Experimental Design of Driving with Distractions at Urban Area using Simulator Driving

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Abstract: BACKGROUND: Traffic accidents can come from the drivers, vehicles and environment. Based on statistical data, the driver's factor influenced for almost 94% of road accidents. In Indonesia, the number of traffic accidents that have passed in the last three years has increased by 5.63%. OBJECTIVE: This experimental design simulation will use a simple driving simulator and game that portray the conditions of urban roads in Indonesia. The purpose of designing this experiment is to obtain various things that affect the driver while on the highway. METHOD: This experimental design was created by collecting various secondary data and a literature review that examines the various factors that can cause a driver to make a mistake while driving. RESULT: There are several factors that can influence a driver. The experimental design is made using urban road, time, crowds, a city car, the productive age of respondents, and distraction from the cell phone for the secondary task. CONCLUSION: The experimental design of this study is expected to describe the effects, responses, and recommendations that driver should do while driving. The desired long-term result, of course, is to reduce the number of accidents that occur on the road.

1 INTRODUCTION

Basically, driving is an activity to control the vehicle by maintaining the right position, speed and distance (Salvucci & Taatgen, 2011), so driving requires a high level of concentration. There are many factors that influence the driving process to run properly. These factors include internal factors of the driver himself, such as driving ability, physical condition, motivation, concentration and others, as well as external factors such as vehicle conditions, traffic conditions, distraction, and others. Based on this, a driving simulation design is carried out using a

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driving simulator by applying various problems that cause accidents.

There are 3 main factors that cause accidents, namely drivers, vehicles, and environmental conditions and nearly 94% of road accidents are caused by driver. The main problem that occurs with the driver is the occurrence of recognition errors which includes the driver's lack of attention, internal and external distraction, and lack of supervision. Recognition error is the main cause with a percentage of 41% ± 2.2 In addition, there are also problems caused by vehicles, for example, the brakes are 22% ± 15.4%, which is the second cause after the steering wheel, then if based on the environment you see an obstacle, it becomes the third cause, which is 11% ± 7.2%, after the road is slippery and glare (NHTSA, 2015).

Based on the article (WHO, 2020) Some risk factors for an accident when someone is driving are speeding, driving while under the influence of alcohol or drugs, not using safety equipment, such as seat belts, distraction while driving, unsafe road infrastructure, unsafe vehicles, lack of speed handling after accidents and lack of law enforcement on the road. When it comes to distraction while driving, there are many types of distraction that can cause problems while driving, especially those caused by using a cell phone while driving. The use of cell phones while driving is very dangerous because it can cause the driver's concentration to become distracted and not focus while driving. According to data from KORLANTAS, 2012, quoted from (Herawati, 2014), that the causes of traffic accidents by technology are calling on a cellphone by 36% and receiving calls by 22%, which dominates the occurrence of traffic accidents. Reduced concentration while driving can result traffic accidents.

Drivers who use cell phones while driving are 4 times more likely to be involved in accidents because they have slower reaction times, such as braking reaction time and reaction to traffic signals. In addition, drivers will find it more difficult to stay in the right lane and a safe distance from other vehicles (WHO, 2020). Based on the preliminary questionnaire distributed to 264 respondents, it is known that the things that cause concentration problems when a person is driving are vehicles that change lanes suddenly (72.3%) and the driver feels sleepy (73.1%).

Measurement of a person's concentration can be carried out in various ways, one of which is using the reaction time, especially the braking reaction time. In a case that often occurs in the real world, when someone is driving then someone suddenly crosses the road (Pawar, et al., 2020); (Wang, et al., 2019); (Choudhary & Velaga, 2017) and the driver will react and make decisions by hitting the brakes (Pawar, et al., 2020); (Sena, et al., 2016); (Warshawsky-Livne & Shinar, 2002). When the driver is in prime condition and fully concentrated, the reaction time to make a decision to take a certain action can be done very quickly. However, it will be different if the driver is tired, sleepy, bored, and in other cognitive conditions that are not excellent (Sena, et al., 2016). In this study will analyze the reaction time of a driver to the car braking process when distraction appears.

