Smart Traffic System Using Li-Fi Technology For Automobiles

Chandrashekar Akkenapally
Department of Computer Science
Missouri University of Science and Technology
Rolla, MO, United States
ca7kr@mst.edu

Susheel Reddy Pingili
Department of Computer Science
Missouri University of Science and Technology
Rolla, MO, United States
sp493@mst.edu

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***Abstract* - Li-Fi is the advanced technology of the world. This project is concise in the vehicle to vehicle communication to avoid accidents. The ultrasonic sensor is using to find the distances of the front vehicle and measuring the vibration level in the vehicle the gas sensor measuring the alcohol level of the driver and this data is sent through the Li-Fi transmitter to receiver vehicle. If any abnormal condition in a front vehicle means this vehicle will stop on the second. Li-fi is connected with the UART function to the micro controller. Light Fidelity, also known as Li-Fi, is a technology based on communication using light as a medium. This technology is known as Visible Light Communication (VLC) which removes the complexity of cable communication. Li-Fi has evolved over the past years and has been proven to be secure, efficient and can send data at very high . This paper also demonstrates a communication system in which data**

is sent from a transmitter to a receiver using light as a medium to control the speeds of two motors.

Keywords **- Light Fidelity (LiFi), Visible Light Communication (VLC), Wireless communication technologies,IR sensor(Infrared Sensor)**

1 Introduction

Li-Fi knows a light fidelity concept in the world. Li-fi is based on visual light communication. In that, we use an LED light emitting diode to transmit the data'sto the receiver side from the receiver side we used the photovoltaic cell to receive the data'sfrom the transmitter. LiFi [1]the rated speed can reach until 14 Gbps. On body can hack this Li-Fi technology. A predictive analysis or a prevention system for the accidents is a necessity of this moment. That is practically being implemented in the paper with the randomized and extensive use of appropriate sensors and the latest technology data transfer protocol. The data transfer has to be done in the minimum amount of time, since this is a real time scenario. Cost Effectiveness and the material constraint has been taken into account. Analysis of data due to number of accident occurrence in India in the year 2019 will provide an better understanding into the concept of accident detection and prevention. It is clearly understood by the figures that Road Accidents contribute to about 35 percent of the accidents in India (as per NCRB, India)[2]. If there is any chance to reduce this percentage, then is would of great significance in avoiding accidental deaths.

A further deep insight into the accidents in India, provide better understanding that Human mistakes are also a common cause of mishaps. Human mistakes contribute to around 78 percent of the total road accidents in India. Common Human Mistakes during driving are continuous driving with fatigue or drowsiness, drunken driving and ignoring the traffic systems.

2 Literature Review

The proposed paper aims in using the Wi-Fi technology and enabling communication of vehicles with the traffic light system in order to prioritize the vehicles and change the signals accordingly rather than by a process of pre-defined order or by manual order. Traffic lights already use LED lighting, so that this proposed system may seem easy to implement. Sending data through siren lights in an ambulance and fire extinguishers to a traffic light control system and switching the signal in order to allow faster and non interrupted transport.

3 Proposed System For Real-time Scenarios

- Case 1: When two vehicles are travelling in same direction or opposite direction and if a vehicle ahead detects fire hazard within or in front of the vehicle.
- Case 2: When the person driving a vehicle is in drunk state.
- Case 3: When the person driving a vehicle is in sleeping.
- Case 4: When there is animal or car or accident in front of the vehicle.
- Case 5: When there is some mechanical issue inside a vehicle which is casing lot of vibration. Example: improper wheel balance.
- Case 6: When there is a rain or fog or high humidity on the road.
- Case 7: When there issue is some issue in a vehicle causing its engine temperature to rise.

4 System Model Design

4.1 Hardware Requirements

- Arduino Uno[3] : Arduino Uno is an open-source microcontroller board based on the ATmega328P chip. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, USB connection, and a power jack. It is commonly used for prototyping and DIY electronics projects due to its ease of use and versatility.
- Alcohol sensor[4]: The MQ-3 is an alcohol gas sensor that is commonly used in breathalyzer devices to detect alcohol levels in the breath. It is a small and cost-effective sensor that operates at room temperature.
- Photosensitive sensor[5]: The Photo-diode module is highly sensitive to environmental light intensity and can detect ambient brightness and light intensity. It has better directionality than photosensitive resistance sensor modules. When ambient light intensity reaches a set threshold, the DO port output changes from high to low. The module provides digital outputs (D0) that can be connected directly to a micro-controller to detect light intensity changes and can also provide analog output for higher accuracy through the AD conversion process.
- Flame sensor [6]: It is a device that can detect the presence of flames or fire. It usually has three pins - VCC, GND, and D0, where VCC is the power supply pin, GND is the ground pin, and D0 is the digital output pin. The module works by detecting the infrared light emitted by the flames, which triggers the digital output signal.

