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Hardware Development and Analysis of Vehicle's Driver Awareness During Braking Event

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Abstract: Undetermined coefficient method is proposed to derive higher order schemes for solving Burger's equation. The undetermined coefficient method was proved that some well-known schemes can be derived although their original derivations are different from each other. In this proposed method for solving the 1-D Burger's equation, stability and accuracy of the new scheme are analyzed by comparing the computed results with exact solutions of one-dimensional pure convection equation. Effectiveness of the proposed method is also analyzed by comparing with the results using other schemes. This scheme was applied to simulate hydraulic jump in one-dimensional flow with different ratios of initial upstream water depth to downstream one. From the obtained results, it shows that this new scheme has the ability to simulate a moving hydraulic jump well.

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1. Introduction

In the development of the automotive industry, vehicle dynamics plays an important role to achieve the best outcome moving together with the latest technologies nowadays. great progress was made in the theory and experiment of vehicle dynamics. In vehicle dynamics, the sprung mass (vehicle body), the spring and damper (suspension component) and unsprung mass (tire component) are essential parts of the system. Therefore, vehicle dynamic study on how vehicle reacts to driver inputs on a given road. Thus, several models have been developed to describe the human driving behavior and evaluate the vehicle safety in braking and turning. The interaction between driver and the outside world is a very complex process which involves the work of different parts of the brain (identification of position, decision-making, action to complete the task) [1] Therefore, it is proven that driver's respond and input during driving affects the behavior of vehicle. this would be an enough reason on why safety systems in vehicles are developed, invented, and improved.

Passive and active system are the two main categories of safety system. The purpose of the passive safety system is to protect both driver and passengers during an accident, while active safety system allows the vehicle to be maneuvered to prevent any collision. A vehicle's active safety system can avoid a collision, while a vehicle's passive safety system keeps the driver and passengers safe in the event of a collision [2]. There are several technologies that are applied to the braking system are designed to enhance vehicle safety when driving, where in this paper it focuses on the effectiveness of different brake lights. Therefore, in recent years, the number of studies on developing better brake lights that can increase the driver's awareness to optimize a shorter brake time respond is gradually increasing to meet customers' requirements as well as to enhance safety measures when driving to avoid accidents from happening.

The dynamic analysis of vehicle driver's awareness during braking event is the experimental study of braking performance in which to analyze the break time respond between 2 vehicles. The experiment was conducted by using a full vehicle ride model involves driver's response toward brake lights, vehicle body and braking system. This enables further study on the brake response time in car-following situations. But to measure the brake response time, a Data Acquisition System (DAQ) must first be developed. And the results were analyzed respectively. A DAQ is the way of acquiring readings of signals that measure real-world physical events and translating them into digital numeric values that a software (computer) can control. The Dewetron DAQ is an example of an expensive Data Acquisition System. Dewetron creates the most dependable and sophisticated data acquisition systems on the market, capable of handling even the most difficult test and measurement operations 35. The Inter-range instrumentation group timecodes (IRIG) Timecode Dewesoft systems, for example, are compatible with a variety of IRIG time codes. When IRIG is used as the system's time source, absolute time accuracy of 1 µs is attained [3].

In 2004, road traffic injuries were the ninth most frequent cause of death and WHO predicted that by 2030, they would become the fifth most frequent (World Health Organization 2009). Over 1.2 million people die on the road each year, with 20 to 50 million suffering from non-fatal injuries. Malaysia, as one of the developing countries, has acknowledged road safety as a critical problem that should be addressed [4]. As a result, drivers must be aware of several safety precautions to avoid an accident. Specifically on motorcycle type of accidents, Figure 2.1 shows more than 25% involved in a rear end collision for the past 10 years (2001-2010) in which about 7% involved had fatal injury while the rest had severe injuries. Additionally, these accidents tend to happen more during the night compared to during the day as shown in Table 2.1. Recently, Malaysian Institute of Road Safety Research (MIROS) states that in 2018, motorcycle deaths were 66% from the overall road traffic deaths. For the past 10 years motorcycle always more than others user group death [5]. Therefore, it is assumed that the effect of comparing between two brake lights will increase the safety of motorcyclist, and eventually could reduce the rate of accidents, especially rear-end collisions. Table 2.2 shows the average number of accidents within 10 years, shows that and average of accidents happens more at night compared to during the day. Thus, this makes the study became more relevant to be done at night as the number of accidents happened at night increase as year increases.

