Collision avoidance in vehicles using Visible Light Communication

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***Abstract*—**Vehicles assume a significant job in a human's day to day life, simultaneously they may cause hazardous issues in the life of individuals and property because of mishaps. Each day around the globe, a few several individuals pass on from different crashes of vehicles. The primary test experienced to keep away from mishaps is to evade impacts. So as to stay away from impacts there has been a lot of work done in this field. The inquiry that poses itself by what method can we maintain a strategic distance from a deadly out-turn from any accident. The assurance of this question was given by Collision Avoidance using Visible Light Communication (VLC). The fundamental objective of this framework to maintain a strategic distance from death toll and this framework assume a major job in security innovation for the vehicle. Vehicle-to-vehicle (V2V) communication systems involve a remote system where cars send messages to one another with data about what they're doing or intend to do and it has a fast data rate. This information would incorporate speed, direction of motion, location, slowing down, and loss of stability. It is a significant innovation to help future car administrations including intelligent driving, in-vehicle infotainment, and so on. 1G Framework would only warn the driver, but 5G is highly advanced as it would also be able to take control over the automobile.VLC is a data correspondence structure, gives high transfer speed, security, interference immunity, and high information rate. It utilizes visible light for high data transmission and reception. This innovation is widely accepted as Light Fidelity (Li-Fi).

***Keywords*—** *Accident, collision, V2V, LiFi, stability, VLC, data, transmission, reception*

INTRODUCTION

The guarantee of avoiding accidents was brought into the world by the cooperative collision avoidance systems (CCAS). The principal objective of this framework is to keep away from death toll and this framework assumes a major job in wellbeing innovation for the vehicle. This system is achieved by a number of sensors, recognizing various features like the state of the driver, adding to that the framework of the camera, radar and laser, and also geo-terrain and geo-mapping features by GPS and GSM. Each of these innovations and technology are cooperated into one in order to stay away from accidents as much as conceivable.

Visible light communication (VLC) is a rising innovation that expects to empower rapid internet service access in the indoor condition and takes a shot at the intensity of e modulation of existing solid state lighting foundation often provided by light-emanating diodes (LEDs). VLC offers a few key focal points over conventional radio-frequency based access systems including around 300 THz of license free data transfer capacity carried on visible wavelengths, ~10,000' larger than that accessible in radio, which is likewise significantly oversubscribed.[1] Visible light falls between 400 and 800THz which is 780-375nm. It is a subset of optical wireless communication technologies.

In vehicular communication, VLC can be used because vehicles already have LED lights and the existing traffic light infrastructure. All of the high speed applications require very low idleness with solid reachability. Because of the very low reasonable dormancy in the vehicle security correspondence, a rapid obvious light correspondence framework like Li-Fi can be utilized. Visible Light Communication (VLC) is a brilliant technique to overcome the limitations of conventional technologies like RF based mode of communication like interference, congested spectrum, security, etc.[2] In any case, 60 percent of all auto crashes are brought about by driver botch leaving 40 percent caused due to vehicle glitch or ecological conditions, for instance, light, atmosphere, street or traffic. The most widely recognized blunders performed by drivers knowingly or unknowingly are extreme speed, inability to yield the option to proceed, following too intently, ill-advised turns, inappropriate passing and ill-advised support.

I. RESEARCH METHODOLOGY

A. STATEMENT OF THE PROBLEM

The need to minimize the number of collisions between vehicles using a fast and reliable system, more independent of human control and to maintain a strategic distance from death toll and this framework assume a major job in security innovation for the vehicle.

B. OBJECTIVE OF THE PROJECT

Since human conduct is the fundamental cause for event of mishaps (where rear end collisions are the most well-known structure it is basic to equip with safety systems or sensors in vehicles. To lessen the possibility of accidents by enhancing safety and to propose a solution that is cost-effective, robust and has high data rate capabilities.

Collision avoidance and crash warning are the primary focus of the paper. The work should fill in as the presentation for the individuals who are less familiar with the subject

C. TYPE OF PROJECT WORK

This project is a combination of hardware and software. It's hardware part consists of a power distribution system, motor driver to regulate the voltage and motion of the

motors, photodetector to receive the data from LiFi and an APR Module to record and play voice. We have an Arduino UNO microcontroller which acts as the brain of our system. Hence entire system coding is stored in it.

