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Collision Alert Using Visible Light Communication

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Abstract: The ability to own a vehicle increases the rate of usage on the road. Many accidents occur especially on highways due to the distance of vehicles that are too close to each other. If the driver in front of the car slows down or applies the brakes, the following vehicle driver finds it difficult to manage his car, resulting in a collision. In order to reduce road accidents in Malaysia, a car accident alert system is vital as a warning to the driver before the crash. This system is also important to flatten the curve rate of fatalities on road accidents in Malaysia. This project aims to design vehicle accident alert by using Visible Light Communication (VLC). As Malaysia is geographically located on the equatorial line and is receiving plenty of sunshine over the years, the VLC Technology is suitable for this system. Therefore, the proposed project is hoped to save the development cost. The project is divided into four main parts comprised of input (distance), microcontroller (Arduino Uno), Li-Fi transmitter and Li-Fi receiver part and output. The microcontroller acts like a brain that reads the input or signal from the Light Dependent Resistors (LDR). Then, the Li-Fi transmitter and Li-Fi receiver will make a data transfer by using light. The microcontroller will operate to activate the buzzer as an alarm alert in this project. Lastly, the performance is evaluated under realistic collision avoidance scenarios. Results demonstrate that the proposed method performs at 10cm level accuracy. The tally in the experiment, 1 cm equals 100 m in the real world. When the final experimental result was compared to the accepted value for the entire experiment's result, it was discovered that the experiment was perfectly accurate. At the end of this project, the simulation of collision alerting system were also presented. For future recommendation, the development project may implement an increase in model training dataset and to develop a proper prototype for vehicles for better performance and better data transmission results.

Keywords: Wireless, Light Dependent Resistor, Arduino Uno

1. Introduction

During the past two decades, Malaysia has been one of the countries that extensively developed facilities and infrastructure, such as highway expansion, especially in the major metropolitan areas.

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However, the high traffic demand in certain areas resulted in an increased possibility cause of road accidents. From the road accident cases, people usually only know the cause and impact of an accident, without actually being aware of the main problem that brings to the road accident [1].

According to the Director General of Road Transport Department of Malaysia, 40% of road accidents in Malaysia are caused by following the front vehicles too closely. Sometimes, when the driver is not alert with the distance between vehicles are close, it can cause an accident [2]. Ministry of Transport Malaysia also stated that the number of accidents in Malaysia has increased during the last ten years. Meanwhile, the number of fatalities has been reduced and achieved the lowest number of cases in 2019 with 6167 cases. Accidents in Malaysia are increasing by the year, Collision Alert Between Vehicle using Visible Light Communication will be proposed to reduce the number of road accident in Malaysia. Visible Light Communication will be chosen as a data transmission method for this project [3]. The main parameters of this method is light as a data transmission. The light will be used to transmit the data from one point to another point. To be clear, in this project basically light will transmit the data from the transmitter part to the receiver part. To prove that the data are successfully transmitted, the buzzer will produce a sound and the LCD Display will be used to display the data successfully received as a notification [4].

1.1 Problem Statement

Most of these road incidents are now blamed on drivers over speeding and improper overtaking. Some locals living along the town and villages on the major highway have taken the law into their own hands to check some of these irritating drivers, due to their hazardous behavior on our roadways. Department of Road Transport established a goal of lowering fatalities by 30% by the end of the year. When comparing Malaysia's figures to those of several industrialized and developing countries, it appears that Malaysia falls somewhere in the middle of the two groups. However, Malaysia's accident mortality rate remains concerning, with a mortality rate per 10,000 vehicles far higher than the rest of the developed world. Therefore, to reduce the cases of road accidents in Malaysia and the number of fatalities, an ideal car accident alert using Visible Light Communication will be proposed [5]. It will ensure a vehicle alert another vehicle before a collision happens. In line with the statistic by the Director General of Road Transport Department in Malaysia, 40% of road accidents communication for data communication to minimise cost. In addition, visible light communication also doesn't have any radiation exposure, so that this technology is safe to be utilised [6].

