MEKATRONIKA
e-ISSN: 2637-0883
VOL. 4, ISSUE 2, 24 – 31
DOI: https://doi.org/10.15282/mekatronika.v4i2.8942

ORIGINAL ARTICLE

Virtual Driving Simulation for Pedal Error Study

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ABSTRACT – This paper is about the development of a virtual driving simulation for the pedal error study among Malaysian drivers. The project is in collaboration with the Malaysian Institute of Road Safety (MIROS) and The New Car Assessment Program for Southeast Asia (ASEAN NCAP) research grant. Instead of conducting the naturalistic driving test, the virtual driving simulation will be used in the current driving simulator developed for this project. Therefore, the aim of this study is to develop the virtual driving simulation which contain some emergency braking situations, determine the foot placement on the pedal (using video observation) and to measure the total pressure on the pedals during the normal driving and emergency braking situation among Malaysian drivers. This study is focused on automatic transmission car by Malaysian drivers who aged around 20 to 50 years old that have minimum two years driving experience. A questionnaire was also given to participants, asking them about their personal information, their driving behavior, infrastructure, and safety, as well as pedal misapplication. The virtual driving simulator was equipped with some devices such as camera, pressure sensor, screen monitor, steering wheel and driver's pedal. A study was completed successfully to determine the position of the Malaysian driver's foot on the brake pedal during emergency braking. It has been discovered that roughly 6.67% of participants in a driving research use both legs while driving and use their left foot to hit the brake pedal during emergency braking. The study also found that about 26.67% of participants feel dizzy while driving and around 96.67% of participants were surprised by the obstacles.

ARTICLE HISTORY
Received: 12th Oct 2022
Revised: 5th Nov 2022
Accepted: 20th Nov 2022

KEYWORDS
Virtual Driving
Pedal
Kalman Filter
Control

INTRODUCTION

Virtual driving simulation is an activity where people are required to control a vehicle in a racing or driving game. It is known as the "simulation" because it doesn't have any actual physical activity taking place other than the manipulation of onscreen controls. In recent decades, computer systems have made it possible for people to "drive" games with realistic physics and graphics. The pioneers of driving simulator validation, [1-2] offer two methods for assessing driving simulators. The first step is to examine the subject's driving behaviour in a driving simulator and compare it to an on-the-road evaluation. The second is the simulator's physical components' validity, which includes the simulator's design and dynamic properties, as well as its parallels to a real vehicle [1-2]. Although these two do not need to be related, driving performance or driving behaviour is often regarded the most significant validation technique. While there are a variety of methods for evaluating a driving simulator, it is vital that driving behaviour be tested on the road.

In virtual driving simulation compared with other kinds of racing games, violent activities are more common than are sports driving simulation games and death-defying driving races. Because the environment is a game where you drive and not play against humans, there is no real danger. A guide simulator applies an adaptable and easy-to-repeat experimental design. It offers the possibility of changing driving scenarios at any time and exposing drivers to dangerous situations in a method [3].

This virtual driving simulation was developed in Unity 3D game engine and programmed by C# language. Unity (commonly known as Unity3D) is a game engine and integrated development environment (IDE) for creating interactive media, typically video games. As CEO David Helgason put it, Unity "is a toolset used to build games, and it's the technology that executes the graphics, the audio, the physics, the interactions, [and] the networking." [4]. Unity is categorized as a "game engine" which is popular among game developers due to its efficient solution for generating 2D and 3D applications. Not only that, but Unity can also be used for developing augmented reality and virtual reality applications.

Pedal error take place in a numerous situation. Sudden acceleration is a troubling trouble which can bring about severe harm or dying in an automobile accident. Pedal error has been recognized as a first-rate component in preceding studies. There are quite a few sorts of pedal error proper trajectory, confusion, incorrect pedal press, relocation of foot on pedal, all pedals pressed, pedal slide, and others are all examples of pedal faults [5]. Furthermore, surprise, frustration, and haste are all emotions that can lead to incorrect pedal placement. Due to improper posture and pedal action, the driver's foot may move from the brake to the accelerator pedal. Based on the previous study of pedal misapplication on naturalistic

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driving test, the primary consideration that needed to be made was safety to avoid some accident happen between the car and drivers [6]. Therefore, virtual driving simulation is used to replace the naturalistic driving test car in this study because in industry and educational institutes, driving simulation has become a very helpful tool for vehicle design and research [7].

