transmits the captured image or live video stream to a web interface using its unique IP address.

➢ The output can be viewed through a web browser or monitoring dashboard, while system messages are displayed on the serial monitor.

➢ This enables real-time monitoring of traffic violations and improves traffic noise management.

E. Result and Discussion

1) Implementation Plan

Phase 1: System Design and Hardware Setup

- Requirement Analysis :
- Collected system requirements for developing the Hush-Traffic intelligent noise monitoring system, including sound detection, camera monitoring, and real-time traffic observation.
- Identified the required hardware components such as ESP32-CAM module, sound sensor, power supply, and microcontroller interface.
- Defined the system workflow for noise detection, threshold comparison, camera activation, and image capture when excessive honking is detected.

- Hardware Design :
- Designed the hardware architecture integrating the sound sensor with the ESP32-CAM module for monitoring traffic noise levels.
- Configured the system to continuously measure environmental sound intensity and detect horn sound from vehicles.
- Established connections between the sensor module and processing unit to enable automatic triggering of the camera during noise events.

- Embedded System Development :
- Developed the embedded program using Arduino IDE / ESP32 firmware to control the sound sensor and ESP32-CAM module.
- Implemented algorithms to continuously read sound sensor values and compare them with a predefined noise threshold level.
- Programmed the system to automatically activate the camera module for capturing images when excessive honking is detected.

Phase 2: Sensor Integration and System Development

- Sensor Integration :
- Integrated the sound sensor with the ESP32-CAM board to enable real-time monitoring of traffic noise.
- Configured the sensor to capture continuous sound signals from the surrounding traffic environment.
- Calibrated the sensor sensitivity to accurately detected horn sounds and avoid false triggers from environmental noise.

- Camera Monitoring Integration :
- Implemented camera functionality in the ESP32-CAM module to capture images of vehicles when the noise threshold is exceeded.
- Configured the camera settings for optimal image capture under different lighting conditions.
- Integrated the sound detection system with the camera module to create an automated monitoring process.

- Testing and Validation :
- Conducted functional testing of the sound sensor to ensure accurate noise detection.
- Tested the ESP32-CAM image capturing mechanism when honking events are detected.
- Evaluated system performance under different traffic scenarios to verify reliability and responsiveness.

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Phase 3: Deployment and System Evaluation

- System Development :
- Deployed the Hush-Traffic system prototype in a controlled traffic environment for demonstration purposes.
- Enabled continuous monitoring of noise levels and automatic image capture during excessive honking events.
- Ensured proper power supply and connectivity for stable system operation.

- Performance Evaluation :
- Monitored the system performance including noise detection accuracy, camera response time, and system reliability.
- Evaluated the ability of the system to detect repeated honking and capture vehicle images correctly.
- Analysed the collected data to assess the effectiveness of the system in monitoring traffic noise.

- Final Optimization :
- Optimized the sensor threshold values for improved honking detection accuracy.
- Enhanced the camera response mechanism for faster image capture during noise events.
- Improved system stability and prepared the final prototype for project demonstration and documentation.

F. Result

The developed Hush-Traffic system successfully implemented an IoT-based solution for monitoring traffic noise and detecting excessive honking in urban environments. The system integrated a sound sensor and ESP32-CAM module to continuously monitor environmental noise levels and capture vehicle images when abnormal honking activity was detected. During system operation, the sound sensor continuously measured surrounding noise levels in the traffic area. When the detected sound exceeded the predefined threshold value, the system identified it as excessive honking and automatically triggered the ESP32-CAM module to capture images of vehicles present in the monitored zone. This allowed the system to record traffic activity associated with high noise levels. The captured images and sensor readings demonstrated that the system could effectively detect repeated honking events and respond by activating the camera module in real time. The prototype was tested under different conditions to verify that the sound sensor accurately detected horn sounds while avoiding unnecessary triggers from normal environmental noise. Performance evaluation showed that the system responded quickly to honking events and successfully captured clear images during detection. The integration of embedded hardware, sensor technology, and camera monitoring enabled efficient detection of noise disturbances caused by traffic. Overall, the Hush-Traffic system demonstrated its potential as a low-cost and intelligent solution for monitoring traffic noise and reducing unnecessary honking, contributing to improved traffic discipline and quieter urban environments.