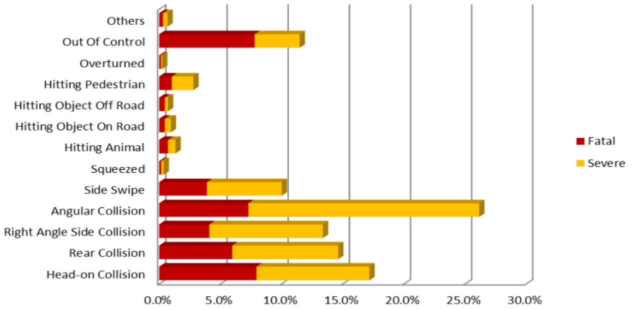


Fig. 2.1 - Motorcyclist (Rider) Involved in Killed and Seriously Injured (KSI) Road Crashes by Type of First Collision (2001 - 2010) [4]

Table 2.1 - Motorcycle Accidents—Road Geometry and Time [5]

Years	No. of Motorcyclist Accidents by Road Geometry				No. of Motorcycle Accidents by Hours	
	Straight	Bend	Cross Junction	T/Y Junction	Day (0601-1800)	Night (1801-0600)
2000	2415	652	195	490	1752	1589
2001	2107	578	201	458	1553	1503
2002	2123	550	190	483	1662	1492
2003	1994	472	156	422	1592	1517
2004	1939	462	163	385	574	528
2005	2295	544	167	463	1836	1679
2006	2121	468	351	430	1804	1611
2007	2392	528	173	494	1866	1749
2008	2607	591	181	556	2081	1882
2009	2930	558	192	444	1463	2728

Source: PDRM road accident annual statistic reports

Table 2.2 - Average of Motorcycle Accidents by Hours

No. of Motorcycle accidents by Hours	Average
Day (0601-1800)	1618
Night (1801-0600)	1628

There is a requirement to correctly characterize the beginning circumstances of a frontal collision for the vehicle occupant in the field of numerical accident simulations in road safety research. Human models designed to mimic such collisions hardly account for muscle contraction effects [6]. In many situations, the capacity to respond quickly, or response time, is the determining factor in determining culpability. When evaluating a case, it is typical for accident reconstructionist to simply employ a conventional reaction time value. In reality, response time is a complex behavior that is influenced by a broad variety of factors. There cannot possibly be a single number that applies to everyone.

Researchers in [7] claim that they may have a hypothesis that in unexpected and even surprising scenarios, drivers who concentrate on driving, avoid sharing attention, and find a situation urgent enough to respond by braking may well do so with an average delay of approximately 1 second. When distracted, low arousal, weariness, momentary attentional lapses, old age, neurological disorders, and narcotics, all of which are prevalent in traffic, sluggish reaction, and skewed response time (RT) distributions result, even in life-threatening situations.

2. Equipment and Methodology

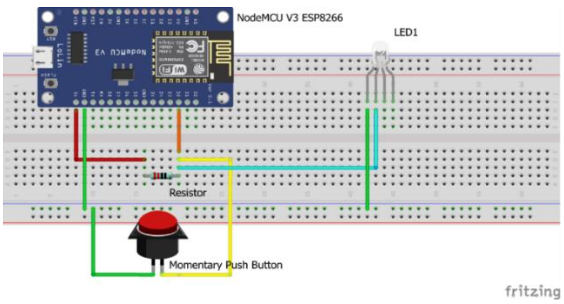
Experimental parameters were set based on the literature reviews, the objective, and the scope. It is followed by the testing method that uses different types of brake lights which are the current brake lights, and the flashing brake lights. The data collected is then tabulated as the result based on the conducted experiment.