Pedal failure can cause the car to accelerate quickly, sometimes to full throttle, without the braking effort slowing it down. As a result, the purpose for this research is to determine the foot placement on pedal by using video observation and to measure the total pressure on the pedals during the normal driving and emergency braking situation by using pressure sensor among Malaysian drivers.

METHODOLOGY

In this section it will focus on the method and process flow throughout this project including the process to make the virtual driving simulation, apparatus required to run the study, actual driving simulation test and the method for data collection. The apparatus required are application of driving simulation, camera, pressure sensor and a microcontroller using Arduino UNO. Hence, there will be an instrumented car simulator that will be used to collect all the required data. The instrumented car simulator will be occupied with some devices such as cameras, sensor and data acquisition. All the equipment mentioned will help in collecting the data.

Developing the Road Feature

UMP Pekan roads have been chosen as the environment and roads in the driving simulation. Because the target drivers for this study were taken among UMP students and staffs, it will give them familiar with the roads. Figure 1 shows the map for UMP Pekan road that was taken from Google Maps.

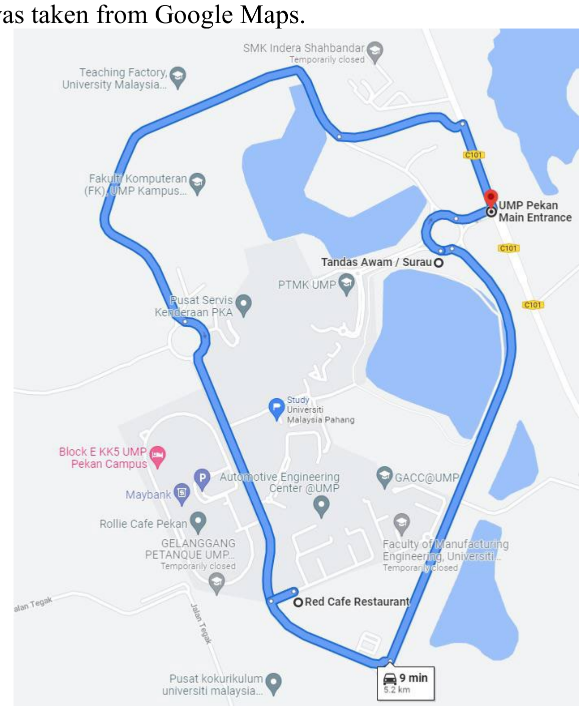

Figure 1. Simulated Kalman filter (SKF) algorithm.

Figure 2 visualizes the UMP Pekan road that was created in Unity software by using Road architect assets. The scale for creating the road were taken 1:1 from the original road. The time taken for the driver to complete one lap in this road was around 8 minutes based on normal speed car which is between 60 and 70 kilometres per hour.

Figure 2. UMP Pekan Map from Unity.

Developing the Automatic Transmission Car Feature

Inside the Unity software, drag the prefab file of the car that want to be used as the driver car into the scene. Then the car Game Object (GO) will pop out at the Hierarchy as shown in Figure 3. Put the "Main Camera" GO as a child for car GO, then adjust the position of the camera at the right side of car to make the view just like the real driving.

Figure 3. Step 1 in developing the automatic transmission car feature

Then, create the input action by right click on the Project menu. The input action is associate degree abstraction over the supply of input(s) it receives. Once enabled, the action can actively monitor all controls on devices gift within the system as shown in Figure 3.5 that match any of the binding ways related to the action. Once input is received on controls certain to an action, the action will trigger backs in response.

