SAFETY ANALYSIS OF UNSIGNALIZED INTERSECTIONS UNDER ERRONEOUS ROAD CRASH DATA INFLUENCE

by

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LIST OF SYMBOLS

A_i	Number of terms with i^{th}% of Motorcycles Far Side
B_j	Number of terms with j^{th} Number of Accident(s)
β	Coefficient of an independent variable in the model
β_i	Coefficients of the independent variables x_i
β_o	Constant of the equation
C	Number of terms with near to far volume ratio > 1
C_{IU}	Concentration of uncontrolled unsignalized intersections
$l(\beta)$	Likelihood function
$L(\beta)$	Log of the likelihood function
Pr	Probability
R^2	Coefficient of correlation
S.D	Standard Deviation
t_{sc}	Safe critical gap
T_{IU}	Total number of uncontrolled intersections along a particular road
x_i	Series of independent variables i ranging from 1 to n with n being the total number of variables
z	Latent variable

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LIST OF ABBREVIATIONS

AD	Accident Database
AES	Automated Enforcement System
ARF	Accident Reporting Form
AT	Area Type
CBP	Community-Based Programs
DRL	Day-Running Light
FD	Field Database
G	Gap acceptance
GPS	Global Positioning System
HCMM	Highway Capacity Manual Malaysia
IRTAD	International Traffic Safety Data and Analysis Group
L	Total length of road in kilometer
LM	Lane Marking
MC	Motorcycle
MIROS	Malaysian Institute of Road Safety Research
ML	Master Loop
MTW	Motorized Two Wheelers

NCAP	New Car Assessment Program
NFSA	Nested Filtered Search Algorithm
OR	Odds Ratio
R	Road width
RTI	Road Traffic Injuries
S	Average speed on road
SPF	Safety Performance Function
TC	Traffic Control
UI	Unsignalized Intersections
V	Vehicle type
W	WMRT
WHO	World Health Organization
WMRT	Weaving Merging Right Turn

ANALISIS KESELAMATAN DI PERSIMPANGAN TIDAK BERLAMPU ISYARAT DI BAWAH PENGARUH DATA KEMALANGAN JALANRAYA YANG MEMPUNYAI RALAT

ABSTRAK

Data kemalangan merupakan asas data pengangkutan yang sangat penting bagi sesebuah negeri, Pengecaman kawasan berisiko tinggi lazimnya menggunakan data kemalangan ini. Tanpa maklumat tepat dan yang boleh tentang lokasi kemalangan maka tiada kemalangan boleh dikenalpasti dengan tepat pada seluruh rangkaian pengangkutan. Walaupun kekurangan ini telah disebutkan dalam pelbagai dokumen ilmiah tetapi kajian untuk memperbaiki kekurangan ini masih tidak dapat dikenalpasti. Ini merupakan motivasi untuk penyelidikan ini. Tujuan penyelidikan ini adalah untuk membangunkan kaedah yang boleh digunakan untuk menganggar lokasi tepat bagi kemalangan yang telah berlaku, menjalankan analisis mikroskopik pada tapak yang dikenalpasti dan untuk merumuskan model anggaran risiko yang boleh merangkumi tingkah laku serta parameter trafik yang bersesuaian dengan keadaan di Malaysia. Kaedah menganggar lokasi memerlukan data daripada dua punca; iaitu data lapangan dicerap daripada tapak manakala data kemalangan diperolehi dari MIROS (Institut Penyelidikan Keselamatan Jalan Raya, Malaysia). Daripada keputusan proses pembaikan, setelah menggunakan Algoritma "Nested Filtered Search (NFSA)" untuk memadankan kemalangan dengan persimpangan di mana kemalangan itu mungkin berlaku, maka 16 persimpangan telah berjaya dipadankan dengan betul. Lanjutan dari langkah pertama, fasa kedua telah dimulakan. Dalam fasa ini, data telah dicerap di setiap lokasi menggunakan pencerap data bersama rakaman video digunakan secara serentak untuk memperolehi data tingkahlaku. Hasil kajian telah mengenalpasti pergerakan belokan khusus yang diistilahkan sebagai perjalinan percantuman ke kanan (WMRT) yang dilakukan oleh kenderaan dari jalanraya minor telah dikenalpasti. Analisis selanjutnya, menggunakan teknik konflik, mendedahkan bahawa WMRT adalah lebih selamat daripada pembelokan ke kanan yang konvensional. Parameter ini telah digunakan dalam pembentukan model bersama dengan penerimaan sela dan jenis kenderaan untuk menganggarkan kebarangkalian konflik serius berlaku. Model ini telah berjaya menganggarkan sela genting selamat untuk motorsikal dan kenderaan lain yang membelok ke kanan daripada jalanraya minor ke major. Satu parameter baharu dikenali sebagai 'nisbah kepadatan sisi dekat kepada sisi jauh' telah diperkenalkan dan didapati mempunyai hubungan yang tinggi antara kemalangan dan konflik ditapak. Ini telah menghasilkan penemuan kepada hubungan bersyarat antara peratusan motorsikal, nisbah itu dan kemalangan serta konflik yang berlaku ditapak. Kebarangkalian kemalangan dan konflik meningkat dengan penurunan peratusan motorsikal yang bergerak pada arah sisi jauh dengan syarat nisbah kepadatan sisi dekat kepada sisi jauh adalah lebih daripada satu. Hasil penyelidikan ini telah berjaya menangani ralat daripada data kemalangan dan meningkatkan keselamatan pada persimpangan yang tidak mempunyai lampu isyarat.

