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Li-Fi technology for automated transport

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ABSTRACT

India is now one of the countries that is growing quickly worldwide. Today, practically for everything, a vehicle is necessary. Vehicle production is growing rapidly. One of the downsides of this enormous increase is the ineffective management of traffic. The well-planned expansion of transport organizations has resulted in a variety of challenges with travel. It is detrimental to both mankind and the economy when emergency vehicles like ambulances and fire engines are late in arriving. Smart transport is the most effective strategy to lower vehicle accidents and communicate with other cars to open a way for emergency vehicles. Here, the preliminary ideas and findings of a small-scale model of an automated transport system are presented using an innovative discovery known as Li-Fi, also known as light-fidelity. Full duplex communication is accomplished with Li-Fi, in which light is modified at speeds that are too rapid for the eye to follow. Li-Fi may be used to create intelligent transportation systems since it offers various advantages over other communication protocols.

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1. INTRODUCTION

For the past few years, our nation has struggled with terrible traffic congestion in major cities. Transportation is a major area that needs improvement [1], [2]. Numerous issues with transport and travel are being caused by the steadily growing number of transport services. Human mistake plays a large part in many incidents [3]–[5]. A proper understanding of the surrounding vehicles' speed and direction reduces accidents [6], [7]. If the vehicle is able to send information to the other vehicles nearby, while they reduce or increase speed or while changing direction, with the help of a vehicle-to-vehicle communication system, accidents can be reduced [8], [9]. The following two cases are examples where assistance is needed.

- Case 1: when the first vehicle applies the brakes, the speedometer detects that its present velocity has been reduced from the previous one speed and transmits a signal to the vehicle using the transmitter. The photodiode of the second vehicle will be used by vehicle 2 to receive the message. In the second vehicle, the "slow down" message is displayed on the LCD screen.
- Case 2: using the LED in the headlamps, vehicle 1 will continue to transmit information about its speed to vehicle 2 when it is at a T-intersection. The photodiode in vehicle 2 will get the information about the speed. The driver of the car will be warned to observe the other automobile that is nearby if the second vehicle plans to enter the junction when the first vehicle continues to travel at a high speed.

The essential emergency services, such as firefighters and medical vehicles, do not arrive in time, causing both human and financial losses [10]. For the patient's family members who were being evacuated in ambulances, it is a difficult time. The large amount of traffic is one of the crucial concerns ambulances deal with. Due to excessive traffic, ambulances become trapped in the road for longer periods of time, endangering the patients' lives in ways that are common in day-to-day activities. We require a dependable wireless vehicle-to-vehicle communication system to address all of these issues [11].

The only medium for communication that is wireless has been radio waves. Technology advancements have caused congestion in the spectrum. It is extremely challenging to create a vehicle-to-vehicle communication system using the radio frequencies that have been chosen for this purpose because the electromagnetic spectrum is already overloaded with other applications [12]. The requirement for a different spectrum is growing every day. Due to their negative effects on human health, gamma, X, infrared, and ultraviolet rays cannot be employed to construct a vehicle-to-vehicle communication system. Visible light communication (VLC) is a novel type of telecommunication that makes use of visible light at frequencies between 400 and 800 terahertz.

Light-fidelity (Li-Fi) is a visible light communication protocol that is similar to Wi-Fi in all but the physical layer [13], [14]. At the transmitter, a light bulb is used to implement it. It only uses light in its normal operation; the light bulb can produce optical outputs with quick and small changes in current. Because of this, it is simple to use in aero planes, hospitals, and other locations where radio frequency communication is frequently problematic [15]. The operation is relatively simple; a digital one is transmitted when the light emitting diode (LED) is on, and when the LED is off, a zero is transmitted. The light bulb could be instantly turned on and off, creating great chances for data transmission. Therefore, all that is needed is an LED and a controller that encodes data into flickering LEDs in accordance with the data we want to encode. The more data that can be processed with the more LEDs in the bulb [16]. The photo-detector or photo-diode is used to recognize these changes in LED brightness and transfer the acquired information into a form that can be transmitted further. Numerous other applications for LEDs include remote control devices, automotive brake lights, as well as street lights, and many more. Due to the fact that the visible light spectrum is unregulated, it may be used for communication at extremely fast rates while also resolving the issue of spectrum space shortage [17]. This technique, known technically as visible light communication, uses brief bursts of light to communicate data without the use of wires. It has the potential to rival Wi-Fi, which is how it came to be known as Li-Fi.