- Ultrasonic sensor[7]: It is a module that uses sound waves to detect the presence and proximity of objects. It emits high-frequency sound waves and measures the time it takes for the sound waves to bounce back, allowing it to determine the distance to an object.

- Infrared Rays(IR) sensor[8]: An infrared sensor for Arduino is a device that detects infrared radiation in its surroundings. It can be used to detect objects, measure distances, and for remote control applications. It works by emitting and detecting infrared signals.

- Vibration sensor[9]: It is a module that can detect and measure vibrations, such as those caused by motion, tapping, or vibration. It can be powered by either 3.3V or 5V, and is commonly used with Arduino or other microcontrollers to detect and respond to vibrations in a project.

- Humidity and Temperature sensor[10]: The DHT-22 (also named as AM2302) is a digital-output, relative humidity, and temperature sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and sends a digital signal on the data pin.

- 16*2 LCD Display[11]: The 16x2 LCD display is a popular output device for Arduino that can display 16 characters per row and two rows. Its pins configuration typically includes VSS, VDD, VO, RS, RW, E, D0-D7, where VSS and VDD are for power supply, VO is for contrast adjustment, RS is for selecting data/command register, RW is for read/write selection, E is for enabling the module, and D0-D7 are for transmitting data.

4.2 Software Requirements

- Arduino IDE : The Arduino Integrated Development Environment (IDE) is a free and open-source software (OSS) application that runs on Windows, macOS, Linux, and other operating systems. It is used to write and upload programs to Arduino boards.

- Microsoft Excel : Microsoft Excel is a spreadsheet program that is part of the Microsoft Office suite of software. It is used to organize, analyze, and present data in a variety of ways. Excel can be used to create budgets, track expenses, create charts and graphs, and much more.

4.3 Circuit Design

The design of the circuit has been accomplished by utilizing all the components that have been mentioned in the hardware requirements. The circuit has been implemented on a breadboard. There exist two distinct circuits which are responsible for the transmission and reception of data through Li-Fi technology.

4.3.1 Li-Fi Transmitter

Li-Fi transmitter consists of 7 sensors for deleting various abnormalities. All these sensors are placed on the breadboard and their data pins are connected to Arduino UNO input analog and digital pins. In the circuit diagram shown below, the Vibration sensor is connected to pin "A4", Gas Sensor is connected to pin "D4", DHTPIN(Humidity Sensor) is connected to pin "D5", Flame Sensor is connected to pin "D8" and Alcohol Sensor is connected to pin "D9". Ultra-Sonic consists of two pins: Trigger Pin and Echo Pin. Trigger pin is connected to pin "D10". Echo Pin is connected to pin "D10". IR Sensor is connected to pin "A5". LED is connected to pin "D3".

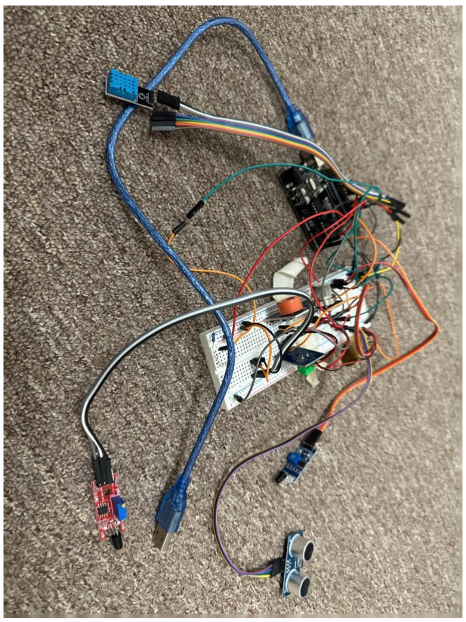


Figure 1 : The above figure shows the circuit diagram of Transmitter.

