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# VEHICLE TO VEHICLE COMMUNICATION USING LI-FI TECHNOLOGY

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## ABSTRACT

This paper presents an innovative Vehicle-to-Vehicle (V2V) communication system based on Light Fidelity (Li-Fi) technology aimed at enhancing traffic safety through advanced accident detection and prevention mechanisms. Traffic accidents remain a leading cause of death and injury worldwide, with human error, adverse weather conditions, and road hazards often contributing to accidents. The conventional methods for preventing such accidents, including passive safety features and traffic regulation systems, have limitations in responding to real-time driving conditions and situations. To overcome these challenges, the proposed system integrates the latest advancements in Li-Fi technology, which uses light signals for high-speed, secure communication between vehicles, enabling them to share critical information in real time. This approach allows for faster, more reliable vehicle-to-vehicle communication than traditional radio frequency (RF) communication systems, particularly in complex or dense traffic environments. The core of this accident prevention system is based on a variety of sensors, such as alcohol detectors, ultrasonic proximity sensors, and real-time vehicle data collectors. These sensors continuously monitor critical conditions in and around the vehicle, including the driver's state (e.g., whether the driver is intoxicated) and the vehicle's proximity to others on the road. For example, the alcohol sensor detects if the driver is under the influence of alcohol, sending an alert to the system that could trigger automatic actions, such as warning signals or even disabling the vehicle's engine if necessary. The ultrasonic sensors monitor the distance between the vehicle and others around it, detecting when the distance becomes dangerously small. In such cases, the system communicates this information to the front vehicle via Li-Fi, allowing drivers to be alerted in real-time and take appropriate actions to avoid collisions. This V2V communication system leverages the benefits of Li-Fi's high-speed data transmission to facilitate the rapid exchange of information between vehicles. If a vehicle detects an imminent collision, whether from a sudden stop, rapid deceleration,

or an obstacle in the road, the system immediately communicates this information to surrounding vehicles. By doing so, the nearby vehicles can receive warnings and adjust their speed or position, greatly reducing the chances of secondary accidents or pile-ups. Unlike conventional RF-based communication methods, Li-Fi offers a more secure and interference-resistant medium for data transmission, making it especially suitable for high-density urban traffic where the likelihood of interference and congestion in communication systems is higher. Moreover, the system not only focuses on collision prevention but also aims to provide continuous feedback to the driver to mitigate risky behaviors. For instance, if a vehicle is found to be speeding or performing unsafe lane changes, the system's sensors and analytics software can send warnings or initiate corrective actions such as activating the vehicle's automatic braking system or steering assist mechanisms. This proactive approach to driver assistance reduces the risk of accidents due to human error and enhances the overall safety of roadways. The system's ability to analyze driver behavior and adjust the vehicle's operations based on real-time data offers a significant improvement over traditional passive safety measures like airbags and seat belts.

**Keywords-**LI-FI transmitter, receiver, Arduino UNO, gas sensor, ultrasonic sensor, buzzer, LED

## I.INTRODUCTION

Li-Fi, short for Light Fidelity, is a ground breaking technology that offers an alternative to traditional radio-frequency (RF) communication systems by using light, specifically light emitted from light-emitting diodes (LEDs), to transmit data. This technology falls under the category of optical wireless communications (OWC), and its operation relies on visible light communication (VLC). The fundamental principle behind Li-Fi is the rapid switching of LED currents, which occurs at such high speeds that it is imperceptible to the human eye, thus eliminating any visible flickering. This allows Li-Fi to continuously transmit data while providing illumination, a feature

that traditional wireless technologies like Wi-Fi do not offer. Li-Fi represents a significant leap forward in network communication because it operates in the visible light, infrared, and near-ultraviolet spectrums, offering a much larger bandwidth compared to the limited RF spectrum. This capability allows Li-Fi to provide high-speed data transmission, which can support a range of applications from home networks to more