2.1 The Equipment

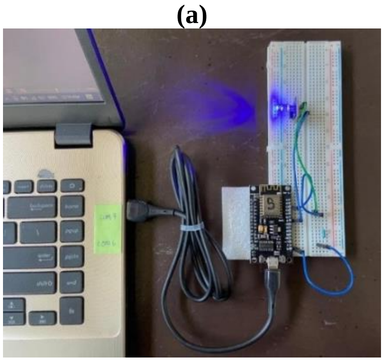
The brake response time was measured using a DAQ system that is developed and is installed in TV 1 and TV 2 respectively. The two ESP8266 microcontrollers were connected to each other. One functions as the server, and the other as client. The server application received data from the client, that is programmed as the input of the system.

2.1.1 DAQ System using ESP8266

The program keep logged the time in milliseconds (ms) following the laptop time. When the brake at TV 1 as shown in Appendix A is applied, button is pushed, the timer stopped. Then as the driver in TV 2 brakes, it starts the timer until the brake pedal is released. Figures 2.1 (a) and (b) shows the circuit diagram and hardware used for the Server board placed in TV 2. Figures 2.2 (a) and (b) is the circuit diagram and hardware that is placed in TV 1 as the client. The client uses power bank as power source, while server is connected directly to the laptop as the output was monitored there.

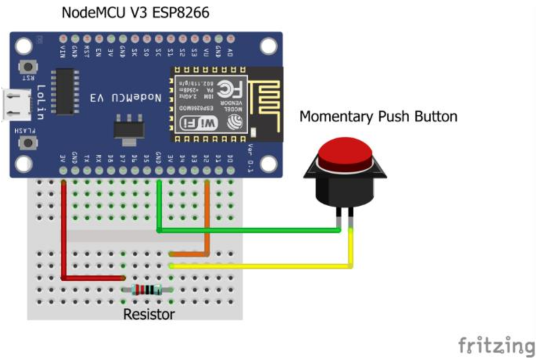


(a)



(b)

Fig. 2.1 - Server ESP8266 component setup; (a) Circuit Diagram, (b) Actual Hardware



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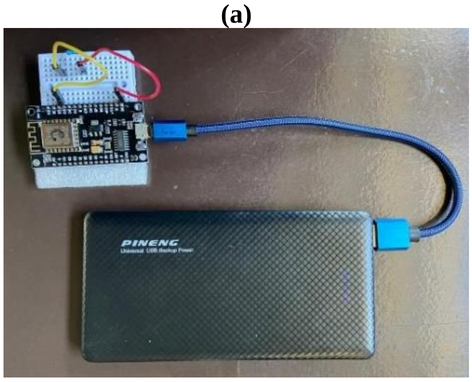

(b)

Fig. 2.2 - Client ESP8266 component setup; (a) Circuit diagram, (b) Actual HardwareNumerical Results

2.1.1 Brake Lights

Section 12 of the Road Transport Act of 1987 outlines the forms of vehicle modifications that are and are not permitted. For motorcycles, specifically for the rear lights (night lamp) and brake lights are limited to red only. The use of colored lights other than red is not allowed as it may confuse other road users that could jeopardize their safety. The standard lumen that is allowed for both standard and flashing brake lights are 900 – 1000 lumens. Besides that, there is no regulation that states that the use of flashing brake lights on motorcycle are illegal. Thus, flashing brake lights can be used on road. The model used for standard brake lights and flashing brake lights bulbs are as shown in Figure 2.3 and Figure 2.4.