4.3.2 Li-Fi Receiver

In the receiver circuit we have 16*2 LCD display which consists of two data pins SDA and SCL. We have connected SDA to "A4", SCL is connected to "A5". The data transmission is received by LDR(Photo Sensitive Resistor) which is connected to "D9". The positive and the negative of all the sensor modules are connected to "Vcc" and Ground of the Arduino board.

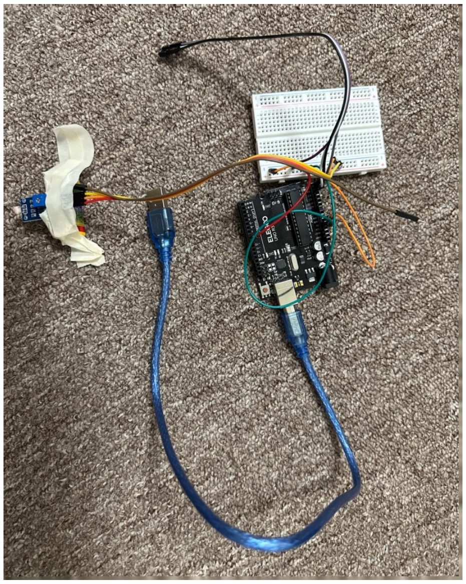


Figure 2 : The above figure shows the circuit diagram of Receiver.

4.4 Flow Diagram

4.4.1 Li-Fi Transmitter

First, the data from all the sensors is read in the sequential manner starting from the flame sensor and ends at Gas sensor as shown in the flow diagram.Once all the data is read, the data packet is concatenated and is transmitted to the receiver .

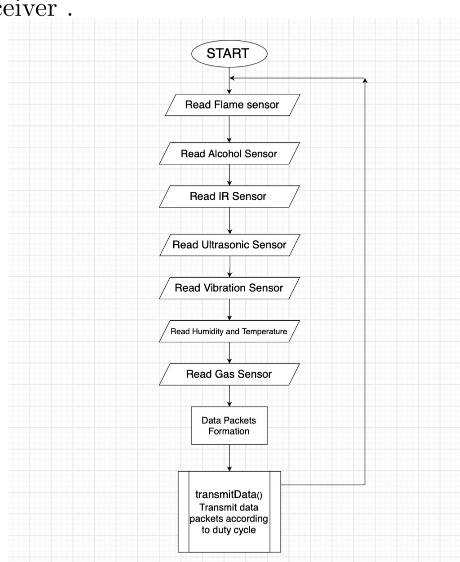


Figure 3 : The above figure shows the Flow diagram of Transmitter.

4.4.2 Li-Fi Receiver

The data transmitted from the transmitter is received by the receiver. While receiving until 19 bits of data is received the receiver will not stop reading the data. Once the 19 bits of data is received the data is decoded into meaningful data. If there are any data anomalies present they will be discarded. For meaningful data if they are crossing the threshold limit then the corresponding LCD message is displayed.

For Example, if the receiver receives "A1" then "Fire Hazzard in the opposite Vehicle" is displayed and if the receiver receives "G35" then as the temperature is more than threshold limit that is 30 degree Celsius a message will be displayed "High temperature in opp vehicle".

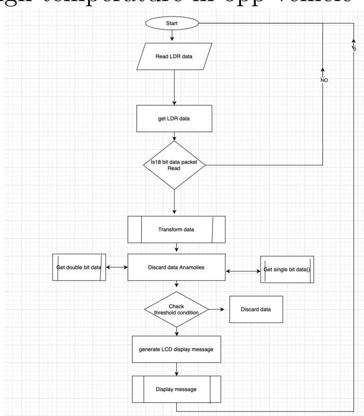


Figure 4 : The above figure shows the Flow diagram of Receiver.

5 Working Principle

5.1 Duty Cycle

In electronics, duty cycle refers to the percentage of time a signal is in an active state compared to the total time of one cycle. It is commonly used in pulse width modulation (PWM) and other digital signal applications. A duty cycle of 50% means the signal is on for half the time and off for the other half, while a duty cycle of 25% means the signal is on for a quarter of the time and off for three-quarters of the time. The duty cycle affects the average power of a signal, with higher duty cycles resulting in higher average power. It can be calculated by dividing the active time of the signal by the total cycle time and multiplying by 100.

