Road Safety and Inter-vehicular Surveillance using V2V Communication

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ABSTRACT

Vehicle-to-vehicle (V2V) communication is a promising technology that can enhance road safety and traffic management. This project aims to develop a V2V communication system using ZigBee wireless technology and sensors to improve overtaking safety, overspeed detection and penalty system to prevent accidents. The system consists of a ZigBee wireless communication module and a set of sensors installed in each vehicle for establishing V2V communication between vehicles, allowing them to exchange real-time data. Sensors such as ultrasonic sensors and speed sensors are used to gather information about the surrounding vehicles and the speed of the host vehicle. Arduino is used for processing the sensor data and controlling the communication module, while NodeMCU is used to establish communication between the Arduino and the Blynk app, providing a user-friendly interface for monitoring and controlling the system. The system detects overtaking maneuvers by analyzing the distance and speed of the surrounding vehicles. When an overtaking maneuver is detected, the system sends an alert signal to the overtaken vehicle using Zigbee communication. The overtaken vehicle receives the alert and can take appropriate actions to avoid any potential collision. Additionally, an overspeed detection system is implemented using speed sensors, and if the host vehicle exceeds the speed limit, a penalty system is activated to impose a penalty on the driver. The overspeed information is communicated to the front vehicle using NodeMCU and Zigbee This project contributes to the field of intelligent transportation systems by leveraging V2V communication and IoT technologies to improve road safety and reduce accidents.

Keywords: Road safety, Speed monitoring, safety in overtaking

1 Introduction

In 2022 1,55,622 deaths were recorded due to road accidents, out of these 59.7 percent of the total death rate was due to over speeding. Road accidents pose a significant risk to human lives and financial well-being. Despite manufacturers' efforts to design reliable and safe vehicles, accidents still occur due to human error, circumstantial factors, and negligence. As a result, there is increasing emphasis on technologies that can mitigate traffic accidents. V2V (Vehicle-to-Vehicle) technologies are relatively straightforward to implement as they rely on wireless communication. Vehicle-to-Vehicle (V2V) communication is a promising technology that enables real- time communication between vehicles on the road, offering immense potential for improving road safety. In this project paper, we propose and implement a V2V communication system to enhance safety during overtaking maneuvers and alerting other vehicles using sensors, Zigbee, Arduino, and GPS. The system also includes an overspeed detection and penalty system within the vehicle and alerts the overspeed condition to the front vehicle using NodeMCU, Zigbee, the Blynk app, and GPS. The communication protocol includes Zigbee to communicate information between two vehicles.

Overtaking maneuvers can be risky and often lead to accidents due to limited visibility and lack of communication between vehicles. The proposed V2V communication system aims to address this issue by enabling vehicles to exchange real-time data during overtaking maneuvers. Sensors such as ultrasonic sensors and speed sensors are used to gather information about the surrounding vehicles and the speed of the host vehicle. Arduino is utilized for processing the sensor data and controlling the communication module, while NodeMCU is used to establish

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communication between the Arduino and the Blynk app, providing a user-friendly interface for system monitoring and control. The system also includes an overspeed detection system using speed sensors and GPS. If the host vehicle exceeds the speed limit, a penalty system is activated to impose a penalty on the driver. The overspeed information, along with the vehicle's location data from GPS, is communicated to the front vehicle using NodeMCU, Zigbee, Blynk app, and GPS, alerting the front vehicle about the potential risk of an over speeding vehicle approaching. The paper provides a detailed description of the system architecture, including the hardware and software components, sensor interfacing, communication protocols, and the implementation of the overtaking and overspeed detection systems. Experimental results and performance evaluation of the proposed system are presented to showcase its effective- ness in enhancing safety during overtaking maneuvers, alerting other vehicles about overspeed conditions, and successfully implementing the overspeed detection and penalty system.

The existing papers in the V2V communication field are rather complex systems with expensive components and high installation cost. This paper discusses a much better cost effective, simple yet efficient way by which two independent systems are integrated into one.

Low power consumption: Zigbee is designed for low-power wireless communication, making it ideal for battery-powered devices such as sensors and remote controls.

Range: Zigbee has a range of up to 100 meters, which is more than enough for V2V communication.

Cost-effective: Arduino and NodeMCU are affordable and widely available.