Fig. 2.3 - LED bulb for standard brake lights

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Fig. 2.4 - LED bulb for flashing brake lights

2.1.2 Test Vehicles

The test vehicle that was used as the leading vehicle which was called as Test Vehicle 1 (TV 1) is the Yamaha 135LC motorcycle. The motorcycle runs by single cylinder. Its transmission type is the rotary type 4-speed transmission. Most importantly the front and rear brake system uses hydraulic single disc and drum. The specification of the brake lights used are explained in section 2.1.2.

While the Test Vehicle 2 (TV 2) that was used as the following vehicle in this experiment is the Perodua Myvi 1.3L. The test vehicle is run by four-stroke engines that powered by gasoline. This car has four piston movement over two engine revolutions for each cycle. The engine transmits power to the wheels via a 5-speed manual gearbox and the front brake uses ventilated disc brakes, while rear uses drum brakes.

2.2 Experiment Procedures

The wiring was set up in both TV 1 and TV 2 respectively. Shown on Figure 2.5 is the overview of the whole experiment setup, which is known as the DAQ where it was used to record the brake response time. There were two system installed. One in each test vehicle. The DAQ consists of the push-button sensor as its input, ESP8266 and the output data shown in the laptop via Arduino IDE software. The push-button sensor was placed on the brake pedal of each vehicle. The sensor is then connected using wires to the two ESP8266 boards as the medium to convert analog signal read from the sensor to digital signal and was connected to each other.

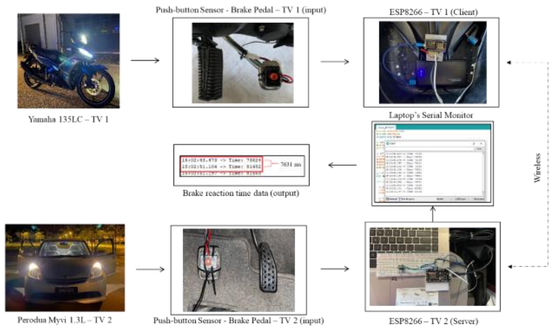


Fig. 2.5 - Overview of experiment setup

The system in TV 1 and in TV 2 is connected wirelessly with the help of the ESP8266 where it was connected to each other (Server and client). When the brake pedal is pressed in TV 1, push-button sensor was triggered, and it stopped the time at the serial monitor of the Arduino IDE software. As the brake is pressed, the brake light is visible, thus driver in TV 2 reacted towards the brake lights and applied brake, this is when the push-button sensor at the brake pedal in TV 2 was triggered and start the time again. The output of brake response time was shown in one laptop that is connect with the system in TV 2. The experiment varies in speed of 20, 30 and 40 km/h, and two different brake lights which are the standard brake light and flashing brake light were tested for each speed. The data was analyzed respectively.

The experiment was carried out at night to minimize any distractions during the experiment such as the sunlight, having other vehicles and pedestrians on the road for safety purposes and to allow driver's maximum focus towards the brake lights. Graph of Number of braking attempts vs Time (ms) was plotted for each brake lights. Before starting the experiment ensure the road is safe from pedestrians and other vehicles as the test vehicles moved in a quite high speed. The standard brake lights were installed for the first experiment. Then, it starts with both test vehicles are at a speed of 20 km/h. The vehicles are drove around the campus, and TV 1 braked randomly at any straight roads. The distance between the vehicles is ensured to be sufficient (approximately 10 m) to prevent any accidents from happening. The same procedure was carried out for speed of 30 and 40 km/h respectively. Each speed was repeated 3 times, to get 3 different brake response time data.

For the second experiment, the flashing brake lights were installed. Then, the experiment procedure is the same as for the standard brake lights. The speed of test vehicles is varied to 20, 30 and 40 km/h. Each speed was repeated three times, to get the average brake response time. Throughout the experiment, the process was observed. Lastly, the data of the two experiment of different brake lights in specific file was recorded to be tabulate, analyze and plot the graph of speed against time. Figure 2.6 shows experiment was carried out at night.