Li-Fi offers fast connectivity at a 500 Mbps rate. Since it relies on light signals instead of radio frequency ones, it is not vulnerable to interruptions [18], [19]. VLC might be utilized on airplanes securely without interfering with aviation signals. As this kind of technology has nothing to do with radio waves, it may easily be employed in any place where infrared, Bluetooth, Wi-Fi, and the internet are widely used [20]–[22]. It can also be incorporated into medical equipment and in hospitals. Wi-Fi fails to work at all in the sea's depths, but light could be employed; thus, underwater investigations are now much easier to conduct [23]. To transfer data, billions of light bulbs already available just have to be changed to LED bulbs. The additional advantage of employing light for the transmission of data is security because light cannot pass through walls [24]. On roadways for traffic control applications, front lights replaced with LED, LED-based rear lights, of the car can be used to transmit data between them and prevent accidents. Each lantern in the globe might serve as a free data access station if this technology is used. Li-Fi could provide a solution to the problems caused by the lack of radio frequency bandwidth [25].

Li-Fi can be described as a visible light communication technology that is utilized for wireless communication with low latency. Due to its resemblance to Wi-Fi but utilizing light rather than radio, it was given the name Li-Fi. The two technologies can be seen as complementary because Li-Fi is perfect for high-density wireless data coverage in restricted areas and for resolving radio interference difficulties, while Wi-Fi is wonderful for broad wireless access within buildings [26]. We proposed a cost-effective Li-Fi-based system for communication between vehicles.

The document is structured according to the format below: section 1 contains an introductory paragraph. Section 2 then presents an overview of the hardware, software, and method used in the proposed approach. Section 3 presents the findings. The conclusion is given in section 4.

2. RESEARCH METHOD

The proposed technology can be used where an intelligent transport system is required. It contains a transmitter and receiver. Vehicles could potentially be able to exchange information through LED light. The recommended system has fewer negative environmental consequences and lower installation costs as a result. Figure 1 displays the block diagram. It includes an ultrasonic sensor, Arduino UNO, LCD display, LED, buzzer, Li-Fi transmitter, and Li-Fi receiver.

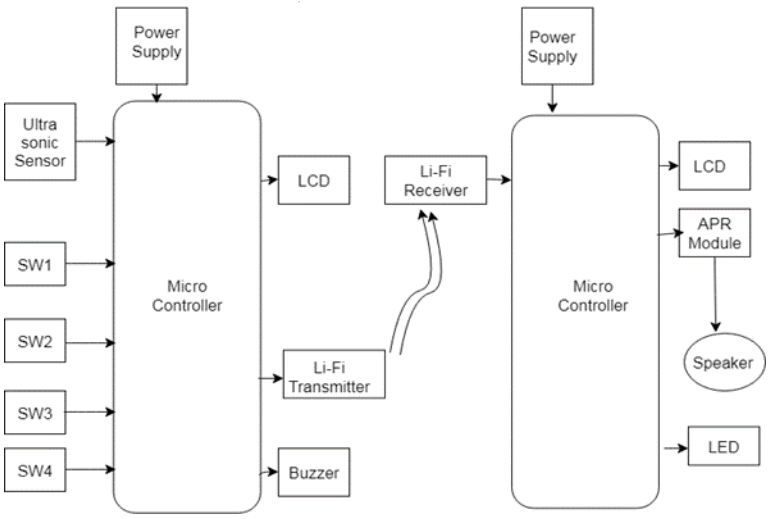


Figure 1. Block diagram of the suggested technique

2.1. Arduino Uno

An open-source microcontroller board called the Arduino Uno was developed by Arduino.cc and originally made accessible in 2010. It is based on the Microchip ATmega328P microprocessor. The board includes a number of both digital and analogue input/output (I/O) pins that enable it to connect to various motherboards for expansion as well as additional circuitry. The board has 14 digital I/O pins, six of which can be utilized for pulse width modulation (PWM) output, and six analogue I/O pins. By utilizing the Arduino IDE, it may be programmed with a type B USB connector. It can be powered by a USB cable or a barrel connector, which can accept voltage from 7 to 20 volts, like a rectangular 9-volt cell. It shares several similarities with the Arduino Nano and Leonardo. The reference design for the hardware is made available under the restrictions of a Creative Commons license.

2.2. Ultrasonic sensor

Sensors, also known as transceivers, transmit and receive data using a similar principle to radar and sonar, which identify a target's properties by examining the reflections of electromagnetic or sound waves, respectively. Ultrasonic sensors generate high-frequency sound pulses, and they assess the echoes they receive. Sensors determine the object's distance based on the amount of time that has passed between emitting a signal and receiving an echo.

2.3. LCD display

A liquid crystal is used by LCDs to create viewable images. Technology display panels called liquid crystal displays are incredibly tiny. A liquid crystal display is made up of a number of layers, including electrodes and two polarized panel filters. A layer of liquid crystal receives a light projection from a lens. The colored image is created by combining colored light with the crystal's grayscale image. The screen then shows this picture.

