DEVELOPMENT OF VEHICLE LANE CHANGING MODEL WITHIN U-TURN FACILITIES

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ABSTRACT

U-turning movements at roadway segments are channelized and aided with splitting islands in the middle so that drivers can be on their desired trajectories and the road segment are often accompanied with weaving, merging and diverging movement. The objectives are to determine the speed differences (V_d), reaction time (RT) and safe distance where from those parameters and their relationships, the statistical model was developed and used in estimating the safe distances to execute the lane changing within the U-turn facilities. The data were taken from the field which is video recording, picture and geometric design and was used to simulate the driving simulator like an actual environment while the driving simulator come out with the speed differences, reaction time and distance as a raw data. Result show that the mean value of reaction time (RT) of the driver in making the lane changing at the U-turn area is 2.5s where the distance to execute the lane changing is 16.467m from the merging vehicle. Through the relationship between the RT, V_d and distance of the subject vehicle within U-turn facilities, the findings from the statistical model has been developed with the equation [Safe distance = (13.448 + 1.410 RT – 0.075 V_d)]. The model was used to estimate the safe distance which is 15.00m within U-turn facilities. The result shown that the safe distance will increase when the driver slowing down their speed and increasing the reaction time. The research concluded that the speed difference and reaction time have a significant relationship in estimating the safe distance in executing the lane changing within U-turn facilities.

ABSTRAK

Pergerakan pusingan U pada segmen jalan biasanya dibantu oleh pemisah pada bahagian tengah jalan yang membolehkan pemandu berada pada kawasan yang betul dan kebiasaanya disertai oleh pergerakan seperti *weaving*, *merging* dan *diverging*. Objektif kajian ini adalah untuk mendapatkan perbezaan halaju, masa tindak balas dan jarak selamat dalam melakukan pertukaran lorong dimana melalui parameter-parameter tersebut dan hubungkait, model pertukaran lorong dibangunkan dan digunakan untuk membuat anggaran jarak selamat untuk melakukan pertukaran lorong dalam kawasan pusingan U. Data diambil pada kawasan kajian seperti rakaman video, gambar dan rekabentuk jalan dimana ianya digunakan untuk mensimulasikan *driving simulator* menyamai persekitaran jalan sebenar dan *driving simulator* akan mengeluarkan data-data yang diperlukan seperti halaju, masa tindakbalas dan jarak melakukan pertukaran lorong. Hasil kajian ini menunjukkan purata bacaan untuk masa tindakbalas pemandu dalam melakukan pertukaran lorong iaitu 2.5s dimana jarak daripada *merging vehicle* ialah 16.467m. Melalui hubungkait diantara masa tindakbalas (RT), perbezaan halaju (V_d) dan jarak kenderaan subjek kepada *merging vehicle*, model statistik telah dibina iaitu [Jarak selamat = (13.448 + 1.410 RT – 0.075 V_d)]. Model tersebut telah menganggarkan jarak selamat untuk melakukan pertukaran lorong iaitu 15.00m daripada *merging vehicle*. Kajian ini juga menunjukkan jarak selamat akan meningkat apabila pemandu menurunkan halaju dan meningkatkan masa tindakbalas mereka. Kajian ini membuat kesimpulan bahawa perbezaan halaju, masa tindakbalas mempunyai hubungkait yang ketara dan penting dalam membuat anggaran jarak selamat untuk melakukan pertukaran lorong dalam kawasan pusingan U.

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LIST OF SYMBOLS AND ABBREVIATIONS

FT	-	Federal Route
KM	-	Kilometer
m	-	Meter
m^2	-	Meter square
RMP	-	Royal Malaysia Police
JKR	-	Malaysia Public Work Department
V	-	Speed
RT	-	Reaction Time
SSD	-	Stopping sight distance
D	-	Distance
Safe distance	-	Distance in approaching the U-turn
DLC	-	Discretionary lane changing
MLC	-	Mandatory lane changing
s	-	Second
β	-	Beta
%	-	Percent
t_c	-	Critical gap
ADT	-	Annual daily traffic
R5	-	Road standard 5

g	-	Gravity
SD	-	Standard deviation
LAA	-	Lane assignment approach
ANOVA	-	Analysis of variance
km/h	-	Kilometer per hour
ASIS	-	Automotive simulator for driving behaviour and competency evaluation
VIF	-	Variance inflation factor
UTHM	-	Universiti Tun Hussein Onn Malaysia
UiTM	-	Universiti Teknologi Mara

