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RESEARCH PAPER

Time Gap Modeling using Mixture Distributions under Mixed Traffic Conditions

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Abstract: The time-gap data have been modeled through non-composite distribution up to a flow level of 1,800 vph. It has been found that these models are not capable of modeling time gap data at higher flow levels. Some composite distributions have been proposed to overcome this problem. But, due to the fact that the calibration of model parameters used in composite distributions is tedious, there use may be relatively limited. In this paper, five mixture models namely Exponential+Extreme-value (EEV), Lognormal+Extreme-value (LEV), Weibull +Extreme-value (WEV), Weibull+Lognormal (WLN) and Exponential+ Lognormal (ELN) have been used to model time gap data for flows ranging from 1900 vph to 4100 vph. Two types of goodness-of-fit tests namely cumulative distribution function (CDF) based and two-sample (Cramer-von Mises test) & K-sample (Anderson-Darling test) based tests were performed. Among all the five models, Weibull+ Extreme Value was found to be the best mixture model for modeling time gap data as it performed consistently well in Cramer-von Mises test and K-sample Anderson-Darling test.

Key Words: urban traffic; mixed traffic; vehicular time gap; AD test; Cramer-von Mises test

1 Introduction

Mixed traffic conditions in developing countries like India, are entirely different as compared to the homogeneous traffic conditions prevailing in developed countries. They consist of many vehicles including: Auto-Rickshaws, two-wheelers, small cars (including jeeps and vans), sports utility vehicle, and heavy vehicles (including buses and trucks of different axles). Additionally, there is no lane discipline i.e., vehicles can occupy any lateral space available on the road irrespective of lane markings. Some vehicles follow each other and some do not. Vehicles can move parallel to each other within a single lane, leading to the distance between each vehicle to be almost zero. Considering the fact that there is no lane discipline, it would be better to consider time headway of homogeneous traffic to be analogous to inter vehicular time gap under heterogeneous traffic conditions. Headway for homogeneous traffic is defined as the time between two successive vehicles in a traffic lane or a single file traffic stream as they pass a point on the road way, measured from bumper to bumper (front to front or rear to rear), in seconds. However, this definition is not appropriate for heterogeneous traffic in India with imperfect lane discipline. The reasons are: (i) complex movement patterns are not restricted to a single file stream, (ii) near parallel movements of smaller vehicles within a single lane, (iii) the possibility of multiple leaders and/or followers, (iv) absence of lane discipline and lane markings, (v) higher degree of lateral movement and vehicle occupancy of entire road width without reference to lanes, (vi) varying lateral dimensions of vehicles, and (vii) littleor no enforcement measures. On the other hand, inter vehicular time gap is defined as the time interval between arrivals of consecutive vehicles, this is more pertinent to heterogeneous traffic. Time gap is independent of lead lag vehicle types and incorporates various types of non-following interactions that are typical of heterogeneous traffic conditions[1]. Also, this definition ensures a unique time ordering of all vehicles crossing an observation point and is more appropriate for simulation models for heterogeneous traffic. A snapshot of both homogeneous and heterogeneous traffic flows is shown in Fig. 1, which justifies the application of time gap concept under heterogeneous traffic conditions explained above.

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(a) (b)

Fig. 1 Traffic flow under different types of traffic condition (a: homogeneous traffic; b: heterogeneous traffic)

Many researchers[2,3] have used entire road space based arrivals at a reference line on the road for the modeling of time gap under heterogeneous conditions. Vehicular time gap incorporates both following and non-following interactions typical of the heterogeneous traffic scenario in developing countries like India. In spite of this advantage, there are a few challenges in time gap modeling. Due to the presence of both fast and slow moving, small and large vehicles, time gaps may range from 0 to 25 s, with a significant amount (0–20%) of data in the tail regions. Hence modeling of both zero time gaps and the data in tail regions assumes paramount importance and leads to erroneous results when neglected. In a nut shell, it becomes imperative to perform statistical modeling of entire road width based time gaps under heterogeneous traffic conditions coupled with better tail modeling.

A lot of work has been done in the past to model headways and time gaps under homogeneous and heterogeneous traffic conditions respectively though there are noticeable differences between the two parameters. As seen earlier, traffic is lane based in homogeneous traffic conditions and hence if one wants to simulate homogenous traffic condition for a multilane road, the multilane road can be divided into separate lanes for the purpose of analysis. In this situation, traffic volume is limited to one lane capacity i.e., 2,000–2,200 passenger cars per hour. Due to this reason, most of the research works on time headway modeling are limited to a flow range of 1,800 vph. On the other hand, under heterogeneous traffic conditions as there is no lane discipline, the entire roadway has to be considered. In these cases, traffic volume on four-lane divided roads may reach a high flow level of up to 4,000 vph (for two lanes in each direction). In addition to this, heterogeneous traffic conditions comprise many vehicle categories such as cars, two-wheelers, three-wheelers, light commercial vehicle, and trucks. Generally, two-wheeler's concentration is very high, which makes it possible to observe traffic volume up to 4,000 vph on four-lane divided roads. Non-composite probability distributions such as Weibull, Erlang, exponential, and lognormal distributions, which have been used to model time gaps up to 1,800 vph, are not capable of modeling time gaps at higher flow rates (i.e., volume levels of 2,000 to 4,000 vph). To address this problem, few researchers have proposed composite distributions to model headways at higher flow rates. These models are very complex in nature and calibration of the parameters involved in them is also a challenge. Considering the above and motivated by the fact that there are no works on mixture distributions for modeling time gaps, this study aims to model time gap data at flow levels ranging from 1,900 to 4,100 vph using mixture distributions. Thiswork is also motivated by the research works done in the area of accountancy[4,5], where lot of work has been done to model insurance payment data. The nature of insurance payment data is very similar to time gap data at higher flow rates. Both are highly positively skewed and distributed with a long tail.

2 Literature review

As seen above, time gaps under heterogeneous traffic conditions are different from that of time headways under homogeneous traffic conditions, as they both measure two different quantities. Nevertheless, many researchers on time gap modeling have adopted distributions such as exponential, gamma, Erlang, and lognormal which have been used by researchers for headway modeling. Researchers of heterogeneous traffic conditions have also referred the entire road width based inter-arrival rate as 'headway' though it is not the same as the lane based follower headway that prevails in homogeneous conditions. Extensive literature is available based on research done for modeling time headway and time gaps. But this work would restrict itself to the review of the