2 METHOD

This research begins with preliminary study to find out what kinds of things a driver does besides doing his primary task, which is driving. Based on the survey, many secondary tasks were apparently carried out by a driver, starting from using a cellphone, listening to music, chatting with traveling companions and many more. The intensity of these various activities varies from very often, frequently, rarely, and even never.

2.1 Search for Influential Factors

Multitasking is an activity where a person does several activities at once, for example, an office worker who picks up the phone while looking for a file from the computer and records messages sent by callers, or people who drive while listening to music and chatting with other passengers. Multitasking does not always give a bad meaning, even with multitasking, activities can be done more effectively and efficiently (Salvucci & Taatgen, 2011). However, there are some activities that, if done simultaneously or multitasking, can be dangerous. In a study conducted by GMAC, 2006, quoted from (Salvucci & Taatgen, 2011) reported that 40% of drivers talk on their cell phones while driving, 24% of young drivers in the 18-25 age range send messages, and another 20% choose a song on their iPod while driving.

Based on data obtained from the Central Statistics Agency, it was found that in the last 3 years, from 2017 to 2019 there has been an increase in the average number of accidents by 5.63% per year in Indonesia. Accidents that occur in urban areas which tend to be densely populated are certainly higher than in rural areas. The characteristics of the vehicles used and the vehicles around them certainly have an influence too. Driving time is also a factor that has been widely

studied in terms of its effect on the number of accidents that occur.

2.1.1 Human Factor

About more than 90% of accidents are caused by human negligence (Hole, 2007); (Shinar, 1978); (Ulleberg & Rundmo, 2003); (Yilmaz & Celik, 2004). As a driver, humans have factors that influence driving, which is psychological and physiological factors. Psychological factors can be in the form of attitudes, mental abilities, and driver skills. Meanwhile, physiological factors related to physical conditions include sight, hearing, touch, fatigue, drowsiness, and others.

In addition, individual characteristics also play an important role, such as age, gender, driving experience, average daily driving duration, hours of sleep, and activities performed before driving. The characteristics of the driver are further investigated, one of which is to simulate a near collision condition (Luo, et al., 2020). The influence of age is also one of the factors considered by several studies with varying results depending on other factors studied (Warshawsky-Livne & Shinar, 2002); (Sena, et al., 2016); (Wang, et al., 2019); (Yadav & Velaga, 2019). The influence of gender has also been investigated by many studies where one of them states that although women have a slower reaction time, women tend to maintain a safe distance from the vehicle in front of them (Li, et al., 2016). The driving experience of a new driver and an experienced driver is researched (Divekar, 2011) which states that experienced drivers have the ability to control the vehicle better than new drivers, but they still have the same risk of having to look the other way when experiencing distraction.

Based on research conducted by (AAA Foundation for Traffic Safety, 2018) it is estimated that 16.5% of traffic accidents are caused by drowsy drivers. In the study that was conducted, the researchers examined a video of the driver's face in the three minutes leading up to the accident. The result was that the researchers determined that 9.5% of all significant collisions were due to drowsiness. In addition, based on the research, it was found that 96% of drivers saw that driving in a sleepy state was a serious threat to their safety. According to Jake Nelson, director of traffic safety research and advocacy for the AAA Foundation, saying two to three hours of sleep deprivation can quadruple the risk of a driver having a traffic accident, which is the equivalent of drunk while driving.

2.1.2 Environmental Factor

Another factor that also affects the driver is environmental factors. Environmental factors that are widely used in research are related to time factors, road conditions, and road density factors.

The time factor is closely related to the circadian rhythm of the driver. Several studies conducted gave mixed results related to time which is bad for driving activities. On research (Lenne, et al., 1997) bad times to drive are 2 a.m. and 6 a.m., while the best times are 10 a.m. to 10 p.m. Different results are given by the research conducted by (Saputra, 2017) based on accident data collection (KNKT, 2007-2016) in Indonesia that the time for many accidents to occur is from 12 noon to 7 pm.

The road density factor is a factor that affects a person's speed when driving. When someone is on a very congested or busy road, they tend to slow down. Meanwhile, when on a road that tends to be quiet, the driver will tend to increase his speed.