We have two units Transmitter unit and Receiver Unit. Both units act as Transceivers based on concept. Both Units consist of LCD which shows each status and whatever sensor data. The software part consists of the code which is used to set the distance and instructions to the DC Motor etc.

D. LIMITATIONS OF THE PROJECT

1. Although the upper limit of the ultrasonic sensor is 400 cm, the system responds only till 200 cm when the vehicle is running on road.
2. Practically possible in dual lane or multilane highways.
3. Light has the property of Rectilinear Propagation, so it requires integration of multiple Li Fi sensors on the vehicle in order to avoid crashing into vehicles coming sideways, Thereby increasing the cost.

II. SYSTEM MODELLING

Before executing the proposed framework into hardware design each segment of the framework configuration is recreated utilizing the PCB design software, Proteus Professional. Simulation was also performed using this software. Starting with , the response of a solitary LED is tested by shifting frequencies of 1kHz. Then the response of the LED is examined, an ON LED will indicate a high signal, Logic 1 in Binary and an OFF LED represents a low signal i.e. Logic 0 in Binary. As a result, the ON and OFF of LED output response generates square pulse.

Initially the module is set to be high, when it detects the signal from the indicator, the signal goes low.[3] This is how a square wave is generated.

There exists a voltage structure representation of data in digital frameworks. Voltage differs from 0V to 5V. The LED remains off when the voltage is said to be at 0V; in this state there is no current through this element of the circuit. And to the contrary, at 5V, current passes through the LED and the element receives current to be in ON state.

To shield the used LED from voltage fluctuations and current errors, a steady flow of the same current needs to be established. The LED drivers direct the current and flow when it passes through the LED in the circuit.

A. Block Diagram

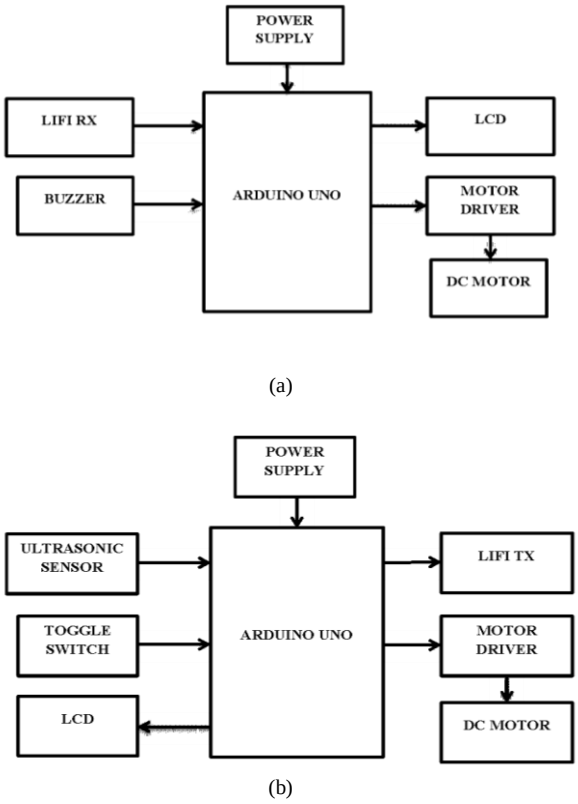


Fig. 1: (a) Transmitter Circuit (b) Receiver Circuit

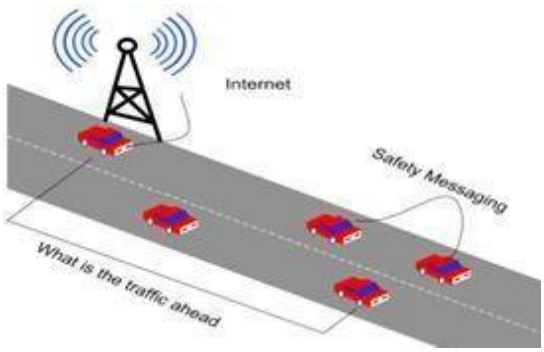


Fig 2. - VLC in Vehicular Communication

III. ADVANTAGES OF LI FI TECHNOLOGY

1. If we compare it to Radio Frequency, RF is vulnerable against impedance from devices like cordless telephones, microwaves and neighboring Wi-Fi systems. LiFi can be utilized in RF hotspots, for example, emergency clinics, power plants and planes.
2. It offers low latency by a factor of three times lower than Wi-Fi and can drastically empower development, automation, and applications, for example, AR and VR.
3. It provides faster communication.

