International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 12 Issue: 02 |Feb 2025 www.irjet.net p-ISSN: 2395-0072

A Review on Multi Sense Traffic Analyzer

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Abstract - *The growing challenges in urban traffic management necessitate innovative solutions that can enhance road safety, environmental sustainability, and law enforcement efficiency. The Multi-Sense Traffic Analyzer is a portable, all-in-one device designed to assist traffic police by integrating four essential functionalities: vehicle speed measurement using Doppler radar, alcohol detection through a high-sensitivity breath analyzer, carbon monoxide emission analysis, and CNG leak detection for safety. This device aims to provide a comprehensive solution to modern traffic enforcement challenges by combining multiple sensors in a single unit, offering real-time, accurate, and reliable data. The Multi-Sense Traffic Analyzer is intended to streamline traffic law enforcement, reduce accidents caused by speeding or intoxicated driving, and help control vehicle emissions, contributing to environmental protection. By offering a lightweight and user-friendly design, this system serves as a cost-effective, scalable solution for traffic management in urban environments, aligning with the goals of smart city initiatives. Through this project, the team aims to develop an innovative and socially responsible product that benefits public safety and contributes to building safer and more sustainable cities.*

Key Words*: *Multi-Sense Traffic Analyzer, Doppler Radar, Breath Analyzer, Carbon Monoxide Emission, CNG Leak Detection, Traffic Enforcement, Road Safety, Smart Cities

1.INTRODUCTION

Traffic management is an essential aspect of modern urban planning, ensuring smooth traffic flow and enhancing road safety. Over the years, various technologies have emerged to address the challenges of traffic monitoring, management, and enforcement. Sensor networks, for instance, have gained significant attention for their role in real-time traffic monitoring. These networks help detect and measure traffic conditions, providing critical data for efficient traffic management [1]. Additionally, traffic management systems have evolved significantly with the advent of real-time data processing, enabling more efficient management of vehicular movement [2]. The incorporation of these systems has sparked interest in classification models, which aim to assess traffic-related challenges while providing potential solutions [3].

In parallel, advancements in automated systems have made their way into traffic enforcement. One such innovation is the E-Challan system, designed for the online management of traffic rule violations and penalties, which has streamlined enforcement processes [4].Additionally, various technologies such as Doppler radar have been explored for their applications in measuring human walking speeds and vehicle speeds, crucial for safety in areas such as elderly care [5] and law enforcement [6]. These innovations have also been extended to enhance the accuracy and portability of radar systems used in traffic monitoring [7].

Another important aspect of traffic safety is pollution monitoring. The role of automated systems in monitoring carbon monoxide emissions from vehicles has been increasingly emphasized, as the environmental impact of automobiles continues to be a significant concern [9]. Alongside, the integration of breath analyzer technology into vehicles as part of alcohol detection systems has the potential to greatly reduce alcohol-related accidents on the road [11] [12]. Furthermore, the introduction of monitoring systems for compressed natural gas (CNG) vehicles addresses potential safety hazards linked to fuel leaks, thus promoting safer and more sustainable transportation [13].

Finally, the application of speed detection instruments continues to evolve. Various systems have been proposed for accurate and reliable vehicle speed measurement, ensuring that speed limits are adhered to for road safety purposes [14] [15]. These technologies provide essential data to help enforce speed regulations, ultimately enhancing traffic management and safety.

2. LITERATURE SURVEY

In cities experiencing rapid vehicle growth, traffic congestion and associated challenges like accidents, pollution, and health problems, pose significant challenges. Traffic management systems, designed to enhance efficiency and safety, gather data from diverse sources to identify and mitigate hazards effectively [1]. One approach uses wireless sensor networks for traffic monitoring, achieving high accuracy in vehicle detection and speed measurement [2]. Real-time traffic management mechanisms, such as adaptive scheduling and regulation, ensure efficiency under fluctuating network conditions [3]. Online platforms, like the E-Challan system, streamline traffic infraction management, enhancing user convenience while reducing manual processes and encouraging compliance with traffic laws [4].

