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ZIGBEE Communication based Smart Vehicle Safety and Alert System

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***Abstract*—The design of real time wireless system represents an innovative technology that facilitates safety and notification alert system, aiming to mitigate traffic congestion, reduce accidents, and enhance overall safety. The primary goal of the real time wireless system is to establish an efficient communication for intelligent transport system. Technological progress has spurred the automotive industry to develop autonomous vehicles capable of exchanging real-time information, thereby contributing to accident prevention. This research paper provides outlining its benefits, and addressing the challenges associated with implementing such communication system. The paper also delves into the crucial aspects of safety and the utilization of the Zigbee Protocol in this context. The discussion encompasses the advancements in technology that have paved the way for vehicles to share critical information seamlessly to the trailing vehicles, fostering a collective approach to safeguarding against accidents and enhancing overall road safety.**

***Index Terms*— Vehicle to Vehicle Communication, Safety Application, Road Safety, Collision avoidance, Zigbee, Wireless system, Intelligent Transport System.**

I. INTRODUCTION

Factors such as tough terrain, unfavorable weather conditions, and unforeseen vehicular problems play a significant role in contributing to over 92% of accidents. Such incidents are usually the result of drivers' difficulties in managing unexpected emergencies effectively. Nevertheless, vehicle-to-vehicle communication technology integration presents an encouraging remedy for boosting road safety. This cutting-edge technology enables real-time sharing of critical information regarding traffic flow patterns, speed limits, accidents reports and weather updates within a specific range. This proactive data exchange empowers drivers by providing them with prompt insights that help anticipate potential hazards while enhancing overall driving security and convenience simultaneously. [2]

II. RELATED WORKS

[1] Daniel, Alfred (2014) explored Zigbee-based vehicle-to-vehicle (V2V) communication in their paper "Vehicle to Vehicle Communication Using Zigbee Protocol." They discussed Zigbee network architecture, protocols, and design considerations for V2V communication, highlighting its potential for cooperative driving and traffic safety systems. This research advances V2V communication, promoting safer and more efficient transportation.
[2] Harding, J., Powell, G., R., Yoon, R., Fikentscher, J., Doyle, C., Sade, D., Lukuc, M., Simons, J., & Wang, J.

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(2014) assessed V2V communication technology in their paper "Vehicle-to-Vehicle Communications: Readiness of V2V Technology for Application." They examined technical challenges, regulations, and deployment scenarios, offering insights into practical implementation and benefits. V2V communication's potential in enhancing road safety and transportation efficiency makes it a transformative tool for the automotive industry, shaping future mobility.

[3] P.S.G Arunasri and P. Gopikrishna (2017) introduced a novel V2V communication method combining CAN and Zigbee technologies in their paper "Vehicle-to-Vehicle Communication using CAN Network and Zigbee Technology." Their integrated approach aims for a robust, versatile system suitable for various vehicular applications, emphasizing interoperability, reliability, and low-latency communication. This research contributes to advancing V2V communication, enabling cooperative driving, collision avoidance, and efficient traffic management.

[4] Dinesh V (2023) detailed the SPK system for traffic violation detection in their paper "SPK: A Traffic Violation Detection System." Using sensor tech, image processing, and real-time analytics, they offer an innovative solution to enhance traffic management. SPK automates violation detection, promising safer roads, reduced congestion, and improved transportation efficiency, showcasing the potential of intelligent transportation systems.

[5] Somnath A. Karmude, Prof. G. R. Gidveer (2014) introduced a Zigbee-based system for vehicular identification and authentication in their paper "Vehicular Identification and Authentication System using Zigbee." Their solution offers secure access control and tracking in vehicular environments, emphasizing reliability and interoperability. This system has the potential to seamlessly integrate with existing vehicular systems, enhancing overall security and efficiency in transportation.

[6] Dinesh V (2023) introduced a system for detecting and notifying emergency services about unidentified accident victims in their paper "Detection and Notification System in Emergency Vehicles for Unidentified Accident Victims." This system integrates sensors, GPS tracking, and communication devices in emergency vehicles, improving response times and victim identification accuracy. With its emphasis on real-time data acquisition and analytics, Dinesh V's system enhances emergency response effectiveness and contributes to safer communities.