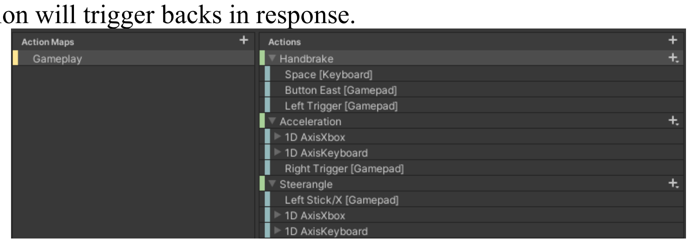

Figure 4. Step 2 in developing the automatic transmission car feature

After creating the input action feature, make sure to save the assets and click on generate C# class as shown in Figure 5. Click apply and it will automatically create the C# class based on the binding ways related to the action.

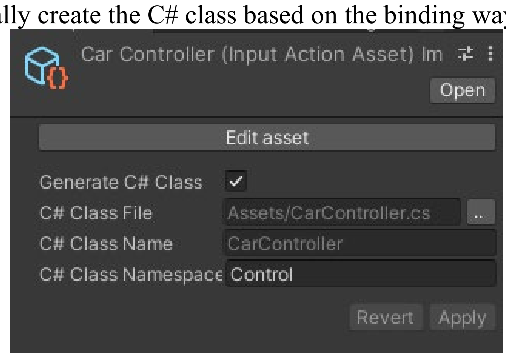

Figure 5. Generate the C# class for the input actions

Next step, place the Wheel Controller Script inside the car GO as shown in the Figure 6. Based on this script, the drive type for this car will be selected as front wheel drive and the transmission will set into automatic transmission car. Make sure to drag the Car Controller Input Action on the input action slot. It will move the car based on the device input that already been insert before.

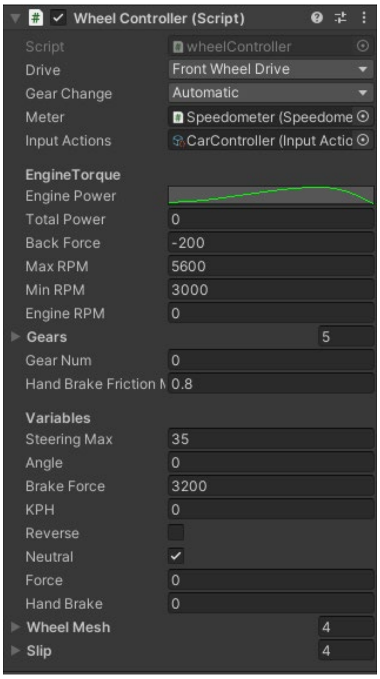

Figure 6. Step 3 in developing the automatic transmission car feature

Emergency Braking Situations

The main purpose for this emergency braking situation is to see the reaction of the driver when something appears and to test their driving skills. There are six emergency braking situations that have been identified based on the previous research. The following are the six types of emergency braking situations (see Figure 7):

i) The bulls suddenly cross the road.
ii) Traffic light system.
iii) Motorcyclist suddenly came out of the junction.
iv) Random car driving on the road.
v) Parking task.
vi) Pedestrian suddenly cross the road.

Figure 7. Location for emergency braking situations

Driving Simulator Setup

The driving simulator was setup at the Design Lab, Faculty Technology of Mechanical and Automotive. This simulator is used and drives by the participant to collect the data for this research.

Figure 8. Driving Simulator setup

Based on the Figure 3.24, the driving simulator setup contain:

i) Webcam to record the driver's reaction.
ii) Screen monitor to display the driving simulation software.
iii) GoPro camera to record the foot movement of the driver.
iv) Pressure sensor to detect the pressure applied from the driver.
v) Steering wheel and driver's pedal to control the simulation car.

RESULT AND DISCUSSION

The point of this part is to present and examinations the consequences of the analyses that have been acted to accomplish the goals of this investigation. The data that will be discussed in this subchapter including driving experience, driving simulation study feedback and pedal pressure comparison.

Participants' Driving Experience

Only those who took part in the virtual driving simulation study received a copy of this questionnaire. Before they began driving the simulator, they completed the form by answering all the questionnaire. The total number of people that took part in the driving simulation study was 30. There were 23 males and 7 females, which resulting in a male-to-female ratio of 76.67% and 23.33%, respectively. Participants are divided into three age groups: 21 to 30 years old, 31 to 40 years old, and 41to 50 years old. The first group accounted for 70% of all participants, the second group was 13.33%, and those aged 40 and up accounted for 16.67%.