This paper presents a human walking speed estimation algorithm utilizing Doppler radar for passive gait assessment in elderly adults, improving accuracy over traditional FFT methods [5]. The second study surveys recent developments in VHF and UHF Doppler radars for probing clear atmospheric conditions, offering insights into system design considerations [6]. A portable radar test system, designed for rapid deployment in battlefield scenarios, is introduced, providing a comprehensive approach to radar testing and evaluation [7]. The fourth study compares the accuracy of traffic data collection devices, highlighting the V-BOX GPS and automated traffic classifiers as the most accurate [8]. Hollman reports that the first mandated oxygenated fuels program in Colorado in 1988 resulted in an 8-11% reduction in carbon monoxide levels, though the Mobile3 modelling used to predict improvements has shown errors [9]. A Smart PUC Monitoring system was developed to measure CO concentration in vehicles. Using RFID, GSM modem, and microcontroller technology, the system tracks CO levels and flags vehicles with excessive emissions. This system promotes transparency, compliance with emissions standards, and mitigates the negative impacts of pollution and global warming [10]. Recent advancements in breath analyzer technology focus on enhancing usability, cost-effectiveness, and accuracy. A new prototype eliminates the mouthpiece, reduces expiration time, and employs infrared transmission spectroscopy to measure both alcohol and CO2 levels, compensating for sample dilution. Experimental results on sensitivity and resolution demonstrated promising outcomes, though further optimization is needed for improved performance [11]. A study on college students' drinking habits used the BACtrack Mobile Pro, a personal breathalyzer connected to a smartphone app, to explore responsible drinking behaviors. Based on the findings, a new system and app interface were designed to encourage safer drinking practices [12]. CNG vehicle fuel tank standards aim to minimize tank failures through fire exposure testing and the evaluation of pressurized tank failures. Some failures have occurred because fire exposure did not activate the Pressure Relief Devices (PRDs). Revisions to fire testing, thermal protection, and inspection practices are recommended to prevent these failures [13]. This study refines a method for measuring cosmological distances in AGN by using intrinsic brightness temperature, exploring how future observations could improve the accuracy of cosmological parameters based on flare data [14]. The study also examines the performance of MQ-2 and MQ-6 gas sensors with an Arduino system for LPG leak detection. Both sensors had similar response times, but MQ-6 showed greater sensitivity with higher ppm values. The optimal sensor placement for accurate detection was found to be between 20 cm and 40 cm from the gas source. These findings indicate that while both sensors can effectively detect LPG gas, MQ-6 provides better sensitivity, making it a more reliable choice for practical applications. this is the input [15].

3. Problem Statement

The rapid growth in urbanization and increasing numbers of vehicles, managing traffic, ensuring road safety, and keeping the environment clean have become much harder. The tools currently used by traffic police are often large, designed to do only one specific job, and not very efficient. This makes it difficult for officers to handle their work effectively and deal with all the challenges they face on the road. Traffic police require a modern, efficient, and integrated solution to address critical issues such as:

- 1.Enforcing speed limits to reduce accidents caused by speeding.
- 2.Identifying intoxicated drivers to prevent alcohol-related road incidents.
- 3.Monitoring vehicular carbon monoxide emissions to ensure compliance with environmental regulations.
- 4.Detecting CNG (Compressed Natural Gas) leaks to enhance vehicle and public safety.

The Multi Sense Traffic Analyzer aims to solve this problem by developing a lightweight, portable, and user-friendly device that integrates four key functionalities: vehicle speed measurement using image processing, alcohol detection via a breath analyzer, carbon monoxide emission analysis, and CNG leak detection using advanced sensors. This solution will empower traffic officers to carry out their duties efficiently, improving road safety, environmental compliance, and overall urban traffic management.

4. Methodology

4.1 Design and Integration

The initial step in developing the portable all-in-one traffic gadget involves creating a compact and integrated design. The device aims to combine multiple functionalities, including speed measurement, alcohol detection, carbon monoxide monitoring, and CNG leak detection. To achieve this, the design must focus on a speed monitoring by image processing, a breath analyzer, a carbon monoxide sensor, and a CNG leak detector into a single, portable unit.

