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AN OVERVIEW OF VEHICLES LANE CHANGING MODEL DEVELOPMENT IN APPROACHING AT U-TURN FACILITY ROAD SEGMENT

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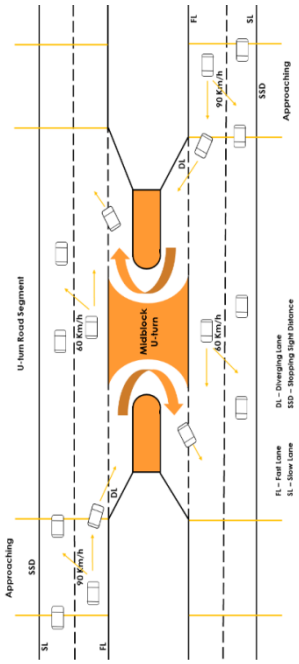

Abstract

Accidents are in rising mode and became the main problem in all over the world, especially in Malaysia. Many reasons have contributed to an accident including the condition of the road, driver's behavior and the environment of the road that may lead the drivers to make a lane changing. Lane changing is a process that experienced by all drivers such as in U-turn segment. In approaching U-turn segment, drivers need to make a decision whenever any disruption in front of them such as diverge vehicle because they have their own perspective and desire. However, the lane changing model in approaching U-turn road segment yet to develop. Therefore, this study will develop a model to determine the relationship between the reaction time (RT), speed (V) and distance from the behind vehicle to the front vehicle due to the changing lane at U-turn facility road segment. For that purpose, this study is focusing on the safe distance entry of a vehicle to the fast lane with the fast lane and slow lane vehicles before make a decision to change the lane in this U-turn facility. The data will be taken from the field and driving simulator. The equipment to be used to collect the field data is automatic traffic counting (ATC), controller area network-bus (CAN-bus), radar gun and video recording. The video recording will be used to simulate the driving simulator. Furthermore, driving simulator will be used to achieve the objective of the study. Regression analysis will be done for final model for estimating the safe distance entry of a vehicle to the fast lane with the fast lane and slow lane vehicles before making a decision to change the lane in this U-turn facility road segment to make sure that the model development is valid. Finally, the model can be used to estimate the safe distance for the road user to slow down their rate of speed while approaching the U-turn facility road segment and can be used to estimate the speed and safe distance in lane changing process.

Keywords: Changing lane, U-turn, speed, reaction Time

1.0 INTRODUCTION

Roads serve as the primary mean of access to employment, services and social activities. Moreover, by linking people and other modes of transport, roadways are a tremendous asset for achieving the greater travel passage within and beyond in Malaysia. Marizwan in [1] stated that, roads are built to provide better accessibility and enhance mobility in Malaysia. R. Rahman in [2] described that Malaysia consists of thirteen states and three (3) federal territories and has a total landmass of 329,847m^2 separated by the South China Sea into two (2) similarly sized regions, Peninsular Malaysia and Malaysian Borneo. The capital city is Kuala Lumpur. R. Rahman in [2] also stated that in year 2010, the population exceeded 27.5 million and now in 2015 it has grown into 30 million, with over 20 million living on the peninsular. Malaysia has a good road network which are paved or unpaved, private or public. Public roads are often referred to as highways and a road network is a combination of highways. A

highway irrespective of functional classification is made up of segments and intersections.

In Malaysia, peak hour traffic conflicts and congestions have continued to worsen at the highway intersections. One (1) commendable attempt by authorities to solve the problems of intersection conflicts and congestions problems is through the installation of direct midblock facilities that will allow motorists to make U-turning movements before reaching the intersection. U-turning movements involve the diverging, converging and merging movement for the vehicle to enter the preferred lane. Therefore, the scenario will produce a lot of movement for the road that may lead to traffic accident and fatal.