1.2 Literature Review

Several journals have been referred in order to plan this project. This project will be using the same components as the Vehicle-to-Vehicle Communication System by A. Kumar. The project presents a simple module of vehicle to vehicle communication through visible light communication that can be implemented in future vehicles. The idea of using simple LED lights as transmitter, photo diode as a receiver and simple circuitry makes it cost effective. Paper [7] discusses a vehicle-to-vehicle communication using a wireless system to provide a warning in the first place before an accident happened. It was an attempt to reduce road accidents. Besides, this paper has proposed using Li-Fi Technology in vehicle-to -vehicle communication systems. The Light Emitting Diode (LED) bulbs can send data through the optical spectrum as a wireless optical medium. The article also has provided block diagram for vehicle-to-vehicle communication, as shown in Figure 1. The paper illustrates the scenario of vehicle-to-vehicle communication by using VLC technology as Figure 2.

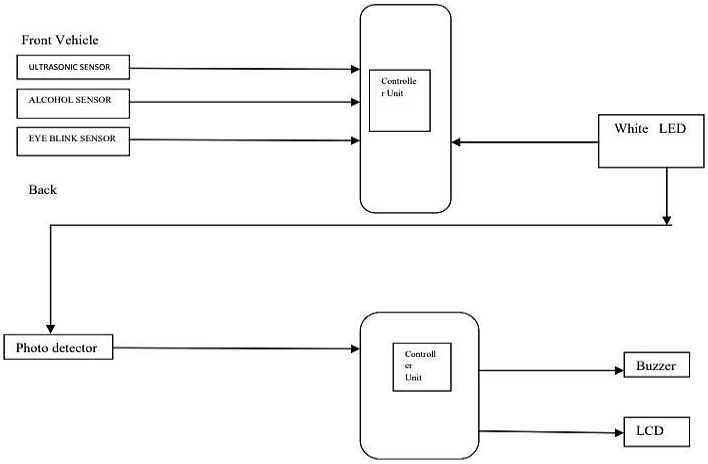


Figure 1: Vehicle-to-vehicle block diagram

Figure 2: Scenario of vehicle-to-vehicle communication using VLC

2. Materials and Methods

The Arduino Uno board is utilized for computational and data processing purposes. The board collects real-time data from sensors and processes it in accordance with system requirements, serving as the proposed system's central processing unit or backbone. The proposed system is divided into two parts which is transmitter and the receiver part. The former will be concern with electronics on the transmitter side, whereas the latter is concerned with circuitry on the reception side. Figure 3 presents the developed project system flow.

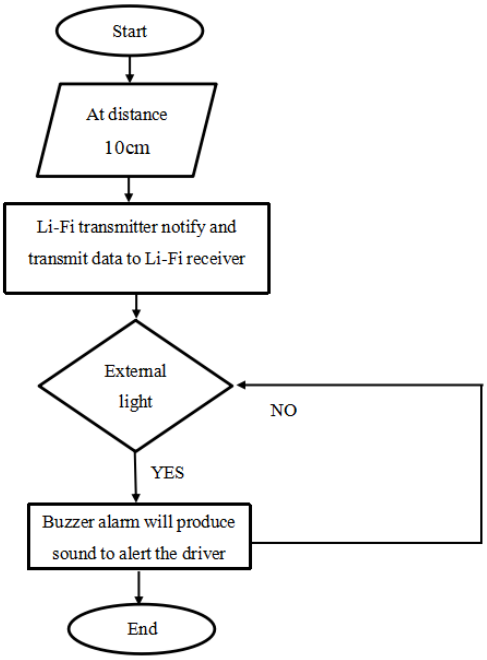


Figure 3: The development of project system flow

2.1 Design Block Diagram

The project comprised two parts which are transmitter and receiver. Figure 4 presents the block diagram of the transmitter, while Figure 5 presents the block diagram of the receiver. The transmitter part was developed using Arduino Uno, Li-Fi transmitter in the coding that uploaded into the Arduino for the LED part. The button was used in this project was to start the LED to give a signal to the receiver part. The receiver part consists of Arduino Uno, Li-Fi receiver, LDR sensor, Buzzer and LCD Display. In this part, Li-Fi receiver also was used in the coding and uploaded to the microcontroller, Arduino Uno. When the LDR sensor detect the light from the LED at the transmitter part, the Li-Fi Receiver will trigger the alarm alert which is Buzzer and the buzzer will produce a sound to alert the driver. While, LCD Display will display “Data Received” if the signal is received.