LIST OF PUBLICATIONS

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CHAPTER 1

INTRODUCTION

1.1 Overview

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 greater travel passage within and beyond Malaysia. Generally, roads are built to provide better accessibility and enhance mobility in Malaysia. The capital city is Kuala Lumpur. Statistic department (2010) described that Malaysia consists of thirteen states and three federal territories and has a total landmass of 329,847m^2 separated by the South China Sea into two similarly sized regions, Peninsular Malaysia and Malaysian Borneo. The researcher also stated that in year 2010, the population was exceeded from 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/interchanges.

In Malaysia, peak hour traffic conflicts and congestions have continued to worsen at the highway intersections. One 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 (Ben-Edigbe *et al*., 2013). U-turning movements involve the diverging, weaving 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 behaviour whether for roundabout, traffic light, junction and road curve/ design for heavy and light vehicle. The latest research done by Sharma *et al*. (2017) studied the critical gap for the merging vehicle to enter the freeways for U-turning operation for median opening and the studies was focuses on the U-turn without the midblock facility for the vehicle to accelerate to merge into the freeways. Other than that, Mohanty *et al*. (2017) studied the effect the movement of approaching vehicles at the freeways leading them to either slow down or change their lanes just to avoid the conflict with U-turn and the present study applies Markov's process to estimate lane changing patterns of approaching through vehicles due to the presence of U-turns. However, in this research focusing on lane changing model. This research was developed a vehicle lane changing model within U-turn facility road segment. It requires the performance of vehicle movement by considering the parameters which related to Malaysian driver's reaction such as reaction time, speed and distance in executing the lane changing. The establishment of suitable U-turn and 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. Leitão *et al*. (1999) stated that driving simulator can give a real scenario for the driver that can make the model valid to use. In addition, this research concerns on the U-turn road segment situation due to the study implementation. Therefore, this research provided knowledge, understandings and new findings in the field of traffic engineering.

1.2 Problem statement

Abdul Manan and Várhelyi (2012) stated that roads accident has caused a major problem in all over the world especially in Malaysia. Some accidents occurred because of the aggressiveness and inappropriate driving behaviours of driver. (Abdul Manan and Várhelyi, 2012; Abdul Manan, 2015a) shows that in Malaysia, there are 56,513 people killed, 234,959 people were slightly injured and 55,295 people were seriously injured on the road crashes that recorded from year 2000 to 2009.

Referring to Figure 1.1, Royal Malaysia Police, RMP (2014) shows that Johor was the second highest for the accident statistic with 64,473 accident cases which is 73,336 number of accident differences behind Selangor with 137,809 cases. Comparing the number of fatal for that single year, Johor was also the second highest for the number of fatal with 1,018 with only 50 number of fatal differences compared to Selangor with 1,068. It shows that Johor has a highest percent of fatal by comparing the number of accident and the number of fatal statistics.