Component Selection:

Careful selection of components is critical to the performance and reliability of the gadget. High-quality sensors with proven accuracy and durability are chosen. Compatibility between these sensors is ensured to facilitate seamless data integration. Additional considerations include the size and weight of components, as the device's portability is a key design requirement. Power efficiency is also prioritized to ensure prolonged field use.

4.2 Prototype Development

Hardware Assembly:

In the prototype stage, the selected sensors and components are physically assembled into a durable casing. This casing is designed to withstand field conditions, including potential drops or environmental stressors. The layout of the components within the casing ensures minimal interference between sensors and optimizes accessibility for both users and maintenance purposes. Lightweight but robust materials, such as reinforced polymers or aluminum alloys, are used to construct the casing.

Software Development:

The software aspect of the device involves developing an interface that processes and displays real-time sensor data.

- Data integration from all sensors.
- Real-time alerts and feedback to the user.
- An intuitive graphical interface, possibly with touchscreen capabilities, to ensure easy navigation.
- Support for data logging and export for further analysis. The software is built with modularity in mind to allow for future updates and integration of additional features.

4.3 Testing

Functional Testing:

Each component of the gadget undergoes functional testing. This involves verifying that the image processing accurately measures vehicle speed, the breath analyzer reliably detects alcohol levels, the carbon monoxide sensor provides precise readings, and the CNG leak detector identifies gas leaks within safety thresholds. These tests ensure individual sensor accuracy and reliability.

Calibration:

After initial functional testing, the sensors are calibrated to ensure precision. For example:

- The breath analyzer is calibrated against standard alcohol concentration levels.
- The carbon monoxide sensor and CNG leak detector are tested against controlled concentrations of gases. The calibration process involves adjusting sensor settings and recalibrating as needed based on observed discrepancies.

4.4 Components:

- Speed monitoring by image processing

Speed monitoring through image processing uses a camera to capture images or video of vehicles. The system analyses these images to calculate the vehicle's speed by measuring the time it takes to travel between two points of known distance.

- MQ3 Sensor for Alcohol Detection

The MQ3 sensor is a gas sensor is used to detect alcohol in the air. It uses a sensitive semiconductor layer that reacts to alcohol molecules, causing changes in its electrical conductivity.

- MQ4 Sensor for CNG Detection

The MQ4 sensor is a gas sensor designed to detect methane (CH_4) and CNG in the air. It uses a sensitive semiconductor layer that changes its conductivity based on the presence of these gases.

- MQ5 Sensor for LPG Detection

The MQ5 sensor is a gas sensor designed to detect liquefied petroleum gas (LPG), as well as methane and natural gas. It operates using a sensitive semiconductor layer that changes its conductivity when exposed to these gases.

- MQ7 Sensor for Carbon Monoxide (CO) Detection

The MQ7 sensor is designed to detect carbon monoxide (CO) gas. It uses a semiconductor layer that reacts to CO, changing its electrical conductivity based on the gas concentration.

- MiCS-6814 Sensor for NO, NO_2, and NH_3 Detection

The MiCS-6814 is a multi-gas sensor that detects nitrogen oxide (NO), nitrogen dioxide (NO_2), and ammonia (NH_3). It uses multiple sensing elements on a semiconductor layer to identify and measure these gases.

4.5 Field Trials

A series of field trials is conducted to evaluate the prototype in real-world scenarios. These trials involve collaborating with traffic officers, who use the device in various situations, including speed monitoring, roadside breath tests, and air quality checks. Feedback is collected regarding performance, accuracy, and usability.

4.6 Finalization

Design Finalization:

Incorporating insights from field trials and further testing, the device design is finalized. Key considerations include portability, durability, accuracy, and ease of use. The final

design is documented in detail, covering specifications for components, hardware layout, and software functionality.