A lot of studies have been done about the lane changing behavior either for roundabout, traffic light, junction and road curve/design whether for heavy and light vehicle. Unfortunately, there are no researches have been done for lane changing behavior in U-turn. This study will develop a vehicles lane changing model in approaching at U-turn facility road segment. It requires the performance of vehicle movement by considering the traffic engineering parameters which related to Malaysian driver's behavior. The establishment of suitable U-turn and the appropriate condition is needed in order to achieve the entire objectives. The reasonable method to perform the data is by using driving simulator where this technique can allow data collection to be reliable and well-organized. Leitao *et al.* in [3] stated that driving simulator can give a real scenario for the driver that can make the model is valid. In addition, this study is concerns on U-turn road segment situation due to the study implementation. The automatic traffic counter (ATC), CAN-bus, video capture and simulation will be use to collect the data in order to develop the model. Therefore, this study will provide new knowledge, understandings and new findings in the field of traffic engineering. Cannot be argued that this study is very important especially in guiding the drivers that will eventually lead in reduction in number of accidents.

2.0 OBJECTIVES OF THE STUDY

The objectives of the study are:

i. to investigate the effects of midblock facility on speed, reaction time and distance of vehicles in approaching U-turn facility;
ii. to identify the safe distance of lane changing between fast lane vehicle with the slow lane vehicle in approaching U-turn facility and the safe distance of entry vehicle to enter the fast lane with the fast lane vehicle before make decision to change the lane at this U-turn facility road segment; and
iii. to implement the relationship between the reaction time (RT), speed (V) and distance from the behind vehicle to the front vehicle due to lane changing at U-turn facility road segment by developed the model.

3.0 BACKGROUND OF PROBLEM STATEMENT AND LITERATURE REVIEW

Marizwan stated in [4] that, roads have caused an accidents which are major problem in all over the world especially in Malaysia. The definition of accident according to Polis Diraja Malaysia (PDRM) in [5] is an occurrence on the public or private roads due to the negligence or omission by any party concerned (on the aspect of road users conduct, maintenance of vehicle and road condition) or due to environmental factor (excluding natural disaster) resulting in a collision (including "out of control" cases and collision or victims in a vehicle against object inside or outside the vehicles) which involves at least a moving vehicle whereby damage or injury is caused to any person, property, vehicle, structure or any animal and is recorded by the police. Marizwan *et al.* in[4], and Table in [6] shows that in Malaysia from year 2000 to 2009, there are 56,513 people killed on the road, 65,294 people were serious injured and 234,959 people were slightly injured in road crashes. While, PDRM in [5] stated that in Johor from year 2003 to 2012, there are 488,858 number of accidents occurred which is the second highest in Malaysia after Kuala Lumpur. The data recorded by PDRM in [5] also shows the accident increasing every year where in year 2012 the number of accident was 62,316 with 1,073 fatal and showed that accident rate which is in Batu Pahat, the number of accident recorded was 7,439 where it is the second highest in Johor with 176 fatal recorded which is the highest in Johor. Marizwan also in [4], [7] mentioned that Batu Pahat – Kluang road recorded 1000 accidents and 36 deaths since 2006 while *The Star* newspaper reported on 4 May 2009 that Jalan Batu Pahat – Kluang (FT050) has been identified as the "deadliest stretch of road "in Malaysia, as announced by the Works Ministry of Malaysia (KKR). The federal routes chosen is at Batu Pahat-Ayer Hitam-Kluang (FT50) roads which is connects Batu Pahat in the west and Kluang in the east. The Batu Pahat-Kluang road was completed in year 1919. The Km0 of the Federal Route 50 is located at Batu Pahat near Mount Soga. The road was partially upgraded on 2002 with four (4) lane carriageway (from Batu Pahat to Kluang), else remain two (2) lane alignment. It is a dual carriageway highway with some road having a median of Km0 until Km20 and without median of Km20 until Km32 from Batu Pahat to Ayer Hitam. Before the upgrading, it was a four lane undivided highway. The road is classified as a paved federal roadway built under JKR R5 road standard. According to Ambak. K in his research[8] that conducted at the site location stated that, impact of upgrading the route from a two (2) lane road to a four (4) lane road increased the number of accidents especially during its construction stage from year 2002 to 2004. While Idrus*et.al* in [9] also proved that the road infrastructure level in the study area was

less satisfying. The road has six (6) midblock U-turn facility in total from Batu Pahat to Parit Raja. That is proved the dangerousness of this road that can cause a lot of fatalities.