Driving experience is another factor that is taken into account. Figure 9 reveals that 25.81% of the 30 participants have 2 to 4 years of driving experience, 41.94% have 5 to 6 years, only 3.23% have 7-8 years of driving experience, and 29.03% have more than 9 years of driving experience.

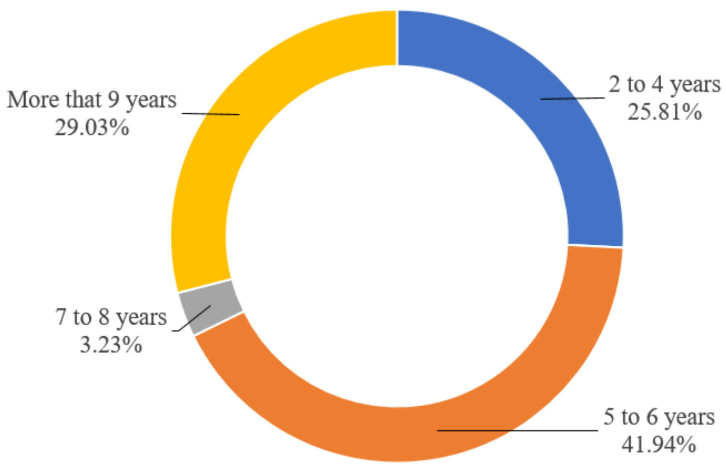

Figure 9. Percentage of driving experience (years) of the participants

According to Figure 10, 22.58% of the total participants drive for less than 2 hours per day, 58.06% drive for 2 to 3 hours, and 19.35% drive for more than 4 hours per day. It can be concluded that the majority of the participants drive for about 2 to 3 hours every day.

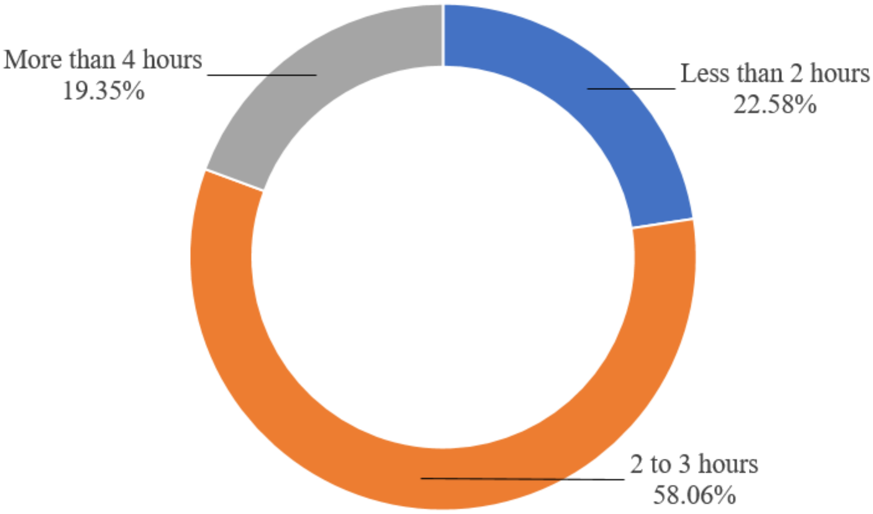

Figure 10. Driving period per day (hour) by the participants

Pedal Pressure Comparison

The majority of the participants in the driving simulation study only used one leg while driving. As a result, two distinct participants who use one leg while driving are chosen to be compared to each other to see if there are any differences between them in this subchapter. The comparison of pedal's pressure between two participants were taken starting at traffic light (point 2) until the bulls suddenly cross the road (point 1) as shown in Figure 7.