Real-time data: This allows for better coordination between vehicles, which can improve safety and reduce congestion on the road.

Robustness: Zigbee is designed to be robust and reliable, even in noisy wireless environments.

2 Literature Review

From [1], we examine candidate detection technologies, communication technologies, and the application of AI-based collision detection algorithms for safe driving. It provides a broad foundation for readers to understand the three key steps of CA design and how the popular AI algorithm is applied to various CA systems. It also examines the different sensors and the different communication methods used. The survey aims to identify and analyze the differences between the sensors used in AVs. They discussed Bluetooth, ZigBee, and UWB to classify communication technologies based on transmission. The advantages and limitations of each communication technology are briefly explained. Intermediate technologies such as Dedicated Short Range Communications (DSRC) and Wireless Fidelity (Wi-Fi) are reviewed. Long-term technologies such as mobile-to-everything (C-V2X) and fifth-generation radio (5G-NR) technologies are reviewed.

The aim of the study described in [2] was to identify the causes of accidents and establish links between the key components of an effective crash avoidance and overtaking advice system, including the driver, operating environment, vehicle, and technology. The authors reviewed various methods for achieving this objective, highlighting their individual limitations and challenges. They analyzed issues such as perception difficulties, blind spots, driver inattentiveness, and misjudgements, and provided an in-depth examination of sensors, human-computer interactions, and vehicle communication, while also identifying gaps in current crash avoidance systems. The study also addressed the constraints and challenges of different operating environments.

From [3] we identified different types of accidents causing hazardous occurrences namely speed breakers, sharp turns, and various naturally occurring factors like fog and rain. The system they proposed used V2V communication to facilitate communication between vehicles. Various sensors together made up the embedded system, which was used to detect the hazards. The detection of the hazardous occurrence was communicated to the user with the help of V2V (vehicle- to-vehicle) communication and V2I (vehicle-to-infrastructure) communication.

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From [4] we understood the importance of secure communication between vehicles and infrastructures were discussed. V2V communication facilitates the exchange of information about drivers' data, vehicle data, speed of the vehicle, position, direction of travel, real-time location of the vehicle, and even the brake were monitored to share these statuses with other vehicles for it to make smart decisions. OBUs warn drivers about speed bumps, over-speeding, rain and fog, sharp turns, potholes, aggressive drivers, etc whether it is safe to overtake or not, etc. So, if these messages were to be corrupted, it will pave the way to serious accidents and loss of life.

From [5] vehicle to vehicle (V2V) communication technologies are used to alert the driver and apply brakes in case of emergencies which will reduce the possibility of an accident, which in terms is acting as a safety system. This system gives drivers a clear view of what is going on around them to help avoid accidents and improve traffic flow. It helped us gather the hardware idea. Here the system used Zigbee for the communication or transfer of information between the two devices. Using Zigbee communication we can make the reaction instantly before the driver knows. Here the information transmitted between the vehicles is indicated using different LED lights.

As outlined in [6], the Internet of Vehicles (IoV) is a specific form of the Internet of Things (IoT), which this paper examines in terms of its architectures, applications, clustering methods, standards, and protocols. In the realm of mobility, accessing internet resources and services is not always straightforward unless we harness the objects in our surrounding environment, such as vehicles, to form a connected network. This leads to the development of Vehicle Ad- hoc Networks (VANETs), where vehicles and the road infrastructure serve as the base stations for this specialized network. Different types of IoV architectures are designed for various applications, and some of these require clustering techniques to manage the vehicular network more effectively. The paper also describes wireless communication technologies that use specific protocols to ensure reliable communication. It outlines the cases in which each technology and related protocol is used and highlights how combining wireless communication technologies can enhance communication reliability in certain scenarios.

From [7] we could understand the importance of the use of IoT in road safety management. It also helps in v2v communication. It also helps in the vehicle to vehicle communication where the RSU units are absent.

[8] suggests the importance of designing an efficient over- speed detection system. This will reduce the chance of road accidents with subsequent loss of life and property. Here they use Arduino Mega to monitor the location and speed of the vehicle, GPRS+GPS, and GSM antenna. When over speeding is detected that is alerted using a buzzer and SMS alerting system

From [9] we have studied the detection of moving vehicles, speed limit violation, and estimation of speed. This uses the method of a relative system for the selection of vehicles in consecutive frames. Contributes towards smart city development. Here the system saves the details of the traffic-violating vehicles. Thus, we can easily merge this into the existing technology for improvising the technology application.