Fig. 2.6 - Experiment carried out at night

3. Results and Discussion

The client is ensured to be connected to the server' application. Figure 3.1 shows the serial monitor (output) for the client's application to prove the connection. Figure 3.2 shows the output that is monitored from the server's application serial monitor. The system keep logged the time in milliseconds (ms) following the laptop time. When the brake at TV 1 as shown in Figure 3.2 is applied, button is pushed, timer was stopped. Then as the driver in TV 2 brakes, it starts the timer until the brake pedal is released. The time delay of 7631 ms (example) proves that the system works, and data of brake response time can be collected.

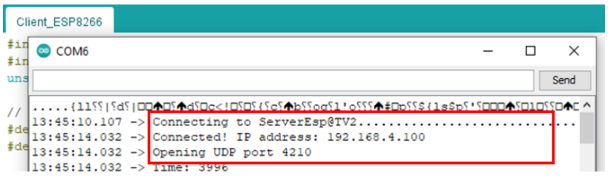


Fig. 3.1 - Serial Monitor of Client's application

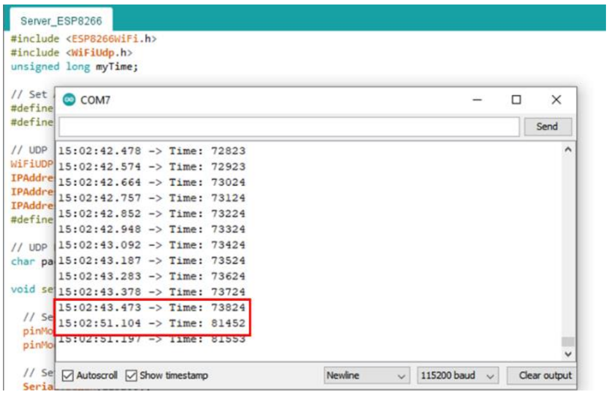
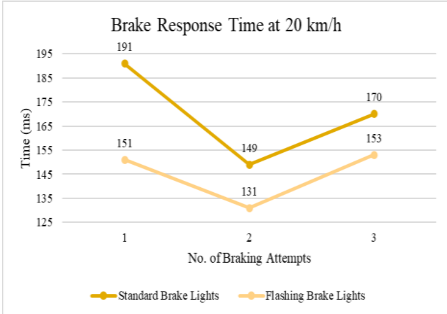


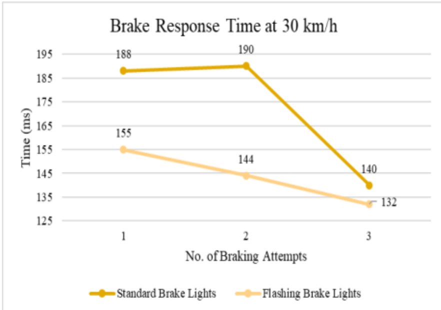
Fig. 3.2 - Serial Monitor of Server's application – Brake Response Time

The results for brake response time for both brake lights with speed of 20 km/h is shown in Figure 3.3 (a). Based on the graph shown, the first braking attempt for standard brake lights has the longest brake response time with data of 190 ms, while flashing brake lights is 151 ms. The pattern for second and third braking attempt for both brake lights are the same with response time 149 ms and 170 ms for standard brake lights. While 131 and 153 ms for flashing brake lights respectively. Significantly shows that flashing brake lights has shorter brake response time with percentage of 14.6% faster brake response time for 20 km/h.

Moving on to speed 30 km/h shown in Figure 3.3 (b). With percentage of 16.8% flashing brake lights has faster response time compared to standard brake lights. Each braking attempts for standard and flashing brake lights has response time of 188, 199 and 140 ms, and 155, 144 and 132 ms respectively. Lastly for speed 40 km/h (Figure 3.3 (c)). For standard brake lights, the response time decrease proportionally with results of 232, 187 and 140 ms. While flashing brake lights has the shortest response time on the first braking attempt (154 ms). The second braking attempt mark the longest response time with data 187 ms. Anyhow, flashing brake lights still has faster brake response time by 7.3%. The percentage of flashing brake lights more effective compares to standard brake lights is shown in Table 3.1.