Most of accidents happened because of the behaviors of the drivers such as anger, selfish and so on. The behavior of the drivers that cannot change is rude manners. It is including impatient, compete and always in hurry especially when the drivers want to change their lane, at the traffic light, make a U-turn or enter the roundabout. When the drivers are overtaken by this emotions and manners, they would speed and the possibility possibility for an accident to occur with the surrounding vehicles also high. Furthermore, Crundall *et al.* in[10] and Darren *et al.* in [11]stated that attitudes can indirectly influence whether drivers make all appropriate visual checks and many factors can influence a behavior such as environment, mechanical or design of the road. Besides that, Yeoh *et al.* in [12] stated that attitude changes is believed to increase the driving behavior to achieve the traffic safety. Therefore, the behavior can be neutralized by giving a knowledge about the safe driving information. Through this study, the model can guide the drivers to know the safe distance, speed and reaction time that needed to change the lane especially in approaching the U-turn facility road segment. Midblock U-turning facilities are median openings on multi-lane highways. U-turning facilities aimed at easing traffic conflicts and pressures at highway intersections. Joewono *et al.* in [13] stated that traffic conflicts are created when two or more vehicular movements on the roads cross each other and that conflicts may cause traffic congestion and delay with the possibility of road accidents. Thus, each intersection requires traffic control.

Midblock U-turning facilities are median openings on multi-lane highways as illustrated in Figure 1. U-turning facilities aimed at easing traffic conflicts and pressures at highway intersections. While some are built as complimentary facilities to existing road geometric designs, others are built as a complete replacement to existing facilities on the premises that they will reduce conflicts and ease traffic congestions at adjoining intersections. In Malaysia, where the right hand driving rule is in place, drivers decelerate when diverging, accelerate when converging at the midblock facilities. Therefore, it is not surprising that the issue of midblock U-turning facilities has provoked fierce national debates. Proponents of midblock facilities argued that their installation has brought some help to motorists plagued with conflicts and congestions at adjoining intersections. According to Forward. S in [14] claimed that to reduce the number of accident, the skill and knowledge of the drivers need to be increased. So, this research will identify the safe distance of entry vehicle to enter the main lane and the safe distance of fast lane vehicle with the slow lane vehicle before make decision to change the lane at this U-turn facility road segment. Other than that, this study will also focus on developing a lane changing model in order to determine the relationship between the reaction time (RT), speed (V) and distance from behind vehicle to the front vehicle due to changing lane at U-turn facility road segment. Finally, the model can be used to estimate the safe distance for road user to slow down their rate of speed while approaching the U-turn facility road segment and can be used to estimate the speed, safe distance in lane changing process. The result can be put into driver's guideline in daily driving process and can be used in real case scenario.

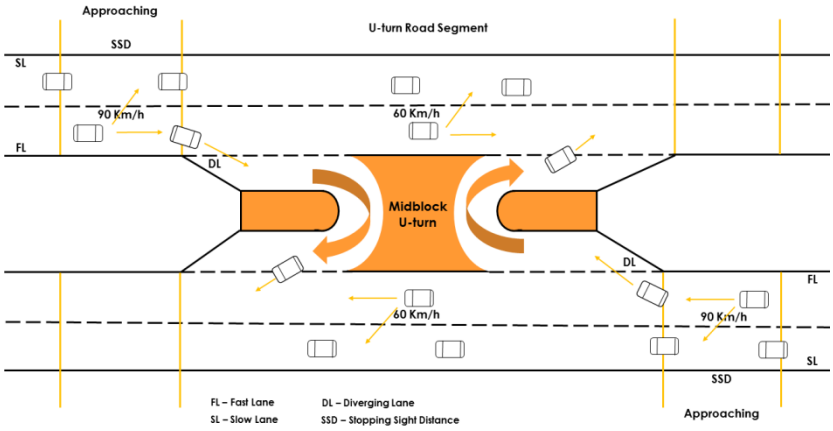

Figure 1 Typical Direct Midblock U-turn Facility in Malaysia [15]

4.0 PREVIOUS STUDY OF LANE CHANGING

Many studies have been done by the researchers about the lane changing such as in weaving, merging and car following in terms of speed, characteristics, gap acceptances and driver behavior. Taylor *et al*. in [16] stated that speed of drivers was strongly related to the characteristics of the road they were driving.

