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NOISESENS - A SYSTEM FOR IDENTIFYING NOISE OFFENDERS IN ROAD TRAFFIC

Ferdinand Fuhrmann[1*] **Richard Ladstädter**[1] **Martin Blass**[1]
Anna Maly[1] **Ana Gregorac**[1] **Franz Graf**[1]
[1] Institute for Digital Technologies, JOANNEUM RESEARCH, Austria

ABSTRACT

The increasing number of modified vehicles and the associated noise pollution have become significant issues in urban areas. In response, the NoiseSens project introduces a multimodal measurement system aimed at providing law enforcement with reliable tools to identify and track noise offenders in real-time. The system combines acoustic, visual, and thermal sensor technologies to capture and analyze noise events caused by modified vehicles. This paper presents the technical architecture, the system components, and the methodology for using the system in a mobile, real-time law enforcement application.

Keywords: *traffic monitoring, noise offenders, multimodal sensor processing, noise pollution*

1. INTRODUCTION

Over the past few years, illegal street racing and the widespread modification of vehicles for enhanced engine and exhaust sound have shown increased popularity in urban environments [1]. These loud and often dangerous activities have become a nuisance to communities and a serious concern for public safety [2]. While police forces struggle to maintain order and enforce noise regulations, current technological solutions for detecting and prosecuting noise offenses remain insufficient. The NoiseSens project offers an innovative solution to address this gap, providing law enforcement with a comprehensive system for identifying, tracking, and documenting noise offenders in road traffic.

2. RELATED WORK

Modern solutions have emerged that synergistically utilize multiple sensor types to detect and document noise disturbances.

The SoundVue Noise Camera System, developed by Intelligent Instruments, integrates sound level meters, microphone arrays, and number plate recognition cameras [3]. This combination allows for precise detection and documentation of noisy vehicles, supporting enforcement efforts without the immediate issuance of fines during trial periods. These system have been installed in New South Wales, Australia, to capture noisy vehicles involved in anti-social behavior. They have successfully identified numerous offenders, demonstrating the efficacy of combining acoustic detection with visual identification technologies [4].

MicroDB in France has presented a similar system. Here, microphone arrays and cameras are combined for two different application scenarios. First, the surveillance of traffic in urban settings and second, the application of the technology for dynamic noise control on motorsport racetracks [5].

3. SYSTEM OVERVIEW

NoiseSens is a mobile system designed to detect and document loud noise events from vehicles, particularly those resulting from modifications such as tuning. The system utilizes a combination of acoustic, visual, and thermal sensors to analyze the sound and track the vehicles involved in such events. This data is processed in real-time and presented to law enforcement officers through a user-friendly interface on a tablet or other mobile devices. The

[*] ***Corresponding author***: ferdinand.fuhrmann@joanneum.at.

system's mobile nature allows it to be deployed rapidly at various locations, ensuring flexibility in enforcement operations.

4. SYSTEM COMPONENTS

The NoiseSens system consists of several integrated components, which are distributed next to the road. Figure 1 illustrates the measurement setup.

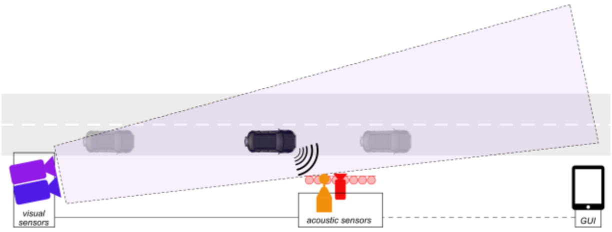

Figure 1. Measurement setup with distributed sensors next to the road.

Figure 1 shows the key components included in the presented system:

Acoustic Sensors: These sensors measure the noise levels produced by vehicles, capturing sound events with high precision. They include a Class-1 sound level meter, a 16-channel microphone array and a 360° surveillance camera. The latter two components form the acoustic camera, which visualizes the acoustic event onto the image. Figure 3 shows the acoustic sensors during measurements.
RGB-TIR Camera: The system includes an RGB camera paired with a thermal infrared (TIR) camera, offering a combined visual and thermal perspective for vehicle tracking, thermal event detection and vehicle identification via license plate recognition. Figure 2 shows the dual camera setup.
Router and Communication Interface: The system is connected through a central router, which facilitates communication between the sensors and the mobile devices. The router supports both cellular (4G/5G) and Wi-Fi connections, ensuring reliable data transmission even in challenging environments.
Tablet Interface: A tablet device, running a custom application, serves as the display unit for law enforcement officers. This interface provides real-time analysis of the sensor data, including noise levels, visual tracking of the noise source, and vehicle identification.

Figure 2. Visual sensors consisting of a synchronized RGB and TIR camera.

