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Evaluation of pedestrian mid-block road crossing behaviour using artificial neural network

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Abstract: Pedestrians usually cross the road at mid-block locations in India because of the ease and convenience to reach their destination as compared to intersection locations. It is important to evaluate the pedestrian gap acceptance behavior at mid-block locations because of inadequate vehicular gaps under mixed traffic condition, which translates into the pedestrian road crossing behavior. The present study examines the pedestrian gap acceptance behaviour by employing an artificial neural network (ANN) model for understanding the decision making process of pedestrians, i. e., acceptance or rejection of vehicular gaps at a mid-block location. From the results it has been found that the pedestrian rolling gap, frequency of attempt, vehicular gap size, pedestrian speed change condition and vehicle speed have major role in pedestrian gap acceptance. These results can lead to a better design of pedestrian crossing facilities where adequate gaps are not available in vehicular flow at mid-block crosswalk locations.

Key words: pedestrian; mid-block; artificial neural network; rolling gap; gap acceptance behavior

1 Introduction

Walking is a daily necessary activity for human beings and most of the walk trips involve road crossing, which is potentially hazardous activity at unprotected mid-block locations. Pedestrians need to search for adequate vehicular gaps to cross the road safely. It is rare to get adequate gaps under mixed traffic conditions at unprotected mid-block locations. So, pedestrians utilize different behavioural characteristics to cross the road quickly by using non-safe gaps. If the vehicle drivers are unable to yield to pedestrians due to higher vehicle speed then it results in unsafe crossing.

The individual road crossing behaviour of a pedestrian can be modeled by gap acceptance mechanism. The pedestrian gap acceptance mechanism involves pedestrian as well as vehicle arrival processes and the response of pedestrians to available gaps in traffic stream. The pedestrian-vehicle conflicts will increase with increase in trade-off between pedestrian misjudgment of vehicular gaps and vehicular driver yield behaviour. Generally, pedestrians increase their cross-

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ing speed or change their crossing path when the available time gap (headway) of an approaching vehicle is less than safe gap. The pedestrian fatalities increase due to attempts of non-safe gaps under mixed traffic conditions. So, in this context there is a need to study the pedestrian road crossing behaviour at unprotected mid-block locations under mixed traffic condition. The rest of paper consists of following sections. Section 2 presents the literature review. In section 3, methodology is presented and it also includes data collection and model formulation. Section 4 presents analysis and results. Conclusions and study limitations are discussed in Section 5.

2 Literature review

A detailed review of literature was carried out to understand the previous studies related to pedestrian road crossing behaviour. The underlying mechanism of individual decision making process to cross the road is well explained by gap acceptance theory (Di Pietro and King 1970; Himanen and Kulmala 1988). The gap acceptance theory indicates that pedestrians search for suitable vehicular gaps to cross the road. During this process each individual pedestrian or a group of pedestrians have a critical vehicular gap (Sun et al. 2003; Brewer et al. 2006). There are diverse factors such as pedestrian, vehicular and roadway characteristics which influence the pedestrian road crossing behaviour. Studies have explored the effect of pedestrian gender and age in pedestrian road crossing behaviour (Holland and Hill 2007). Females wait for longer time than males while crossing the road (Tiwari et al. 2007). The elderly pedestrians' road crossing behaviour was significantly safer as compared to that of younger pedestrians especially while crossing one-way divided road when compared to two-way divided road crossing (Oxley et al. 1997).

In recent studies researchers have examined the effect of marked crosswalk on pedestrian road crossing behaviour (Havard and Willis 2012; Kadali and Vedagiri 2013a). Studies have shown that illegal (viz., non-compliant) road crossing is more hazardous than the legal road crossing (Yang et al. 2006; King et al. 2009). Researchers have explored the effect of looking at vehicles before and while crossing, on pedestrian safe road crossing behaviour (Zhuang and Wu 2011; Kadali and Vedagiri 2013b). In order to find the factors influencing the pedestrian road crossing behaviour, researchers have developed several models such as log normal regression model (Yannis et al. 2013) and binary logit model (Himanen and Kulamal 1988; Sun et al. 2003; Das et al. 2005; Yannis et al. 2013). However, these models eliminated several influencing variable due to the statistical insignificance. So, the present study utilizes the artificial neural network (ANN) modeling technique to find out the influence of various contributing factors on pedestrian road crossing behaviour.

ANN modeling technique is currently being used in diverse fields like engineering applications, biology, medical and business problems. In general, based on the independent and dependent variables a precise equation must be developed in the regression analysis, whereas, the general structure of ANN architecture can be applied to practically any system (Zealand et al. 1999). In transportation engineering, driver gap acceptance has been modeled by ANN at stop controlled intersection location (Pant and Balakrishman 1994). Further, researchers have modeled pedestrian gap acceptance by using ANN at signalized mid-block location (Lyons et al. 2001). However, there are very limited studies carried out on pedestrian gap acceptance by using ANN technique at unprotected road crossing locations under mixed traffic conditions. With this background, the primary objective of this study is to develop an ANN based pedestrian gap acceptance model at unprotected mid-block crosswalk location. Further, the influence of various contributing input variables on the pedestrian gap acceptance behaviour has been studied.

3 Methodology

3.1 Data collection

Six lane divided urban mid-block section with median opening which is partially controlled by zebra cross marking at Worli in Mumbai, India was chosen as the experimental site. The selected site has a good interaction between pedestrians as well as vehicles and it is 120 m away from the signalized intersection. The video-graphic data was captured with the help of three high resolution cameras one of which was used to capture the pedestrian behaviour and the remaining