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IoT-Based Alcohol Detection and Prototype Vehicle-to-Vehicle Communication System for Enhanced Road Safety: A Survey

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Abstract: *Alcohol-impaired driving remains an important road-safety concern because an unsafe driver can create a risk not only for the occupants of the vehicle but also for other road users. Conventional detection methods such as roadside checks and breath testing are generally performed after a vehicle is already on the road. IoT-based sensing provides another approach in which alcohol levels can be monitored continuously using an embedded sensor. This survey examines recent research related to IoT-based alcohol detection, Vehicle-to-Vehicle (V2V) communication, Vehicular Ad Hoc Networks (VANETs), and intelligent transportation systems. The reviewed studies were compared with respect to their sensing methods, communication technologies, hardware platforms, security approaches, and limitations. The comparison shows that alcohol detection and vehicular communication are commonly investigated as separate problems. Based on this observation, the survey considers a low-cost prototype approach in which an MQ-3 alcohol sensor and an ESP32 microcontroller are used for impairment detection and wireless warning transmission. A threshold-based decision rule is considered for classifying the vehicle condition, after which a warning can be communicated to nearby prototype vehicles. The survey also discusses the limitations of existing approaches and identifies possible directions for extending such systems toward more capable connected-vehicle safety applications.*

Key Words: IoT-Based Driver Safety, Alcohol Detection System, Vehicle-to-Vehicle Communication, Intelligent Transportation Systems, VANET, ESP32, Road Safety, Connected Vehicles

1. INTRODUCTION

Road safety has become an important area of research as the number of vehicles and the complexity of transportation networks continue to increase. Alcohol-impaired driving is one of the conditions that can significantly affect a driver's ability to respond to road situations. Traditional methods for identifying intoxicated drivers include roadside inspections and breath-based testing. Although these methods are useful, they do not provide continuous monitoring while a vehicle is being operated.

The Internet of Things (IoT) has made it possible to develop vehicle-monitoring systems using sensors and compact embedded controllers. A sensor installed inside a vehicle can collect information about the surrounding condition, while a microcontroller can process the readings and initiate an appropriate response. Such systems are attractive for prototype development because the sensing and processing hardware can be relatively compact and inexpensive.

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Another development in intelligent transportation is communication between vehicles. V2V communication allows information about road conditions or safety events to be exchanged among nearby vehicles. Technologies used for connected-vehicle communication include DSRC, IEEE 802.11p and C-V2X, while lightweight wireless technologies can also be used for demonstrating the concept in prototype environments. Sharing safety information can provide approaching vehicles with additional time to respond to a possible hazard.

The literature reviewed in this survey covers both of these areas. Several studies investigate alcohol detection or driver monitoring, while another group focuses on V2V communication, VANET security, trust management, and related intelligent transportation technologies. These studies show that considerable progress has been made in individual parts of the problem. However, the combination of alcohol detection and warning dissemination to nearby vehicles is less commonly addressed, particularly on a low-cost embedded platform.

This survey therefore examines the recent research surrounding IoT-based alcohol detection and connected-vehicle communication. The objective is to compare the approaches reported in the literature, identify their major limitations, and examine the scope for combining sensing and prototype V2V communication. The discussion provides the background for a prototype framework based on an MQ-3 alcohol sensor and ESP32 hardware.

A. Problem Statement

Existing alcohol-detection systems generally generate an alert within the vehicle in which the sensor is installed. Such an alert can inform the driver, but it does not necessarily provide information to nearby vehicles. At the other end, advanced V2V communication technologies provide mechanisms for exchanging safety messages but may require infrastructure and hardware that are unsuitable for a small academic prototype. This creates a requirement for a simple embedded approach that can detect an unsafe alcohol level and communicate a corresponding warning to nearby prototype vehicles without relying on expensive vehicular infrastructure.

B. Objectives

- To examine recent IoT-based approaches for alcohol detection and driver safety.
- To study communication techniques used for exchanging safety information between vehicles.
- To compare the hardware, methodologies, communication technologies, advantages, and limitations reported in the selected literature.
- To identify the research gap between impaired-driving detection and prototype V2V warning systems.
- To examine the feasibility of combining alcohol sensing and low-cost wireless communication on an embedded platform.

