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ENHANCING ROAD SAFETY WITH V2V COMMUNICATION: INTEGRATING LI-FI AND LORAWAN TECHNOLOGIES FOR ACCIDENT PREVENTION

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Abstract
Road accidents pose a persistent global threat, resulting in numerous injuries and fatalities annually. Despite existing preventive measures, innovative solutions are needed to address this issue effectively. Vehicle-to-Vehicle (V2V) communication has emerged as a crucial tool in accident prevention. Two emerging wireless communication technologies, Light Fidelity (Li-Fi) and LoRaWAN (Low Power Wide Area Network), offer distinct advantages over traditional methods like Wi-Fi and cellular networks. Li-Fi utilizes light waves for data transmission, while LoRaWAN employs radio waves for long-distance communication. This paper evaluates and compares the performance of these technologies in terms of communication range, data rate, and power consumption, while also examining their potential applications and associated challenges. The proposed system integrates both Li-Fi and LoRaWAN to operate effectively across both short and long ranges. With road accidents claiming over 1.2 million lives in 2020 alone, safety remains paramount. Particularly concerning are nighttime accidents, which account for over 40% of all fatal car accidents despite reduced traffic. Leveraging Li-Fi as a means of Visible Light Communication presents a highly accurate method for preventing collisions between vehicles. By implementing a communication protocol in all vehicles, drivers can receive real-time positional information to proactively avoid accidents, thus enhancing vehicle and pedestrian safety on the roads.
Keywords: Road accidents, Vehicle-to-Vehicle (V2V) communication, Light Fidelity (Li-Fi), LoRaWAN (Low Power Wide Area Network), Wireless communication technologies, Accident prevention, Traffic safety.

1 Introduction

Li-Fi, a revolutionary technology conceptualized by Harald Haas, proposes a groundbreaking approach to wireless communication by utilizing the visible light spectrum. In his TED Global talks, Haas elucidated the concept of Visible Light Communication (VLC), which operates on a simple principle: when an LED is illuminated, it represents a digital '1', and when it's switched off, it signifies a digital '0'. This binary system enables rapid data transmission by exploiting the quick-switching capabilities of LEDs. At the core of Li-Fi lies the remarkable potential of light-emitting diodes (LEDs), which can be modulated at high speeds to encode and transmit data. This capability offers a significant advantage over traditional radio frequency (RF) communication utilized in Wi-Fi technology. While RF spectrum, used by Wi-Fi, is becoming increasingly congested due to the surging demand for wireless connectivity, the visible light spectrum remains largely untapped. Li-Fi harnesses this vast and unexploited bandwidth, offering transmission rates that are potentially thousands of times faster than conventional Wi-Fi. This technology's potential for advancement is evident in its ability to address the growing need for faster, more reliable wireless communication while alleviating the strain on existing RF spectrum. By utilizing light waves for data transmission, Li-Fi holds promise for enhancing data transfer speeds, reducing network congestion, and facilitating seamless connectivity in environments where traditional wireless technologies face limitations. Li-Fi technology holds immense promise for addressing the increasing demand for high-speed data transmission, particularly in environments where traditional RF spectrum-based technologies like Wi-Fi face limitations due to congestion. By utilizing the visible light spectrum, Li-Fi offers a significantly broader bandwidth, potentially providing data transmission rates up to 10,000 times faster than Wi-Fi. One of the key features of Li-Fi is its ability to modulate the flicker rate of LEDs to encode and transmit data. By varying the flicker rate depending on the data to be transmitted, Li-Fi can achieve efficient and high-speed communication. Moreover, advancements in this method, such as employing combinations of red, green, and blue LEDs or utilizing parallel data transmission LED arrays, can further enhance the technology's capabilities. These enhancements enable the encoding of multiple data channels, effectively increasing the overall throughput of the system. The theoretical speed of up to 10 Gbps offered by Li-Fi opens up a wide range of applications across various sectors. For instance, in healthcare settings such as hospitals, Li-Fi can facilitate high-speed data transmission for medical instruments, enabling real-time monitoring and analysis. Similarly, in transportation applications, Li-Fi can revolutionize vehicle-to-vehicle (V2V) communications by offering a more efficient and reliable alternative to existing RF-based technologies like Dedicated Short Range Communications (DSRC). By leveraging Li-Fi technology, V2V communication systems can enhance road safety and improve traffic management. Furthermore, Li-Fi holds promise for enhancing accessibility and communication for visually impaired individuals. By embedding location data into the visible light emitted by LEDs and utilizing Li-Fi receivers, an embedded system can calculate optimal paths to destinations and relay this information to visually impaired individuals through headphones or speakers. This application demonstrates the potential of Li-Fi to not only provide high-speed data transmission but also to contribute to societal advancements in accessibility and inclusivity. In summary, Li-Fi technology represents a significant advancement in wireless communication, offering unparalleled speed, reliability, and efficiency. With its wide-ranging applications in various sectors, from healthcare to transportation and accessibility, Li-Fi has the potential to reshape the way we transmit and receive data in the near future.