4. It provides a transfer rate of upto 3Gbit/s and does not interfere with radio systems, making it practically realizable on roads.

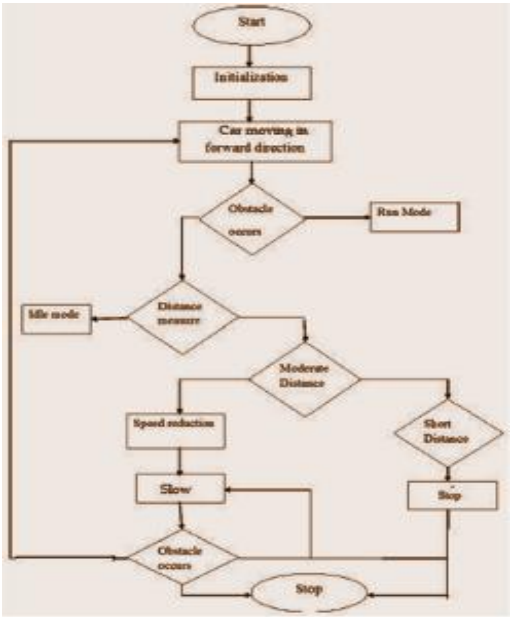
IV. SYSTEM ALGORITHM AND IMPLEMENTATION

The system was designed keeping a few points in mind, by charting out and prioritizing work. To assemble a model utilizing off the rack electronic gadgets, fixing them to set up an effective connection for proper transmission and reception of computerized information and give a working system where visible light is the only method of communication, is the primary goal of the system.[4]

The project is divided into transmitter and receiver unit. Both the transmitting and receiving structure have been tried and executed by methods for reenactment and the model of the practical framework system setup is completed and inspected. In the wake of organizing the final circuit, we have executed by directing the light from LiFi in the transmitter section to the phototransistor in the decoder circuit of the receiver section.

We have set 3 channels for the system i.e. STOP, LEFT and RIGHT. When the vehicle in front (vehicle A) changes its position, the transmitter circuit present in the back of vehicle A transfers the message to the receiver circuit of vehicle behind(vehicle B).Automatically the DC motor slows down the moment it reaches the threshold distance. The APR module records human voice and alerts the driver in vehicle B when vehicle A is about to change its direction.There is also a buzzer that beeps along with the instruction given by the speaker. Voices can be overwritten as per choice and more channels can be added. When the principle goals of framework configuration are accomplished, the model is executed.

V. FLOWCHART



VI. REALISTIC CONSTRAINTS IN DESIGN

Constraints are planning decisions forced by nature or a stakeholder that effects or restrains the structure being assembled. The realistic constraints that we have focussed upon include: reliability, learnability, accessibility, maintainability, durability, adaptability, failure transparency, monetary, and lawfulness.

a. Reliability

There is a minor restriction on the type of the software and technology used. The task execution is identified with programming which is compatible with the motors that influences its exhibition.

- This project best works in a one-way road.
- Safe driving requires high communication.
- The motor drivers need to be checked and maintained on a timely basis in order to maintain proper functioning of the circuit.

b. Learnability

We have chosen basic electronic components that do not require much learning and skills but the LCD and the LiFi need to be properly interfaced to prevent malfunctioning and garbage data. The Arduino coding is burned on the microprocessor so it doesn't require the driver to have coding skills.

c. Availability

Our system does not require any outer source to operate. For small scale design, DC adapters can be used for power supply that converts AC to DC which can be safely used by the circuit.

d. Maintainability

The system requires very little maintenance and keeps in good shape. The code basically slows down the motors the moment it receives the indication of an obstacle. The Pinterface between the microcontroller, motor driver and motors need to be rigid to perform the task. We have chosen components to be simple and flexible to make maintenance easier and faster.

e. Durability

Depending upon the sorts of products and nature of the devices we are utilizing to manufacture the framework, the solidness of the framework will fluctuate. But considering the sensors and the LCD screen that we are using, we expect the system to be sensitive and needs to be calibrated before integrating on the vehicle.

f. Customizability

System can be customised according to customer needs. More number of sensors can be attached on different sides for better obstacle detection. IP generation for the LiFi sensors can be done to digitally connect the cars on the road. The delay can be increased or decreased for efficiency and customer requirements.

g. Failure Transparency

For our system, failure could be in any of the electronic components depending on its use or if it exceeds the lifespan of individual components. The system may show discrepancies in a single lane as there are chances of head-on collision and the system might not respond as instructed.

h. Economic

Software requirements include Arduino IDE which is open source and easy-to learn, Proteus Professional can also be downloaded from the internet and the license keys come along with it. Windows Operating System or Linux are in-built or can be easily downloaded. Hence softwares did not cost us a single penny.