2.1.3 Distraction Factor

The driving process can run smoothly if there are no distractions while driving that can disturb the driver's concentration. This distraction can occur during the driving process itself which is widely used in previous research such as the emergence of road crossers, motorbikes breaking the lane, and animals crossing suddenly. (Wang, et al., 2019); (Choudhary & Velaga, 2019); (Choudhary & Velaga, 2017) or static obstruction (Pawar, et al., 2020).

In addition to the factors originating from the driver, another thing that greatly influences the occurrence of road accidents is the secondary task, in this case, the use of cell phones. At this time cell phones are electronic devices that have many functions and complement today's lifestyle. Several studies related to driving and the use of cell phones have been carried out by considering various factors (Hancock, et al., 2003). Research using cell phones is very much done because of the various variations in the use of the cell phone itself, such as the use of cell phones hands free which does not reduce the risk of accidents that can occur (Li, et al., 2016). Reaction time when talking on cell phone (Calvi, et al., 2017); (Mohebbi, et al., 2009); (Drews, et al., 2008); (Laberge, et al., 2004), send short messages either simple or complex messages (Choudhary & Velaga, 2019), compare it with the use of a music player (Choudhary & Velaga, 2017); (Yannis, et al., 2013).

2.2 Driving Simulation Device

Driving activity in this experiment will be represented using a driving simulator, although of course the use of a driving simulator cannot fully describe driving conditions directly. Lots of driving research is done using simulations because of the cost efficiency and safety factors. On his research (McGehee, et al., 2000) trying to validate by comparing the driving conditions using a driving simulator and directly on the track, where the results obtained state that there is a statistical equivalence of the two experiments.

2.2.1 Software (Game Simulation)

The design of a simulation game for driving uses unity software. Unity is a 3D Game Engine created by Unity Technology which is widely used to create three-dimensional game animations. Some of the advantages of designing a driving simulation game using Unity are that it can be configured with various scenarios. In addition, it can also be done recording the parameter data needed for further processing.

The following is a display of a simulation game that has been designed using unity.

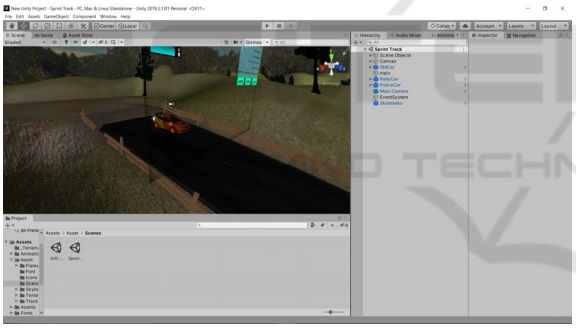

Figure 1: Display Unity.

Figure 1 is a display in unity. On the main page of Unity, there is a toolbar on the top side that functions to move, rotate, scale objects, and buttons to run, pause, and stop the project. On the lower side, there is an assets page that functions as a folder where materials for game creation such as audio files, shaders, materials, scripts, and so on are stored. Then on the assets page, there is a scene window that functions as a game creation place and a game page to see how the game will look when the project is run. Then there is also a hierarchy, which is a list of objects in the scene, then next to it there is an inspector page that functions as an editor for objects in the assets and hierarchy.

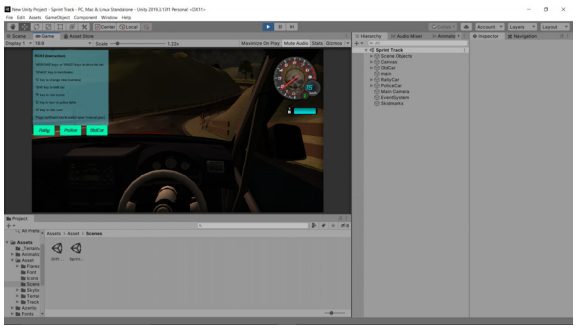

Figure 2: Project View.

Figure 2 is an example when the project is running, you can see that the scene page can move automatically to the game page so you can see what if the project is run.

