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ENHANCING VEHICLE CONNECTIVITY: LI-FI TECHNOLOGY FOR VEHICULAR COMMUNICATION

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ABSTRACT: This paper aims to prevent accidents and ensure road safety by highlighting the importance of Vehicle-to-Vehicle (V2V) communication. V2V can ensure road safety, reduce vehicle collisions and enhance driver focus. we use Li-Fi technology for V2V communication, utilizing a Light Emitting Diode (LED) as the transmitter and a Light Dependent Resistor (LDR) as the receiver. The purpose of this project is to develop and implement a low-cost prototype system with advanced features designed to alert drivers in real-time. As a result, without any communication errors or delays, two vehicles can communicate within 3 meters. This enhances both vehicle and human security. Additionally, by integrating an alarm system, the project aims to help drivers focus more on avoiding accidents and improving road safety.

Keywords: Light Emitting Diode (LED), Li-fi and Light Dependent Resistor (LDR), Vehicle-to-Vehicle (V2V)

1. INTRODUCTION

The increasing number of vehicles globally presents several challenges, with road accidents rising daily due to traffic congestion. One solution to mitigate road accidents is the use of Li-Fi technology, which overcomes the limitations of microwave wireless communications. Li-Fi is a wireless communication technology that facilitates communication between two or more vehicles. In microwave communication working on MHz and GHz frequency ranges and Li-fi works on the THz frequency range. Li-fi technology uses light waves to transmit data. Li-fi is a subset of wireless optical communication. Light waves can communicate with Line of Sight (LoS) and communication speed is high and provides reliable communication. V2V communication is a popular concept and there are models with simulations. With Li-fi technology and sensor applications, it can achieve multiple services and able to avoid collisions between two vehicles.

Li-fi technology helps to transmit data more quickly than Wi-Fi. Li-fi is 100 times faster than Wi-fi. Li-Fi potential range is 10 Gbps and it is operating in THz frequency range. Also, it is a short-range communication method, and it can transfer data within milliseconds in V2V communication. In addition, LED and LDR are low-cost components, and these are the main components for the transmitter and the receiver in Li-Fi technology. With consideration of the Field of View (FoV) of LED and the LDR, they can communicate using the LoS. It is a huge benefit for such kinds of V2V applications. Limitations of the V2V communication using Li-fi are required LoS, response to the ambient light and limited coverage area due to the short-range communication system. Last few years, there have been a lot of road accidents on Sothern Expressway in Sri Lanka and the number of accidents has increased day by day as per (Daily Mirror, 2023 August 18). We identified the importance of a reliable communication system to communicate with adjacent vehicles and the need to pay more attention to drivers as per (Iftikhar et al., 2022). According to the literature survey, we discovered that implementing the system with new technologies ensures road safety as per (Song et al., 2022). Increase the communication between two vehicles using Li-fi technology and use as headlight and other light sources to transmit the message as per (Shafiqurrahman et at., 2023). Using existing sources of the vehicles can transmit data and implement the advanced communication system as per (Das et al., 2023). The most important factors are efficiency and real-time updates for reliable communication as per (Nguyen et.al., 2023).

The main contributions of the paper are 1. Implement prototype hardware system. 2. Implement a real-time update display system and emergency buzzer system. As a future development, we identify to implement additional safe modes such as overtaking and turns. It can improve road safety and avoid accidents.

2. METHODOLOGY

Sstem design

The proposed system is designed so that when the first vehicle applies its brakes, the brake lights are activated. In our prototype system, we used a transmitter with LED and a Receiver as a panel of LDR sensors. To develop the entire prototype system, we used Arduino Uno boards, Motor drivers, TT gear motor wheels, LCD, LDR sensors, LED lights, Battery holders, Batteries, Buzzer Module. The total cost for the overall system is 9000/-. The LDR panel in the second vehicle detects the illuminated brake lights, signalling that the front vehicle is slowing down. This information is then communicated to the driver of the second vehicle through a visual display and an alarm, providing an immediate alert to take necessary action.

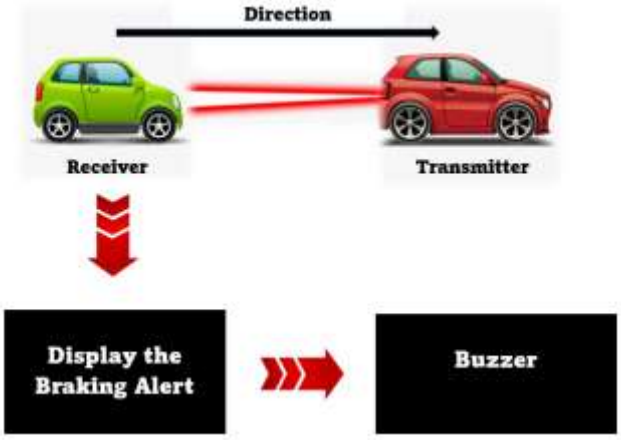

Fig. 1. The system block diagram of V2V communication**.**

Fig. 1 illustrates the block diagram of the V2V communication system designed for braking incidents of the front vehicle. Fig. 2 presents the schematic diagram of the transmitter with all technical details, while Fig. 3 depicts the schematic diagram of the receiver within the V2V communication system.