Zhao. D *et al*. in [17] defined lane changing as a driving manoeuvre that moves a vehicle from one lane to another lane where both lanes have the same direction of travel. Moridpour *et al*. in [18] asserted that lane changing models are one of the essential components of microscopic traffic simulation that need the accuracy in developing alane changing model. When a lane change, is considered, it is assumed that a driver makes consideration between expected own advantage and the disadvantage. Kesting *et al*. in [19] divided the lane changing model into multistep process which is on a strategic level, the drivers know the route and a network that can influence the lane choice. In the tactical stage, the intended lane change is prepared and initiated by advanced acceleration. Finally, in operational stage, immediate lane change is both safe and desirable. Their research in developing car-following model uses a concept to simulate two lane freeway traffic with an on-ramp as merging zone.

Other than that, (Ben-Edigbe & R. Rahman; R. Rahman & A. Hassan; Kusuma *et al.*) defined weaving in [20]–[22] asone of the lane changing process involved. Weaving occurs when vehicles crisscross the carriageway lanes often with a view to repositioning for traffic stream advantage which are crossing two (2) or more traffic stream travelling in the same direction along a significant length of the roadway without traffic control device. It is inherent because of driver's desire to position their vehicle along the appropriate carriageway lane. Kusuma *et al.*[23]said that the driving behavior at weaving section using traffic surveillance system data, they used two (2) empirical data collection and data extraction processes based on traffic surveillance camera whey the studies find out that 25.25% weaving movements took place in the first 50-100 meters from the point of merge and around 30% of the total traffic involved in one (1) lane changing movement. Wei & Wanjing in [24] showed the weaving section capacity as the total number of vehicles passing through the section and crossing among the traffic along the weaving section length. They stated the maximum flow for through traffic is 2200 PCU/hr/ln and for cross traffic is between 1100 and 1200 per hour per 76 m of weaving section.

While in merging process, Wang in [25] stated that traditional studies of merging behavior are based on gap acceptance models developed mainly for urban intersections, which tend to oversimplify the very complex dynamic interactive merging behavior. Ben-Edigbe in [20] concluded that there is correlation between traffic safety and midblock U-turning facilities and got the estimated delay of about 8.55 s per vehicle at the exit lane of U-turn.

Some of the studies also studied about the driver's behaviour in lane changing. Driver's behaviour are the main factors to be considered in all road design in order to make the road free from an accident. Kusuma *et al.* in [22] defined that driving behaviour is an intention behind the manoeuvres from the current position towards a target position, significantly affects the traffic performances. The manners of driver's action during driving in real traffic situations with certain vehicle in road and environmental conditions. The driver's behaviour may include many aspects, such as the perception of traffic conditions, decision making, vehicle operation, using cell phones and navigation systems, talking to other people in the vehicle, eating, drinking, applying cosmetics and looking around. The vehicle operation includes longitudinal and lateral driving, which reflects the perception of the road, decision-making, and driver's intention and action, such as car following, lane changing, lane keeping, acceleration and deceleration.

