Smart Traffic Monitoring Device for Accident Detection and Automated Traffic Violation Management

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***Abstract*—Rapid growth in vehicular population has intensified problems related to road safety, traffic congestion, and enforcement of traffic regulations. Conventional traffic monitoring systems depend largely on roadside infrastructure and manual policing, resulting in delayed detection of accidents and traffic violations. This paper presents a smart traffic monitoring system based on a tyre-mounted sensing device integrated with a centralized server. The device continuously collects GPS location and motion data, which are analyzed using Keyhole Markup Language (KML) based road mapping. Traffic violations such as wrong-way driving, overspeeding, illegal parking, accidents, and congestion are identified automatically. In the event of an accident, emergency alerts containing vehicle identification details and precise location information are transmitted to nearby police stations and hospitals. Integration with local traffic surveillance cameras provides photographic evidence for violations such as no seat belt usage, helmet violations, mobile phone usage, and signal jumping. Performance evaluation demonstrates that the proposed system improves detection accuracy, reduces emergency response time, and supports intelligent transportation and smart city traffic management**

***Index Terms*—Smart Traffic Monitoring, Tyre-Mounted Sensor, GPS and KML Mapping, Accident Detection, Intelligent Transportation System**

I. INTRODUCTION

The continuous increase in vehicle ownership due to urbanization, economic development, and improved mobility has significantly increased pressure on existing road infrastructure. As a result, road safety, traffic congestion, and effective enforcement of traffic regulations have emerged as major concerns for transportation authorities. Traffic accidents remain one of the leading causes of fatalities and economic losses, especially in urban and semi-urban areas. Delayed accident detection and slow emergency response further increase the severity of injuries and damage.

Conventional traffic monitoring systems mainly depend on roadside infrastructure such as surveillance cameras, traffic signals, and manual patrolling. While these systems provide limited monitoring capabilities, they are constrained by high installation and maintenance costs, restricted coverage, and dependence on human intervention. Recent advancements in embedded systems, Global Positioning System (GPS), and wireless communication have created opportunities for vehicle-based traffic monitoring solutions. Vehicle-mounted systems enable continuous data collection regardless of location and time. However, many existing systems depend on factory-installed sensors, limiting their applicability across different vehicle types. This research addresses these limitations by proposing a tyre-mounted smart traffic monitoring device that operates independently while integrating with centralized server analytics.

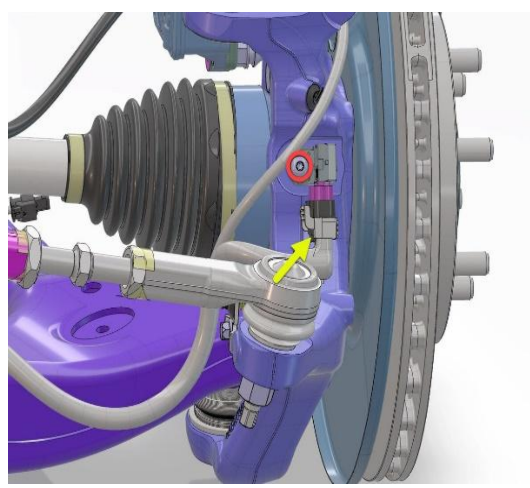

Fig. 1. Installation of tyre-mounted smart traffic monitoring device

.II. SYSTEM OPERATION PROCEDURE

The proposed smart traffic monitoring system follows a systematic procedure consisting of vehicle data collection, centralized processing, violation detection, and alert generation. The overall procedure is described step by step as follows.

1. the smart traffic monitoring device is mounted near the vehicle tyre to capture wheel motion, vibration, speed, and impact-related parameters. The device is powered on and initialized with vehicle identification details. A GPS module continuously acquires real-time location coordinates, while motion and impact sensors monitor vehicle dynamics.

2. The collected GPS and sensor data are transmitted to a centralized server using wireless communication at regular time intervals or immediately when abnormal events occur. Basic preprocessing is performed to remove noise and invalid data.

3. The server maps the received GPS coordinates to predefined road networks stored in Keyhole Markup Language (KML) format. Road direction, speed limits, parking zones, and restricted areas are extracted from the mapped data.