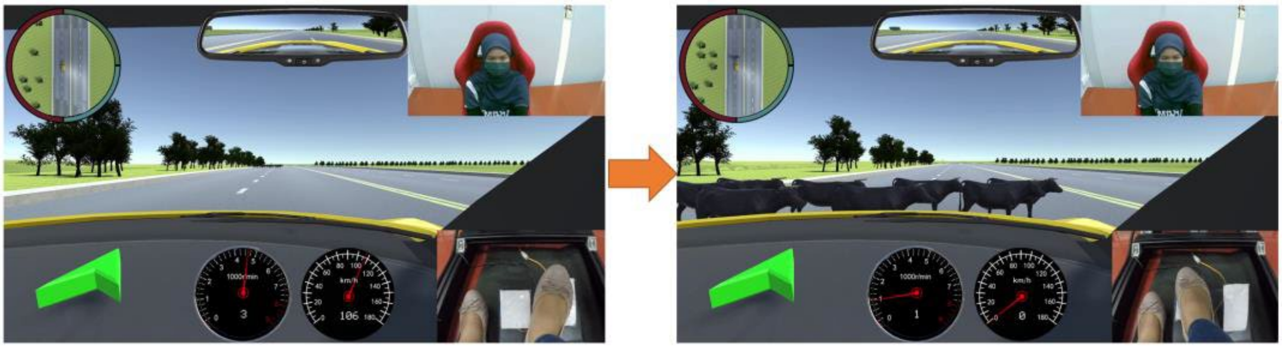

Figure 11. Participant 05 (excellent braking)

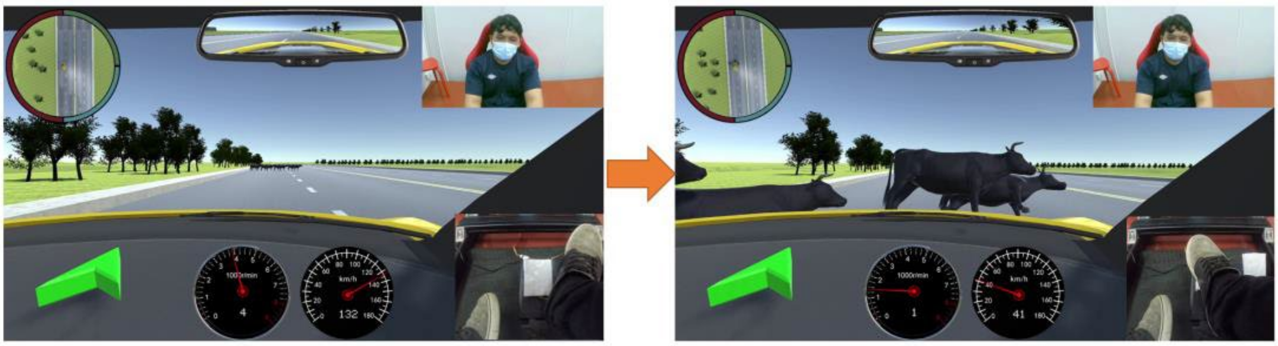

Figure 12. Participant 13 (hit the bulls)

Figure 11 shows the excellent braking that done by the Participant 05 after sawing the bulls suddenly cross the road. The top speed of the car before emergency braking was at 106 km/h, which means the total pressure that applied on accelerator pedal are around 600 to 800 bytes as shown in Figure 13. According to Figure 12, it shows that the Participant 13 was hitting the bulls because the top speed of the car before the bulls appeared was at 132 km/h. Figure 14 shows that the Participant 13 applied the pressure on the accelerator around 800 to 900 bytes. Therefore, it can be concluded that when the participant applied more pressure on the accelerator pedal, the higher chance of the road accident will occur.