Figure 3. Acoustic sensors including the Class-1 sound level meter and the acoustic camera. The latter consists of a 2D-elliptic, 16 channel microphone array and a 360° camera.

5. SENSOR PROCESSING

Figure 4 illustrates the involved sensor processing. The NoiseSens system operates by first detecting an acoustic event, such as a loud engine noise or exhaust backfire, using the Class-1 sound level meter. Next, the acoustic camera visualizes the current sound scene by generating an acoustic heat-map, which is layered onto the image of the 360° camera. The system then triangulates the location of the noise event using geometric relationships derived from the microphone array. Concurrently, the RGB and thermal cameras evaluate the visual and thermal images for vehicle tracking and thermal analysis. The corresponding video buffer is analyzed to identify the vehicle and its license plate, providing the necessary evidence for law enforcement.

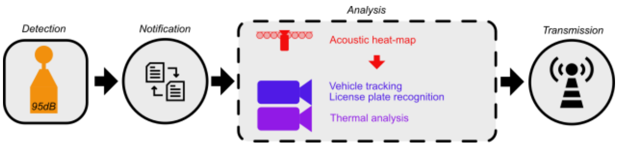

Figure 4. Sensor processing of the proposed system.

The resulting data is processed and transmitted to the mobile device, where officers can view a comprehensive report of the event, including:

- Visualization of the acoustic event (acoustic heat-map) at the event location (Figure 5) and estimation of the vehicle's emitted noise level.
- Visual confirmation of the noise source through the RGB (Figure 6 right) and Thermal camera.
- Tracking of the vehicle involved in the event using RGB video buffer data.
- License plate recognition for vehicle identification (Figure 6 left).

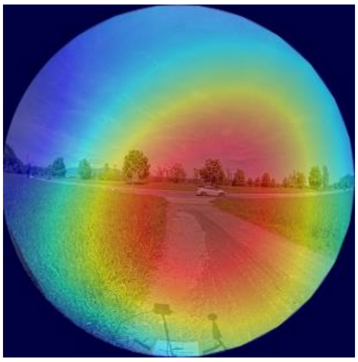

Figure 5. Acoustic heat-map of a car passing by. The emitted noise is visualized and can be assigned to the vehicle.

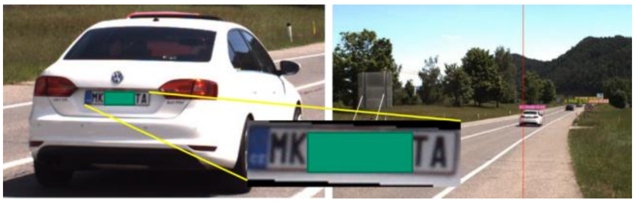

Figure 6. Results from the visual analysis of the sound event from Figure 5. The vehicle is detected in the corresponding RGB frame and identified by the license plate recognition.

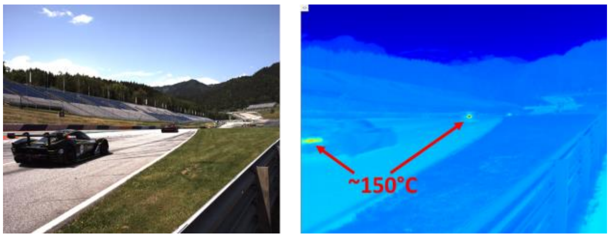

Figure 7. Synchronized RGB and TIR image. The calibrated thermal camera allows for absolute temperature measurements.

The system can function independently of external infrastructure through Wi-Fi connectivity or utilize cellular networks for broader coverage. This ensures operational flexibility in different environments, whether in urban areas with available cellular coverage or in remote locations where Wi-Fi may be the preferred method of communication.

6. DATA SECURITY & PRIVACY

All communications between the system components are encrypted via VPN (Virtual Private Network) to ensure secure data transmission. The collected sensor data is stored temporarily in a network-attached storage (NAS) device, only for as long as needed for analysis. If an event is deemed irrelevant or inconclusive, the data is promptly deleted to ensure privacy and compliance with data protection regulations.

7. CONCLUSIONS

The NoiseSens project represents a significant advancement in noise monitoring for traffic enforcement. By combining acoustic, visual, and thermal sensor technologies, it offers a robust solution for real-time detection, tracking, and documentation of noise pollution caused by road users. This system provides law enforcement agencies with the tools necessary to take effective action against illegal street racing and other noise disturbances, ensuring both public safety and environmental protection.

Future developments may include expanding the system's capabilities to monitor other environmental factors and enhancing its integration with broader law enforcement networks. The successful deployment of NoiseSens could serve as a model for other regions grappling with similar issues of noise pollution in urban environments.

8. ACKNOWLEDGMENTS

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