1) Results/ Outputs

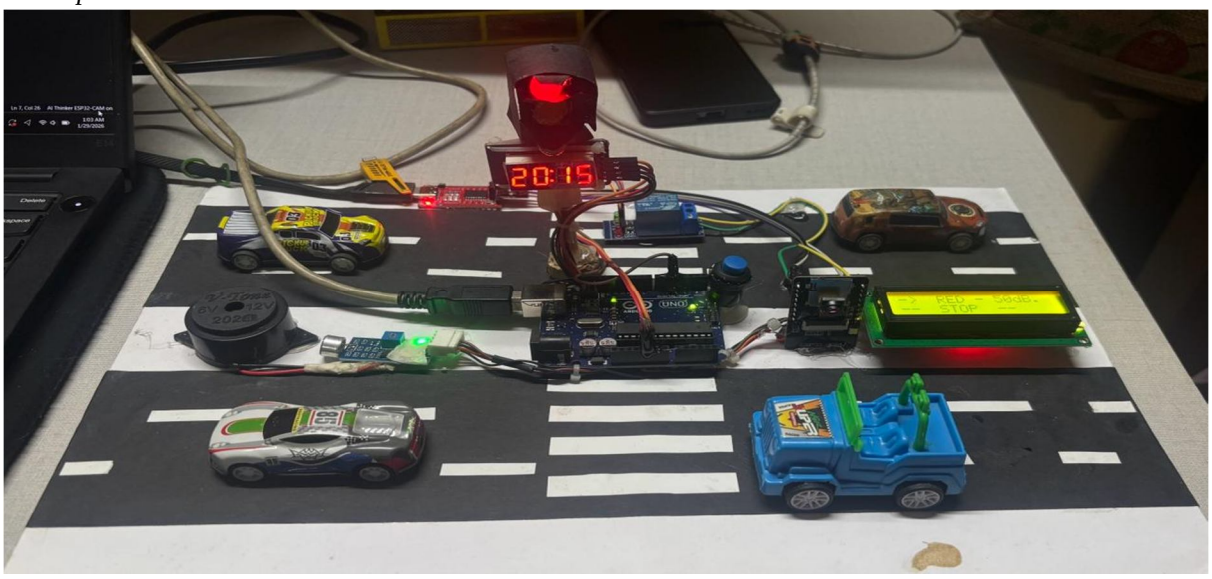


Figure. 2.1 – Implementation of the module

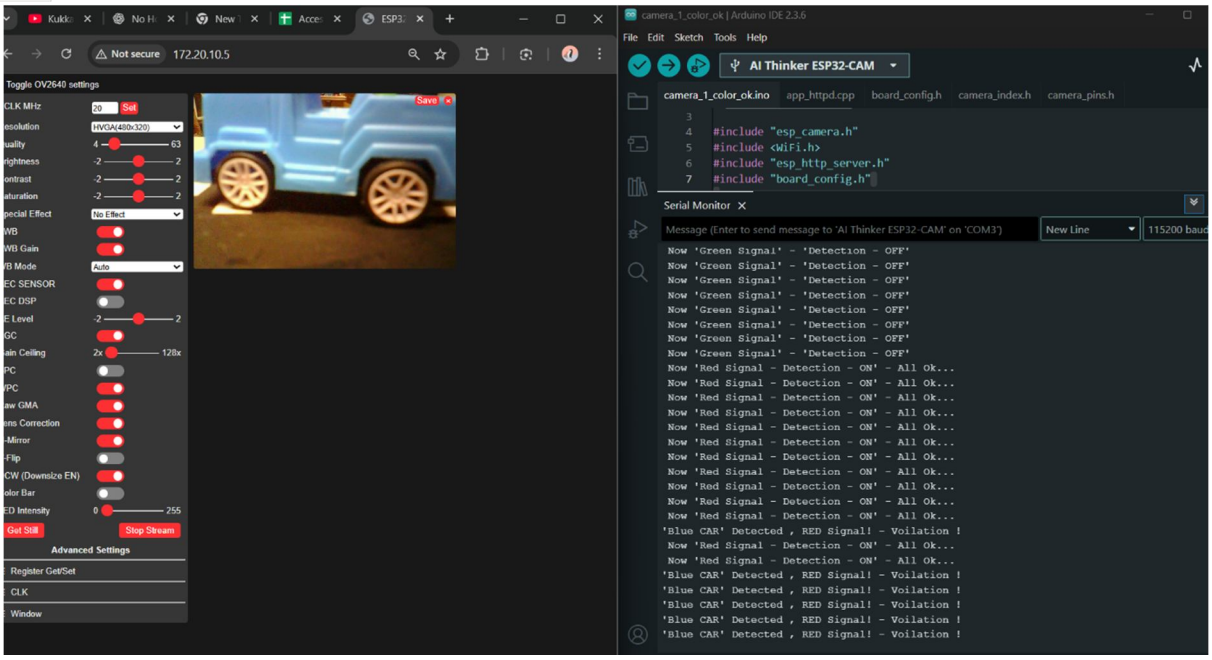


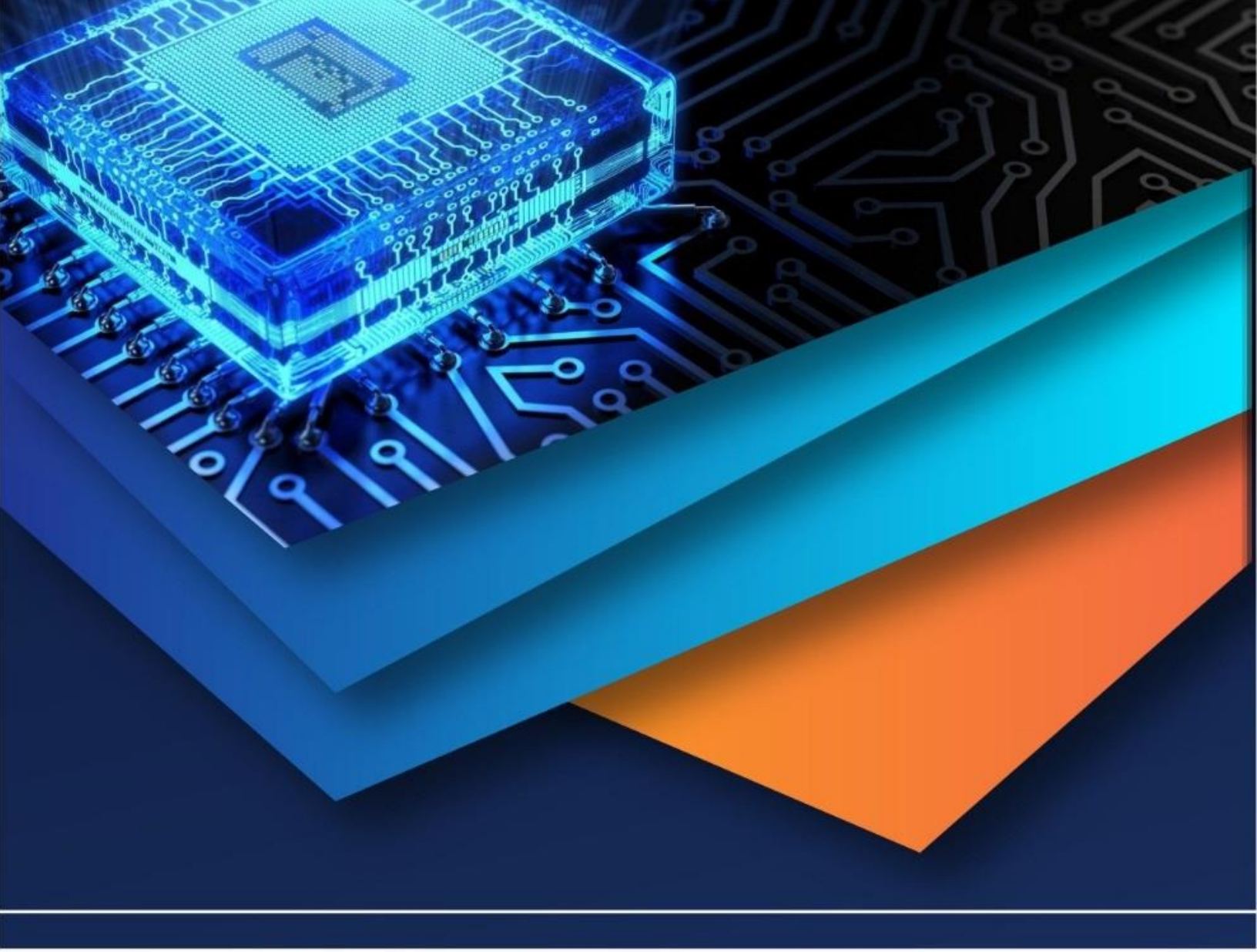
Figure. 2.2 – Web Browser Screen

III. CONCLUSION

The Hush-Traffic system provides an effective IoT-based solution for monitoring traffic noise and detecting excessive honking in urban environments. By integrating a sound sensor with the ESP32-CAM module, the system continuously monitors environmental noise levels and captures vehicle images when abnormal honking activity is detected, enabling automated traffic observation without constant manual supervision. The system helps address the growing problem of noise pollution caused by unnecessary honking, especially in crowded urban areas and sensitive zones such as hospitals and schools. The prototype demonstrated reliable performance in detecting honking events and activating the camera for image capture. Overall, the Hush-Traffic system shows the potential of IoT-based intelligent monitoring to improve traffic discipline, reduce noise pollution, and support smarter urban traffic management in future smart city environments.

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