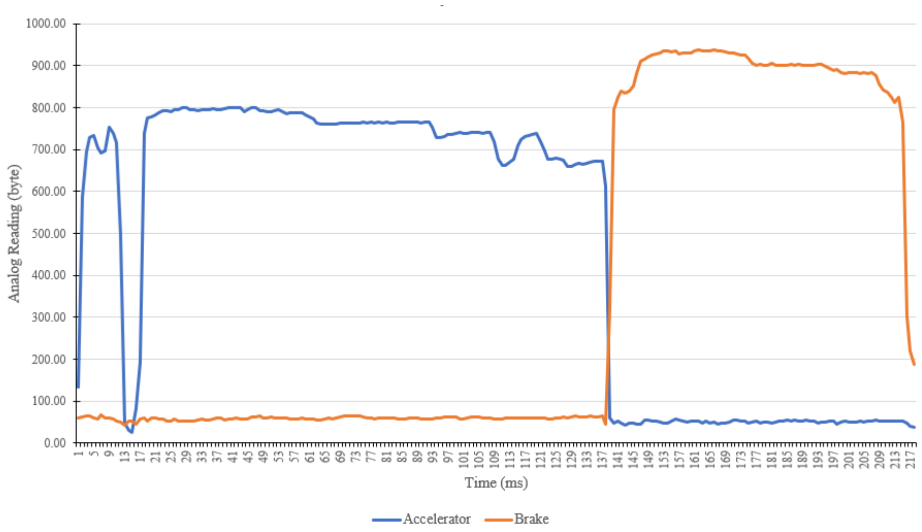

Figure 13. Participant 05 (Analog Reading)

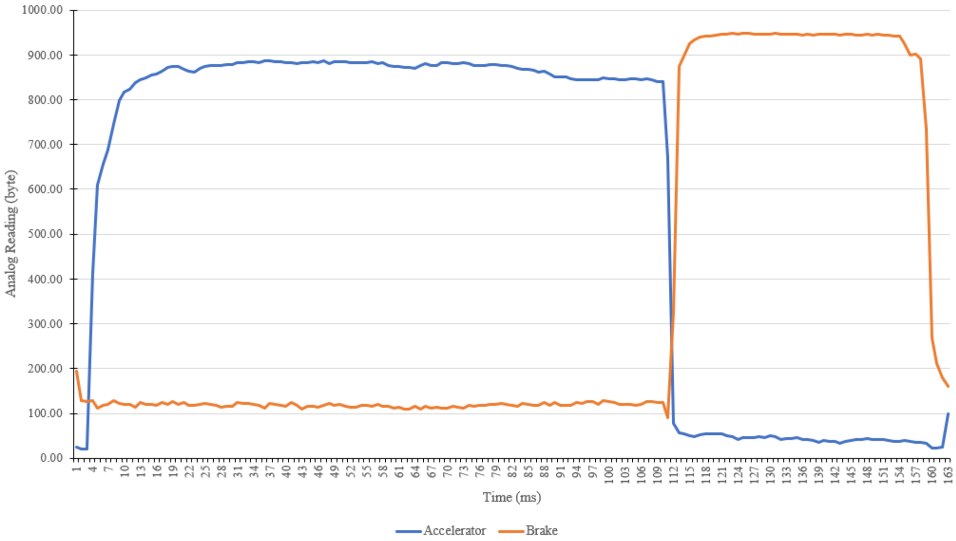

Figure 14. Participant 13 (Analog Reading)

Comparison Between One-Legged And Two-Legged Driving Behaviour

The pressure obtained from a one-legged subject will be compared to that obtained from a two-legged person while driving. It's to see whether there's any difference in the amount of pressure placed to the pedals between the two driving behaviours.

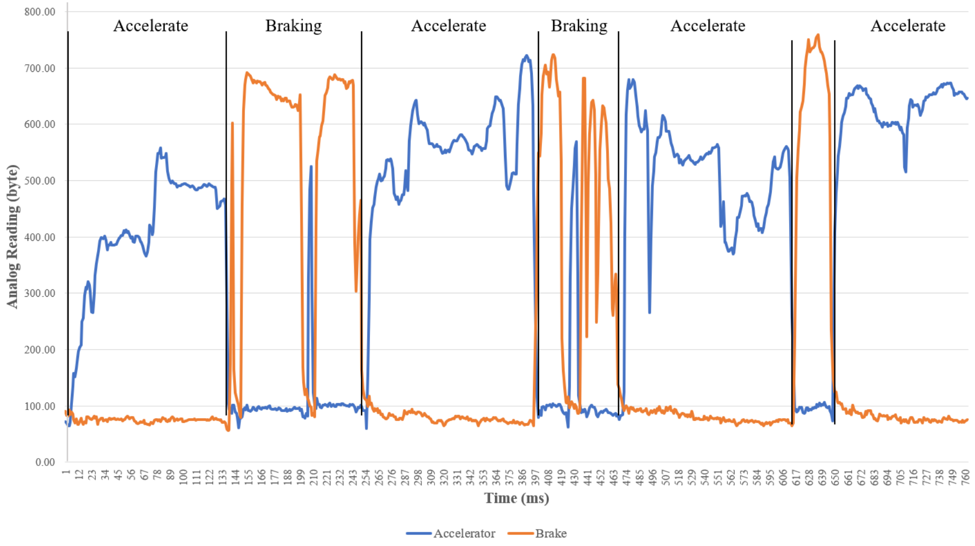

Figure 15. One-legged driving behaviour (P30)