3 Methodology

3.1 Hardware Used

Ultrasonic Sensor: This sensor is used to detect the presence of any object in the front of the vehicle. It works by sending high-frequency sound waves and measuring the time taken for the sound waves to return after hitting an object. Based on this time measurement, the sensor can calculate the distance of the object from the vehicle.

Zigbee Module: This module is used for wireless communication between the two vehicles. It establishes a connection between the two vehicles and enables them to exchange information about their position, speed, and direction.

Arduino Uno: This microcontroller is used to control the overall operation of the system. It receives data from the ultrasonic sensor and the GPS module, processes the data, and sends commands to the Zigbee module to transmit the information to the other vehicle.

GPS Module: This module is used to determine the position, speed, and direction of the vehicle. It receives signals from GPS satellites and calculates the coordinates of the vehicle.

LCD Display: This display is used to show the information received from the other vehicle. It displays the distance, speed, and direction of the other vehicle, and alerts the driver in case of any danger.

NodeMCU: Use NodeMCU, which is an ESP8266-based development board, for communication with the Blynk app. NodeMCU can connect to the internet and facilitate remote monitoring and control.

Speed Sensor: A speed sensor, such as a potentiometer or other suitable sensor, will be used to measure the speed of the host vehicle. The speed data will be used to detect over- speeding and trigger alerts if the speed exceeds a predefined threshold.

Motor and Potentiometer: Set up a motor and a potentiometer as the penalty system within the vehicle. The motor can be used to provide feedback to the driver, and the potentiometer can be used to adjust the penalty level.
The overall hardware connection is shown in Fig 1.

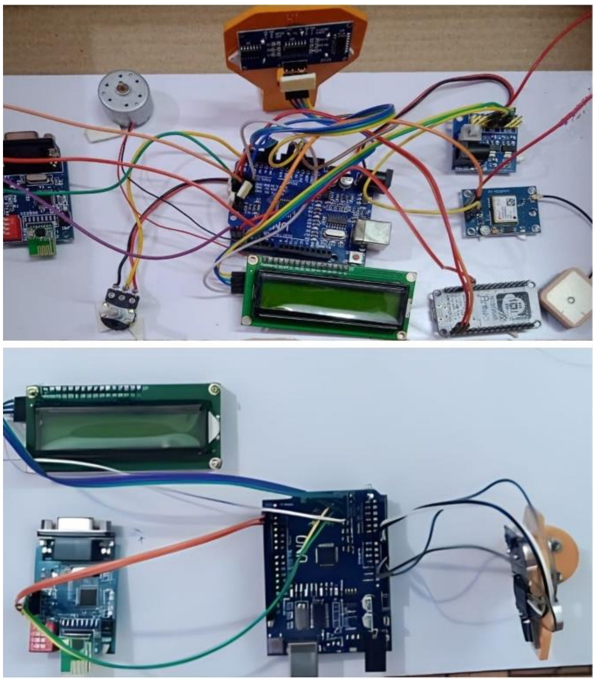

Figure 1: *Hardware*

3.2 Software Implementation

Arduino Programming: Write Arduino code to interface with the ultrasonic sensors, Zigbee modules, LCD, GPS, speed sensor, motor, and potentiometer. The code should include functions for object detection using ultrasonic sensors, data transmission and reception using Zigbee modules, LCD display, overspeed detection using GPS and speed sensor, and penalty system control using the motor and potentiometer.

NodeMCU Programming: Write NodeMCU code to establish a connection between Arduino and the Blynk app. The code should include functions for data transmission and reception between NodeMCU and the Blynk app, and for remote monitoring and control of the V2V communication system.

Blynk App Configuration: Create a Blynk app and configure it to display relevant information from the V2V communication system, such as speed, distance, and warnings. Set up buttons or sliders in the app for remote control of the penalty system, such as adjusting the penalty level.