Hardware components include Ultrasonic sensors, LiFi transmitter and receiver i.e. phototransistor, LCD Screen, Arduino UNO Board, APR module cost us 8000 INR approximately. But this can be customised according to user needs for example more number of sensors could be attached thereby increasing the cost.

i. Legality

The system uses concepts that are protected by patents, software is legally used. It does not violate any law.

VII. SYSTEM ARCHITECTURE

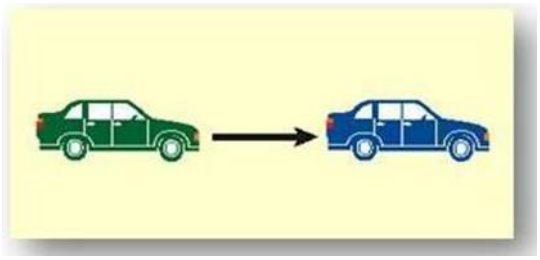
LiFi is a high speed, bidirectional, fully networked wireless communication, allowing us to use the light that we use to illuminate places for different purposes and not just waste this conventional source of energy. LiFi enabled LED lights modulate illumination levels to send data like Morse Code.[5] Modulation happens at a very fast rate that the human vision can't perceive. LiFi can transmit at multiple gigabits.

At the point when an electrical flow is applied to an LED light a surge of light (photons) is discharged from the bulb. LED bulbs are semiconductor devices, which implies that the intensity of the light moving through them can be dipped and dimmed at extremely high speeds. This permits us to impart a sign by tweaking the light at various rates. Data is transmitted in the form of light pulses.[6] ON indicates binary 1 and OFF indicates binary 0. The sign would then be able to be gotten by a photodetector which deciphers the adjustments in light intensity (the signal) as information. Data is decoded from binary to ASCII values.

a. System Framework

In our system, we have used 3 key signals: STOP, RIGHT and LEFT.

Let us consider two vehicles, Vehicle A is the car in front and Vehicle B is the car behind vehicle A.



Vehicle B Vehicle A

Fig 3 - Pictorial representation of two cars running

Each driver must maintain a sufficient distance from other vehicles in order to avoid collision. Many countries follow the Two- Second Rule and many countries follow the Three-Second Rule.

But in India, being the 2nd most populated country in the world, its difficult to abide by these rules. It is either the driver's professionalism or his approximation in calculating the minimum distance it can keep to ensure that no mishap occurs.

The simple design that we have constructed mainly revolves around 3 basic sensors, the ultrasonic sensor and the LiFi transmitter and the photodetector. The ultrasonic sensor is utilized to quantify the separation of the following vehicle which ought to be not exactly the host vehicle halting separation to decrease crash. This project work proposes a calculation which utilizes these sensors to guarantee the wellbeing relying upon the reaction time.

If Vehicle A is about to STOP, which can be understood with the help of ultrasonic sensors when it crosses the threshold distance, the information is transmitted to Vehicle B via visible light, the motors of both the cars stop i.e. the wheels come to a halt. With the help of APR Module, a voice saying, "The vehicle in front will stop" is also added in order to ensure extra safety.

If Vehicle A is about to take a RIGHT, automatically the photo detector at the receiving end decodes the signal a voice saying, "The vehicle in front will turn right" is given out and the motors of vehicle B slows down.

If Vehicle B tends to take a LEFT, the decoder decodes the binary pulses received from the light and alerts the driver saying, "The vehicle in front will turn left" and simultaneously the motors slow down.

Timing and Control Electronics is used to measure the time required by the trigger pulse in order to find out the distance of the obstacle from the vehicle.

Now if we know the timing difference between the received and the transmitted pulse, we can calculate the distance between objects by assuming the speed of the sound wave returned by the echo pin in microseconds.

Let us say that the total distance of the object from the vehicle is 'D' and the time travelled is 'T'.