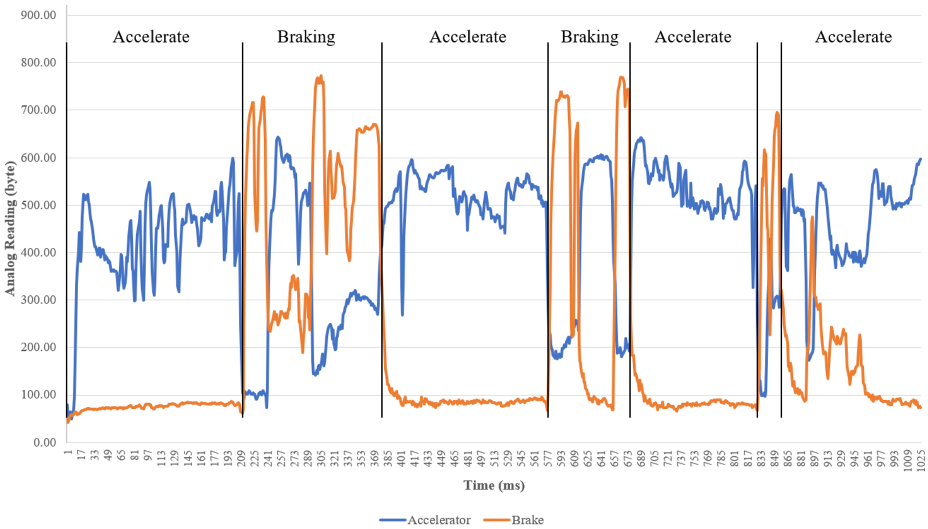

Figure 16. Two-legged driving behaviour (P28)

Figure 15 illustrates the graph of analogue reading versus time for participant 30 which was one-legged driving behaviour, while Figure 16 illustrates the analogue graph reading versus time for participant 28's two-legged driving behaviour. The readings for accelerate and brake in one-legged driving behaviour always contradict to each other, according to the graphs. Meanwhile, the readings for the accelerator and brake pedals for two-legged driving behaviour are practically identical, except while braking. When the acceleration pedal is pressed, the brake pedal is also pressed for two-legged driving. Participants who drive with both legs always put their feet on the brake and accelerator pedals, according to observations made during the study. According to the Figure 16, the pressure applied when the driver places their left foot on the brake pedal while their right foot presses the acceleration pedal is rather high. It differs from one-legged driving since one-legged drivers only press their right foot on the accelerator pedal and their left foot on the footrest or on the floor. As a result, because no pressure is applied to the brake pedal while accelerating, the analogue reading for the brake pedal is null.

CONCLUSION

As a conclusion, the main objectives of this project which to develop the software of virtual driving simulation in computer based that reflected the actual UMP Pekan environments had been achieved. Basically, this project has been carried out within four months at University Malaysia Pahang is successfully done. Summing up briefly, the virtual driving simulation software that contain some emergency braking situation for pedal error study was complete successfully. Besides, the driving simulator setup that contain webcam to record driver's reaction, screen monitor to display the driving simulation software, GoPro camera to record the driver's foot movement, steering wheel and pedal to control the simulation car and pressure sensor to detect the pressure applied at both pedals were assembled completely. Based on the questionnaire that completely answered by 30 participants, the main factors that contributing the pedal misapplication among Malaysian drivers are surprised. Lastly, the two types of driving behaviour had been obtained, including one-legged and two-legged driving behaviour. Drivers who drive with both feet are extremely risky since brake disc friction in braking systems is always produced by the pressure applied to the brake pedal. Drivers who drive on two legs always put their foot on the brake pedal, even when accelerating.

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