INTER-VEHICLE ALERT NOTIFICATION USING LIGHT-FIDELITY TECHNOLOGY

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***Abstract*—This paper presents the initial designs and results of a small-scale prototype of a vehicle to vehicle communication (V2V) using light-fidelity (Li-Fi) technology, a technology which was introduced back in 2011 by Professor Harald Haas that still needs more exploration on its sustainability especially for vehicular communication networks. Communication via vehicles proposed the most essential solution where in order to mitigate one main problem which is road accidents. For this proposed system, the functionality of Li-Fi technology will be tested accordingly by following several guidelines and objectives. Visible Light Spectrum (VLS) is used as the medium of communication between vehicles. Data transfers begins only at the time of transmitter and receiver are located within the range of line-of-sight. Whenever a vehicle triggers a communication, binary bits will be transferred corresponding to any information from the transmitter side. Both communication process and experimental results are also presented.**

Keywords—Li-Fi (Light Fidelity); V2V (Vehicle to Vehicle Communication); VLS (Visual Light Spectrum); LED (Light Emitting Diode); Data Transmission

I. INTRODUCTION

Over the past century, mankind has innovatively transformed our transportation of mobility choices with vehicles that are powered by fossil fuels. Vehicles produced by manufacturers nowadays have incrementally undergone changes in terms of both comfort and safety. In recent years, the automotive industry has worked hand-in-hand with major technology companies in order to deliver the most advanced, safest and most comfortable vehicles out there [1]. Much like smartphones are now capable of doing more than making calls, cars are becoming large smart devices with advanced emergency brake assisting capabilities, mapping technology for autonomous driving, blind-spot monitoring, better fuel efficiency and Cars-as-a-Service (CaaS).

Vehicle-to-vehicle (V2V) communication is a developing technology which enables our transportation system to interact with each other. This system has recently drawn a great attention, because they have the potential to improve convenience and safety of vehicle traffic. V2V communication makes automobiles to send messages to each other with information about what they're doing. In order for the vehicles to communicate, they need to exchange data among themselves. This data would include location, direction of travel, vehicle conditions, and loss of stability. Exchange of information regarding vehicle dynamics and road condition among vehicles could play a crucial role in driver and passenger safety. Crashes occur by errors of judgment or inattention by the drivers [2]. A driver, provided with information about road condition and movement of vehicle around it, is able to make better decisions concerning vehicle control and travel path. The Internet of Things (IOT) concept will be used in this project where all data will be sent from one vehicle to another.

Light Fidelity or Li-Fi is an eco-friendly method and also act as a medium of communication to transfer data by using visible light spectrum. It also provides high speed in terms of Gbps. The visible light spectrum is 10,000 times wider than the spectrum of radio waves. Additionally, the light sources are already installed. Hence Li-Fi has greater bandwidth and equipment which is already available [3]. The high speed will minimize the risk of data loss. This research will show how Li-Fi technology and V2V communication technology to be merged into one project.

II. LITERATURE REVIEW

This project [4] proposed a system which provides an alert and safe driving scenario to improve the crash prevention performance. In this method, an LCD type display is installed at the back of a car for displaying the warning signs a driver has seen to the vehicle which is coming behind. A touch-enabled and a voice recognition devises are mounted on the dashboard for receiving the inputs from the driver of the vehicle which is connected a wireless transceiver, a microcontroller device as well as a display device on the back side of the vehicle so that the driver can alert the vehicle which is following. The proposed method costs less to implement and it is completely networking free since it does not require any establishment of the connection between vehicles.

This research paper [5] discussed the increases the risk of conflict between frequencies of the bandwidth which is happening with Wi-Fi these days. To overcome these problems

permanently, a new concept of super-fast wireless communication has been introduced, known as Light Fidelity or Li-Fi. In the present paper the authors have given a systematic study on latest development in Li-Fi technology. The authors explained Li-Fi uses the visible spectrum as well as ultraviolet and infrared radiations. It allows the data to be transferred by modulating the intensity of the light, which is then received by a photo-sensitive detector. The light signal is then demodulated into electronic form. Then the paper compares Li-Fi technology with Wi-Fi where the researchers mentioned that Li-Fi is 100 times faster than Wi-Fi but only cover up to 10 meters while Wi-Fi can cover up to 32 meters.