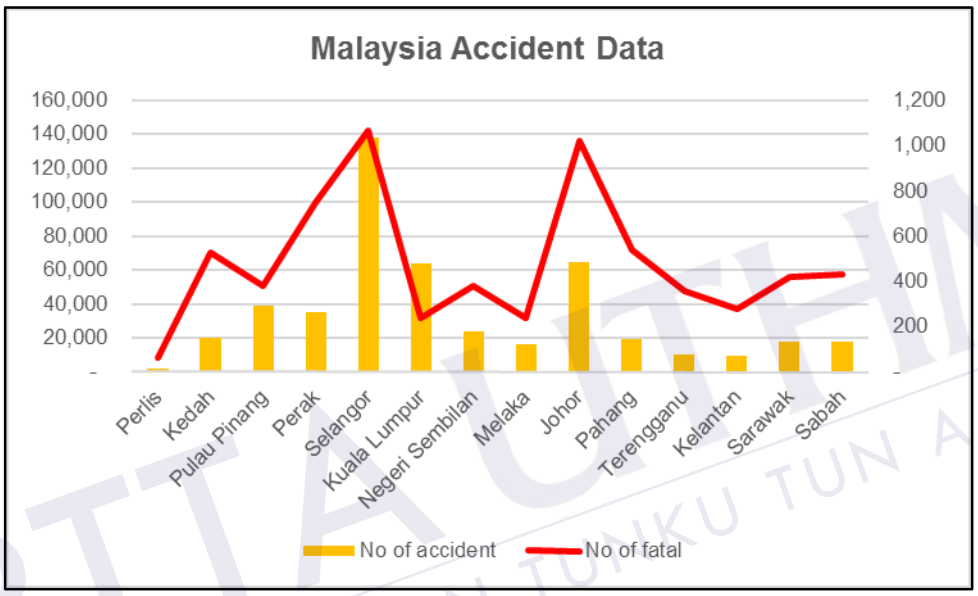

Figure 1.1: Malaysia Accident Data (Royal Malaysia Police, 2014)

Figure 1.2 shows the accident data for Johor district in year 2014. The figure shows that Batu Pahat was the second highest in number of accident occurred with 7,445 cases behind the combination of Johor Bahru Utara and Johor Bahru Selatan area with 22,563 cases. However, for the number of fatal cases, Batu pahat district was the highest with 165 cases. RMP (2014) showed the number of accident in U-turning facilities segment in 2014 the number of accident in the U-turn road segment is 469 accident cases with 104 fatal. This cases shows high number of accident occurred in U-turn that need to re-visualize and rearrange to give a better focus in this types of facilities. In single year of 2014 that recorded by Batu Pahat police station have stated 1286 accident cases in this FT050 road which is the site location. Table 1.1 shows the number of U-turn for all types of U-turn where there are 6 midblock U-turn from 8 U-turn facilities along the KM0 to KM21. Therefore, there are highest possibilities for the number of accident to keep increasing every year if the area is not treated properly.

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). That is proved the dangerousness of this road that can cause a lot of fatal.

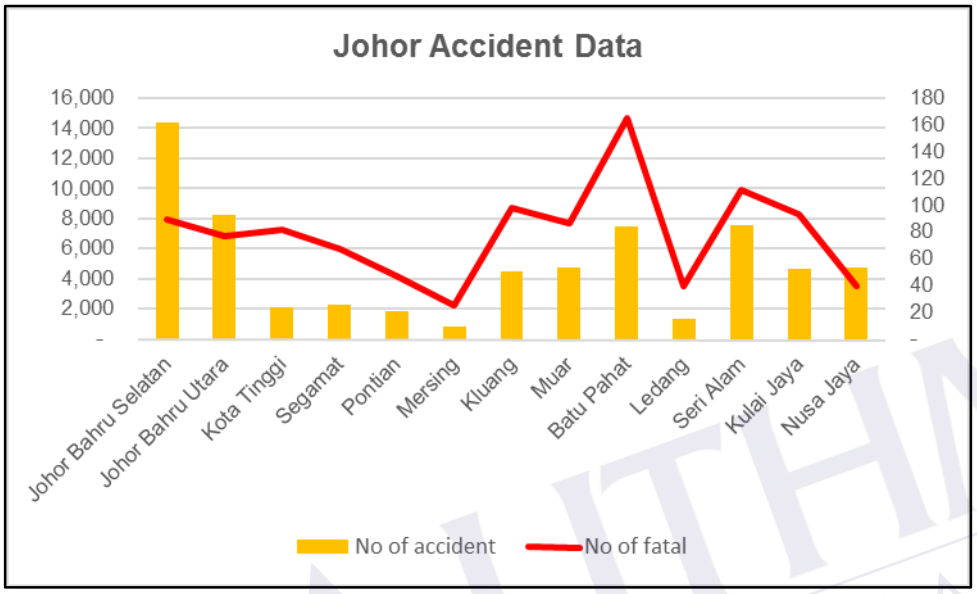

Figure 1.2: Johor Accident Data (Royal Malaysia Police, 2014)

Table 1.1: Summary of U-turn from KM1 to KM21 FT050 Batu Pahat - Kluang

Segment	Intersection (km)	U-Turn	
		All Vehicle	Light Vehicle
1	1 – 5	2	1
2	5 – 10	1	
3	10 – 15	1	2
4	15 – 18		1