[7] P. Sriram, M. Palanichamy, G. Alexander, G. Vijay, Mr. R. Sathish (2018) presented a real-time embedded system for vehicle-to-vehicle (V2V) communication in their paper "Design and Implementation of Real-Time Embedded based Vehicle to Vehicle Communication System." This system focuses on reliable and low-latency communication between vehicles, enhancing road safety, traffic efficiency, and overall transportation effectiveness. Their research addresses challenges in vehicular communication and contributes to shaping the future of connected and autonomous mobility.

[8] Gaurav Sharad Patil, Nandkishor Vithoba Shirsat (2016) thesis on V2V communication encompasses a comprehensive investigation into design, implementation, and performance evaluation, serving as a valuable resource for improving road safety and transportation efficiency. Their research contributes significantly to advancing vehicular communication technology, offering insights for researchers, policymakers, and industry stakeholders.

[9] In "An Overview of Vehicular Communications Fabio Arena, Giovanni Pau (2019) likely delve into the evolution of communication standards, emerging applications, and future research areas, providing insights into the transformative potential of vehicular communication. Their paper serves as a roadmap for intelligent transportation systems, cooperative driving applications, and connected mobility solutions, informing stakeholders about opportunities and challenges in shaping transportation's future.

[10] Mohamed El Zorkany, Ahmed Yasser, Ahmed I. Galal (2020) likely provided a comprehensive overview of vehicle-to-vehicle (V2V) communication technology, covering its scope, importance, challenges, and future research directions in their paper titled "Vehicle to Vehicle 'V2V' Communication." By addressing potential applications, technical hurdles, and regulatory considerations, their work serves as a valuable resource for stakeholders interested in leveraging V2V communication for enhanced road safety and transportation efficiency, shaping the future of connected mobility and autonomous vehicles.

III. Working Methodology

Using Zigbee technology, this innovative alert system enables efficient communication for intelligent transport systems to reduce traffic congestion and enhance safety. The continuous monitoring of road conditions identifies hazards such as potholes before promptly notifying trailing vehicles and highway authorities. Drivers can use designated keys with audio alerts in emergencies to communicate swiftly while reliable data transmission through the Zigbee protocol contributes towards safe transportation by preventing accidents. Collaborating technological advancements into seamless communication makes a significant move towards optimizing driving experiences whilst ensuring collective efforts toward enhancing road safety take place effectively in smart traffic systems.[18]

A. Transmitter section

It is placed [10] in the rear side of every vehicle. Upon pressing the push button, the appropriate control signals will be sent wirelessly to the receiver unit placed at the front end of vehicle.[11]

B. Receiver Section

It is placed in front end of every vehicle. The receiver section tends to receive the signal from the leading vehicle. For an instance, in an emergency kind of situation when the driver pressed the push button from the leading vehicle, the receiver unit picks the corresponding signal and displays a notification in the LCD display to ensure the vehicle safety.

C. Communication Protocol

Efficient short-range communication in vehicles is made possible by Zigbee, a low-power wireless protocol that adheres to the IEEE 802.15.4 standard. It guarantees reliability and energy efficiency, making it ideal for vehicular communication systems and other applications requiring optimized energy consumption.

D. Data Transmission Method

```
Start
|
v
Initialize Components
|
v
Connect to Wi-Fi Network
|
v
Loop:
|    |
|    v
|    Check Button Presses & Sensor Readings
|    |
|    v
|    If Button Pressed:
|    |    |
|    |    v
|    |    Trigger Corresponding Action
|    |    |
|    |    v
|    |    Send Data to Web Server
|    |
|    v
|    Measure Distance with Ultrasonic Sensors
|    |
|    v
|    If Pothole Detected:
|    |    |
|    |    v
|    |    Display Alert on LCD
|    |    |
|    |    v
|    |    Send Pothole Data to Web Server
|    |
|    v
|    Calculate Vehicle Speed
|    |
|    v
|    Adjust LED Intensity Based on Speed
|
v
End
```

Fig 3.3 Flowchart of data transmission

In Fig 3.3, the context of Zigbee communication in this model, data is typically transmitted in characters that convey the status of the vehicle such as speed, acceleration, braking and turning signals. For example, ‘S’ for speed, ‘A’ for acceleration etc. It can indicate safety related alerts such as ‘E’ for emergency situations, ‘O’ obstacle detection, ‘C’ for collision warning. It also represents location and positional data including latitude and longitude coordinates, direction and altitudes.

E. Basis of Communication

Zigbee enables communication between vehicles using predetermined protocols designed to transmit alert messages after detecting events such as potholes or emergencies. These alerts contain specific event details and are deciphered by the Zigbee system of the receiving vehicle, which triggers actions like driver warnings or safety measures based on the information received.

