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VEHICLE TO VEHICLE COMMUNICATION USING ESP 32 DEV KIT

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ABSTRACT

Vehicle-to-Vehicle (V2V) communication is an important technology that helps improve road safety and traffic management by enabling direct communication between nearby vehicles. This research presents a low-cost prototype of a V2V communication system using the ESP-32 microcontroller. The ESP-32 module supports wireless communication between vehicles through protocols such as Wi-Fi, Bluetooth, and ESP-NOW, allowing vehicles to exchange information without the need for a central router or infrastructure.

In the proposed system, three vehicles are used to demonstrate real-time communication and safety message exchange. Each vehicle is equipped with an ultrasonic sensor mounted at the front to continuously measure the distance from obstacles or other vehicles. If the detected distance becomes smaller than the predefined safe limit, the system automatically reduces the vehicle speed or stops the vehicle to avoid possible collisions. The system is also capable of transmitting important information such as vehicle speed, position, sudden braking alerts, accident detection signals, and emergency notifications to nearby vehicles.

The hardware components used in this prototype include the ESP-32 DEVKit, ultrasonic sensor, motor driver, OLED display, and DC gear motor. The main objective of this work is to enhance road safety, improve traffic efficiency, and reduce the risk of vehicle collisions through real-time communication. V2V communication is based on Dedicated Short-Range Communication (DSRC), which is commonly used in Intelligent Transportation Systems and generally supports communication within a range of approximately 100–300 meters.

KEYWORDS

Vehicle-to-Vehicle Communication (V2V), Dedicated Short Range Communication (DSRC), (VANET), Road Safety, collision avoidance, Intelligent Transportation System (ITS).

INTRODUCTION

The rapid growth of vehicles on modern roads has created serious challenges for transportation systems, including heavy traffic congestion and a rising number of road accidents. Many of these accidents occur because drivers are unable to obtain timely information about road conditions, sudden braking, or unexpected obstacles. Traditional transportation systems mainly depend on road signs, traffic signals, and driver awareness, which often fail to provide real-time communication between vehicles. As a result, drivers may receive important warnings too late to take appropriate action.

Vehicle-to-Vehicle (V2V) communication has emerged as an important technology within Intelligent Transportation Systems (ITS). This technology allows vehicles to exchange critical information such as speed, position, direction, and traffic conditions through wireless communication networks. By continuously sharing real-time data, vehicles can notify nearby vehicles about possible dangers, including sudden braking, collisions, or hazardous road situations. Such communication helps drivers make faster decisions and significantly improves road awareness.

In this work, a prototype V2V communication system is developed using ESP32 microcontrollers to demonstrate real-time communication between vehicles. The proposed system enables multiple vehicles to exchange warning messages wirelessly, allowing them to detect and respond to potential road hazards. By implementing this approach, the system aims to enhance driving safety, reduce the likelihood of accidents, and support the development of intelligent and connected transportation environments.

LITERATURE REVIEW

[3] Reddy, K.; Rao, P.; Chandra, S. IoT Based Smart Transportation System for Accident Prevention. International Journal of Advanced Research in Computer and Communication Engineering (IJARCCE), 2022.

Reddy et al. presented an IoT-based smart transportation system that enables vehicles to communicate with each other and with nearby infrastructure to prevent road accidents. The system integrates sensors, microcontrollers, and wireless communication modules to transmit vehicle information such as speed, location, and movement direction.

The proposed system improves driver awareness and road safety by providing early warning messages to nearby vehicles. It also helps in reducing traffic congestion by sharing real-time traffic data. However, the system does not incorporate advanced vehicle control mechanisms that allow automatic response based on received information, which could further enhance accident prevention capabilities.

[4] Sharma, P.; Verma, R.; Singh, A. IoT Based Vehicle Collision Avoidance System. International Journal of Engineering Research & Technology (IJERT), 2021.

Sharma et al. proposed an IoT-based vehicle collision avoidance system designed to improve road safety by enabling communication between nearby vehicles. The system uses wireless communication modules along with microcontrollers to transmit real-time information such as vehicle speed, direction, and braking signals. Sensors detect obstacles and vehicle movement, while the microcontroller processes the data and sends warning messages to nearby vehicles.

The proposed system helps drivers become aware of sudden braking or obstacles ahead, thereby reducing the chances of road accidents. However, the system mainly focuses on basic alert transmission and does not include advanced communication mechanisms or intelligent decision-making capabilities. The study suggests that more advanced controllers and communication technologies can further improve system efficiency and reliability.