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3.3 Working

Overtaking safety: The ultrasonic sensor continuously sends out sound waves and measures the time taken for them to return. It calculates the distance of any object in the front of the vehicle and sends this information to the Arduino Uno. The GPS module receives signals from GPS satellites and calculates the position, speed, and direction of the vehicle. It sends this information to the Arduino Uno. The Arduino Uno processes this information and sends it to the Zigbee module. The Zigbee module establishes a connection with the other vehicle and transmits the information about the position, speed, and direction of the vehicle. The other vehicle receives this information and displays it on its LCD display. If the distance between the two vehicles is less than a certain threshold, the system alerts the driver with a warning message on the LCD display. If the other vehicle tries to overtake, the system detects this and sends a warning message to the driver of the first vehicle. If both vehicles are moving in the same direction, the system alerts the driver of the first vehicle when it is safe to overtake. If both vehicles are moving in opposite directions, the system alerts both drivers and advises them to slow down or stop to avoid a collision. Thus, the system enables safe and effic ient overtaking by providing real-time information about the position, speed, and direction of the other vehicle.

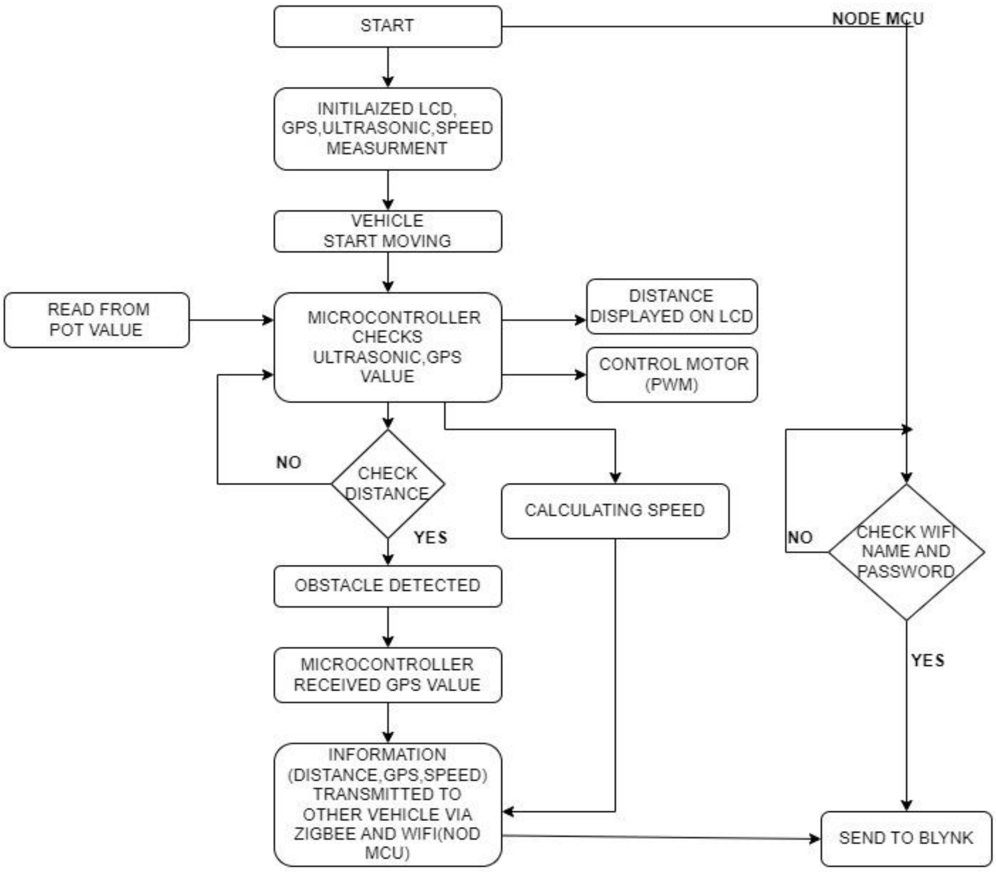

Figure 2: *Flow chart*

Overspeed detection and penalty system: The GPS module and speed sensor continuously monitor the vehicle's

speed. If the vehicle exceeds the predefined speed limit, the Arduino detects it as overspeed. Arduino informs the NodeMCU about the speed limit violation. Arduino monitors the working of the motor and the potentiometer. The NodeMCU sends a notification to the Blynk app, alerting the driver about the penalty. The Arduino sends overspeed alerts to the front vehicle's Zigbee module, indicating that the vehicle behind it is over speeding.
The working is explained with the help of a flow chart in Fig 2.