4. Rule-based algorithms are applied to detect traffic violations such as wrong-way driving, overspeeding, illegal parking, and congestion. Accident detection is performed by identifying sudden acceleration changes combined with abrupt speed reduction.

Finally, upon confirmation of accidents or violations, automated alerts are generated. Accident alerts containing vehicle identification details and location information are transmitted to nearby police stations and hospitals. For traffic violations, relevant data are logged and shared with enforcement systems, including local traffic surveillance cameras, to enable photographic evidence collection and fine generation

III. RESEARCH METHODOLOGY

The research methodology begins with the installation of the tyre-mounted smart traffic monitoring device on selected vehicles. The device continuously collects GPS coordinates and motion sensor data at fixed intervals. Raw sensor data are filtered to remove noise and erroneous readings before transmission to the centralized server.

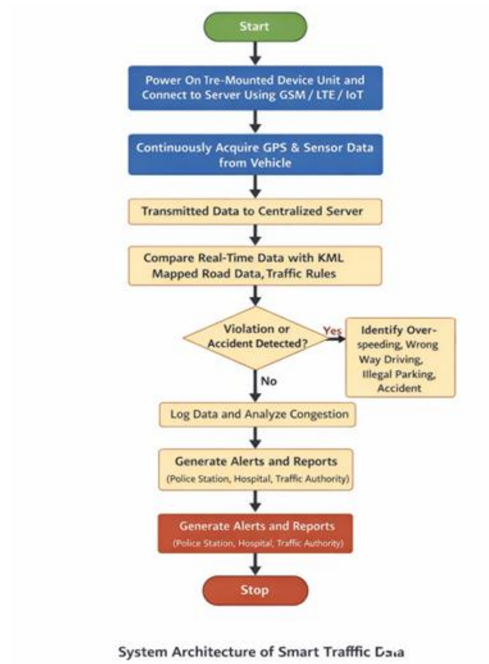

Fig. 3. Flowchart of the proposed research methodology

At the server, incoming GPS coordinates are matched with road segments defined in KML files. Vehicle direction, speed, and stoppage duration are computed from successive GPS points. Rule-based algorithms are applied to detect wrong-way driving, over speeding, and illegal parking. Accident detection is carried out by analyzing sudden spikes in acceleration and vibration combined with abrupt speed reduction. Once an accident is confirmed, automated alerts containing vehicle registration number, identification details, and precise location are transmitted to nearby police stations and hospitals.

For enforcement validation, the system communicates event details to nearby traffic surveillance cameras. Captured images provide evidence for violations such as no seat belt usage, helmet violations, mobile phone usage, signal jumping, lane violations, and suspected drink-and-drive cases. All events are logged for reporting and fine generation.

IV. OBSERVATIONS AND RESULT

The smart traffic monitoring system operated reliably under different traffic conditions. The tyre-mounted device accurately captured vehicle motion and speed data, while GPS tracking provided consistent location information. Road direction mapping using KML data enabled correct detection of wrong-way driving and overspeeding events. Illegal parking was identified effectively based on vehicle stoppage duration and location.

Accident detection was achieved by combining impact sensor readings with sudden speed reduction, resulting in timely and accurate alerts. Automatic notifications sent to nearby police stations and hospitals reduced response time compared to conventional reporting methods. Integration with traffic surveillance cameras supported visual verification of detected violations. Overall, the system demonstrated improved accuracy, faster response, and suitability for practical traffic monitoring applications.

V. CONCLUSION

This paper presented a smart traffic monitoring system based on a tyre mounted sensing device integrated with a centralized server. The system effectively monitors vehicle movement using GPS and sensor data to detect traffic violations such as wrong-way driving, over speeding, illegal parking, and accidents. The use of KML-based road mapping improves violation identification by accurately correlating vehicle paths with road geometry. Automated accident alerts sent to nearby police stations and hospitals significantly reduce response time. Integration with traffic surveillance cameras provides visual evidence, enhancing enforcement reliability and transparency. The proposed system offers a scalable, cost-effective solution for intelligent traffic management and smart city applications.

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