In the Li-Fi system, the transmitter component plays a crucial role in reading data from all the sensors that are connected to it. Once it has the data, it encodes it into a 19-bit data packet that includes information from all the sensors. To transmit the data, it converts it into a string format, where each character is transmitted using an LED light with its corresponding delays. The data packet information is shown in a figure to provide a clear understanding of the transmitted data. Essentially, the Li-Fi transmitter reads and encodes sensor data and transmits it via LED light, with a fixed time period of 50 microseconds for the LED to remain on. After this time, the LED will remain turned off for a period equivalent to the delay of each character. This ensures that the LED is synchronized with the data transmission and turns on and off at the right times to accurately transmit the data.

Data	Delay	Data	Delay
A	100	1	1000
B	200	2	1100
C	300	3	1200
D	400	4	1300
E	500	5	1400
F	600	6	1500
G	700	7	1600
H	800	8	1700
0	900	9	1800

Figure 5 : The above table shows information about each character data and their delay in microseconds.

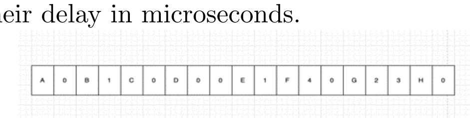


Figure 6 : The above figure shows the encoded data packet.

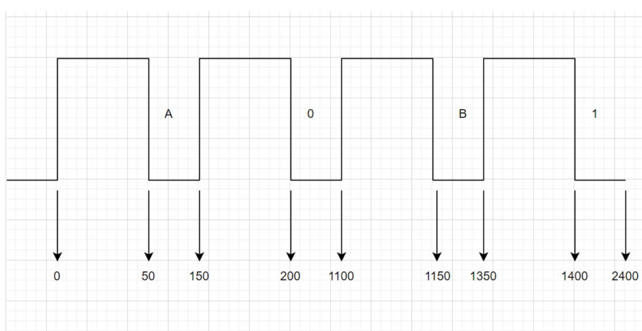


Figure 7 : The above figure shows transmission of a data packet.

5.2 Synchronization

Synchronization refers to the process of ensuring that the Li-Fi transmitter and receiver are operating in unison, and that the data being transmitted is being received accurately. Since Li-Fi uses light as a medium for data transmission, it is important that the transmitter and receiver are synchronized to ensure that the data is transmitted and received at the correct time intervals.

Synchronization in Li-Fi involves ensuring that the receiver is able to detect and interpret the data being transmitted by the transmitter, even in the presence of interference from ambient light sources. This is achieved through the use of various synchronization techniques such as signal processing algorithms, error correction codes, and clock synchronization.

Synchronization plays a crucial role in getting appropriate data with low power sensor modules. In this case the transmitter transmits the data signal from time t $\equiv$ 0 microseconds as shown in Figure 8. The Li-Fi Receiver might start listening to transmitter from t $\equiv$ 20 or 100 or 12000 microseconds late. There is also a scenario where the Li-Fi Receiver will start listening in between the transmission of a character as shown in the figure 8. In the figure 8 the receiver started to listen while character A is in mid of transmission. Now the receiver has to wait till the transmission of character A is completed and fixed character delay of 50 microseconds. After the 50 microseconds high-pulse is completed, then the receiver will start listening to the transmitted data and after reading of 19 bits of data is completed, then the decode algorithm will decode packet data into meaningful data.

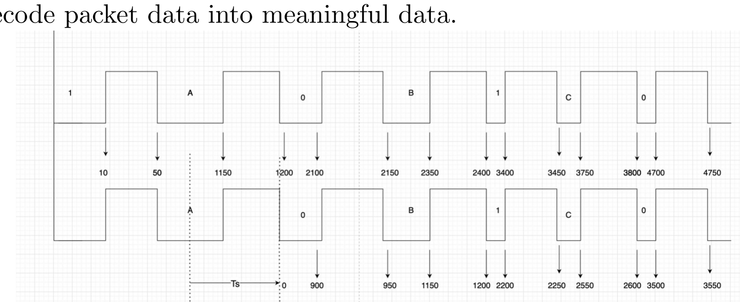


Figure 8 : The above figure shows Synchronization of the data packets .

5.3 Data Transmission

In this Li-Fi research, the data transmission is designed in such a way that the data is transmitted in the form of data packet which consists of 19 bits of data. The data from Flame, Alcohol, IR, Vibration and Gas Sensor are encoded with an specific alphabet assigned to it, which can be seen in the table below. For each of the sensor mentioned, their on state is represented as alphabet and state combined(For eg: A0, B1 etc). The 0 beside the alphabet represents low/off state and 1 represents the on state. Similarly, the Ultrasonic, Humidity and Temperature data is encoded but they vary from 0cm to 99 cm if it is ultrasonic sensor or 0 degrees to 99 degrees Celsius if it temperature sensor.