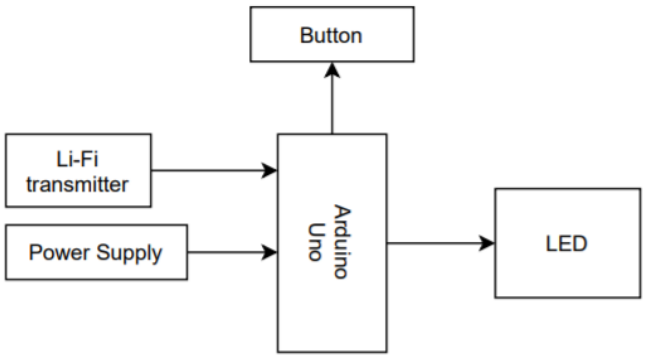


Figure 4: Block diagram of the transmitter

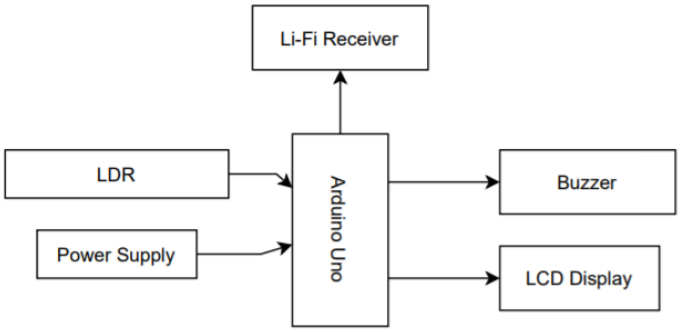
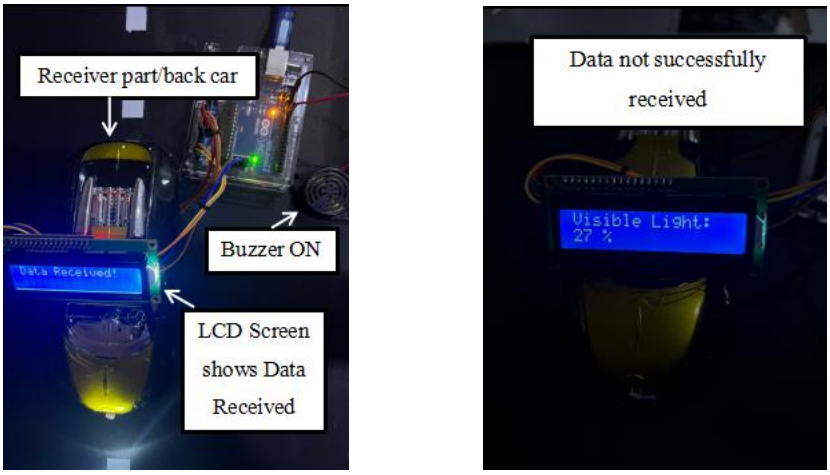


Figure 5: Block diagram of the receiver

3. Results and Discussion

This project is divided into two parts which are transmitter and receiver parts. For the transmitter part, this hardware consists of LEDs in the toy cars. It has a button to stop the buzzer when the signal has been received. Meanwhile, the receiver part consists of an LDR sensor that will receive the LED's signal. The LDR sensor in the toy cars used to reduce the external light. But the pros when the sensor in the toy cars is the angle of the hardware are limited. Besides, the receiver also has an LCD to display the data received. Figure 6 shows two scenarios which are vehicle distance is out of the allowable range and near to other vehicle and vehicles distance is allowable and distance is safe between vehicles. Scenario (a) is vehicle distance is out of the allowable range and near to another vehicle. The LCD displayed the "Data Received" when the receiver part receives the light signal from the transmitter part. The distance that configured for hardware testing is at 10 cm distance. The signal from the transmitter transmitted to the receiver part, and the buzzer produce a sound when the distance still is not allowable, which is 10 cm or less. Scenario (b) is vehicles distance is allowable and distance is safe between vehicles. The LCD displayed transmitted data from the transmitter is not received to the receiver part. It will indicate that the distance between vehicles is far and safe. Hence, the buzzer will not produce a sound.