III. METHODOLOGY

Methodology is comprehensive, multi-step approaches to system development that provide guides and may impact the quality of the final project. Methodology is generally a guideline system for solving a problem, techniques and tools. Also, it can be defined as the analysis of the principle of methods, rules and postulates employed by a discipline. The process model that has been proposed for this project is Iterative Waterfall Model. This model supports redesign for any changes inside the project. If the project lacks any requirements or any error while running the program, the phase can be looped back to the previous iteration It is a systematic study method that can be or have been applied within a discipline.

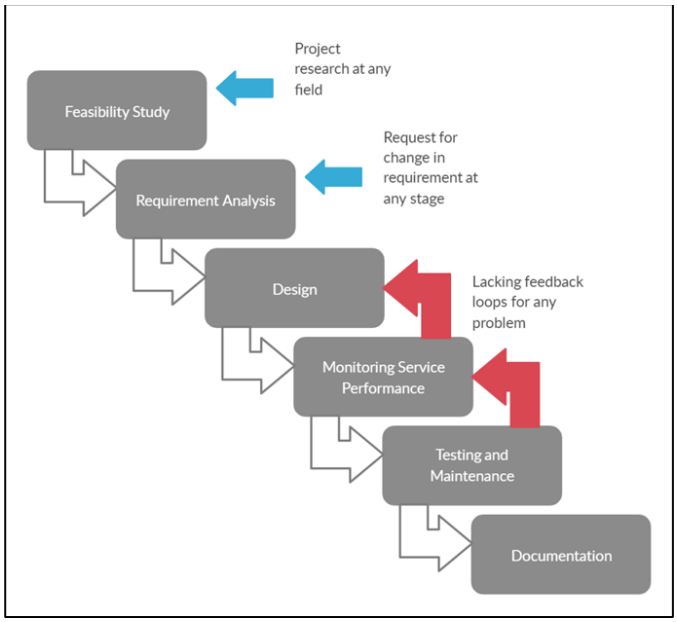


Figure 3.1: Iterative Waterfall Model

A. *Feasibility Study*

Feasibility study defines all problems, the objectives, the gaps and the work that related to this project. To find out the additional resources of information is conducted through the articles, books, journals, and internet which is related to the research to help the conducting this project.

B. *Requirement Analysis*

All possible information for the project and the requirements needed are captured and documented. The most important part in this project is brainstorming. The hardware and software, parameters required to run this project have been identified. Arduino Uno microcontroller, Light Emitting Diode (LED), Solar Panel, LCD display, Buzzer and Keypad Button are chosen for the hardware part. For software part, Arduino IDE, CoolTerm and Fritzing are chosen.

C. *Design*

For the third phase, every project plan is designed and simulated to get the idea of the process journey. Block diagram, flowchart, circuit design and schematic diagram are sketched. These designs will be used as reference later in the next phase so the project is able to produce the results as intended.

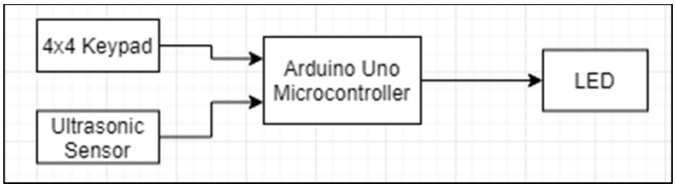


Figure 3.2: Block Diagram of Transmitter Vehicle

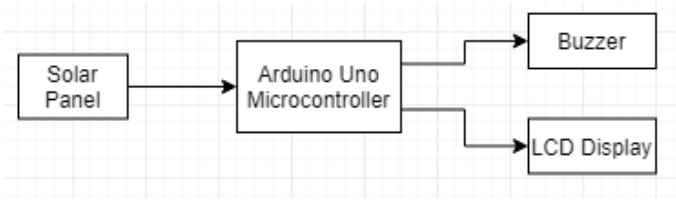


Figure 3.3: Block Diagram of Receiver Vehicle

D. *Monitoring Service Performance*

All hardware and software will be monitored to ensure everything is in good condition and can functionally well. This is important to ensure that no issues or problems will occur that could affect the completion of this project. The circuit diagram will be revised to make sure the installation of all components is according to the design. If there is any issue persists during this stage, the project has to go back to Design phase and designing work has to be revised again.

E. *Testing and Maintenance*

This phase is intended to ensure the prototype works accordingly. The prototype will be tested on several matters. If the performance of data transmission is not capable to achieve as expected, the project has to go back to previous phase before it can proceed. This phase is also where every result of the experiment will be logged and recorded for analysis purpose to meet the objectives.