Flame sensor	A0/A1
Alcohol sensor	B0/B1
IR sensor	C0/C1
Ultrasonic Sensor	D00/D99
Vibration	E0/E1
Humidity	F00/F99
Temperature	G00/G99
Gas	H0/H1

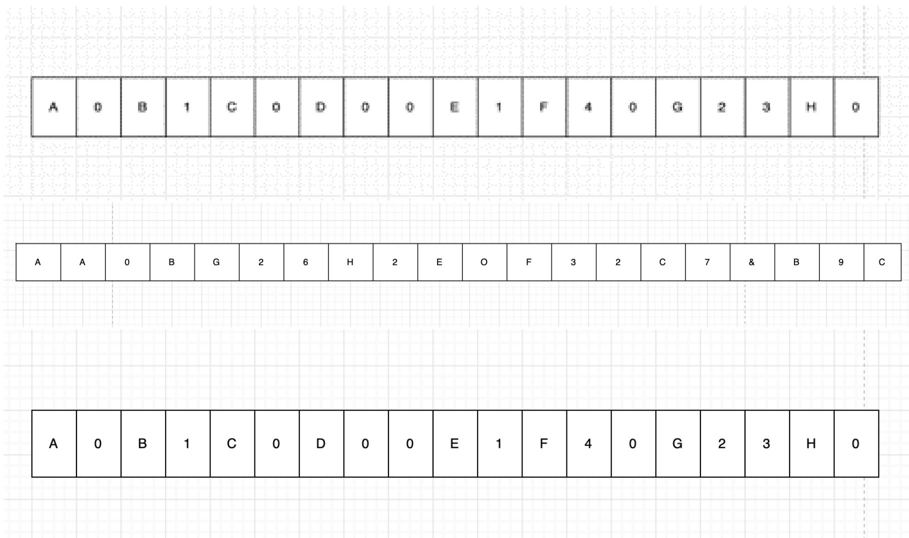


Figure 9 : The above figures shows the data transmission in the form of packets .

6 Demonstration

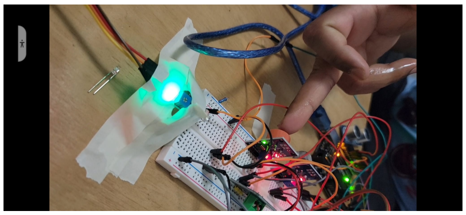
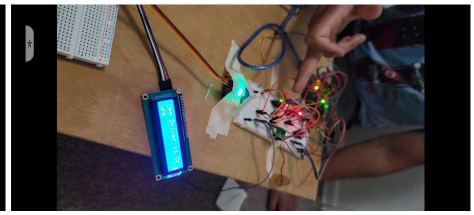
6.1 Fire Hazard Detection

This is used to detect any fire accident in the cars and sends the alert message to the near by cars to take the preventive steps to avoid going near to that car.

As soon as if there is any fire in the car the sensor detects it and the alert is sent to surrounding cars through Li-Fi signal.

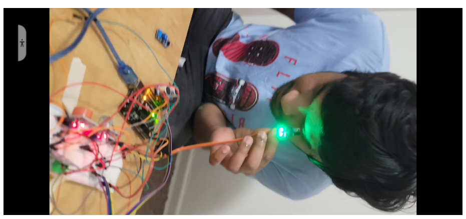
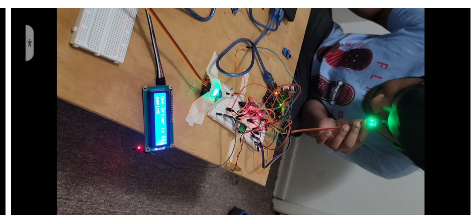
6.2 Alcohol Detection

This uses the Alcohol sensor to detect if the driver is drunk or not.If the driver is drunk the sensor detects it and sends the alert message to all the cars near to it through Li-Fi signals.

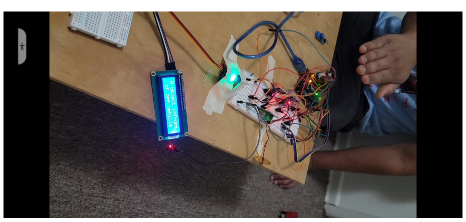
6.3 Driver Sleep State Detection

If the person driving car is sleepy the IR sensor detects it and sends the alert message to the car near by it through Li-Fi signals,so that the cars travelling near to it can go slow and avoid accidents.