Some researcher also studied about the mandatory lane changing (MLC) and discretionary lane changing (DLC). Moridpour *et al.* in [26] stated that MLC happens when the drivers have to leave the current lane such as when merging onto freeway from an on-ramp or off-ramp. While, DLC manouvres are executed when the drivers are not satisfied with the driving condition in the current lane and wish to gain a speed advantages. That means the drivers want to maintain or increase the speed because of the disruption from any vehicle such as diverge car in U-turn facility. When the driving conditions are not satisfactory, automatically the drivers will compare the driving conditions to the other lane. Previous study about the MLC carried out by Zhao. D *et al.* [17]found that 640 mandatory lane changing occurred from a naturalistic driving database. The result show that MLC's are approximately 4.5 times to have a critical gap to occur. While for DLC, carried out by Zhao. D *et al.* [17] found out 2035 numbers of DLC's occur and find out over 10% reduction of elapsed time in lane line crossing stage. It shows that the lane changing is very important process in traffic that make various type of movement that need to be investigated.

Other than that, in car following lane changing model in freeways also have been studied. Wu & Yang in [27] studied the car following behavior using the model that developed by MATLAB simulation. While, Ahmed & Sarah in [28] studied the car following interaction in two lane rural highways that's studies about time headways and speed. Zhongyin *et al.* in [29] studied about lane changing using driving simulation on multilane freeway. The research finds out the characteristics such as speed, acceleration rate, glancing and glancing of drivers. The behaviors of lane changing also have been studied. Lane changing behaviors has a direct influence on traffic safety. E Tian in [30] claimed that in lane changing process, the different types of drivers have a different manner and

in different environment will show different behavior. While Aghabayk *et al.* in [31] claimed that different longitudinal driving manner to a large extent determines the distributions of speeds and densities throughout the lanes can lead to lane changing. With the traffic scale growing, lane changing has become driving routine that most drivers face. Deeper understanding of long term driving assistance is required to provide drivers with versatile and various advanced assistant services especially in midblock U-turn facilities road segment. Some studies on lane changing behavior have been conducted such as Wei & Wanjing in [24] that studies simulation based study on a lane assignment approach for freeway weaving section. Their study on freeway simulator with real world weaving data with new concept which is lane assignment approach (LAA) to reduce the disruption between the cars of different destinations and prevent unsafe weaving manouevres. Moreover, Keyban-Ekbatani*et al.* in [32] categorized the lane changing decision process on freeways using microscopic traffic simulation. They asked drivers to drive on a freeway with a camera equipped vehicle and asked the driver to comment on lane and speed preferred. Zheng *et al.* in [33] studied the effects of lane changing on the immediate follower by measuring the induced transient behavior and the change of driver behavior because of immediate follower. Lv *et al.* in [34] studied lane changing behavior on three lane highways using simulation. The optimal velocity model obtained continuous position and velocity in space and time.

The method that always and familiar to be used in all the research of lane changing is video recording. (Kusuma *et al.*, Liu & Wang; Jooho *et al.*; Benedetto *et al.;* Itoh *et al.*) in [22], [35]–[37] used video recording in developing model and analysis of driving behavior and validation of car following model which are can extract the vehicle trajectory and the movement characteristic of each vehicle. Corresponding to Itoh *et al.* in [38] analyzed the video image stored by the driving recorder. Through observing the video image, they extracted behavior of other vehicles on the passing lane. Other than that, the cameras system makes the possibility to localize exactly the point when driver change lane where it can help in setting up the simulation and scenario for driving simulator.

However, from all the research, the studies on lane changing in approaching U-turn facility road segment is yet to be developed. Therefore, this study will become an important result to be achieved.

4.1 Decision Making in Lane Changing

Lane changing is a process of determining the best lane to drive without any interruption on the road. Lane changing also occurred when a driver wants to enter the preferred lane of destination. The process of lane changing will have caused a weaving, merging and diverging process that will vary the road environment. Weaving, merging and diverging are traffic stream deft maneuver that are often laden with profound risk of accident occurring. Weaving occurs when vehicles crisscross the carriageway lanes often with a view to repositioning for traffic stream advantage. It is inherent because of driver's desire to position their vehicle along the appropriate carriageway lane. Traditional studies of merging behavior are based on the gap acceptance models developed mainly for urban intersections, which tend to oversimplify the very complex dynamic interactive merging behavior involved as done by.