F. *Documentation*

Last phase for the model, correction and amendment are made to the report. All the previous five phases will be

included in the report to evaluate as the whole progress for this project. Project presentation and report submission are also done under this phase.

IV. RESULTS AND DISCUSSIONS

This chapter discuss the findings and results obtained from the created prototype to meet the objectives. The results will be discussed further and the implementation of hardware and software design been developed. The functionality of this communication system is tested and the result will be explained.

A. Process of End-to-End Communication

The End-to-End Communication Process starts with the input devices being triggered. Microcontroller then assign unique binary bits to represent the particular alert message. Then, the LED flashes on and off according to the binary bits to transmit the data. If the nearby vehicle's Solar Panel unable to receive the data, it means to communication is not successful. If the data is received, the Solar Panel listens to the binary bits accordingly and microcontroller from receiver side will store the binary bits and translates it into decimal numbers. From decimal numbers, it then translated back into original alert message. The alert message then will be displayed on the LCD as the notification message for the driver. After every successful communication process, the alert message then will be logged and recorded and the communication process will end.

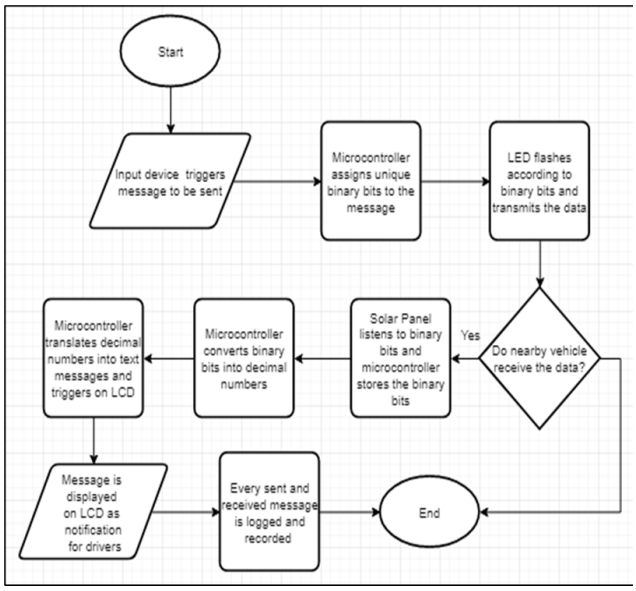
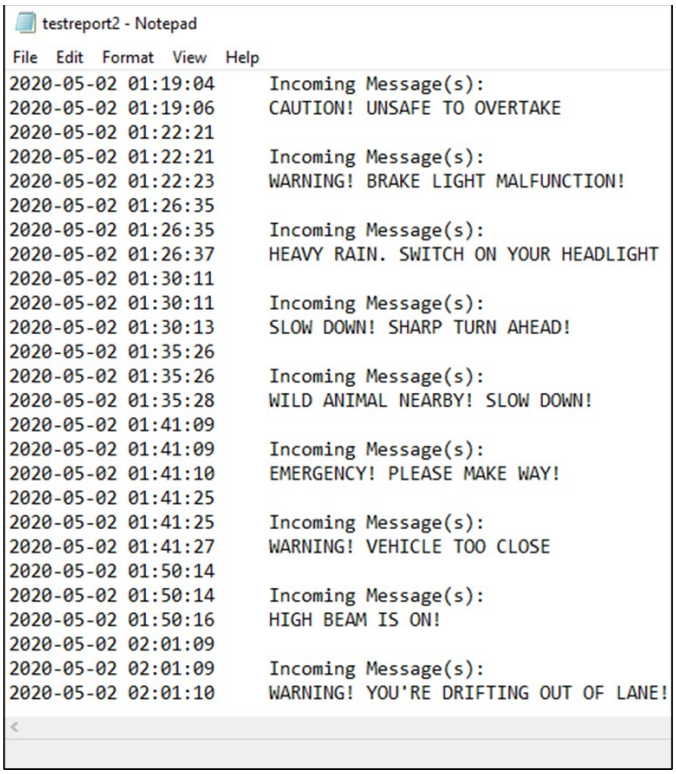


Figure 4.1: Flowchart of End-to-End Communication Process

B. Recorded Message from the System

Every transmitted and received message can be registered into a single file that holds log messages. This feature is important in V2V Communication system in order to trace every single communication message in case if there is any accident occurred involving the vehicles. This feature offers the data that is often valuable to experts investigating the events leading up to an accident. Like flight data recorders in aircraft, "black box" technology can now play a key role in motor vehicle crash investigations [16].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File Edit Format View Help