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complex setups in commercial, industrial, and even urban environments. The ability to transmit vast amounts of data over optical wavelengths without interference from traditional RF signals opens up numerous possibilities for improving communication in environments where RF communication is not feasible or is prone to congestion and interference, such as in crowded public spaces or areas with high electromagnetic interference. One of the key strengths of Li-Fi technology is its capacity to offer secure, high-speed wireless communication in places where traditional RF-based wireless systems, such as Wi-Fi, might struggle. Unlike Wi-Fi, which operates over the radio spectrum, Li-Fi uses light, a medium that cannot easily penetrate walls or other opaque surfaces. This results in an added layer of security, as the data transmitted via Li-Fi is contained within the illuminated area and cannot be intercepted from outside that space. Furthermore, Li-Fi can significantly reduce network congestion by providing a high data rate through the use of optical wavelengths, which have a much higher frequency and bandwidth compared to RF signals. Additionally, Li-Fi can be integrated into existing infrastructure, such as lighting systems, making it an efficient and cost-effective solution for enhancing network connectivity in both residential and commercial settings. A critical feature of Li-Fi that extends its potential is its ability to allow for roaming or handover between different Li-Fi cells, ensuring a seamless transition for users moving through a Li-Fi-enabled environment, such as from one room to another or between different floors in a building. This is particularly advantageous in scenarios like smart cities or transportation systems, where mobility and continuous connectivity are essential. Despite its promising capabilities, Li-Fi technology faces some challenges that need to be addressed for widespread adoption. One of the main obstacles is the need for line-of-sight communication, as the transmission of data via light requires a direct path between the transmitter (LED) and the receiver. This can limit its application in certain environments or situations where obstructions exist. Additionally, while Li-Fi LEDs can be dimmed to levels below human visibility, allowing for continuous data transmission, this creates potential bottlenecks, particularly since the LEDs used for illumination may not be optimized for high-speed data transfer. This could impact the efficiency and performance of Li-Fi systems in scenarios where the primary purpose of the LED lights is to provide general lighting rather than data transmission. However, the future of Li-Fi lies in its integration with other communication technologies, such as Wi-Fi and cellular networks, creating a hybrid network that combines the best of both optical and RF communications.

## II.METHODOLOGY

### A) System Architecture

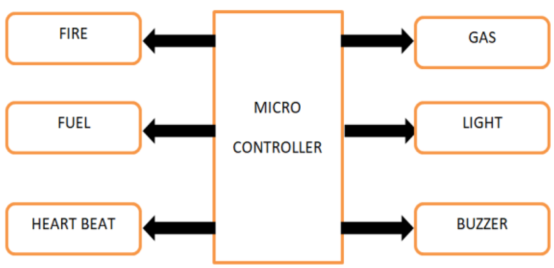


**Fig1 .Block Diagram**

The system architecture for smart monitoring in vehicle-to-vehicle (V2V) communication using Li-Fi technology involves integrating Li-Fi-enabled communication modules into vehicles, which transmit data through visible light instead of radio waves. Vehicles are equipped with Li-Fi receivers and LED transmitters that exchange critical data such as speed, location, and traffic conditions in real time. The data is transmitted to nearby vehicles using light communication for high-speed, secure, and interference-free connectivity. The system enhances road safety by enabling vehicles to communicate with each other and with infrastructure, facilitating collision avoidance, traffic flow optimization, and emergency alerts.

### B) Proposed Raspberry pi

The Raspberry Pi Pico is an affordable microcontroller board created by the Raspberry Pi Foundation. Unlike full-fledged computers, microcontrollers are small and have limited storage and peripheral options, such as the absence of devices like monitors or keyboards. However, the Raspberry Pi Pico is equipped with General Purpose Input/Output (GPIO) pins, similar to the ones found on Raspberry Pi computers, allowing it to connect with and control a variety of electronic devices. Introduced in January 2021, the Raspberry Pi Pico is based on the RP2040 System on Chip (SoC), which is both cost-effective and highly efficient. The RP2040 SoC includes a dual-core ARM Cortex-M0+ processor that is well-known for its low power consumption. The Raspberry Pi Pico is compact, versatile, and performs efficiently, with the RP2040 chip as its core. It can be programmed using either Micro Python or C, providing a flexible platform for users of various experience levels. The board contains several important components, including the RP2040 microcontroller, debugging pins, flash memory, a boot selection button, a programmable LED, a USB port, and a power pin. The RP2040 microcontroller, custom-built by the Raspberry Pi Foundation, is a powerful and affordable processor. It features a dual-core ARM Cortex-M0+ processor running at 133 MHz, 264 KB of internal RAM, and supports up to 16 MB of flash memory. The microcontroller provides a wide range of input/output options, such as I2C, SPI, and GPIO. The Raspberry Pi Pico has 40 pins, including ground (GND) and power (Vcc) pins. These pins are grouped into categories such as Power, Ground, UART, GPIO, PWM, ADC, SPI, I2C, System Control, and Debugging. Unlike the Raspberry Pi computers, the GPIO pins on the Pico can serve multiple functions. For instance, the GP4 and GP5 pins can be set up for digital input/output, or as I2C1 (SDA and SCK) or UART1 (Rx and Tx), though only one function can be used at a time.