(a) **(b)**

Figure 6: (a) Data received; (b) Data not successfully received

3.1 Analysis of parameter changing

I. Distance changed

Figure 7 and Table 1 show the analysis between distance (cm) and the accuracy of detection (%) between the transmitter and receiver. For this distance analysis, the distance between transmitter and receiver was fixed at 10 cm, the further distance can be measured using the developed hardware. This analysis observed that at 1cm to 10 cm distance between the transmitter and receiver, the accuracy of detection is 100%. On the other hand, the accuracy of detection reduced to 86% at 11 cm and the more the distance traced the lower the accuracy of detection. The buzzer will produce an alarm to notify when the distance is very near and less than the allowable range. The distance that had been configured this project is 10 cm for the testing. Lastly, this is preferable for short-distance communication and is possible in electromagnetically sensitive areas. The proposed system has two modules, one acting as a transmitter and the other as a receiver.

Table 1: Distance changed

Distance (cm)	Accuracy of detection (%)
1	100
2	100
3	100
4	100
5	100
6	100
7	100
8	100
9	100
10	100
11	86
12	85
13	84
14	83
15	83

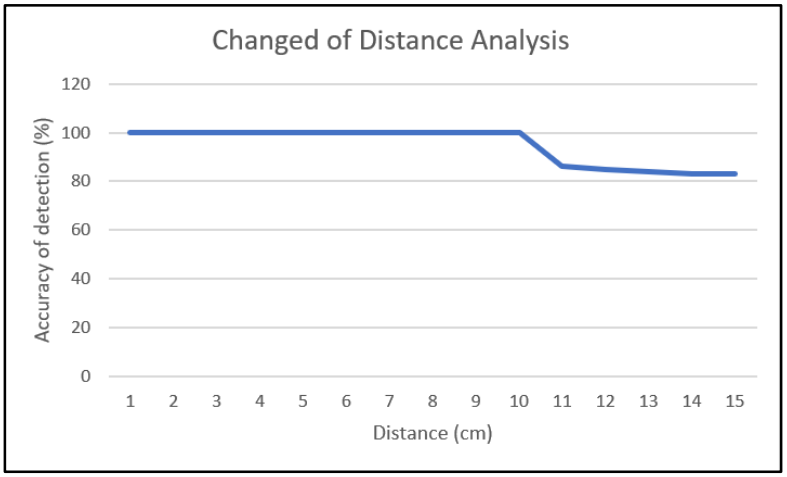


Figure 7: Graph representation for Changed of Distance analysis

II. Angle Changed

Table 2 and Figure 8 show the analysis angle (°) and the accuracy of detection (%) between the transmitter and receiver. The distance between transmitter and receiver was fixed at 10 cm and between the range. This analysis observed that at an angle of 90°, the angle of detection is 100% as the transmitter signal was directly received by the LDR at the receiver. On the other hand, at 180°, LDR was not receiving any signal, thus, the angle of detection drop is the highest. Meanwhile, slightly lower angle of detection at 0°. Lastly, vehicles travel on flat roads, for example, and neighboring vehicles share flat road sections with no pitch angle difference. This, which enables the vehicle localization problem to be defined in 0° and 180°, is reasonably valid for collision avoidance because these scenarios consider vehicles within 1 to 10 cm at 90° of each other.