2.2.2 Hardware (Simulator Driving Apparatus)

The hardware used has the following specifications Logitech G29 Driving Force (Steering Wheel & Pedals), Driving Force Shifter, and a projector or monitor.

Figure 3: Steering Wheel & Pedals (Source: www.logitechg.com).

Figure 4 is a display of the data collection condition settings carried out.

Figure 4: Game Simulation (Source: Personal Documentation).

3 RESULT AND DISCCUSION

Based on the previous survey and literature review, an experimental design was carried out as illustrated in the following diagram:

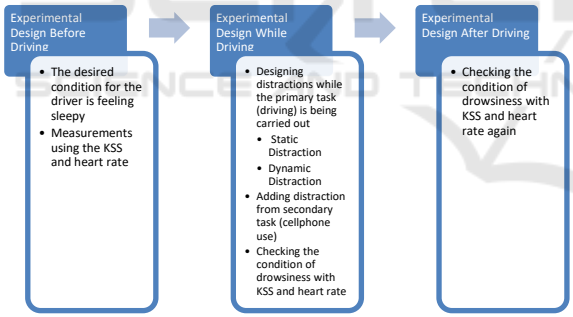

Figure 5: Experimental Design.

3.1 Experimental Design before and after Driving

After knowing the impact of traffic accidents due to fatigue and drowsiness caused by a lack of sleep duration and other activities that cause fatigue, which is monotonous work, the intensity and duration of work are out of tolerance. The impact of fatigue and drowsiness will be measured using subjective measurements using the Karolinska Sleepiness Scale (KSS) method. Meanwhile, the objective measurement is to measure the heart rate, which is to assess the physical condition of a person.

According to (Akerstedt & Gillberg, 1990) Karolinska Sleepiness Scale (KSS) the Karolinska Sleepiness Scale (KSS) is a questionnaire to measure the subjective level of sleepiness at a certain time which shows the psycho-physical experience experienced in the last 10 minutes. The KSS questionnaire was research by (Kaida, et al., 2006) whose reliability and validity had been tested, the results showed that KSS had high validity. The author has investigated the validity of KSS and found that it is highly correlated to EEG (Electroencephalogram) and behavioral variables. The results showed that KSS has high validity. However, because the KSS scores varied according to sleep earlier, time of day, and other parameters, it was difficult to infer the reliability of the test-retest. This rating is from a scale of 1 (extremely alert) to a scale of 10 (extremely sleepy, falls asleep all the time). Score in KSS increases with longer periods of awake and it is highly correlated with time of day (Shahid, et al., 2012).

In addition to the Karolinska Sleepiness Scale (KSS) questionnaire, another method is the objective measurement by measuring heart rate. Heart rate measurement is used to detect when the pulse is below normal, this indicates that the blood supply to the body system is reduced. So the nutrients and oxygen that flow in the blood are not optimal, causing the body to feel weak and drowsy. The measurement of heart rate will be converted into the total value of energy expenditure to measure the physical fatigue of the driver which will later be processed using the energy expenditure classification method developed by (Kroemer, et al., 2001).

3.2 Experimental Design While Driving

In this study will design a driving simulation with the distractions that exist in urban areas. The distraction that will be applied is the distraction that is directly related to the driving condition that is being carried out, which is in the form of distraction that has been predicted from a distance or is referred to as static distraction, for example the appearance of road obstacles such as a car parked on the shoulder of the road, road closing signs, and others. In addition, there will also be distractions that appear suddenly, for example a car or motorcycle suddenly overtaking, people or animals crossing the road suddenly and others.

3.2.1 Primary Task

The primary task in this study is the main task when a person is driving, namely controlling the movement

and speed of the vehicle being driven. As previously explained, driving is a very complex activity that requires high concentration. When a person just focuses on driving, there are many distractions that can be found, for example, the road conditions they are traveling on, the movement of other vehicles, and many more. In the experimental design that will be carried out, the distraction related to driving is designed to be static distraction and dynamic distraction.

a. Static Distraction
   The nature of this distraction should be easily detected by the driver because it can be seen from a distance, if the driver is fully concentrated while driving. Some examples of this distraction are road closure signs, cars parked on the shoulder of the road, and other objects in the driver's travel path.
b. Dynamic Distraction
   Unlike the case with stationary distraction that can be predicted beforehand, there is dynamic distraction, its appearance is sometimes unpredictable, for example, other vehicles that suddenly overtake, people or animals crossing the road suddenly and many more.

