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Wi-Fi Based Vehicle to Vehicle Communication

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Abstract: Roadway crashes remain a significant contributor to fatalities and serious injuries globally. A primary factor in these incidents is the time lag in driver reaction, coupled with issues like poor visibility, impaired driving, and the absence of immediate information sharing between vehicles. Vehicle-to-Vehicle (V2V) communication is a cutting-edge Intelligent Transportation System (ITS) technology designed to allow vehicles to autonomously exchange critical safety data to prevent collisions. This research details the development and practical implementation of a V2V communication platform utilizing Wi-Fi and ESP8266 microcontrollers, augmented by multiple sensors, to bolster road safety.
Keywords: Vehicle-to-Vehicle communication, ESP8266, Wi-Fi, road safety, intelligent transportation system.

I. INTRODUCTION

Traffic accidents represent one of the most pressing challenges in contemporary transport networks, especially in developing regions where vehicle density is rising rapidly and safety compliance is often lacking. A majority of these crashes can be attributed to human factors, including speeding, impaired driving, inattentiveness, and delayed response to sudden roadway hazards. Conventional safety features, like seat belts and airbags, are primarily designed to mitigate accident severity after impact, but they do not actively prevent the incident. Consequently, there is an urgent and increasing demand for proactive safety systems capable of anticipating and avoiding potential collisions. V2V communication establishes a direct, short-range wireless link between vehicles, facilitating the exchange of dynamic data such as speed, precise location, braking status, and immediate hazard notifications.

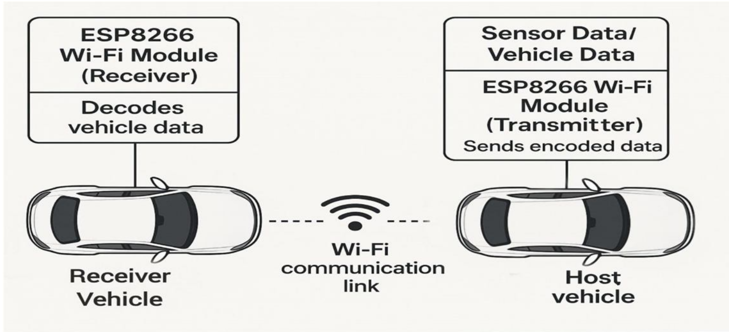
II. OBJECTIVE

The main objective of our project is to

1) To develop a low-cost Wi-Fi-based V2V communication system using ESP8266 modules.
2) To detect road hazards in real time using ultrasonic, vibration, and alcohol sensors.
3) To transmit safety alerts instantly between vehicles without internet dependency.
4) To provide clear visual and audible warnings to improve driver reaction time.
5) To evaluate communication range, delay, and reliability in short-distance vehicle scenarios.
6) To demonstrate Wi-Fi as an affordable alternative for basic ITS safety applications.
7) To build a system architecture that can be expanded for multi-vehicle and V2I communication.

III. RESEARCH METHODOLOGY

The methodology adopted for the Wi-Fi–based Vehicle-to-Vehicle (V2V) communication system focuses on enabling continuous detection of hazardous conditions and reliable transmission of safety alerts between two moving vehicles. The process begins in the host vehicle, where multiple sensors—such as ultrasonic, vibration, and alcohol sensors—continuously monitor the environment and driving behaviour. Each sensor generates real-time data that is fed into the ESP8266 Wi-Fi module, which serves as the central processing unit. The module evaluates these sensor readings by comparing them with predefined threshold values to determine if any unsafe condition has occurred, such as a nearby obstacle, collision impact, or alcohol presence. Once a hazard is identified, the ESP8266 encodes the event into a structured alert message and prepares it for wireless transmission. The encoded data is then sent through a direct Wi-Fi communication link established between the two vehicles, eliminating the need for internet connectivity or the external network infrastructure.On the receiving side, another ESP8266 module is configured to operate in a continuous listening mode, ensuring that all incoming messages from the host vehicle are promptly captured.When a packet is detected, the receiver decodes the message and extracts the hazard information. This decoded alert is immediately presented to the driver through a 16×2 LCD display, while a buzzer generates an audible warning to ensure quick recognition of critical events. The entire system operates in a continuous loop, enabling the vehicles to monitor their environments, exchange data, and respond instantly throughout their journey. This method ensures alow latency, dependable communication, and an effective early-warning mechanism, making the prototype suitable for low-speed traffic environments and academic intelligent transportation system applications.



The overall procedure is as follows:-

1) Identify system requirements for low-cost Wi-Fi-based V2V communication and safety monitoring.
2) Select and gather hardware components including ESP8266, ultrasonic sensor, vibration sensor, alcohol sensor, LCD & Buzzer.
3) Design the system architecture with separate transmitter and receiver units.
4) Assemble the transmitter hardware and connect all sensors to the ESP8266.
5) Develop the receiver module with LCD and buzzer connected to the ESP8266.
6) Write and upload embedded C programs using Arduino IDE for sensor reading and message transmission.
7) Configure the ESP8266 modules in Access Point (AP) and Station (STA) mode for communication.
8) Establish Wi-Fi link between vehicles and test real-time message exchange.
9) Validate sensor performance for obstacle detection, vibration, and alcohol alerts.
10) Analyze system performance for range, response time, accuracy, and reliability.

