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Models for pedestrian gap acceptance behaviour analysis at unprotected mid-block crosswalks under mixed traffic conditions

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ABSTRACT

Pedestrian safety is an important aspect while crossing the road and it can be explained by pedestrian gap acceptance behaviour. The statistical models such as multiple linear regression (MLR) is often used to model linear relationships between dependent variable (viz., pedestrian gap acceptance behaviour) and independent variables, due to their ability to quantitatively predict the effect of various factors on the dependent variable. However such linear models cannot consider the effect of several variables on the output variable, due to primary assumptions of normality, linear, homoscedasticity and multicollinearity. In this regard, the non-linear models based on the artificial neural network (ANN), which are free from assumptions of linear models, can be easily employed for obtaining the effect of several input variables on the pedestrian accepted gap size. However, researchers have rarely applied ANN modelling technique for predicting the pedestrian gap acceptance behaviour, as the pedestrian gap acceptance behaviour depends on several pedestrian, traffic and vehicular characteristics. The ANN based models would be quite useful in establishing relationship between these factors on the pedestrian gap acceptance behaviour at midblock crosswalks under mixed traffic conditions. In this direction, the present study adopts both MLR as well as ANN with different pedestrian, traffic and vehicular characteristics to assess the significant contributing factors for pedestrians' gap acceptance behaviour at unprotected mid-block crosswalks under mixed traffic conditions. For this purpose, a video graphic survey was conducted at a six lane divided road at unprotected mid-block crossing in Mumbai, India. The data such as pedestrian (gender and age), vehicular, traffic and pedestrian behavioural characteristics were extracted to model pedestrian accepted gaps. The model results show that pedestrian rolling behaviour has a significant effect on pedestrian accepted gap size. The model results concluded that ANN has a better prediction with possibility to consider the effect of more number of variables on the pedestrian gap acceptance behaviour as compared to the MLR model under mixed traffic conditions. However, the quantification of significant contributing variables on pedestrian accepted gap size is easy by MLR model as compared to the ANN technique. So, both models have their own significant role in pedestrian gap acceptance analysis. The developed models may be useful to enhance the existing mid-block crosswalk facilities or planning

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new facilities by more accurate prediction of the pedestrian gap acceptance behaviour considering the influence of various factors under mixed traffic conditions.

1. Introduction

The encouragement of active modes of transportation such as walking and bicycle is more beneficial for urban transportation system to increase the transportation sustainability in developing countries like India. Consequently, walking (pedestrian trips) are also integrated with other modes of transportation such as public transportation system and other motorized vehicles (eg. Para transit). The pedestrian walk trips encompass of sidewalks as well as crosswalks during the course of travel. The pedestrians have freedom to choose their mobility and maneuver on sidewalks when compared to crosswalks. The mobility of pedestrian mainly depends on availability of adequate gaps in vehicular traffic as well as driver behaviour due to non-availability of regulations such as sign boards, signals and speed controls at unprotected mid-block crosswalks. Hence, unprotected mid-block crosswalk locations are chaotic to pedestrians as well as vehicle drivers. Pedestrians have to cross the road at intersection location or designated crosswalk location (in India designated crosswalk refers to median openings) in the course of the trip. In India, as per Indian Road congress (IRC) the unprotected mid-block crosswalk refer to the median opening with or without marking (IRC:103) to access the adjacent land use condition, as shown in Fig. 1. These mid-block crosswalks rarely have signals as well as sign boards to regulate motorized vehicles. Further, the driver yield behaviour is not common at such mid-block crossings unless pedestrians are already using crosswalk area. So, road crossing does not guarantee pedestrian's safety, particularly when a pedestrian chooses unprotected crosswalk locations under mixed traffic conditions. Moreover, the behaviour of pedestrian and vehicular drivers will affect the pedestrian safety at unprotected mid-block crossings under mixed traffic conditions.

Studies show that nearly 1.2 million persons are killed every year and 50 million people are injured because of road crashes globally (Peden et al., 2004). It is also found that approximately 65% of the total road crashes relate to pedestrians (Kareem, 2003). The recent road crashes statistics in the US show an increase of 3 percent in pedestrian fatalities from 2010 to 2011 and almost 73 percent pedestrian crashes occurred in urban areas. Moreover, 70 percent of pedestrian crashes are related to non-intersection locations (mid-block crossings) (NHTSA, 2011). In India, statistics show that 60 percent victims are pedestrians and 85 percent pedestrian fatalities occur at mid-block crossings (Mohan, Tsimhoni, Sivak, & Flannagan, 2009). Some studies have shown that pedestrian crossing activities have higher fatality rate as compared to other activities such as walking and standing on roadside (Kumar & Parida, 2011). All the above collision studies show that pedestrian crash share is higher at unprotected mid-block crossings when compared to intersection location. In India, it can be noticed that there are several unprotected mid-block crossings (median opening shown in Fig. 1) in urban areas, and pedestrian may cross at such mid-block crossings. The developing countries have high population densities in urban areas due to the rapid growth of economy and it increases the vehicular flow density as well as pedestrian trips substantially. Further, high pedestrian density necessitates several unprotected crosswalk trips and hence requires provision of more number of such

Fig. 1. Sample photos of unprotected mid-block crosswalk locations in Mumbai.