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Modeling pedestrian gap crossing index under mixed traffic condition

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ABSTRACT

Nowadays, there are a variety of challenges faced by pedestrians when they walk along and attempt to cross a road as the most recorded accidents occur during this time. Pedestrians of all types, including both sexes with numerous aging groups, are always subjected to risk and are characterized as the most exposed road users. It has been contended that the majority of pedestrian fatalities (71%) occurred at intersection crosswalk in urban areas. Meanwhile, the increasing demand for better traffic management strategies to reduce the risks at intersections, improve quality traffic management, traffic volume and longer cycle time, has further increased concerns over the past decade, has urged the development and research into methods, models, and approaches to reduce the risks at intersections, improve quality traffic management, traffic volume, longer cycle time, as well as pedestrians' safety and comfort ability. This paper aims to develop a sustainable pedestrian gap crossing index model based on traffic flow density. The paper focused on the gaps accepted by pedestrians and their decision for street crossing, where (Log-Gap) logarithm of accepted gaps was used to optimize the result of a model for gap crossing behavior. Through a review of extant literature, 15 influential variables were extracted for further empirical analysis. Subsequently, data from observation at an uncontrolled mid-block in Jalan Ampang in Kuala Lumpur, Malaysia was gathered and multiple linear regression (MLR) and binary logit model (BLM) techniques were employed to analyze the results. From the results, different pedestrian behavioral characteristics were considered for a minimum gap size model, out of which only a few (four) variables could explain the pedestrian road crossing behavior while the remaining variables have an insignificant effect. Among the different variables, age, rolling gap, vehicle type, and crossing were the most influential variables. This study would increase our understanding of pedestrians' crossing behaviors, improve pedestrians' crossing behaviors, and lead to better pedestrian crossing behaviors at gap and zebra in Malaysia.

1. Introduction

These days, there are a variety of challenges faced by pedestrians when they walk along and attempt to cross the road as the most recorded accidents occur during this time. Pedestrians of all types, including both sexes with numerous aging groups, are always subjected to risk; besides, pedestrians are characterized as the most exposed road users. Young and aged people are always at an increased threat regarding pedestrian mishaps or crashes (Tanaboriboon & Satiennam, 2005). According to the National Highway Transportation Safety Administration (Administration, N.H.T.S, 2016), the majority of pedestrian fatalities (71%) occurred at intersection crosswalks in urban areas. Malaysia is considered as one of the countries experiencing rapid growth in motorization, automobile and transportation systems (Clauses, 2012). This rapid growth is due to the escalation of the population, to which the necessity of this project becomes inevitable. Several reports on pedestrians' injuries and deaths have been recorded in literature. Fig. 1 presents statistical data on the distribution of different road injuries (Clauses, 2012). The multiplicity of pedestrians' injuries and sometimes deaths at road intersections has become an actual concern over the past decade (Clauses, 2012), and thus, have urged the development and research into methods, models and approaches to reduce the risks at intersections, improve quality traffic management, traffic volume, longer cycle time as well as pedestrians' safety and comfort ability.

Pedestrian crossing behaviors are very tough to classify at signalized intersection zones. Available signal phases have been provided to manage the interaction between pedestrians and vehicles at intersection crosswalks where they share the same road space. Still pedestrian–vehicular interaction occurs due to pedestrian refusal behavior with traffic signals. Most important reasons for pedestrian noncompliance with traffic signals could be due to low-quality traffic management, traffic volume and longer cycle time (Serag, 2014). Apart from these, there are many other parameters that affect the pedestrian compliance behaviors with these signals and interactions.

While a variety of relevant techniques, criteria and strategies for measuring different factors such as pedestrian perception, roadway,

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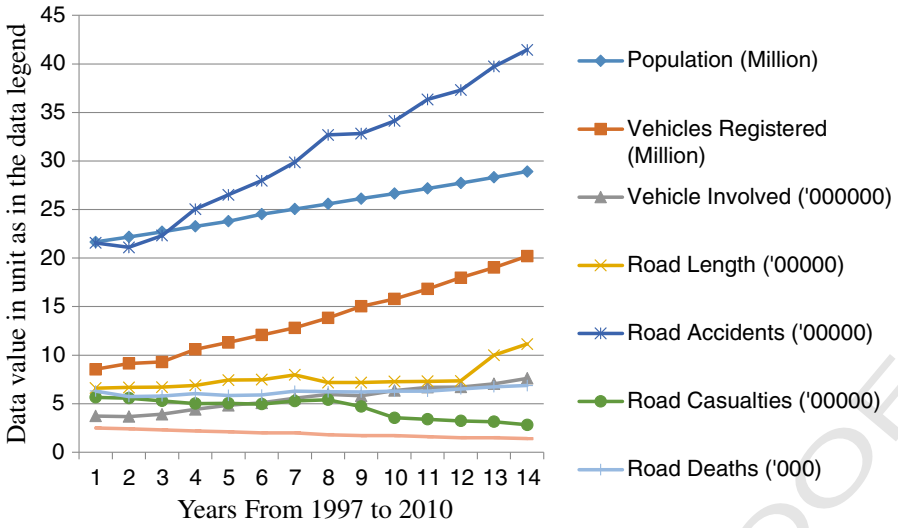