[5] Patel, H.; Mehta, D.; Shah, R. Smart Vehicle Communication System using IoT Technology. International Research Journal of Engineering and Technology (IRJET), 2020.

Patel et al. developed a smart vehicle communication system using IoT technology for improving road safety and traffic management. The proposed system uses microcontrollers and wireless communication modules to enable vehicles to exchange information regarding speed, road conditions, and traffic alerts. The transmitted information is displayed on receiving vehicles to inform drivers about potential hazards.

The study demonstrated that IoT-based vehicle communication systems can significantly reduce traffic accidents by providing early warnings. The system also helps improve driver awareness and decision-making. However, the proposed design mainly focuses on communication alerts and lacks automated response mechanisms that can control vehicle movement based on received data.

[8] Kumar, S.; Gupta, V.; Singh, P. Vehicle-to-Vehicle Communication System for Intelligent Transportation. International Journal of Innovative Technology and Exploring Engineering (IJITEE), 2019.

Kumar et al. proposed a vehicle-to-vehicle communication system aimed at enhancing intelligent transportation systems in urban environments. The system uses wireless modules and embedded controllers to exchange information between vehicles. Communication allows vehicles to share data related to traffic conditions, lane changes, and emergency braking events.

The proposed system improves traffic safety by enabling real-time communication among vehicles. It also assists drivers in making better driving decisions by providing timely alerts about surrounding vehicles. However, the system requires improved wireless communication reliability and faster processing units to handle large amounts of vehicular data effectively.

PROPOSED SYSTEM ARCHITECTURE

The proposed system architecture for the Vehicle-to-Vehicle (V2V) communication system is designed to enable real-time information exchange between nearby vehicles using wireless communication. Each vehicle is equipped with an ESP32 Dev Kit microcontroller, which acts as the central processing unit of the system. The ESP32 uses its built-in Wi-Fi capability to transmit and receive data between vehicles without the need for external communication modules. Additional components such as push buttons, display units, and power supply circuits are integrated to allow drivers to send specific signals like turning left, turning right, overtaking, or emergency alerts.

In this architecture, every vehicle functions as both a transmitter and a receiver. When a driver presses a push button corresponding to a particular driving action, the ESP32 processes the input and transmits a wireless signal to nearby vehicles. The receiving ESP32 module interprets the signal and displays the message on an OLED or LCD display installed inside the vehicle. This allows surrounding drivers to receive real-time alerts and respond accordingly.

The system architecture also includes a communication protocol that ensures reliable data transmission between vehicles. By using peer-to-peer wireless communication, the system reduces dependency on external infrastructure such as cellular networks or roadside units. This decentralized approach improves communication efficiency and allows vehicles to exchange safety-related information quickly, thereby enhancing road safety and reducing the risk of accidents.

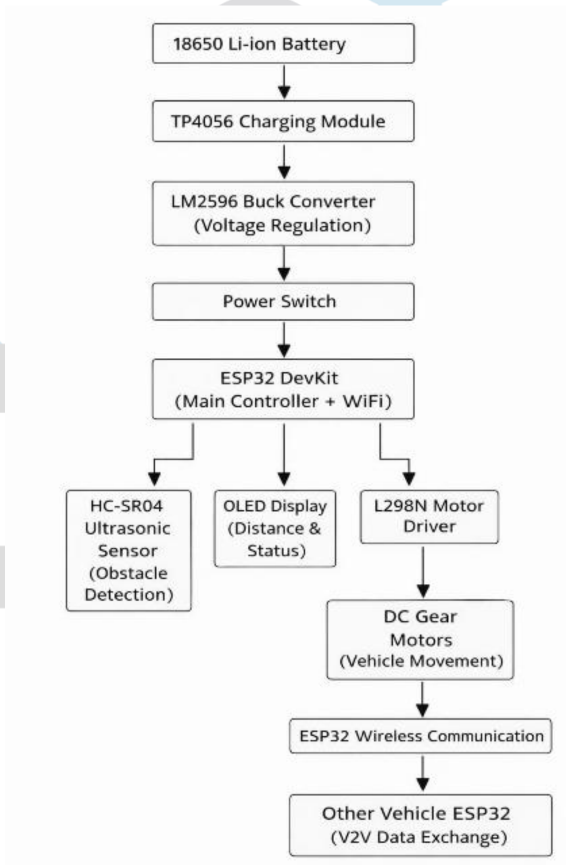


Fig 1. Block Diagram

Component	Purpose
ESP32 DevKit	Main microcontroller and wireless communication
HC-SR04 Ultrasonic Sensor	Distance and obstacle detection
L298N Motor Driver	Controls DC motor movement
DC Gear Motors	Vehicle movement