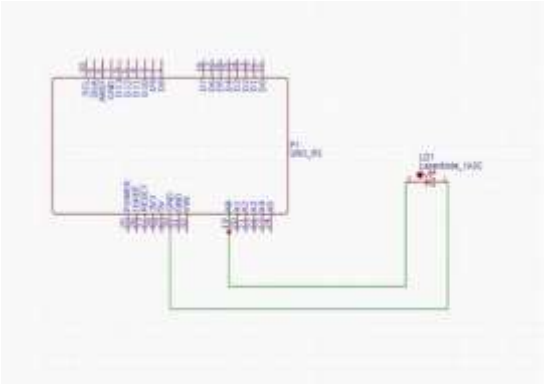

Fig. 2. Schematic diagram of transmitter.

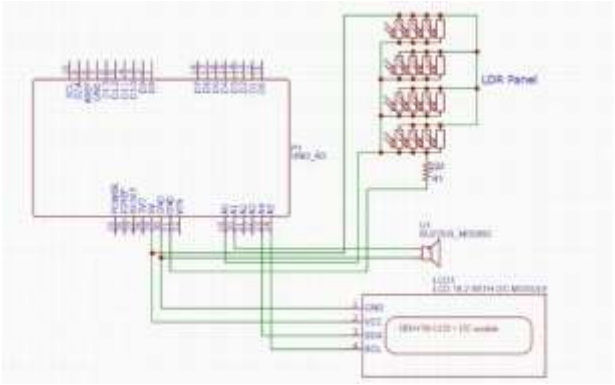

Fig. 3. Schematic diagram of receiver.

3. RESULTS AND DISCUSSION

In this section, we present the implemented circuit and results of the gas detection centralized system.

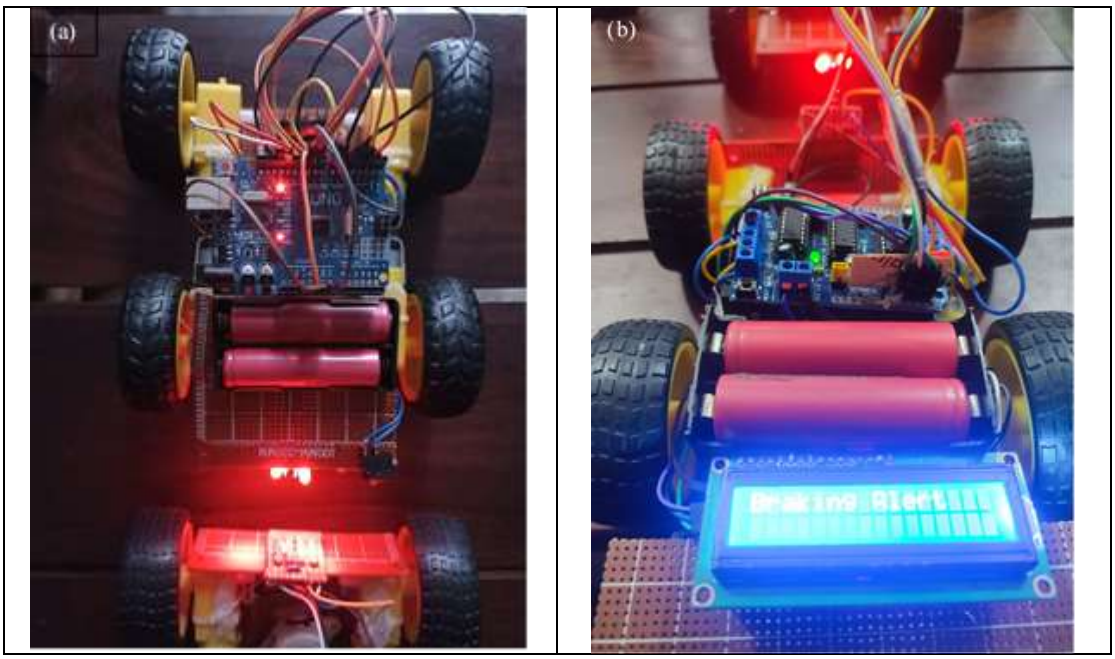

Fig. 4. (a) Implemented prototype design and communicate V2V (b) Display the braking alert and buzzer in the implemented design.

Fig. 4(a) shows the implemented prototype design, demonstrating the communication between two vehicles when one vehicle applies its brakes. Fig. 4(b) depicts the system in action, showing how the braking alert is displayed and accompanied by a buzzer sound to capture the driver's attention. In addition, tested within 3 meters of two vehicles. Without any error communicate the two vehicles and show in the display.

4. CONCLUSIONS

The proposed V2V communication system effectively enhances road safety by providing timely alerts to the driver of a following vehicle when the leading vehicle applies its brakes. By using a transmitter equipped with LEDs to simulate brake lights and a receiver comprising an array of LDR sensors, the system successfully detects the braking actions of the front vehicle. Upon detection, the system promptly communicates this critical information to the driver of the second vehicle through a visual display and an audible alarm. This immediate feedback allows the driver to react swiftly, reducing the chances of rear-end collisions and contributing to safer driving conditions.

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