SAFETY ANALYSIS OF UNSIGNALIZED INTERSECTIONS UNDER ERRONEOUS ROAD CRASH DATA INFLUENCE

ABSTRACT

Accident data is the backbone of any country's transportation database. Identification of black spots and high risk zones are based on it. Without reliable and accurate information pertinent to accident location not even a single accident could be identified on the entire transportation network. The primary flaw in the Malaysian accident data was the ambiguous location of accident sites. Although this shortcoming was highlighted in the literature by different researchers but none had taken up the task to develop a procedure for its rectification which provided the motivation for this study. The aims of this research were to develop a method that could be used for the estimation of correct location for the accidents that occurred in the past, to conduct microscopic analysis on the sites identified and to formulate risk estimation models that can incorporate the behavioral and traffic parameters relevant to Malaysian conditions. The rectification procedure required data from two sources; therefore, field data was collected from site while accident data was acquired from MIROS (Malaysian Institute of Road Safety Research). As a result of the rectification process, which involved the use of Nested Filtered Search Algorithm (NFSA) to match the accidents with the intersections where they might have occurred, 16 sites were correctly identified that initiated the second phase of the study. In this phase traffic data on each site was collected using data loggers while simultaneous video recording was made to extract behavioural data. A unique type of turning movement termed as the Weaving Merging Right Turn (WMRT) made by

the minor road vehicles was newly identified. Further analysis, using conflict technique, revealed that WMRT results into less number of serious conflicts on wider major roads than the conventional right-turn, thus reducing the chance of occurrence of a serious conflict for all types of motorized vehicles. This parameter was utilized in the model formation along with gap acceptance and vehicle type to estimate the probability of serious conflict. The model enabled the estimation of safe critical gap for motorcycles and other vehicles turning right from the minor to the major road. Another new parameter known as 'near side to far side volume ratio' was formulated and found to be highly related with the accidents and conflicts occurring on site. This led to the discovery of a conditional relationship between the percentage of motorcycles, the ratio and the accidents and conflicts that occurred on each site. The probability of accidents and conflicts increased with decrease in the percentage of motorcycles moving in the far side direction provided that the near side to far side volume ratio remained greater than one. The results of this study will help remove errors from the accident data and improve the safety at unsignalized intersections.

CHAPTER ONE

INTRODUCTION

1.1 Background

High-income countries share only 16% of the world's population with 47% of the world's motorized vehicles registered in them but their share in the global road traffic deaths is only 8%. While middle-income countries contain 72% of the world's population and 52% of the world's motorized vehicles but their share in the global road traffic deaths is 80%. This shows that despite being highly motorized, the road safety environment in high-income countries is 10 times better than middle ones. Unfortunately, Malaysia falls into the category of middle-income countries (WHO, 2015) which have the second highest annual road traffic fatality rates in the world, which is 18.5 per 100,000 population. As per International Traffic Safety Data and Analysis Group-IRTAD (2014) Malaysia had the highest road traffic fatality rate per 100,000 population, which was 23.6, among all the countries evaluated in the report. It is more than double than that of Korea, which had 10.8, and approximately six times than that of Japan, which had 4.1.