Fig. 1. Distribution of different road injuries.

environmental characteristics, transport network, among others, have been developed to address the challenges, most of these studies concentrated only on some aspects of variables such as age, pedestrian rolling gap, etc. (Goh et al., 2012; Hamidun et al.; Hamidun, Ishak, & Endut, 2013; Jain, Gupta, & Rastogi, 2014; Kadali, Rathi, & Perumal, 2014). Some variables, however, including pedestrian crossing gap acceptance and type of vehicle, among others, are under-researched and still need further investigation. For instance, search results of gap crossing behaviors in Scopus database, with "pedestrian gap crossing behavior in Malaysia" in the title, abstract and/or keywords of indexed articles, showed only a few articles. Also, some of these identified factors have different characteristics, operational and traffic conditions, and work environments that are unique to their selected or study areas (Demiroz, Onelcin, & Alver, 2015; Serag, 2014; Yannis, Papadimitriou, & Theofilatos, 2013). Thus, there is a need to consider the different traffic condition and work environment in Malaysia.

To address these gaps, this paper aims to develop a sustainable pedestrian gap crossing index model based on traffic flow density in the metropolitan streets of Jalan Ampang in Kuala Lumpur, Malaysia. It is believed that this study would increase the understanding of the mode of pedestrians' interaction with roads, and may affect the traffic environment, as well as other pedestrians. Consequently, the pedestrians would be comfortable and safe during road crossing and there would be a reduction in the cost of delays within the same framework of existing traffic rules. Also, the findings of the study will serve as a benchmark for continuous improvement and adjustment of road networks to pedestrians, which still need more accurate estimation to reduce the accident risk exposure in different areas.

2. Literature review

This section focuses on the analysis of the main body of the extant literature which is positioned at the center of this study: pedestrians' crossing behaviors.

2.1. Pedestrian crossing behaviors

Developing countries are getting busier and busier; perhaps it happens day by day. As the nation rises economically, the metropolitan cities are designed to commute and support more people to boost economic strength. Hence, the infrastructures are getting closer to one another, having compact living packs. Basic facilities such as schools, hospitals, workplaces, leisure malls and etc., become common for modern era people. So moving around in all these areas becomes a noticeable factor in recent years as the pedestrian accidents escalate over time. Even so, communities are asking for help to make it safer to cross the street, slow traffic down, and make the street more inviting (Serag, 2014). According to Demiroz et al. (2015), the probability that a pedestrian will have an injury or near miss when crossing a stream of traffic depends on several parameters, such as the size of the gap that a pedestrian will accept an oncoming driver, vehicle velocity, driver age, sex and type of oncoming vehicles. Hence, steps which clearly identify crosswalks and aid pedestrians in making their presence known to motorists should be taken into consideration because pedestrians also have the right to use the space at crosswalks.

There are several reported consequences from the experiences of pedestrians' behaviors due to the pedestrian–vehicle interactions at low vehicle speeds in crowded areas. This phenomenon might describe the risk of gap length for the movement of pedestrians or vehicles from the junction to cross or enter the mainstream and have resulted in a number of injuries and deaths. Data on road accidents in Malaysia dates back to 1972, where documentation on the rise in traffic-related deaths began. These deaths increased at an annual rate of 4% in the 1980s and more than 5% in the 1990s. Nevertheless, the number of deaths slightly decreased by 2% from 2000 to 2009, partly because of road safety programs that were executed by government regulators (Clauses, 2012).

Numerous studies have examined pedestrian and driver behavior at the non-signalized intersection (Yannis et al., 2013), and recommended techniques and solutions to these challenges. Among these techniques and approaches include at-grade and grade separated facilities, such as underpasses and overpasses to ensure safe crossings. Also, Gap acceptance can be used to expect the relative risks at intersections, where shorter gaps usually involve higher accident risk. Gap is defined as the time elapsed between the rear bumper of one vehicle and the front bumper of the following vehicle in the traffic stream of a major road at a reference line. Gap acceptance decision includes a judgment made about whether it is possible to complete a crossing before oncoming vehicles will arrive at the gap. According to Hanan et al. (2015), the critical gap may be defined as the minimum time gap in the priority stream that a minor street pedestrian is ready to accept for crossing or entering the major road cone zone.

Pedestrian gap acceptance is one of the most important components in microscopic traffic characteristic in pedestrian road crossing-index. Marisamynathan and Vedagiri (2015) developed a model which compared the walking speed at vertical sides against the gender, aging

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