We know that the velocity of sound wave, C = 0.034cm/microseconds

So, D = Velocity of the sound wave * time travelled /2 D = 0.034* T/2

HC-SR04 Ultrasonic sensor has a range of 2cm-400cm. We have set a threshold distance of 100cm and real time testing was done by placing objects in this range and the response rate was fast which indicates the efficiency of LiFi. Hence the Collision Avoidance framework offers programmed braking for the vehicle alongside the caution.

All the information received by the PC817 photocoupler, the phototransistor present on it converts optical light to electrical signals and is decoded in the decoder circuit, from binary to ASCII. It consists of a transistor to amplify the signals, 7-segment LCD (Liquid Crystal Display), which gives an advantageous method for showing data or digital information as numbers, letters or even alpha-numerical characters.

An inverter (NOT-gate) can be classed as a 1-to-2 paired decoder as 1-information and 2-yields (21) is conceivable on the grounds that with an input A it can create two yields A and A (not-A) as appeared.

At that point we can say that a standard combinational rationale decoder is a n-to-m decoder, where m ≤ 2n, and whose yield, Q is reliant just on its current information states. At the end of the day, a twofold decoder takes a gander at its present information sources, figures out which double code or paired number is available at its data sources and chooses the fitting yield that relates to that parallel information.

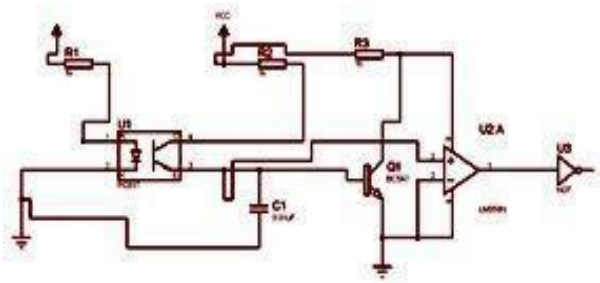
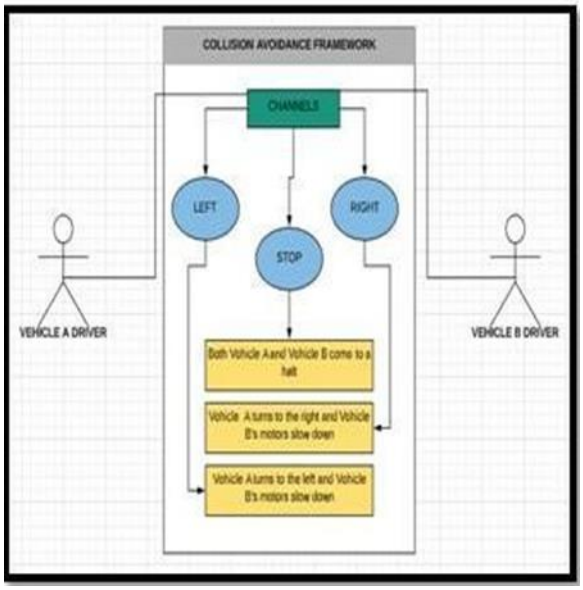


Fig 4 - Detailed circuit diagram of the LiFi Decoder circuit

VIII. UML USE CASE DIAGRAM



These are behavioural diagrams used to represent the relationship of a set of actions performed by entities which are collaborated with actors.

This is a System Use Case diagram, where the representation and flow of signals is represented in the simplest form.

IX. RESULTS

These days utilizing innovation for correspondence has become a significant part of our everyday life. Be that as it may, current remote innovation has been giving low data rates when numerous clients attempt to interface the network. As it gives a restricted data transfer capacity.

The motors slowed down whenever the obstacle crossed the threshold distance and also indicated when the vehicle in front changed direction. The buzzer beeped along with the voice programmed in the circuit as soon as it senses the difference.

The low-cost prototype that we designed is given in the diagram below:

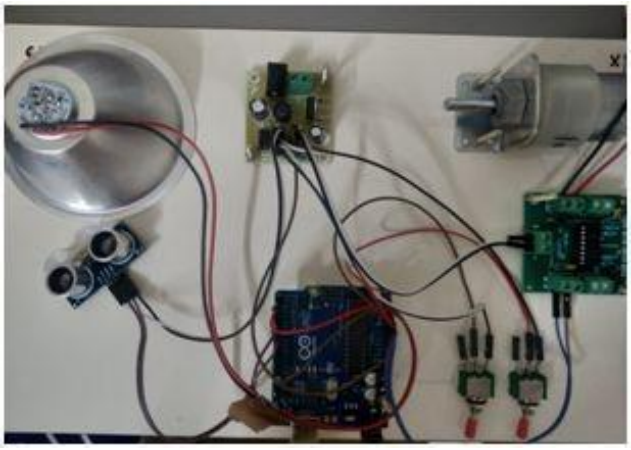


Fig 5-Transmitter circuit in vehicle A

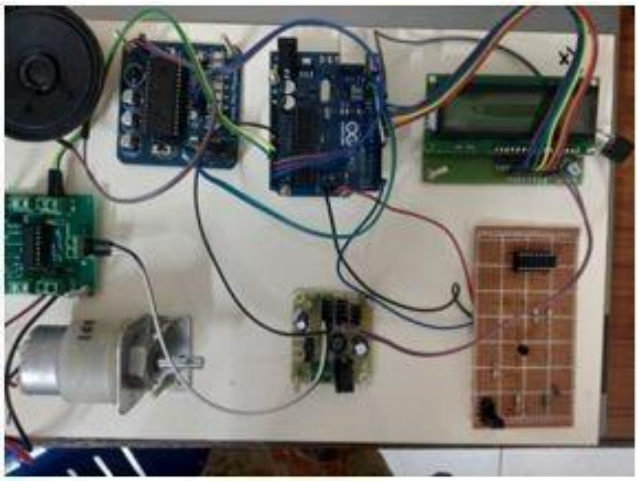


Fig 6 - Receiver circuit in vehicle B

The transmitter and receiver circuit has no direct or wired link and the only connection that they have is via visible light. With the help of LiFi communication, the message travelled faster and motors slowed down instantly. This framework is tried and its capacity is practical and stable. The primary bit of leeway of this framework is the driver never feels awkward and furthermore the framework has capacity to change the speed to keep the accompanying vehicle safe.

The concept of rise of LiFi innovation, using a simple and low-cost LiFi module as transmitter, phototransistor as a receiver and basic hardware makes it financially savvy.

Hence, the desired output is delivered and verified.

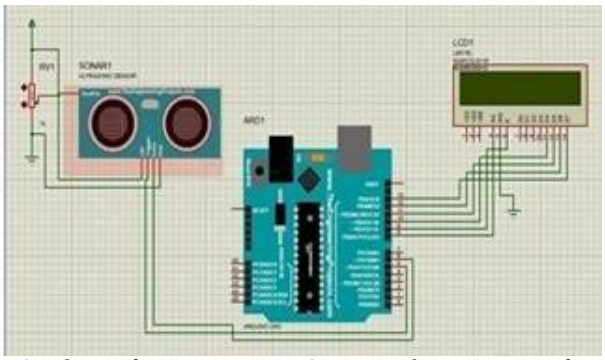


Fig. 7: Simulation of transmitter circuit. On moving the potentiometer from its upper limit to its lower limit, the distance is calculated and displayed on the LCD.

X. APPLICATIONS

- Can be used in vehicles to ensure safety of passengers and vehicles.
- Can be used for detection of obstacles to avoid any kind of damage to property.
- Helpful for new learners in driving. Can be used as a safety system in driving school vehicles.

XI. CONCLUSION AND FUTURE PROSPECTS

As per the overview by 2030, mishaps are going to be the fifth spot in making the demise of individuals. To keep away from impact between vehicles, numerous procedures have been proposed by various researchers all over the world. In this project, we have provided a miniaturized and practical representation of on road vehicle-to-vehicle communication using Visible Light Communication. We have scrutinised a few real and possible factors or cases that might occur when the car is running on the road in order to avoid accidents to an extent. Light is taken to be the communication medium as it is considered to be the less exploited, fastest, cheapest and safest mode of communication, thus making it most convenient to use.

The designed product is easy to use, it only has to be integrated with the car and then it itself performs the programmed operation.

The technique adopted is practically feasible in a multi-lane highway to direct the longitudinal movement of vehicles by using sensors that screen the movement of the vehicle right away ahead. Light is a part of the electromagnetic spectrum and it is a renewable source of energy. We have utilised this energy in the best way possible to the conventional technique of collision avoidance. In the future, the robustness and reliability can be improved using the internet. Multiple LiFi and phototransistors can be integrated to the circuit for future use. We will likewise explore how to improve the proficiency of the elements identifier by using grouping calculations and other optimization techniques.

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