2 Literature Survey

Kalyani et.al [1] proposed system for vehicle accident detection and emergency response, three main components are identified: vibration sensors, GPS, and a GSM module. These components work together to detect accidents, determine the vehicle's location, and communicate with emergency services. However, while this system addresses the immediate need for accident detection and emergency response, it lacks crucial information about the victim's medical history, which could potentially delay medical treatment and hinder the overall effectiveness of the system. When a vehicle experiences an impact, the vibration sensor detects the force of the impact, triggering the system to initiate emergency protocols. The Arduino microcontroller then compares the detected impact with a predefined threshold value to determine if it constitutes an accident. If the impact exceeds the threshold, the system proceeds to activate the emergency response mechanism.

Barış et.al [2] The proposed system aims to not only detect accidents but also to prevent them by identifying signs of driver drowsiness. Leveraging the ubiquity of smartphones, the system integrates them as a key component. However, a potential limitation arises if drivers forget their smartphones or do not own one, which could compromise the system's effectiveness. To address this challenge, researchers Wang et al. (2020) explored the utilization of low-power LoRaWAN wireless

communication for intelligent transportation systems. LoRaWAN offers a promising solution by providing long-range, low-power communication capabilities, which could mitigate the reliance on smartphones for data transmission in the proposed system.
Johri et.al [3] delves into the significance of Vehicular Ad-Hoc Networks (VANETs) in cloud computing, highlighting their role in enhancing efficiency and privacy through various methodologies. The proliferation of web development has led to the widespread usage of applications and service-oriented applications, resulting in a growing need for secured data processing, notification, and transmission within human-vehicle interaction systems. The Project CASA (Car Safety Apps) exemplifies this trend, being a collaborative effort among five industrial partners and one academic institution in France. The project's primary objective is to develop an Android application that promotes safe and eco-friendly driving while ensuring secure data transmission. This paper focuses on elucidating the security features and aspects embedded within the project, emphasizing the safety and confidentiality of multimodal data processing.
Haas et.al [4] offers a comprehensive review of the evolution, development, and future trajectories of driver assistance systems spanning three decades. It underscores the intrinsic human desire for mobility and discusses a potential evolutionary roadmap for these systems. The review begins by examining the foundational goals of driver assistance systems and traces their evolution from early iterations reliant on proprioceptive sensors like ABS or ESC. It then delves into the significant advancements spurred by the integration of exteroceptive sensors such as radar, video, and lidar, which have revolutionized the landscape of driver assistance technologies. Additionally, the paper introduces a novel system designed to enhance driver awareness and safety through the utilization of smartphones as sensor platforms. This system leverages Dynamic Time Warping (DTW) and sensor fusion techniques to detect, recognize, and record driving actions in real-time without the need for external processing.
Wen et.al [5] explores the feasibility of utilizing visible light communications (VLC) systems for information exchange within platoons of vehicles. A comprehensive VLC model is constructed, facilitating precise calculations of the Bit-Error-Rate (BER) considering factors such as inter-vehicle distance, background noise, incidence angle, and receiver electrical bandwidth. Through the analytical model, optical parameters conducive to platooning applications are identified. Furthermore, a SIMULINK model is developed to evaluate the performance of platoon communication exchanges based on the defined optical parameters. This simulation enables an in-depth analysis of VLC system effectiveness within platoon configurations. In a related study, the effectiveness of three pulse amplitude modulations (PAM) - on-off keying (OOK), PAM-4, and generalized space-shift keying (GSSK) - in a vehicular context is compared. Utilizing a prototype built from off-the-shelf light-emitting diodes (LED) headlamps, static tests are conducted in both straight-line and curved configurations, with varying inter-vehicle distances.

