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Behavior of two-wheelers at limited priority uncontrolled T-intersections

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ABSTRACT

Being convenient and affordable, motorized two-wheeler is the most widely used personal mode for short and medium distance trips in India, thereby resulting in a very high concentration of two-wheelers on Indian roads. Its compact size and aggressive nature of two-wheeler riders have significant impact on the overall traffic characteristics and safety. A large number of unsignalized intersections in India do not have stop or yield sign, and even if it exists, drivers in general do not follow the intended priorities. The combinations of these factors create complex conditions at unsignalized intersections. At some intersections, where the drivers clearly perceive major and minor roads, priority rules are followed to a certain extent. Such partially controlled intersections where limited priorities are observed are studied here. The focus of this paper is on analyzing and modeling gap acceptance behavior of two-wheelers at limited priority unsignalized T-intersections in India. The data collected at four intersections revealed that accepted gaps/lags follow lognormal distribution. Logit models are developed for major and minor road right turnings which show that the probability of accepting a gap is higher if the driver is young, the conflicting vehicle is a two-wheeler, or both. Critical gap values are estimated using Raff's method, lag method, Ashworth's method, logit method, and maximum likelihood method. These values vary from 2.38 to 3.06 s for major road right turning and 2.77 to 3.71 s for minor road right turning. The maximum likelihood method is found to give the most consistent values. The findings of this study are useful in developing performance and safety evaluation of uncontrolled intersections in India.

1. Introduction

Motorized two-wheeler is an affordable and primary personal mode of travel in India. Out of about 3.5 million registered vehicles in Mumbai Metropolitan Region (MMR), about 1.9 million (more than 50%) are two-wheelers. In many cities the proportion of two wheelers in road traffic is more than 70%. Physical characteristics of two-wheelers are different as they have narrow width, small size, and high power-to-weight ratio. Subsequently, two-wheeler riders have more adaptability and opportunity on the streets; they are the least followers of any discipline. It is generally observed that two-wheelers respond to the heavy traffic by arranging themselves with some specific behavior, such as filtering, moving side by side of different vehicles in the same path, diagonal accompanying, tailgating, and swerving [1]. Two-wheeler riders in India are more aggressive than other drivers. This is evident from a study by Gowri and Sivanandan [2] at a signalized intersection in Chennai City (India); the longitudinal spacing maintained by two-wheelers with a front vehicle is the minimum among all vehicle types, and their deceleration rates are the highest compared to other vehicles. In other words, the characteristics of two-wheelers and its riders are different than those of other vehicles. The sheer volume of two-wheelers on Indian roads associated with their distinct characteristics demand a large number of studies focused on two-wheelers. Unsignalized intersections in India function as uncontrolled intersections because stop/yield signs are not installed at most intersections, and even if installed, drivers do not follow the indicated priorities. At some intersections where drivers perceive the minor and major roads based on the geometry (for example, width of approaches), pavement conditions, and traffic characteristics (for example, approach speed), limited priorities are observed. An intersection where a village/town road intersects with a national highway or a state highway acts as a limited priority intersection. At such intersections, there may or may not be a stop sign on minor road, but the drivers on the minor road are aware that the cross-road ahead is a major road with vehicles moving at higher speeds. Thus a vehicle on a minor approach intended to cross will be cautious and wait for a suitable gap in the major road streams. Similarly, the right turning vehicles on major road (in India the driving is on the left side of a road) also need to watch for the conflicting traffic in the opposite direction. However, unlike stop sign controlled intersections in developed countries, a minor road