A. System Development Workflow

1) Sensor Integration and Calibration: Each sensor is connected to the ESP8266 and calibrated for accurate threshold detection. For example, the ultrasonic sensor minimum safe distance, vibration sensor shock sensitivity, and MQ-3 alcohol limit are configured.
2) Data Acquisition: The ESP8266 continuously reads sensor values. These inputs are filtered to avoid false triggers caused by noise, vibrations, or sudden light changes.
3) Decision-Making Logic: The microcontroller compares the sensor readings with predefined safety thresholds. If an abnormal condition is detected, an event flag is raised.
4) WiFi Communication Setup: The ESP8266 is configured either in Access Point (AP) Mode or WiFi Direct Mode to create a peer-to-peer network. This allows one vehicle to directly broadcast the alert to another without needing an internet connection or external router.
5) *Packet Transmission*

The alert message is transmitted through HTTP requests or lightweight TCP packets to the receiver ESP8266.

Reception and Alert Response:-The receiving unit continuously listens for incoming messages. Once received:

- The LCD displays the message clearly.
- The buzzer activates if the message indicates a critical hazard.

Performance-Testing:- Multiple tests are conducted to measure:

- Transmission range
- Delay between message sending and receiving
- Accuracy of sensors
- Reliability under different distances and angles

Message-Formation:- Based on the detected hazard, a predefined text message is created. Examples include:

- Obstacle Detected Ahead
- Driver Alcohol Level High

Communication Flow Summary

- Vehicle A detects a hazard → processes sensor data → broadcasts alert via WiFi.
- Vehicle B receives WiFi alert → displays it on LCD → triggers buzzer for driver warning.

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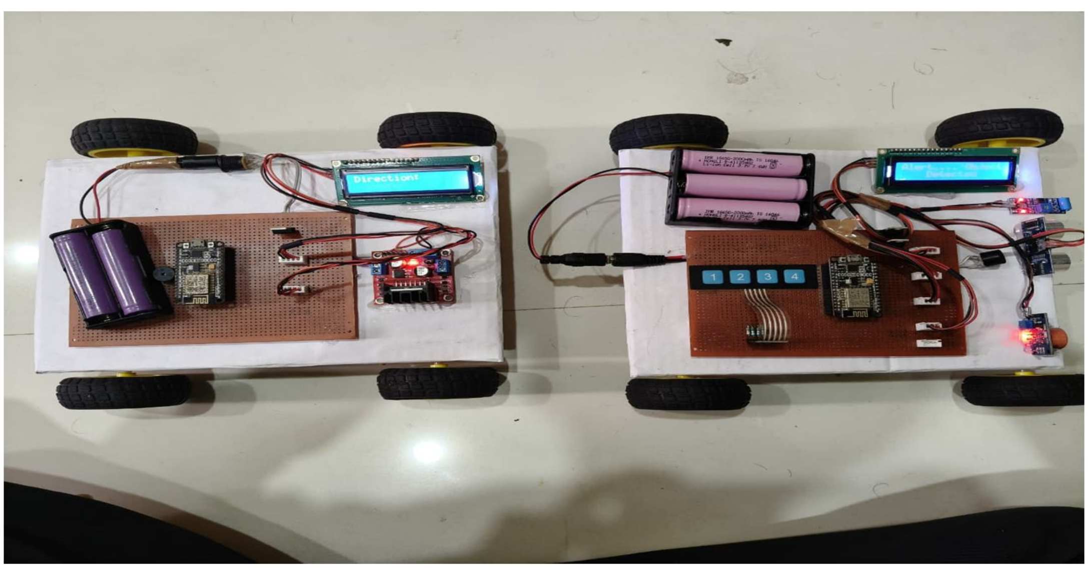
IV. LITERATURE SURVEY

Vehicle-to-Vehicle (V2V) communication has become an essential component in modern Intelligent Transportation Systems (ITS) as it enables vehicles to share safety-related information in real time. Early studies focused primarily on Dedicated Short-Range Communication (DSRC), but the limitations of cost, range, and infrastructure requirements encouraged researchers to explore alternative wireless technologies. Wi-Fi, due to its availability and low deployment cost, has emerged as a promising solution for short-range vehicular communication. Several research works highlight its potential in improving road safety and supporting cooperative driving applications. Alternative approaches, such as those presented by Prajakta Kunjir et al. (2020), demonstrate the technical feasibility of using consumer-grade hardware for vehicular networks. Their research specifically advocates for Wi-Fi modules, such as the ESP8266 and NodeMCU, due to their cost-effectiveness and integrated networking capabilities. Their studies validate that these low-cost platforms provide a practical means for establishing a local area network for V2V data exchange, sufficient for developing proof of-concept warning models. Sharma and Menon (2023) proposed a Wi-Fi–enabled inter-vehicle communication framework that demonstrated reliable short range performance suitable for low-cost road safety systems. Their work established that Wi-Fi modules such as ESP8266 can maintain stable communication links between moving vehicles under controlled conditions. Similarly, Krishnan and Babu (2022) developed a sensor-assisted alert system where ultrasonic, vibration, and alcohol sensors were integrated with Wi-Fi modules to transmit hazard warnings to nearby vehicles. Their model showed that low-cost IoT components can effectively support accident prevention mechanisms.