In order to improve the situation, recent initiatives taken by the Malaysian Government bodies responsible for road safety include the formulation and implementation of the 'Road Safety Action Plan 2014-2020' (IRTAD, 2015), which is based on the UN road safety plan for the decade of action for road safety. The primary target of this plan is to reduce the forecasted number of road fatalities upto 2020 by 50%. This corresponds to fewer than 5368 deaths by 2020 which is a 22% reduction as compared to 2010. Other initiatives with respect to the three pillars of road safety, which are the user/driver, the vehicle and the environment/infrastructure is as follows:

User/Driver

- Community-Based Programs (CBP)
- Automated Enforcement System (AES)
- Concentrated enforcement activity during festival period

Vehicles

- Day-Running Light (DRL)
- New Car Assessment Program (NCAP)
- Safety star grading for bus operators
- Performance indicators for periodic technical inspections

Environment/Infrastructure

- Authorized left turn
- Policy to enhance guardrail standard

The targets set by the governing agencies can not be achieved unless the measures taken are based on accurate investigation of the causes behind road accidents that lead to road fatalities. The primary requirement for the accuracy of the results of an accident investigation is the availability of an error free accident database. Mistakes in the accident database are common not only in low and middle-income countries but in a high-income and highly advanced country like USA as well (Tegge and Ouyang, 2009; Kim and Levine, 1996). Missing or incomplete information, regarding accident location along with other attributes such as traffic signal and road surface condition, recorded by police has been reported in a study in China (Wang et al., 2011). Mistakes such as duplication and missing data along with under-reporting of traffic injury deaths have also been reported in the South African Police Data (Chokotho et al., 2013). It was found that the location of 88% of crashes reported in the data acquired for a study in a low and middle income country could not be associated geographically to a point or an area (Wang et al 2013). Although Saudi Arabia is a high income country but in terms of discrepancies in accident data it is equivalent to a low or middle-income country because of the errors due to incomplete filling of accident reports. The most important missing information in their data is the accurate identification of accident location (Al-Ghamdi, 2003). A recent study has acknowledged the discrepancies in the Malaysian national accident database (Abdul Manan et al., 2013). The most common mistake is the incorrect recording of the location where the accident occurred. Because of the mistakes that may occur in accident data it has been recommended in standard road safety manuals to perform accuracy checks on variables such as location, number of vehicles involved, time, accident severity, number of casualties and accident type (PIARC, 2003). Therefore, the need to conduct a road safety study that aims at developing a rectification procedure for Malaysia arises.

1.2 Problem Statement

Descriptive statistics provides standalone numbers for individual parameters such as volume, speed, number of lanes, road width, curvature, vehicle type, vehicular distribution, directional distribution, etc. While a model provides a specific combination of the above parameters linked together through mathematical operators (such as +, , ×, ÷, e, etc.) such that when values are plugged in for a specific facility (such as an intersection, roundabout, toll plaza, highway, etc.) risk estimates are obtained which are pertinent to the said facility. These values can be utilized by engineers, transportation planners and law enforcers to improve safety. But the estimates can only be accurate if the values provided belong to the site under investigation. Erroneous values will result into faulty estimates, thereby making the entire road safety exercise ineffective. Therefore, it is extremely important to rectify the data before proceeding with the analysis so that those spots could be correctly identified where the problem exists. As mentioned in the previous section, errors in the Malaysian accident database had been reported in the literature, but no known initiative has been taken to establish a comprehensive procedure that can be used to rectify it. This argument became the initial motivation to conduct this study.

Risk estimation can not be accurate without incorporating behavioral parameters. At unsignalized intersections the behavior of vehicles making a right-turn onto the major road is often characterized by their compliance with the stop rule (Kodsi and Muttart, 2009; Kosaka, et al., 2007; Muttart, et al., 2011; Pradhan, et al., 2005), use of turning indicator (Abdul Manan, 2014a) and aggressive driving or force merging (Kaysi and Alam 2000; Kaysi and Abbany 2007). In low and middle income countries the drivers of minor road vehicles make indigenous maneuvers such as the Opposite Indirect Right Turn (Abdul Manan, 2014a). Their behavior is very different from the vehicles in high income countries. Only one previous study was conducted in Malaysia with respect to the behavior and was limited to motorcycles only and did not take into account other types of vehicles which include cars, vans, lorries, high occupancy vehicles, and heavy goods vehicles. Furthermore, such microscopic studies are not possible without a rectified accident data set. Therefore, unavailability of location based microscopic accident data resulted into