2.4. Buzzer

A buzzer or beeper system serves as a crucial auditory indicator for enhancing driver vigilance and ensuring road safety within vehicular-to-vehicle communications utilizing Li-Fi technology. Essential alerts such as near-object notifications, sudden deceleration cues, or collision risks swiftly communicate through car-to-car wireless exchanges using optical impulses. Upon receiving these alerts, the car’s built-in light fidelity system decodes the message and activates its alarm mechanism by producing an audible tone, serving as a warning prior to any visible indicators becoming discernible. A buzzer plays an indispensable role within smart transportation networks utilizing light fidelity due to its instantaneous monitoring capabilities, ensuring swift responses during fluctuating vehicular conditions. The suggested setup includes a buzzer that emits auditory notifications instantly upon detecting crucial alerts like collision alarms or distress signals. It aids drivers in reacting swiftly to dangerous situations, thereby improving comprehensive traffic security. A small yet power-saving buzzer made of piezo materials guarantees dependable operation in vehicles despite vibrations and loud noises.

2.5. Li-Fi transmitter

The Li-Fi transmitter receives data from the controller and converts it into a light signal before sending it to the receiving component. The transmitter part modulates the input signal for the required period of time, then broadcasts data in the form of 1 and 0 s using an LED light. The light flashes from the bulb are all that those 1 and 0 s are. Power supply DC +12 V, data universal asynchronous receiver/transmitter (UART), and input (TTL) are the input specifications for the transmitter part. Figure 2 shows a Li-Fi transmitter.

2.6. Li-Fi receiver

The receiver amplifies the signal, displays the output. Ultrasonic transducers enable the transmission and reception of sound waves. The transducer emits a lot of ultrasonic waves, and objects reflect them. Just a single output and input pin is used to trigger an ultrasonic burst, and the echoes' returning pulse is then monitored. Using a single input output pin, the sensor determines the period of time required for the echo to return and delivers the data to the microprocessor as a pulse of a customizable width. Figure 3 shows the hardware implementation of the Li-Fi receiver. Software used here is Arduino Uno IDE. The working procedure is as follows:

- Open Arduino IDE
- Select the COM Port
- Select the required Arduino board
- Sketch in Arduino IDE

Compile the sketch and upload it to the Arduino board. Figure 4 shows the example sketch.