Attitude of the drivers such as anger, selfish and so on contribute to an accident. For certain drivers, rude manners were the driver attitude that have some difficulties to change. When the drivers want to change their lane, make a U-turn, at the traffic light, and enter the roundabout, drivers always consisting impatient, compete and always in hurry (Md Diah *et al*., 2008). They would in highly of speed and the

possibility for an accident to occur with the surrounding vehicles also high when the drivers are covered by this emotions and manner. Furthermore, (Crundall *et al*., 2008; Darren *et al*., 2009) stated that driver's reaction can be influenced indirectly in making all appropriate visual checks and their reactions can be influenced by environment, mechanical or design of the road. Besides that, Yeoh *et al*. (2011) stated that attitude changes is believed to increase the driving reaction to achieve the traffic safety. Through this research, the model has been developed based on the safe distance, speed and reaction time using the simulator and the model predicted the safe distance for lane changing within the U-turn facilities.

1.3 Research Objectives

The objectives of the research are:

i. to determine driver's speed, reaction time and distance in approaching U-turn facilities;
ii. to developed the vehicle lane changing model within U-turn facilities; and
iii. to predict the safe distance by using the vehicle lane changing model within the midblock U-turn facilities.

1.4 Research scope and limitations

This research was conducted using driving simulation and visualized based on the environment of the research area. This research has been done only at multi-lane dual carriage highways because of direct U-turning movements with the midblock can be found only at this types of road. Central medians are the medium to separate the carriageways where it can be found at the federal routes. Other than that, this research was carried out in a dry condition and daytime to make sure the data taken is valid without any disruption for vehicle to slow down at the site area. Therefore, the data taken is corresponding to the driver reaction when passing through the site area. Driving simulator are used to simulate the condition and environment of the road where driving simulator is fully used in this research in providing the data needed. This research focus on determining the speed, reaction time and distance from subject vehicle to the merging vehicle due to changing lane at U-turn facility road segment

and reaction of the driver when passing through the midblock U-turn facilities at CH000 – CH021 of FT050 Jalan Batu Pahat – Kluang.

1.5 Significance of research

This research finds out the speed of the driver inside the freeways of the U-turn area which are comparing with the speed limit at 60km/h. At the freeways, the speed limit is 90km/h while at the U-turn area is 60km/h. Therefore, along the FT050 Jalan Batu Pahat – Kluang has a lot of speed limit changing for the driver to adapt. Therefore, this research finds out that driver tend to speeding based on their normal speed which is about 90km/h based on the usual speed limit. The lane changing model predicted the safe distance within U-turn facilities. Other than that, this research also developed a model within the U-turn facilities that can be used for driver to implement in real scenario. Therefore, this research will provide the understanding and guide for the driver in order to reduce the number of accident especially in U-turn facility road segment. This research also directly knows the reaction of drivers whether they have a precaution on a safety issue with slowing down the speed or given a chance for merging vehicle at the U-turn road segment to enter the main road of the highways.

1.6 Thesis layout

This section provides brief information about each chapter and there are six chapter in total for this thesis. Chapter one elaborated the introduction and explanation to the problem, aims, and contribution of the research. It is giving general explanation and introduction on the research and the scope of work. Other than that, Chapter two takes a literature review or theoretical review which take a closer look at the U-turn, driver reactions and the driving simulator. Additionally, literatures on multilane highways and midblock facilities are also presented to give an understanding about the work involved in this research.

Chapter three explained the research methodology on midblock U-turn facilities data collection. It gives the criteria for site selection, the survey method and the driving simulator used to carried out all the test and analysis. Chapter four Since this research investigate the effects of midblock facilities road segment into the driver reactions on speed, reaction time, and distance to execute the lane changing, this

chapter explained the results of that parameters especially in approaching a U-turn facility road segment. Other than that, Chapter four also explained about the process and analysis involved in developing the statistical model. The model using three parameters which are, distance, speed differences and the reaction time of the driver. All the data has been screened and follow all the process involved in developing the statistical model using SPSS. Other than that, this chapter involved the regression analysis of the model and the model validation in order to ensure the model developed are relevant and valid to be used. Chapter five shows the summary and conclusion in achieving the aim of the research. The research aim has been achieved by completing the three objectives that has been concluded in this chapter.

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