3 Methodology

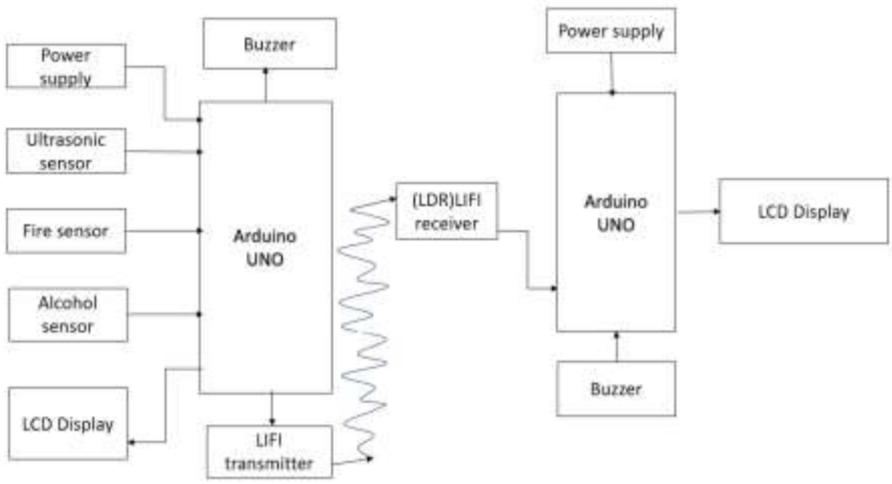


Fig 1 Block Diagram

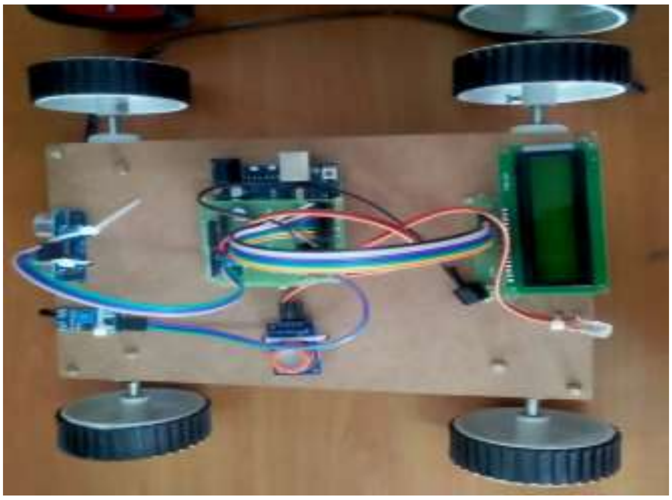
The block diagram you sent appears to be a fire alarm system with several sensors. It likely works as follows: The fire sensor, ultrasonic sensor, and alcohol sensor all detect different types of fires. The LIFI receiver and transmitter then communicate with an Arduino UNO, which triggers the buzzer and LCD display if a fire is detected by any of the sensors. The power supply provides power to the entire system. Here's a breakdown of the components and how they might interact:

- **Sensors:**
  - Fire sensor: This sensor detects smoke or heat and triggers the alarm when a fire is identified.
  - Ultrasonic sensor: This sensor uses sound waves to detect potential fires.
  - Alcohol sensor: This sensor detects the presence of alcohol, which could be a fire hazard.
- **LIFI components:**
  - LIFI receiver: This component likely receives data transmitted by the LIFI transmitter. LIFI stands for Light Fidelity and is a wireless communication technology similar to WiFi but uses visible light instead of radio waves.
  - LIFI transmitter: This component transmits data, possibly to the Arduino UNO, using LIFI technology.
- **Arduino UNO:** This is a microcontroller board that likely controls the entire system's logic based on the signals received from the sensors and LIFI components.
- **LCD Display:** This display shows information about the system, such as fire alarms or system status.
- **Buzzer:** This sounds an alarm when a fire is detected.
- **Power Supply:** This supplies power to the entire system.

Overall, the system appears to use various sensors to detect fire and then communicates the information to the Arduino UNO through wired connections and potentially wirelessly through LIFI. The Arduino UNO then triggers the alarm (buzzer and LCD display) if a fire is identified. The power supply keeps the system operational. It's important to note that this is a high-level overview based on the block diagram, and the specific functionality may vary depending on the system's design.