3.4 Result

The results mentioned below were obtained;

Figure 3: *output 1*

Figure 4: *output 2*

Figure 5: *output 3*

When the distance between the vehicles is less than the critical value of 25cm, then the LCD shows "NOT SAFE TO DRIVE" as shown in Fig 3 When the distance between the vehicles is more than the critical value of 25cm , then the LCD shows "SAFE TO DRIVE" as shown in Fig 4 If both vehicles are moving in the same direction, the system alerts the driver of the vehicle with the intention to overtake, if it is safe or not. If both vehicles are moving in opposite direction, the system alerts both drivers if it is safe to move forward with their speed. In case of overspeed detection, we use NodeMCU along with Arduino for speed detection and penalty system. Here if the speed of the motor exceeds the threshold the vehicle next to the over speeding vehicle will get a message informing the 'BACK VEHICLE OVER SPEED' as shown in Fig.5. Then NodeMCU sends an alerting message to the driver of the over speeding vehicle along with their speed, GPS location, and the penalty charged for that, as shown in Fig 6.

Figure 6: *Blynk app output*

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4 Future Scope

Integration with autonomous vehicles: With the rise of autonomous vehicles, integrating the proposed system with these vehicles could provide an additional layer of safety. The system can be designed to provide real-time communication between autonomous vehicles to avoid collisions and improve traffic flow. Integration with smart cities: Smart cities are designed to improve the quality of life of citizens by using technology to optimize services, such as traffic management. Integrating the proposed system with smart cities can help in reducing traffic congestion, minimizing carbon emissions, and improving road safety. Development of predictive models: The proposed system can be enhanced by developing predictive models that can anticipate traffic patterns and adjust accordingly. This can be done by using machine learning algorithms to analyze historical traffic data and provide real- time recommendations to drivers. Use of advanced communication protocols: The proposed system currently uses Zigbee communication protocol, which has limited range and bandwidth. Future improvements could include the use of advanced communication protocols such as 5G, which provide faster data transfer rates, low latency, and improved reliability. Integration with other sensors: The proposed system currently uses ultrasonic sensors for detecting the distance between vehicles. Future developments could involve integrating other sensors such as LiDAR, radar, or cameras to provide additional information for collision avoidance. Improvements in user interface: The user interface can be improved to provide a more intuitive and user-friendly experience. This can be achieved by designing a graphical interface that displays the real-time data on the LCD, providing alerts and recommendations to the driver. Testing and validation: The proposed system can be tested and validated in real-world scenarios to measure its effectiveness in avoiding collisions and improving road safety. This can be done by conducting field trials with a variety of vehicles and traffic conditions.

5 Conclusions

The vehicle-to-vehicle communication system developed in this project shows great potential in improving road safety by facilitating real-time information exchange between vehicles. By incorporating ZigBee, ultrasonic sensors, Arduino Uno, GPS, and an LCD display, we have successfully designed a system that enables safe overtaking maneuvers, avoiding crashes. The system provides drivers with information, enabling them to make informed decisions when overtaking. Our testing has shown that the system is reliable, efficient, and effective in preventing collisions during overtaking maneuvers. This low-cost, easy-to-install system can be used in various types of vehicles, making it a viable option for widespread implementation. This system also consists of overspeed detection and penalty system using GPS and speed sensor, sending alerts to the driver through the Blynk app, and allowing the driver to adjust the penalty level using the app, which in turn controls the motor and potentiometer to apply the penalty. V2V communication is facilitated using Zigbee modules, where overspeed alerts are sent to the front vehicle's Zigbee module, which transmits the warning to the Zigbee module of the front vehicle. It aims to enhance road safety by utilizing V2V communication and overspeed detection with a penalty system, providing real-time alerts to drivers and promoting responsible driving behavior. Further testing, optimization, and refinement of the system would be necessary for practical implementation and deployment on actual vehicles. Our project highlights the potential for vehicle-to-vehicle communication to significantly improve road safety, reduce the number of accidents caused by overtaking, and ultimately save lives. Further research and development in this area could lead to the widespread adoption of similar systems in vehicles, contributing to a safer and more efficient road network. Overall, this project demonstrates the potential of vehicle-to-vehicle communication in advancing road safety and reducing accidents, paving the way for a more sustainable future.

6 Publisher's Note

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