OLED Display	Displays alerts and system status
Push Buttons	Input for driver actions
18650 Li-ion Battery	Power supply
TP4056 Charging Module	Battery charging and protection
LM2596 Buck Converter	Voltage regulation
Power Switch	System ON/OFF control

METHODOLOGY

The proposed Vehicle-to-Vehicle (V2V) communication system is developed using ESP32 microcontroller boards, wireless communication technology, and sensor-based monitoring to enable real-time data exchange between vehicles. The methodology focuses on designing a prototype system where two vehicles communicate with each other by transmitting information related to movement, direction, and distance. Each vehicle is equipped with an ESP32 controller, motor driver, sensors, and wireless communication modules to ensure continuous communication and coordination between the vehicles.

In the proposed system, one vehicle is controlled manually using a remote control module or input switches, which act as command signals for vehicle movement such as forward, backward, left turn, or right turn. These control signals are processed by the ESP32 microcontroller and simultaneously transmitted wirelessly to the second vehicle. The receiving ESP32 module processes the incoming data and adjusts the movement of the second vehicle accordingly. This communication mechanism allows the second vehicle to follow the movement pattern of the first vehicle while maintaining a safe distance.

Distance monitoring is implemented using ultrasonic sensors to detect the distance between the two vehicles. The sensor continuously measures the gap between vehicles and sends the information to the ESP32 controller. If the distance between vehicles becomes too small, the system automatically slows down or stops the following vehicle to prevent collisions. In addition, alert signals such as braking, turning, or overtaking can be transmitted to the second vehicle, improving safety and coordination.

The system is implemented through hardware integration, programming, and wireless data transmission testing. The ESP32 controllers are programmed using the Arduino IDE environment to process sensor data, transmit control signals, and receive communication messages. The prototype is tested in a controlled environment where the first vehicle acts as the leading vehicle and the second vehicle responds according to received data. This methodology demonstrates the feasibility of low-cost V2V communication systems that can enhance road safety and intelligent transportation applications.

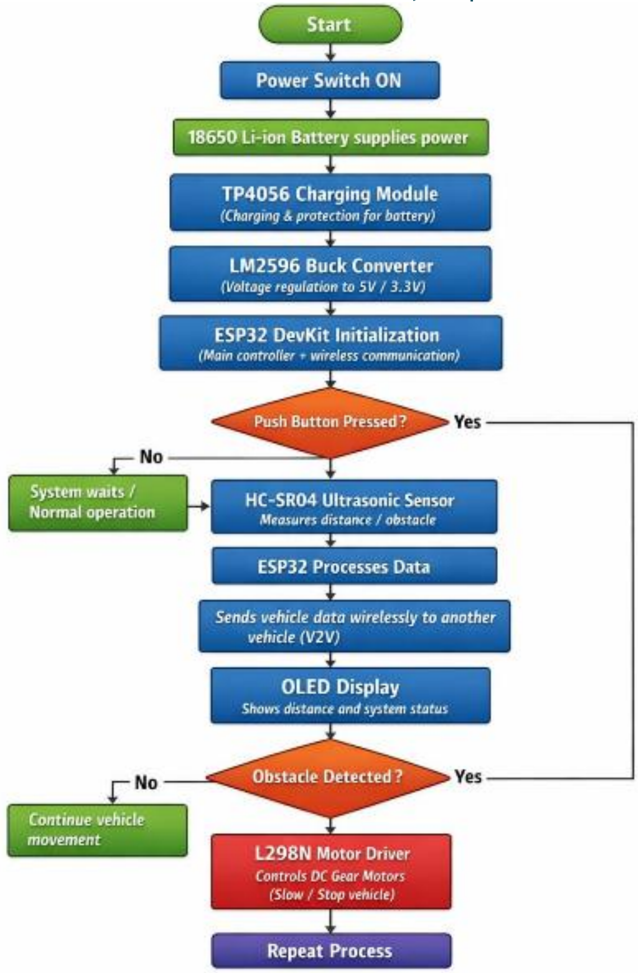


Fig 2. Process Flowchart

WORKING PRINCIPLE

The working principle of the Vehicle-to-Vehicle communication system is based on wireless data transmission between two ESP32 modules. Each ESP32 device continuously monitors the input signals from the push buttons connected to its input pins. When the driver presses a specific button, the ESP32 detects the change in the input signal and processes it through the programmed logic.