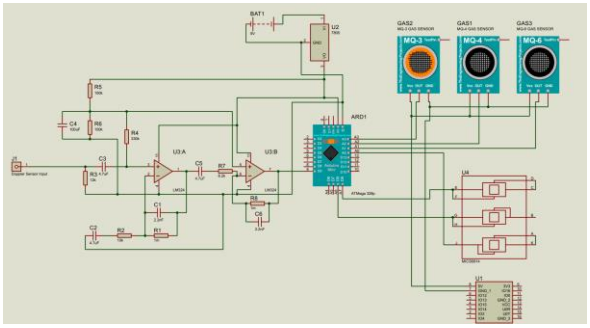

Figure. 1.1 Circuit Diagram

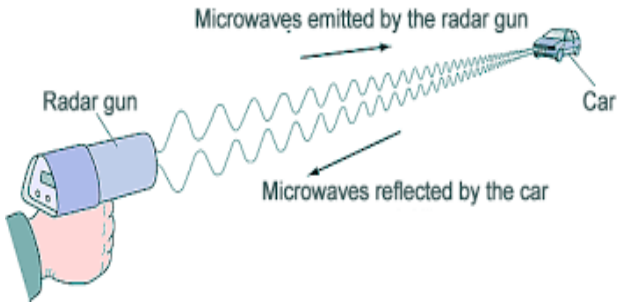

Figure. 1.2 Doppler Radar Effect

A Doppler radar is a specialized radar that uses the Doppler effect to produce velocity& direction data about objects at a distance. It does this by bouncing a microwave signal off a desired target and analyzing how the object's motion has altered the frequency of the returned signal. This variation gives direct and highly accurate measurements of the radial component of a target's velocity relative to the radar. The term applies to radar systems in many domains like aviation, police radar detectors, navigation, meteorology, etc.

The emitted signal toward the car is reflected back with a variation of frequency that depends on the speed away/toward the radar.

v= (f (change in frequency)/f) * (c/2)

where: f-transmitted frequency, c-speed of light

5.EXPECTED OUTCOMES

- Vehicle Speed Measurement: The device will accurately measure vehicle speed, making traffic enforcement more effective and helping to reduce accidents by addressing speeding. This will also aid in better traffic management and decision making. Enhanced speed detection will support improved compliance with traffic laws and safer road conditions. Accurate speed data will contribute to better traffic flow and accident prevention strategies.

- Alcohol Detection: It will reliably detect alcohol, helping to identify impaired drivers and prevent accidents caused by drunk driving. The system will work consistently in various conditions, promoting road safety and encouraging compliance with alcohol limits. Increased detection accuracy will help law enforcement take timely action against impaired drivers. The device will support public safety initiatives and contribute to overall road safety.

- Carbon Monoxide Emission Monitoring: The device will track carbon monoxide emissions to ensure vehicles meet environmental standards and reduce their impact on air quality. This will help enforce emission rules and support cleaner air. Accurate monitoring will aid in identifying vehicles that exceed emission limits and need attention. The device will also provide valuable data for environmental policies and pollution control efforts.

- Leak Detection: CNG It will detect CNG leaks quickly, preventing potential dangers like fires or explosions and improving safety for CNG vehicles. Real-time alerts will allow for immediate action to address leaks.

- Usability and Design: The device will be lightweight and easy to use, making it convenient for traffic police to operate. With real-time data analysis, it will help make quick decisions and improve overall traffic safety. Enhanced detection will ensure safer operation of CNG-powered vehicles in urban environments. The device will contribute to overall safety and help avoid hazardous situations related to CNG leaks. Cost-

- Effectiveness and Integration: By combining multiple sensors into one affordable device, it will be a practical solution for traffic management. This will encourage wider use by different agencies and support smart city projects with advanced monitoring and data collection. The cost-effective design will make it accessible to more organizations and improve traffic safety on a larger scale. Integration of various sensors will provide a comprehensive solution for modern traffic management needs.

CONCLUSIONS

There are many ways in which these techniques can achieve the same result. The Multi-Sense Traffic Analyzer will be used to detect the speed of vehicles, breath alcohol content, flammable gases like CNG and LPG (commonly used as fuel alternatives in cars), and air pollutants like CO, NO_2, and NH_3.

Instead of Doppler, we can also use image processing to detect the speed of vehicles. However, to achieve more efficient results, we used the Doppler technique. This technique can provide an appropriate solution to the current requirements and issues faced by traffic police.

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