(a)



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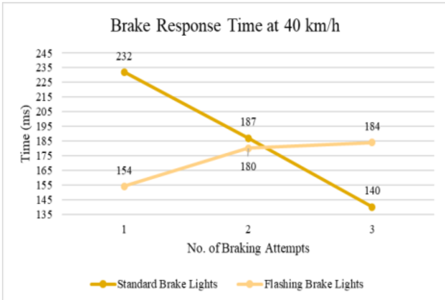

(c)

Fig. 3.3 - Brake response time for standard and flashing brake lights with three braking attempts; (a) At 20 km/h (b) At 30 km/h (c) At 40 km/h

Mainly, from the pattern for each braking attempts for all speeds, the first braking attempt has a pattern of having the longest brake response time. It was assumed that the driver was distracted to maintain the speeds that has been set. While on the other hand, the third braking attempt has a pattern of two records of the shortest brake response time for 30 km/h and 40 km/h. In this situation, reaching the third braking attempt, the driver gets used with maintaining the speed. Thus, has shorter response time. The average brake response time for both brake lights is as shown in Figure 3.4.

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Table 3.1 - Percentage of flashing brake lights more effective compared to standard brake lights

Speed (km/h)	Standard Brake Lights (ms)	Flashing Brake Lights (ms)	Percentage (%)
20	170	145	14.7
30	173	144	16.8
40	186	173	7.3
Average	176	154	12.8

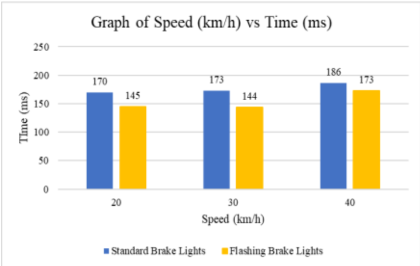

Fig. 3.4 - Average brake response time for both brake lights

In general, the brake response time for both brake lights gradually increase as speed increases. Other research came up with similar conclusions. When following at distances approximately 10 m at all three speeds, drivers would not react to stimuli as quickly as they would if they were driving at a slower speed. Thus, when driving in high speed, the brake response is proven to be slower compared to slower speed. On top of that, comparing the type of brake lights used, flashing brake lights has a faster brake response time compared to standard brake lights. It is proven that driver react faster and is more alert when flashing brake lights are used.

4. Conclusion

The objective of hardware development and analysis of vehicle's driver awareness during braking event is to study the driver's braking response in car-following situations. The experiment was tested with two type of brake lights which are standard brake lights and flashing brake lights. Three different speeds of 20, 30 and 40 km/h are experimented and was carried out at night. Different brake lights installed is proven to affect the driver's brake response time. For both brake lights it shows that as speed increases, the brake response time also increases. And flashing brake lights shows a significantly faster brake response time compared to flashing brake lights with average percentage of. 12.8%. Thus, with the results presented earlier, the DAQ system developed using Arduino IDE software was a success for this preliminary study. This study could contribute to a further study for the safety of all vehicles on road, especially in car-following situation. In this case, is the development of DAQ system that could record the brake response time, and specifically testing effectiveness of motorcycle brake lights.

Based on the findings and problem that has occurred throughout this study. These are some suggestions that could help improve the accuracy into achieving better result in this field of study. The researcher needs to understand the programming language to handle the Arduino IDE software. Avoid any other distractions when the experiment was carried out. Therefore, in further studies it is recommended to add more variables that is like a real-time driving situation. Such as there are pedestrians crossing the road, vehicles change lanes when driving and at different whether (raining). On top of everything, safety must be the first thing to be considered before carrying out any experiments.

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