II. RELATED WORK

The literature surrounding connected-vehicle safety covers several different technical directions. Some studies concentrate on detecting unsafe conditions within an individual vehicle, while others focus on communication between vehicles or on protecting the information exchanged through vehicular networks. These areas are relevant to the present study because an effective safety system needs both reliable detection and a mechanism for sharing the resulting warning.

One commonly investigated approach is the use of IoT hardware for alcohol detection. In such systems, a sensing unit measures the alcohol level and an embedded controller interprets the resulting signal. A warning can then be produced when the measured value reaches a predefined level. The main attraction of this approach is its relatively simple hardware and the possibility of continuous monitoring. A limitation becomes apparent when the warning is restricted to the vehicle in which the sensor is installed. Other vehicles travelling nearby may remain unaware of the detected risk.

Communication between vehicles has been investigated separately in a number of studies. V2V and related vehicular-network technologies allow safety information to move from one vehicle to another. The reviewed work considers technologies such as DSRC, C-V2X, IEEE 802.11p and ESP-NOW for this purpose. Their applications differ, but the

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common idea is to allow vehicles to obtain information that is not available from their own sensors. For a laboratory or academic prototype, however, the infrastructure and hardware associated with full-scale vehicular communication can be difficult to reproduce at low cost.

Security introduces another layer to the problem. A vehicle receiving a message from another vehicle needs some way of determining whether that information can be trusted. The surveyed research therefore includes trust-management methods, blockchain-assisted authentication and machine-learning techniques for detecting abnormal or malicious behaviour in VANETs. These approaches address important security concerns, although their additional computation and communication requirements have to be considered when designing a resource-constrained embedded system.

Intelligent transportation research has also made use of machine-learning and deep-learning methods. The applications represented in the surveyed papers include driver monitoring, accident-related analysis, anomaly detection and traffic management. Such techniques can handle more complex patterns than a simple threshold rule, but their practical use depends on factors such as training data, processing capability and system complexity. These requirements can be significant when the intended platform is a small embedded controller.

The comparison of these studies reveals a useful distinction. Detection-oriented systems mainly answer the question of whether an unsafe condition exists, whereas communication-oriented systems concentrate on how information is delivered to other vehicles. Security studies address whether that information should be trusted. Bringing these three concerns together does not require all of the advanced techniques used in large-scale vehicular networks. For a prototype, a simpler combination can be explored: an alcohol sensor can provide the input, an ESP32 can perform the decision and communication tasks, and a wireless link can carry a warning to nearby prototype vehicles. This forms the specific research direction considered in the present survey.

III. METHODOLOGY

The survey was developed by examining research published between 2020 and 2026 in areas connected with IoT-based driver safety and vehicular communication. The search covered IEEE Xplore, Springer, ScienceDirect and Google Scholar. The intention was not to study only alcohol-detection hardware, but to understand how sensing, communication and security have been addressed across related intelligent-transportation research.

The collected publications were first grouped according to their main technical focus. One group covered IoT and alcohol-detection applications. Other groups dealt with V2V communication, VANETs, intelligent transportation systems, trust management, blockchain-based security, edge computing and machine-learning approaches. This grouping provided a convenient way to compare studies that solve different parts of the broader vehicle-safety problem.

For every paper considered in the survey, the main contribution was examined along with the method used to achieve it. Attention was given to the hardware involved, the communication technology, the advantages reported by the authors and the limitations associated with the approach. Possible directions for further development were also recorded where they were discussed in the source paper.

The comparison was then used to identify what is already well covered and what remains less explored. In particular, the review was used to examine whether alcohol detection and communication with surrounding vehicles are being implemented together on inexpensive embedded platforms. This final comparison provides the basis for the research direction followed by the proposed prototype.

A. Literature Selection

The search terms were chosen from the main concepts represented in the project. The following keywords were used in different combinations:

IoT-Based Driver Safety
Alcohol Detection System
Vehicle-to-Vehicle Communication
Intelligent Transportation Systems

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VANET
ESP32
Road Safety
Connected Vehicles

Journal and conference publications relevant to these subjects were considered for the survey. The review focused on research that could contribute directly to the understanding of impaired-driving detection, connected vehicles, communication, or related vehicle-safety mechanisms.