Basically, this distraction is a distraction that is commonly encountered by a driver while driving on highways, especially urban roads.

3.2.2 Secondary Task

Secondary tasks are activities that are not directly related to the driving activity itself, for example listening to music, changing radio channels in the car, chatting with other passengers, making calls, typing in addresses on GPS, etc. The secondary task in this experiment is the use of cell phones, where the use of cellphones in this study will be divided into simple tasks and complex tasks.

a. Simple Task
   The simple task in this study is a simple task where the driver only needs to press one button on the cell phone, for example picking up or closing an incoming call via a cell phone (motor activity).
b. Complex Task
   Meanwhile, a complex task is a task that is quite differ and complicated, for example, answering a short message with answers such as yes or no (motor activity and mental activity).

The stages that will be carried out during the driving simulation are described in the following flowchart:

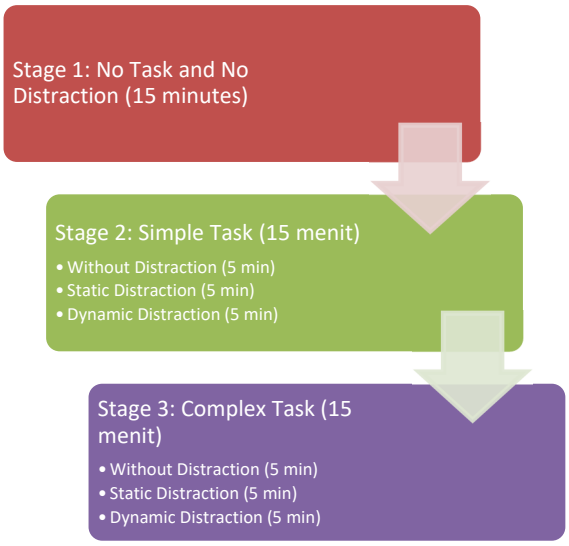

Figure 6: Experimental Design While Driving.

Based on (Gawron, 2019) there are several driving parameters that can be measured using a driving simulator, including average brake reaction time, brake pedal error, control light response time, and many more. The targets to be achieved when driving with various distractions that occur are related to the given braking reaction time which can be detected through the changes in speed that occur.

4 CONCLUSIONS

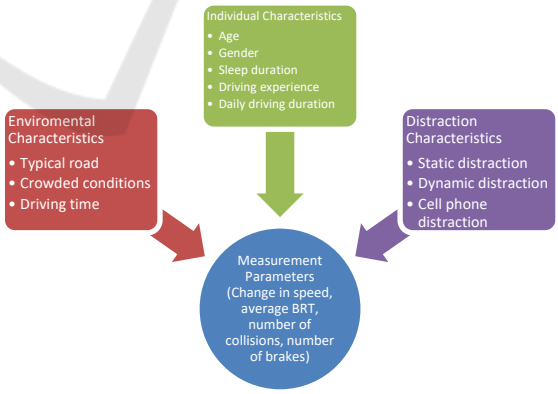

Figure 7: Summary of Factors and Paramaters

The factors that can be identified based on the literature review that have been carried out are included in the experimental design.

These factors are considered in the conditions that exist in the driver that is individual characteristics, conditions in the simulation game that is

environmental characteristics and distraction received is in the form of a static and dynamic obstacle for the main task, and comes from the cell phone for the secondary task. This experimental design is expected to provide an overview of the various experiences experienced by drivers while driving on urban roads. So, through this it can be obtained an overview regarding the influence, response, and recommendations that should be made by a driver on the highway so that they can avoid danger.

The long-term results expected, is to be able to design a control system that can provide warnings to drivers in order to avoid dangers, and can reduce the number of accidents that occur on the highway.

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