After detecting the input action, the ESP32 converts the action into a predefined digital message. This message is transmitted through the wireless communication interface of the ESP32 using Wi-Fi. The wireless signal travels to the receiving ESP32 device located in another vehicle unit.

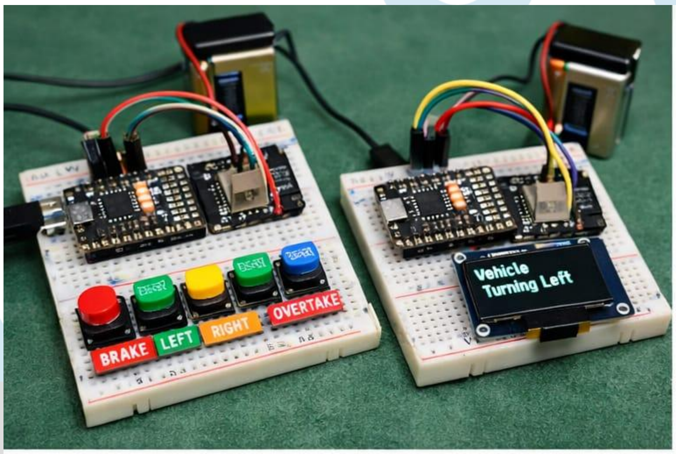
The receiving ESP32 captures the transmitted data and decodes the message to determine the corresponding action. The system then displays a warning message such as “Vehicle Turning Left,” “Vehicle Braking,” or “Vehicle Overtaking” on the display module. This process occurs almost instantly, allowing drivers to receive alerts about nearby vehicle actions in real time.

RESULTS

The implemented prototype successfully demonstrates communication between two vehicles using ESP32 microcontrollers. During testing, when a push button was pressed on the transmitting unit, the corresponding message was successfully sent through the wireless communication link and received by the second ESP32 module. The receiving unit displayed the correct warning message on the display screen.

The experimental results show that the system can transmit driver intentions such as turning, braking, or overtaking with minimal delay. The wireless communication between the two ESP32 devices remained stable within the test range. This confirms that ESP32 can effectively be used for implementing small-scale vehicle communication systems.

Although the prototype is designed for demonstration purposes, it clearly illustrates how V2V communication can improve road awareness among drivers. However, certain limitations such as limited communication distance and dependency on Wi-Fi connectivity were observed. Despite these limitations, the project provides a foundation for further development of intelligent vehicle communication systems.



CONCLUSION

This project presents the design and implementation of a Vehicle-to-Vehicle communication system using ESP32 Dev Kit microcontrollers. The system enables two vehicles to exchange important driving information wirelessly. By using push buttons to simulate vehicle actions and display alerts on a screen, the system demonstrates how communication between vehicles can improve driver awareness and road safety.

The use of ESP32 provides several advantages such as built-in wireless communication, low power consumption, and cost effectiveness. The prototype successfully demonstrates the ability to transmit signals between vehicles and display warning messages in real time.

Overall, the proposed system highlights the potential of integrating IoT technology into transportation systems. With further development and integration with advanced sensors and communication technologies, V2V communication can play a significant role in reducing accidents and improving traffic management in modern transportation networks.

FUTURE SCOPE

The proposed system can be further improved by integrating additional technologies and expanding its capabilities. One possible improvement is the integration of GPS modules to allow vehicles to transmit their exact location along with the warning signals. This would help drivers understand the precise position of nearby vehicles.

Another possible enhancement is the use of long-range communication technologies such as LoRa or dedicated vehicular communication protocols. These technologies can extend the communication range and make the system more suitable for real road environments

In future developments, the system can also be connected to mobile applications or cloud platforms for data analysis and monitoring. Integration with sensors such as speed sensors, distance sensors, and accident detection modules can enable automatic emergency alerts. Such improvements would move the system closer to real intelligent transportation systems used in modern smart cities.

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