There are so many researches has been done about the lane changing behavior whether using driving simulator, video recording, loop detector, paramics model and surveillance data. Jooho *et al.* in [36] defined the reaction time as the time from the moment when a preceding car begins to decelerate their vehicle or when a driver begins to take either braking or steering action to avoid any collision. In emergency situations, drivers operate with a reflex behavior in an open loop mode. At this time the drivers are not yet expecting to feel the effect of their action. The lack of deceleration feedback is therefore not disturbing. MdDiah *et al*. in [39], [40] studied the lane changing behaviour in roundabout using Paramics model where the findings showed that driving habit through gap, speed, aggressiveness and awareness influence the roundabout performances.

MdDiah *et al*. [41] used driving simulator in determining the lane changing behavior in approaching the heavy vehicles at signalized junctions where the research found out that 15.4% reaction time and speed contributes to the safe lane changing distance at the signalized junction. Islam *et al.* in [42] proposed a mandatory lane changing model and extended the work by developing a new model for heavily congested traffic flow. This is because, in heavy congestions there are very little gaps of acceptable lengths. While, Wang in [25]used both the traffic surveillance and MIDAS data to investigate the driving behavior in the merging motorway section and the video observation showed that most of the lane-changing occurs at the first available gap. In the other words, the lane-changing occurs at the upstream traffic where the main traffic and entry-slip road traffic meet at the end of the taper marking. In road curves, Bella [43] studied the effects of combined curves on driver's speed behavior where he used fixed base driving simulator and found out that the combined curves are affecting the driving speed of the driver. Moreover, the study on the lane changing behavior in approaching heavy vehicles at signalized junction have been done by MdDiah *et al.* in [41] as they used driving simulation and regression analysis to find that showed 15.4% vehicles contributed to the safe lane changing at the signalized junction.

Gipps in [44], stated that decision making from the driver involving the lane changing behavior are shown in Figure 2. For the vehicle that want to change lane, they need to consider all the elements in order to make a safe lane changing. Therefore, this chapter will explain in detail about the driver's behavior in lane

changing, driver's reaction and the changing lane in approaching midblock U-turn facilities road segment. Therefore, it is proved that a lot of studies have been done on the lane changing behavior. This study will show the new findings in lane changing behavior by referring previous studies as a guideline.

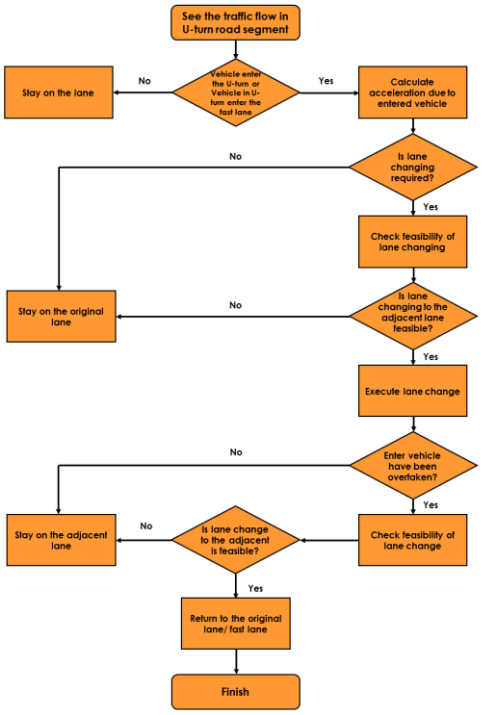

Figure 2 Flow chart of the Lane Changing in Midblock U-turn

4.2 Driver Reaction

Driver's reaction in many cases is the speed with which a person can respond and is the key to assign liability. In fact, reaction time is a complicated behavior and is affected by a large number of variables. There can be no single number that applies universally. Jooho *et al*. in [36] defined the reaction time as the time from when a preceding car begins to decelerate their vehicle to when a driver begins to take either braking or steering action to avoid any collision. While, analysis of reaction time during car following process have been done by Xue *et al*. in [45], they used driving simulation with different speed and found out that increase in traffic flow density, the headway distance between main vehicle and the leading vehicle also decreased. In emergency situations, drivers operate with a reflex behaviour in an open loop mode. At this time the drivers are not yet expecting to feel the effect of their action. The lack of deceleration feedback is therefore not disturbing.