## C) Design Process

The design of embedded systems follows a methodical, data-driven process that requires precise planning and execution. One of the core elements of this approach is the clear separation between functionality and architecture, which is crucial for moving from the initial concept to the final implementation. In recent years, hardware-software (HW/SW) co-design has gained significant attention, becoming a prominent focus in both academia and industry. This methodology aims to align the development of software and hardware components, addressing the integration challenges that have historically affected the electronics field. For large-scale embedded systems, it is essential to account for concurrency at all levels of abstraction, impacting both hardware and software components. To facilitate this, formal models and transformations are employed throughout the design cycle, ensuring efficient verification and synthesis. Simulation tools are vital for exploring design alternatives and confirming the functional and timing behavior of the system. Hardware can be simulated at different stages, including the electrical circuit, logic gate, or RTL level, often using languages like VHDL. In certain setups, software development tools are integrated with hardware simulators, while in other cases, software runs on the simulated hardware. This method is generally more suited for smaller parts of an embedded system. A practical example of this methodology is the design process using Intel's 80C188EB chip. To reduce complexity

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and manage the design more effectively, the process is typically divided into four main phases: specification, system synthesis, implementation synthesis, and performance evaluation of the prototype.

**APPLICATIONS**

Embedded systems are being increasingly incorporated into a wide range of consumer products, such as robotic toys, electronic pets, smart vehicles, and connected home appliances. Leading toy manufacturers have introduced interactive toys designed to create lasting relationships with users, like "Furby" and "AIBO." Furbies mimic a human-like life cycle, starting as babies and growing into adults. "AIBO," which stands for Artificial Intelligence Robot, is an advanced robotic dog with a variety of sophisticated features. In the automotive sector, embedded systems, commonly referred to as telematics systems, are integrated into vehicles to offer services like navigation, security, communication, and entertainment, typically powered by GPS and satellite technology. The use of embedded systems is also expanding in home appliances. For example, LG's DIOS refrigerator allows users to browse the internet, check emails, make video calls, and watch TV. IBM is also developing an air conditioner that can be controlled remotely via the internet. Given the widespread adoption of embedded systems across various industries.

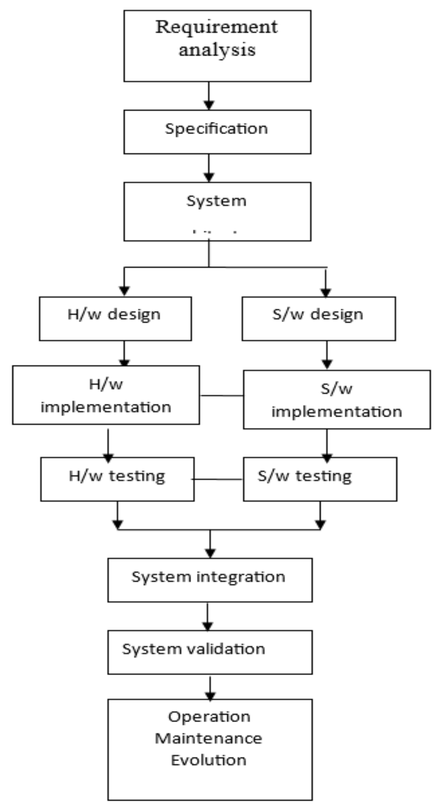


Fig 2. Embedded Development Life Cycle

## III.CONCLUSION

In conclusion, the proposed system utilizing Li-Fi technology for Vehicle-to-Vehicle (V2V) communication provides a promising solution to reduce traffic accidents and enhance road safety. By integrating a variety of sensors such as MQ3 alcohol sensors, vibration sensors, ultrasonic sensors, PC cameras, Arduino boards, and LED lights, the system enables real-time communication between vehicles, allowing them to exchange critical safety data. The use of Li-Fi ensures fast and secure data transmission without interference, making it an ideal communication medium for vehicles. The incorporation of solar panels for power generation further supports the sustainability and energy efficiency of the system, making it suitable for widespread deployment in transportation networks. By notifying vehicles of potential hazards, such as sudden braking, alcohol consumption detection, or close vehicle proximity, the system significantly improves the safety of both drivers and passengers.Moreover, the adoption of this technology on a large scale could lead to a reduction in traffic accidents by enabling proactive accident prevention measures. The system's ability to monitor vehicle conditions and communicate potential risks in real time has the potential to transform how traffic safety is managed. As a result, this approach not only promises to reduce accident rates but also lays the groundwork for the development of smart transportation systems that can improve traffic flow, reduce congestion, and ensure safer roads for everyone. The continuous evolution of Li-Fi and its integration into vehicle communication systems will contribute to the future of safer, smarter, and more efficient transportation networks worldwide.

## IV.FUTURE SCOPE

The future scope includes expanding the range and scalability of Li-Fi communication in various environmental conditions, improving its integration with 5G for faster and more reliable data exchange. The system could evolve to support smart city ecosystems, where vehicles, traffic signals, and other infrastructure work seamlessly together. Additionally, as autonomous vehicles become more prevalent, V2V communication using Li-Fi could play a pivotal role in enabling safer, more efficient navigation and real-time decision-making. Enhanced security protocols and data encryption will ensure the safety and privacy of the communication network.

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