B. Literature Analysis

The selected papers were compared using a common set of observations so that their contributions could be discussed consistently. These observations included:

purpose of the study
technique or methodology adopted
hardware platform
communication method
reported advantages
reported limitations
possible future developments

The resulting comparison was used to locate the gap addressed by this survey: the limited integration of real-time alcohol detection and prototype V2V warning on an affordable embedded platform.

IV. MATHEMATICAL FORMULATION

A threshold-based decision rule is considered for the alcohol-detection process. The MQ-3 sensor provides a reading corresponding to the alcohol level detected inside the vehicle. This value is supplied to the ESP32 controller, where it is compared with a predefined threshold.

Let:

S = alcohol sensor reading obtained from the MQ-3 sensor
T = predefined threshold value
R = resulting vehicle status

The vehicle status can be represented as:

$$R = SAFE, \ if \ S < T$$
$$R = HIGH\text{-}RISK, \ if \ S \geq T \quad (1)$$

When the sensor reading is lower than the selected threshold, the vehicle is considered to be in the SAFE state. If the reading reaches or exceeds the threshold, the status changes to HIGH-RISK. The corresponding local warning can then be activated and a warning message can be transmitted to nearby prototype vehicles through the ESP32-based communication link.

The model requires only a comparison between the sensor reading and a predefined value. This makes the decision process suitable for a resource-constrained embedded controller and allows the detection result to be generated without the computational requirements of a trained machine-learning model.

V. DISCUSSION

The studies considered in this survey cover several aspects of connected-vehicle safety. IoT-based approaches provide a practical means of collecting information from a vehicle, while V2V communication provides a way of sharing safety information with surrounding vehicles. Other studies address the reliability and security of vehicular communication through trust management, blockchain mechanisms, and machine-learning-based detection techniques.

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The comparison also shows that these functions are often developed independently. Alcohol-detection research generally concentrates on sensing and generating a local response. Communication-oriented studies, in contrast, investigate message exchange, network performance, or security. This separation leaves room for systems in which the output of an impairment-detection mechanism becomes the input to a vehicular warning mechanism.

For a prototype implementation, an ESP32 provides a practical embedded platform because it can interface with the sensor and support wireless communication within the same system. A threshold-based decision mechanism also keeps the processing requirements relatively low. The resulting arrangement can demonstrate the basic operation of impaired-driving detection followed by a warning to nearby prototype vehicles, while leaving more advanced communication and security mechanisms for future development.

The reviewed literature therefore supports further investigation of integrated vehicle-safety systems rather than treating sensing and communication as completely separate components. Such integration could provide a foundation for more advanced connected-vehicle safety applications.

VI. FUTURE SCOPE

The present prototype can be extended in several ways as the system is developed further. A GPS module could be incorporated so that the position of a vehicle generating a warning is available along with the safety message. This would be useful when the location of a high-risk vehicle needs to be identified.

The communication layer is another area for improvement. The current prototype is intended to demonstrate the V2V concept using ESP32-based wireless communication. A future implementation could investigate technologies such as 5G or C-V2X when greater coverage, scalability and compatibility with real vehicular networks are required.

The decision mechanism could also be made more adaptive. With a sufficiently large experimental dataset, machine-learning methods could be studied to complement the threshold-based approach and distinguish different driving-risk conditions more effectively. A cloud component could additionally be introduced for storing historical measurements and supporting data analysis.

Security should receive greater attention as communication moves beyond a small prototype. Trust-management mechanisms and blockchain-assisted authentication are possible directions for protecting exchanged messages and reducing the possibility of false information being accepted by participating vehicles.

VII. CONCLUSION

The literature reviewed in this study shows that vehicle safety research is moving toward systems that can sense hazardous conditions and share useful information with other vehicles. Alcohol detection, vehicular communication, network security, and intelligent transportation have each received considerable attention, but they are often studied as separate components.

For the specific problem considered here, an MQ-3 sensor can provide the alcohol-related input while an ESP32 can handle the decision process and wireless communication. A threshold-based approach keeps the prototype simple and allows a warning to be generated when the measured value crosses the selected limit. The warning can then be exchanged with nearby prototype vehicles to demonstrate the basic V2V safety concept.

The proposed direction is intended as a prototype rather than a replacement for standardized automotive V2V technology. Its value lies in demonstrating how sensing and vehicle communication can be combined using accessible hardware. Future development can build on this foundation by considering wider communication coverage, stronger security, location information, and more adaptive detection techniques.

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