5.0 RESEARCH METHODOLOGY

Methodology framework needed in order to guide the research in achieving the objectives. Figure 3 shows the methodology framework involved starting with site selection to carry out the test for data collection. The data collection will be using three (3) methods which is ATC, CAN-bus and video recording. This study will take a video capture or picture at the selected road condition in order to capture lane changing characteristics in approaching U-turn facilities road. Other than that, it is also to identify the acceleration and lane changing location and to design and visualize the monitor of driving simulator. To develop the model, driving simulator will be used. Figure 4 shows the process that will be involved in this research where it is begins with identifying a group of people to use the driving simulator as a sample. This group of people must in 19 years old and above and the most important thing is that they should have a valid Malaysian driving license. Driving license is important in order to make sure that they are already have the driving rule and road knowledge as well as some experiences in driving. Noted that, this study is focusing on the midblock U-turn facilities chosen. The data collection of traffic engineering and the driver behavior with attention to speed, distance and reaction time can be extracted as a data screening. From the result we can make clear relationship about the relationship between the engineering parameters towards the driving behavior in approaching the U-turn facility road segment. The result will also will give some opinion and recommendation.

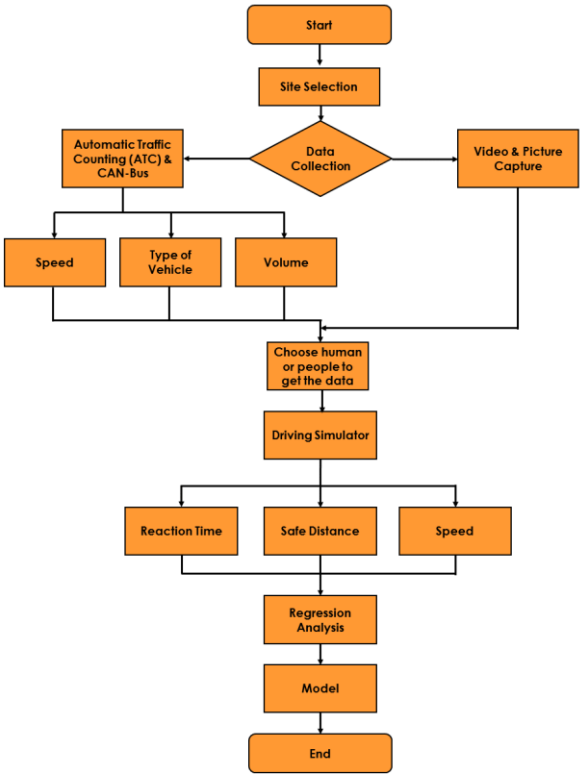

Figure 3 Methodology of the study

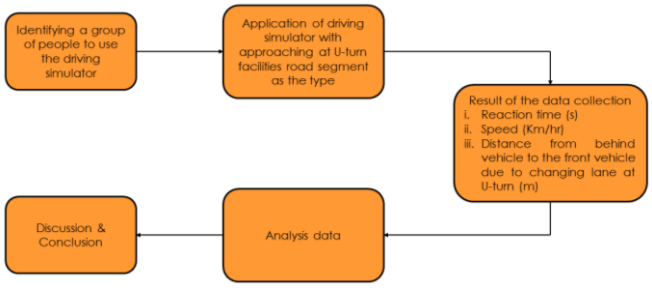

Figure 4 Driving Simulation Process

6.0 CONCLUSION

This study is to identify the relationship between speed differences (V) and reaction time (RT) by developing a model using automotive simulator for driver's behavior and competency evaluation (ASIS). To the best of my knowledge, there is still no study have been done on lane changing in approaching U-turn facility road segment. Therefore, the vehicles lane changing model in approaching at U-turn facility road segment will be developed in this study. The findings from this study can suggest to the road provider such as Works Department (JKR) put into practice guideline and standards of U-turn facilities roadway segment.

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