IV. Result and Discussion

This project initializes components like buttons, sensors (Ultrasonic and Mem), buzzer, and LCD, connects to Wi-Fi, and checks for button presses and sensor readings. It responds to button presses with driver alerts or accident notifications and detects potholes. A speed function adjusts LED intensity based on vehicle velocity. Data transmission to a web server enables monitoring, with real-time feedback displayed on the LCD. Error handling ensures reliable connectivity and smooth operation, enhancing user experience and system reliability.

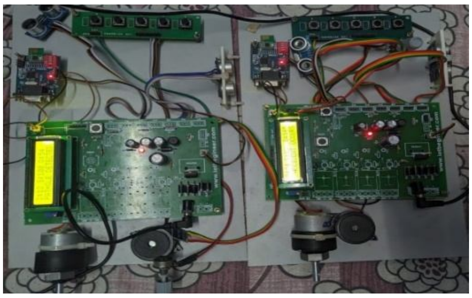

Fig 4.1 The proposed system model

Fig 4.2 Detected output

Here S is assumed to be the speed of the vehicle and D is the distance between the vehicles.

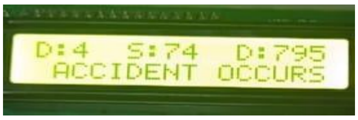

Fig 4.3 Detected output on tilting mem sensor

In fig 4.4, by using the mem sensor, the system detects accidents by monitoring the vehicle's tilt angle beyond a certain threshold. When the angle surpasses this limit, it triggers a message on the LCD display indicating that an accident has occurred. This approach enhances the safety by promptly notifying the drivers of potential incidents based on the vehicle's orientation.

Fig 4.4 Motor stops when the distance detects at 5 to 10 feet

The speed regulation involves an electric motor (fig 4.4) that operates at 74 km/h (Fig 4.4). When the vehicle's proximity sensor detects a range of 5 to 10 feet, it autonomously adjusts the speed, slowing down the car. This functionality is applicable in automated vehicle systems. In manual cars, speed control can be achieved by positioning the sensors at the front side of the vehicle. When the sensors detect to a range close to cm, they activate a warning message prompting the driver to slow down. Additionally, a buzzer installed in the vehicle emits a beeping sound to alert the driver.

#	VEHICLE	POTH HOLE STATUS	LOCATION	Date & Time	Action
1	TN57 0903	ACCIDENT OCCURS	lat:13.0342327long:80.1967513	2024-03-14 11:00:31	
2	TN57 A2110	PATHOLE DETECTED	lat:13.0342327long:80.1967513	2024-03-14 11:00:28	
3	TN57 0903	PATHOLE DETECTED	lat:13.0342327long:80.1967513	2024-03-14 11:00:01	
4	TN57 A2110	ACCIDENT OCCURS	lat:13.0342327long:80.1967513	2024-03-14 10:59:50	
5	TN57 A2110	PATHOLE DETECTED	lat:13.0342327long:80.1967513	2024-03-14 10:59:19	
6	TN57 A2110	PATHOLE DETECTED	lat:13.0342327long:80.1967513	2024-03-14 10:59:12	
7	TN57 0903	ACCIDENT OCCURS	lat:13.0342327long:80.1967513	2024-03-14 10:58:25	
8	TN57 A2110	PATHOLE DETECTED	lat:13.0342327long:80.1967513	2024-03-14 10:58:21	
9	TN57 0903	ACCIDENT OCCURS	lat:13.0342327long:80.1967513	2024-03-14 10:58:06	
10	TN57 0903	ACCIDENT OCCURS	lat:13.0342327long:80.1967513	2024-03-14 10:58:00	

Table 4.5 Designated webserver

Once Zigbee transmits the data as characters, it displays the output on a designated web server (Tab 4.5). This enables us to verify and monitor any shared latitude or longitude information regarding accident occurrences or pothole detection.

V. CONCLUSION

Real-time vehicle monitoring is facilitated by the integration of sensors, buttons and Zigbee communication in this prototype. Emergency situations, accidents and potholes are effectively identified with alerts triggered promptly; followed by transmission to a web server for processing. The system registers dependable connectivity while managing timing besides prompt feedback delivery via LCD screens or buzzers resulting in improved communication efficiency and enhanced safety levels during travel aboard vehicles.

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