Table 2: Angle changed

Angle (^{0})	Accuracy of detection (%)
0	67
90	100
180	79

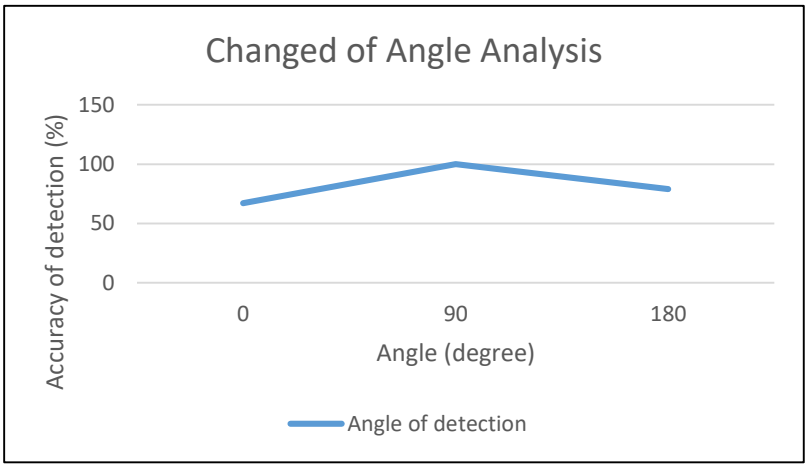


Figure 8: Graph representation for Changed of Angle analysis

III. Brightness changed

Table 3 and Figure 9 show the analysis of brightness when the LDR is ON and OFF. This analysis is to measure the amount of light passing through the LDR by using the mobile application called Light Meter. The distance between transmitter and receiver was fixed at 10cm and between the range. This analysis observed that the brightness detection is high at 630 LUX when the LDR is ON. Meanwhile, the brightness detection drastically dropped to 42 LUX when the LDR is offed. This analysis conducted by locating the LED near the top of the phone's front. Continued by running the fingertip across the phone's surface while the lux meter app is open. When the LED is covered with finger, the reading dropped.

Table 3: Brightness changed

Lights ON/OFF	Brightness of detection (LUX)
ON	630
OFF	42

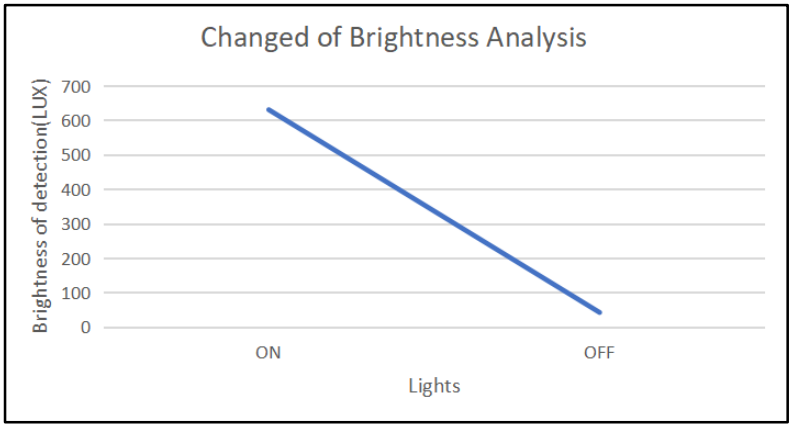


Figure 9: Graph representation for Changed of Brightness analysis

4. Conclusion

This project is necessitated an extensive investigation into the theory and algorithm of the project. Prior to that, studies on several Visible Light Communication (VLC) methods were conducted to determine the optimum approach and hardware for this project that can be used in this project. This project was proven successful and functioning by using Visible Light Communication as data transmission. The LCD at the receiver part displayed the "data received" when the distance is very near between vehicles. Also, the buzzer from the receiver part will produce a sound to trigger the driver at 10 cm and more.

Based on the analysis, we know that all the objectives of this project have been achieved. The resulting system is used to avoid vehicle collisions, and the system checks the sensitivity of the LDR to see if it is sensitive or not. This proposed system will be extremely useful for preventing accidents in vehicles caused by carelessness. Vehicle-to-vehicle (V2V) communication is proposed using this system to monitor the motion of distant vehicles. The vehicle collision can be detected using this system, reducing road accidents. These results demonstrate that the proposed method provides 10cm level accuracy collision avoidance.

This project mainly is to alert the driver when the car is about to hit another car. Therefore, it is an alternative approach to reduce the rate of accidents. This project was proven successful and functioning by using Visible Light Communication as data transmission. The LCD at the receiver part displayed the "signal received" when the distance is very near between vehicles. Also, the buzzer from the receiver part will produce a sound to trigger the driver.

Understanding fundamentals of Visible Light Communication is critical before it can be applied to car accident alert system. Besides, two other difficult parts were the development of transmitter and receiver; to ensure that the data transmission is successful using light. Moreover, an external light must be considered because it might affect data transmission from the transmitter to the receiver. By doing some prior research, all the proposed methods can be applied, and problems were able to be resolved.

At the end of the research, the vehicle accident alert using Visible Light Communication (VLC) was successfully designed and developed. It involved the utilisation of Proteus for circuit simulation and Arduino software for microcontroller's code programming. The hardware of the system was developed and finally tested workable. It was hoped that this project may benefit by adapting to the real environment and reducing the accident rate in Malaysia.

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