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2020-05-02 01:19:04     Incoming Message(s):
2020-05-02 01:19:06     CAUTION! UNSAFE TO OVERTAKE
2020-05-02 01:22:21
2020-05-02 01:22:21     Incoming Message(s):
2020-05-02 01:22:23     WARNING! BRAKE LIGHT MALFUNCTION!
2020-05-02 01:26:35
2020-05-02 01:26:35     Incoming Message(s):
2020-05-02 01:26:37     HEAVY RAIN. SWITCH ON YOUR HEADLIGHT
2020-05-02 01:30:11
2020-05-02 01:30:11     Incoming Message(s):
2020-05-02 01:30:13     SLOW DOWN! SHARP TURN AHEAD!
2020-05-02 01:35:26
2020-05-02 01:35:26     Incoming Message(s):
2020-05-02 01:35:28     WILD ANIMAL NEARBY! SLOW DOWN!
2020-05-02 01:41:09
2020-05-02 01:41:09     Incoming Message(s):
2020-05-02 01:41:10     EMERGENCY! PLEASE MAKE WAY!
2020-05-02 01:41:25
2020-05-02 01:41:25     Incoming Message(s):
2020-05-02 01:41:27     WARNING! VEHICLE TOO CLOSE
2020-05-02 01:50:14
2020-05-02 01:50:14     Incoming Message(s):
2020-05-02 01:50:16     HIGH BEAM IS ON!
2020-05-02 02:01:09
2020-05-02 02:01:09     Incoming Message(s):
2020-05-02 02:01:10     WARNING! YOU'RE DRIFTING OUT OF LANE!
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Figure 4.2: Logged Messages from Receiver Vehicle

C. Performance Analysis

This section performs the message transmission in different aspects and conditions. All the results gained are displayed on serial terminal and will be used to analyze by the performance and the behavior of it (binary result). Some of these conditions include different ambient lights interfered and different simulated weather type. All tests are conducted at the connection of baud rate 9600 and at a fixed distance.

TABLE I. RESULTS OF PERFORMANCE ANALYSIS IN VARIOUS CONDITIONS

Type of Interference	Results		
	Value	Binary Received	Status
Ambient Light	233	110101000	Success
Ambient Light	251	11010100	Success
Ambient Light	388	11010100	Success
Ambient Light	673	11111111	Failed
Simulated Raining	-	11010100	Success
Simulated Raining	-	11101100	Success
Simulated Raining	-	10111000	Success

Type of Interference	Results		
	Value	Binary Received	Status
Simulated Fog/Haze	-	11010100	Success
Simulated Fog/Haze	-	00000100	Failed
Simulated Fog/Haze	-	00010100	Failed
Simulated Fog/Haze	-	11100110	Success
Simulated Fog/Haze	-	00000010	Failed
Simulated Fog/Haze	-	11100010	Success

*Results gathered from the experiment.

Despite all the results and analysis are gathered successfully, it can be vary depending on the components used. The distance of 7 cm to 12 cm between both prototypes only give the best performance of data transmission. This is because this project uses normal LED and smaller size of Solar Panel. Based on the results, it is believed that the data transmission will give better performance if bigger Solar Panel and special purposed LED are used. For fog or hazy environment, it can be concluded that brighter light source such as spotlight or laser would be a good choice since a brighter light spectrum is able to penetrate the thick surface of the natural phenomenon. Thus, every project's objectives stated earlier are unfold and resolve within this chapter.

V. CONCLUSIONS

Li-Fi technology is successfully implemented on the vehicle system, which is needed the form of binary bits to hold the specific messages and for encrypt and decrypt purposes. While key components such as LED and Solar Panel playing the important roles of producing and capturing binary bits, Arduino microcontroller on the other hand does the encrypting and decrypting activities. As mentioned earlier in Chapter 1, the objectives are set as the benchmarks to see how far the development of the project leads to and to this very moment all three objectives are accomplished and well discussed back in Chapter 4. Data transmission between vehicles works as intended, findings and results are recorded.

As if this project to be invested and improvised further, it is recommended to choose the key components that can maximize the performance of the Li-Fi. It is also recommendable to enhance the usage of Li-Fi technology performance. With high data rate that Li-Fi can afford, supposedly V2V communication cannot be limit to text messages transmission only. If this project to be resumed in near future, it is endorsed to generate many forms of data transmission within vehicles such as audio message, image transfer, or even video communication.

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