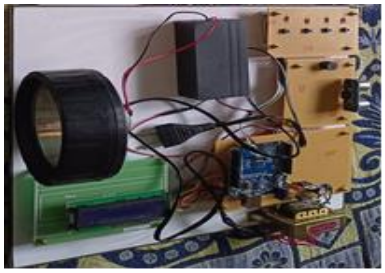


Figure 2. Hardware implementation of Li-Fi transmitter

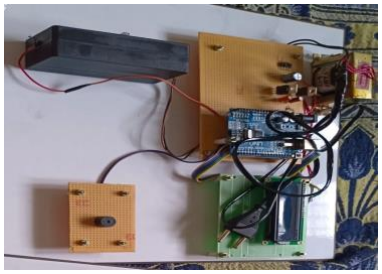


Figure 3. Hardware implementation of Li-Fi receiver

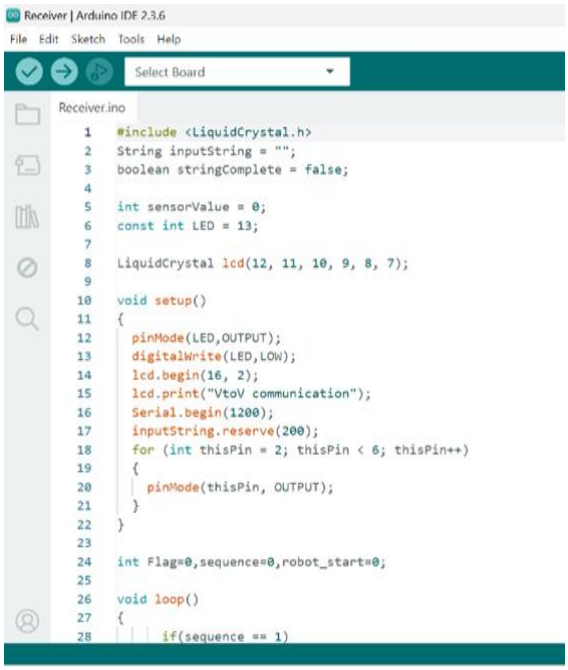
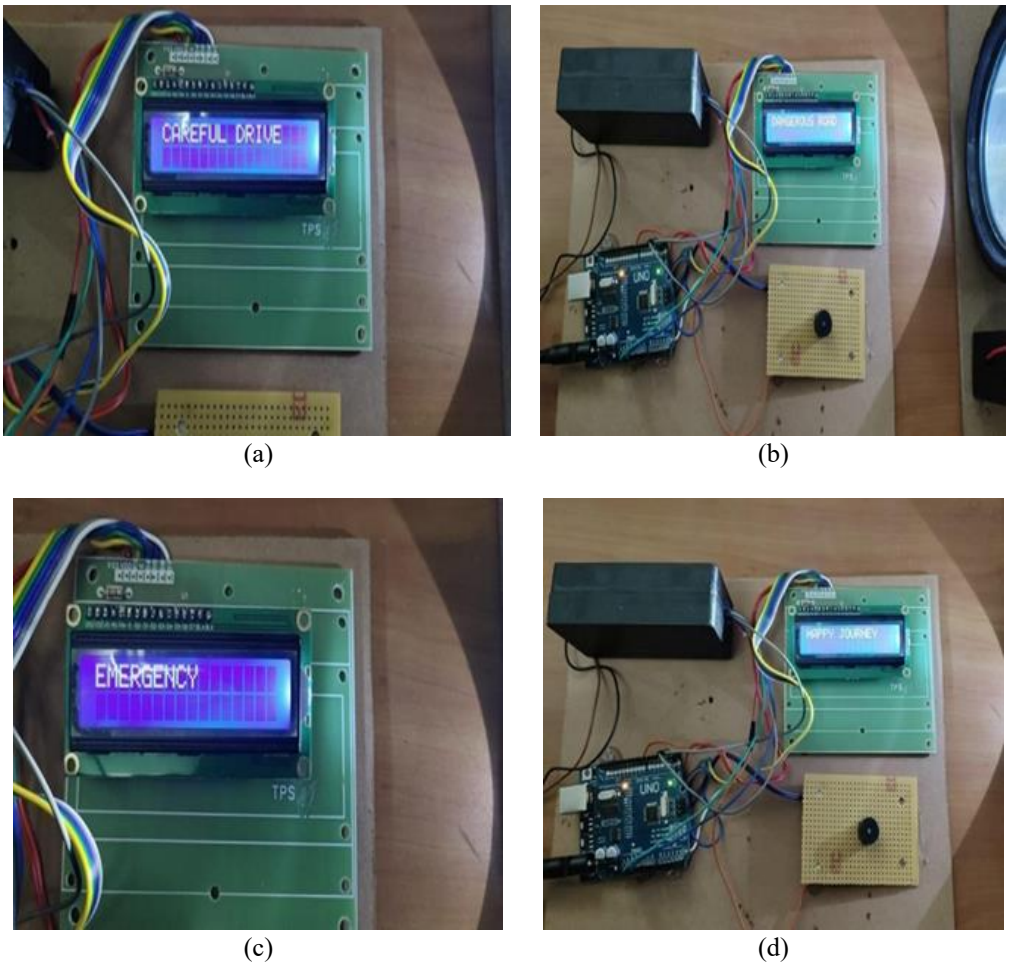


Figure 4. Sketch in Arduino IDE

3. RESULTS AND DISCUSSION

We presented an inter-vehicle communication system with a Li-Fi transmitter and receiver for vehicle-to-vehicle communication. On the basis of pushing the necessary buttons on the prototype or the mobile device, the Li-Fi transmitter generates various messages. Figure 5 displays several transmitted and displayed messages. Figures 5(a)-5(d) are the alert messages indicating careful drive, dangerous road, emergency, and happy journey.



(a) (b)

(c) (d)

Figure 5. The messages transmitted and displayed on LCD with Li-Fi transmitter of (a) careful drive (b) dangerous road, (c) emergency, and (d) happy journey

4. CONCLUSION

In order to establish secure transportation on the road and to control traffic, Li-Fi technology is crucial. Li-Fi can provide a real and extremely effective alternative because we are all aware that our airways are becoming more and more blocked every day. Modern digital transmission systems make Li-Fi feasible. The link between future energy-efficient lights and cellular communications is made possible by optical cell networks built on Li-Fi. They can even enable ever-smaller cells without a requirement for additional facilities by harnessing the huge, uncontrolled, and unutilized electromagnetic spectrum. The sole drawback is it only functions when in direct line of sight of light, which makes it difficult to address radio frequency shortage difficulties. Science and technology have no end in sight. Now, data and messages may be transmitted using both radio waves and light simultaneously.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors state that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The authors state no conflict of interest.

DATA AVAILABILITY

The authors confirm that the data supporting the findings of this study are available within the article.

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