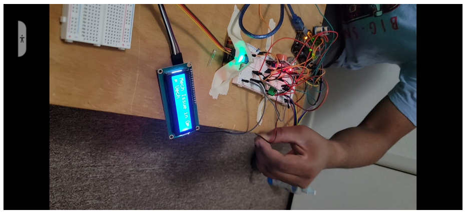
6.4 Vehicle or Object Ahead Detection

If any object comes in front of the car the ultrasonic sensor detect the object and alert message is given the car so that the driver can slow down the car to avoid the accident.



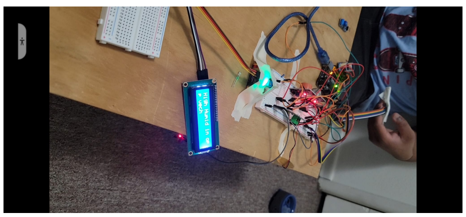
6.5 Vehicle Condition

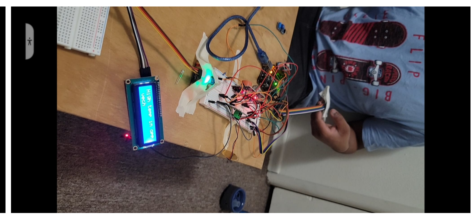
The Vibration sensor is used to detect the condition of the vehicle, If the vehicle has more vibrations in it the alert message is sent to near by vehicle that there is some Mechanical issue in the vehicle.



6.6 Weather Condition

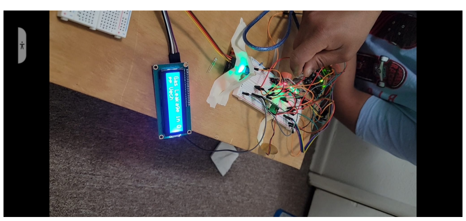
Humidity sensor is used to detect the the humidity or temperature in the car, if the vehicle has more humidity or temperature the sensor detects it and display it in the vehicle that it has high temperature or humidity.





6.7 Gas Leakage Detection

Gas sensor is used to detect any gas leakage in the car,if there is any leakage sensor detects it and sends the alert message to the near by the vechile.



7 Performance Evaluation

7.1 Time for Data Transmission

The time taken for data transmission is given as total time taken for data transmission and for receiving data.

$$\text{Td} \equiv \text{Tt} + \text{Tr}$$

Time taken for data transmission Tt $\equiv$ Time the total time taken by the transmitter to transmit each bit + delay between each bit(Td)*19

Time taken for receiving data Tr ≡ Synchronization time(Ts) + Time the total time taken by the receiver to receive each bit + delay between each bit(Td)*19

Best case time ≡ 13500 ms ≡ 13.5s (A0B0C0D00E0F00G00H0)
Worst case time ≡ 19400 ms ≡ 19.4s (A1B1C1D99E1F99G99H1)

7.2 Efficiency

The efficiency of the project is calculated by using the the data 50 times from transmitter to receiver,each time data is transferred the number of packets transferred from transmitter and received by the receiver is checked and the plot is drawn.

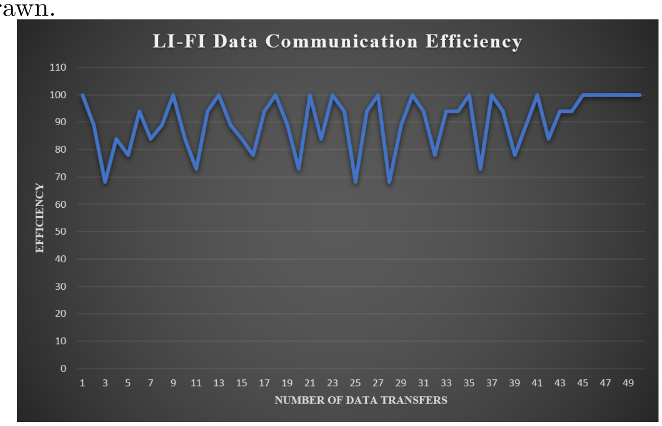


Figure 10 : The above graph shows Li-Fi Data Communication Efficiency .

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