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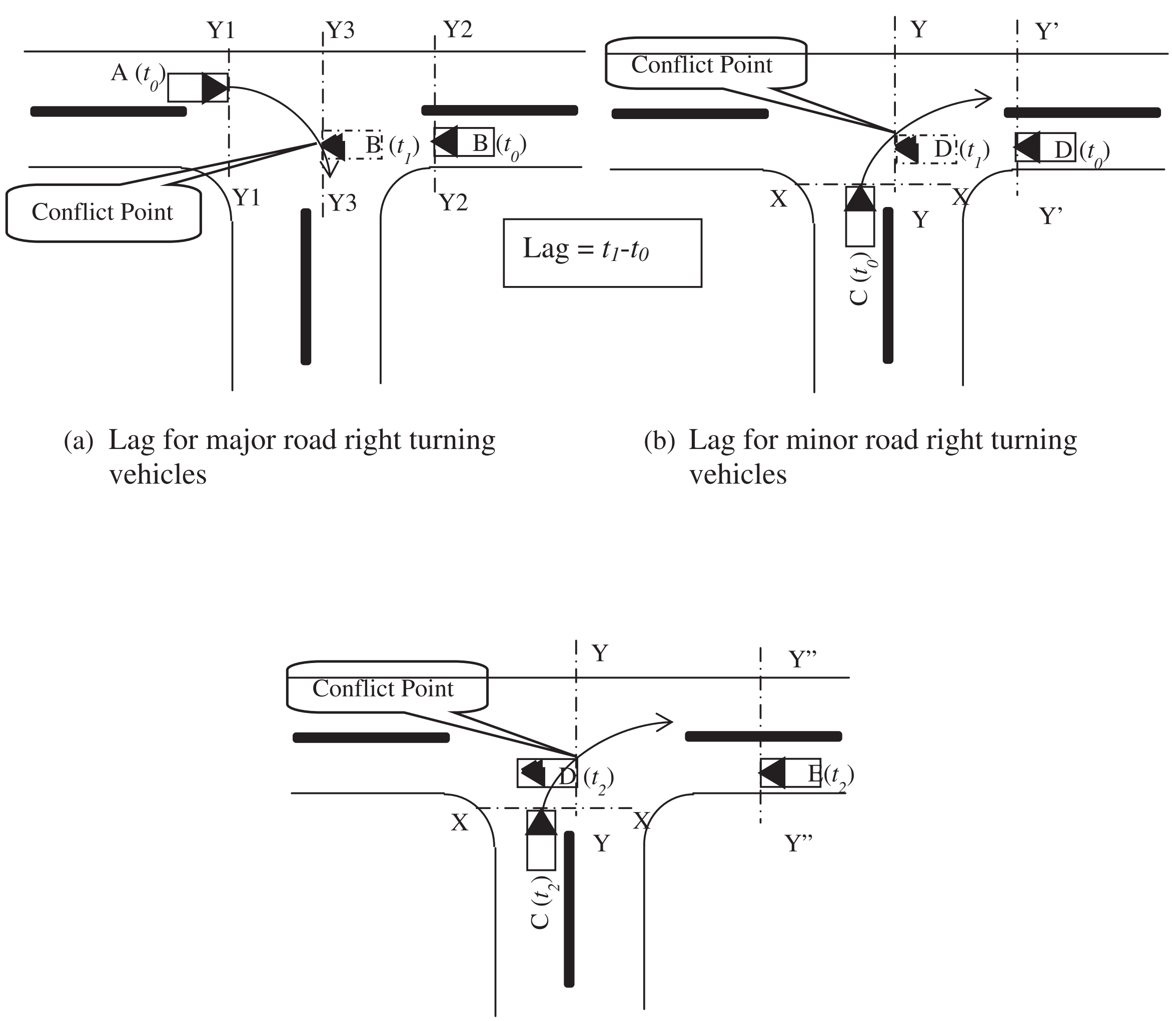
vehicle or a right turning major road vehicle will not come to full stop, if it perceives that the conflicting vehicle is far enough to maneuver. We call such intersections with limited priority as partially controlled intersections. The main aim of this paper is to analyze and model the gap acceptance behavior of the right turning two-wheelers at partially uncontrolled intersections. We are restricting our analysis to T-shaped intersections only.

Most of the intersections in India are unsignalized. For example, in Belgaum – a city of about a half million population in northern Karnataka, India – traffic signals function at about only five intersections in the entire city. The situation is similar in many other Indian cities. In spite of the large number of uncontrolled intersections on Indian road networks and the large proportion of two-wheelers in road traffic, the literature on them is meager. We believe the gap acceptance theory used for evaluating unsignalized intersections in the US Highway Capacity Manual [3] can be applied to partially controlled intersections. In this paper, logit based models are developed considering various influencing variables such as available gap, rider's age, and type of conflicting vehicle. Additionally, critical gaps are estimated and compared for two-wheelers using Raff's method, Ashwarth's method, maximum likelihood method and logit method [4]. An econometric tool NLOGIT 4.0 is used to develop logit models for estimating gap acceptance probabilities.

This paper is organized into 8 sections, including this section. In the second section, a brief background on gap acceptance methods and the literature review on the gap acceptance are presented. The data collection and extraction is discussed in Section 3, and the analysis of the extracted data is presented in Section 4. The structure of the logit model and model estimation is presented in Section 5, whereas the validation of the models is the focus of Section 6. Critical gaps estimation by different methods is presented in Section 7. Section 8 concludes the paper by presenting important observations.

2. Background and literature review

Although a few studies have considered both gap and headway as the same, gap is usually defined as the time interval between the rear bumper of a front vehicle to the front bumper of the following vehicle moving in the same direction on the same lane. Headway is defined with reference to the front bumper of both front and following vehicles and is thus greater than gap. The parameter of interest in this paper is gap which will be used by maneuvering vehicles to make decisions. Another relevant parameter is lag, which is defined between two vehicles belonging to two different streams. The measurement of lag at T-intersections is discussed in Patil and Sangole [5]. We are briefly describing it with the help of Fig. 1 ((a) for major road right turn and (b) for minor road right turn), reproduced from Patil and Sangole [5]. Assume that vehicle A in Fig. 1(a) is intending to take right turn from major road and has reached at stop position Y1-Y1 at time t_0. The first conflicting vehicle B is at Y2-Y2 at time t_0. The vehicle B will reach



(a) Lag for major road right turning vehicles

(b) Lag for minor road right turning vehicles

(c) Gap for minor road right turning vehicles

Fig. 1. Measurement of lag and gap.