V. RESULT AND DISCUSSION

1) Reliable Short-Range Communication: The ESP8266 modules successfully exchanged messages within a range of 25–40 meters, which is suitable for slow and moderate-speed vehicles in academic prototype environments
2) Fast Alert Delivery: Hazard alerts such as obstacle detection, alcohol presence, and vibration impact were transmitted almost instantly. The average communication delay remained low, ensuring timely driver notification.
3) Accurate Sensor Triggering: All three sensors—ultrasonic, vibration, and MQ-3 alcohol—provided stable and consistent readings during testing. False triggers were minimal due to proper threshold calibration.
4) Clear Visual and Audible Warnings: The receiver unit displayed the messages clearly on the LCD, and the buzzer produced an immediate audible alert for critical warnings, improving driver awareness.
5) Low-Cost and Efficient Prototype: The system demonstrated that low-cost components such as ESP8266 and basic sensors can be effectively used for vehicular communication without the need for advanced infrastructure.
6) Real-Time System Performance: All detection, processing, and transmission operations were executed in real time, demonstrating the system's suitability for safety-critical vehicular applications.
7) Potential for Scalability and Extension: The modular structure of the system shows promise for expanding into multi vehicle communication, V2I integration.



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VI. ADVANTAGES

1) Low overall cost: The system is affordable because it uses inexpensive components like the ESP8266, ultrasonic sensor, vibration sensor and alcohol sensor. This makes it suitable for student projects, small research labs, and low-budget ITS prototypes .
2) Works without internet connectivity: Communication happens through a direct Wi-Fi link between vehicles, so the system does not depend on mobile networks or external routers. This ensures continuous operation even in areas with poor or no network coverage.
3) Instant and real-time alert generation: As soon as a sensor detects an abnormal condition, the transmitter vehicle immediately forwards a warning to the receiver. This reduces reaction time and helps drivers respond quickly to avoid accidents.
4) Hardware components are widely available: All modules used in the system are easy to purchase and integrate. Their availability makes assembly, maintenance, and future upgrades simple, even for beginners.
5) Useful for academic, prototype, and ITS research: The system provides a clear understanding of how V2V communication works and can be used for demonstrations, research papers, and intelligent transportation projects without the need for advanced infrastructure.

VII. APPLICATIONS

1) Accident prevention in city and low-speed road conditions: By warning nearby vehicles about obstacles, sudden stops, or unsafe conditions, the system helps reduce collisions in urban traffic where vehicles frequently travel close to each other.
2) Driver impairment identification: The alcohol sensor can detect intoxication and share this information with nearby vehicles, encouraging them to maintain distance and stay alert, reducing the risk of alcohol-related accidents.
3) Detection of collision or strong vibrations: The vibration sensor identifies impacts, potholes, or sudden shocks. This information is immediately transmitted to nearby vehicles, helping them slow down and avoid secondary collisions.
4) Use in intelligent transportation system research: The setup is ideal for experiments involving V2V communication, IoT-based vehicle safety, and cooperative driving models. It supports students and researchers in developing smarter traffic systems.
5) Improved road awareness during low-visibility conditions: When visibility is affected by fog, rain, darkness, or dust, sensor based alerts provide additional safety information to nearby vehicles, reducing the chances of unexpected collisions.

VIII. CONCLUSION

The developed Wi-Fi-based Vehicle-to-Vehicle communication system successfully demonstrates a low-cost and effective method for improving road safety. By integrating ultrasonic, vibration, and alcohol sensors with the ESP8266 module, the system is able to detect obstacles, unsafe driving conditions, and potential accident scenarios in real time. The wireless communication established between two vehicles ensures that critical alerts are transmitted instantly, helping drivers respond quickly to nearby hazards. The results show that the proposed solution offers reliable data transmission, low latency, and consistent performance within short-range vehicular environments. Overall, this project proves that Wi-Fi-enabled V2V communication can be a practical and scalable approach for enhancing driver awareness and reducing the likelihood of accidents, especially in areas where advanced ITS infrastructure is not available. Furthermore, the modular design of the system allows for easy integration with additional sensors, cloud connectivity, and future IoT-based extensions. Its affordability makes it suitable for widespread adoption, especially in developing regions with limited access to costly vehicular communication technologies such as DSRC or 5G-V2X. Overall, the findings of this project highlight that Wi-Fi-enabled V2V communication offers a promising, impactful, and easily deployable solution for improving driver awareness, reducing accident rates, and supporting the transition toward smarter and safer transportation systems. Future enhancements may include vehicle-to-infrastructure (V2I) capabilities, improved encryption for secure data exchange, and large-scale field testing to validate performance under diverse road conditions.

IX. ACKNOWLEDGMENT

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