Results

PROTOTYPE OF THE PROJECT



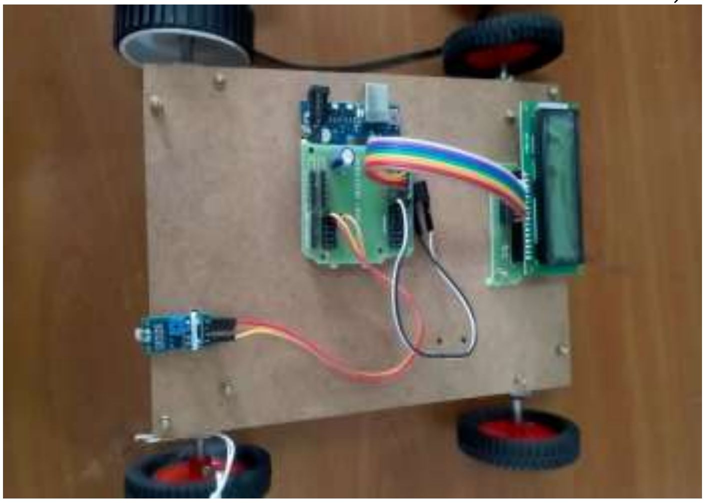
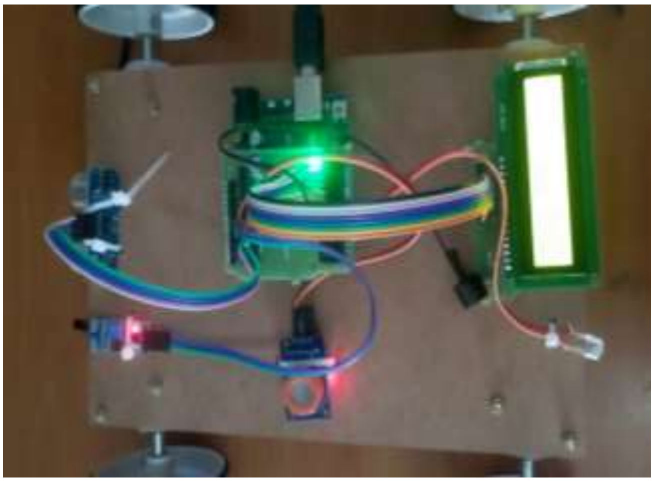


Fig 2 Prototype for transmitter

This project mainly consists of the Arduino, LCD display, Alcohol sensor, fire sensor, ultrasonic sensor. During the execution of the system LCD of the display were identified. The system being a complete hardware design and the data will be taken form the sensors. Test results of the system are given below



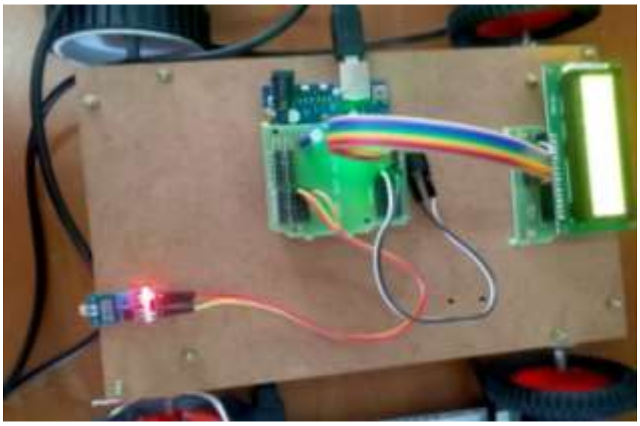


Fig 3 Prototype for receiver

RESULT FOR ULTRASONIC SENSOR:

RESULT FOR FIRE SENSOR:

RESULT FOR ALCOHOL SENSOR:

Conclusion

In conclusion, with road accidents continuing to pose a significant global threat and claiming numerous lives annually, innovative solutions are imperative. Vehicle-to-Vehicle (V2V) communication, facilitated by emerging technologies like Light Fidelity (Li-Fi) and LoRaWAN, presents a promising avenue for accident prevention. This paper has evaluated and compared the performance of Li-Fi and LoRaWAN in terms of communication range, data rate, and power consumption. It also highlighted their potential applications and associated challenges. The proposed system, integrating both Li-Fi and LoRaWAN, aims to leverage the strengths of each technology to effectively address short and long-range communication needs. Considering the alarming statistics, especially concerning nighttime accidents, where visibility is reduced but fatalities remain high, the implementation of Li-Fi as a means of Visible Light Communication holds significant promise. By equipping vehicles with a communication protocol, drivers can receive real-time positional information, enabling proactive collision avoidance and enhancing overall road safety for both vehicles and pedestrians.

Feature Scope

The feature scope encompasses a defined set of functionalities and characteristics that the software or product will include, outlining both its core features and non-functional requirements such as performance, scalability, security, usability, and reliability. It includes user stories or use cases to illustrate specific interactions, acceptance criteria to ensure successful implementation, and constraints and assumptions that may impact development. This comprehensive document serves as a roadmap for the development team, guiding them in building a product that meets user needs while adhering to project constraints and objectives.

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