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Time Headway analysis on urban roads of the city of Marrakesh

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Abstract

Vehicular Time Headway or Inter-arrival time is an important parameter in traffic flow theory. It has a major effect on traffic simulation especially in the traffic generation process. Most of the previous research on Time Headway modeling have focused on homogeneous traffic, on uninterrupted urban roads, freeways or highways. The situation in Marrakesh is very different where traffic is heterogeneous and intersections are close especially signalized ones in the center of the city. This paper proposes a study of Time Headway on four urban roads with heterogeneous traffic conditions, interrupted by a signalized intersection. A sampling approach is used taking into consideration the signal plan of the preceding intersection. Time Headway samples are then compared to theoretical models used in literature adding also a Paretian model (Pareto type IV) which was discussed in the past as a potential candidate. The study shows that TH distribution in these roads is different from the usually studied roads which is why some of the common models are rejected compared to Pareto type IV that fits well all the TH samples representing different traffic flow levels.

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Keywords: data analytics, urban traffic, heterogeneous traffic, time headway modeling, traffic analysis

1. Introduction and literature review

One of the main variables in traffic theory is the Time Headway (TH). Given a measurement point, TH is the time elapsed between two consecutive vehicles arriving to a road section.

This arrival of vehicles is considered as a random time series and therefore the TH is a random variable[1]. The distribution of this variable is the main focus of many studies including (i) level of service analysis which is a qualitative measure used to define the quality of traffic service (fluid, congested...etc.) on a given

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road under given conditions; (ii) capacity analysis which is a quantitative assessment of the ability of a road to handle vehicles; (iii) traffic safety analysis and (iv) traffic generation for simulation.

Many probabilistic models have been used in literature to represent the TH variable. Adams[1] proposed the use the Exponential model for TH distribution for low level traffic (approximately 500 veh/h). Greenberg[2] proposed a Log-Normal model for TH. In an attempt to classify the headway model for each traffic state, May[3] proposed three TH models for three traffic states on a freeway with homogeneous traffic: the Negative Exponential model for low traffic state, the Gamma model (Pearson Type III) for intermediate traffic state and the Normal model for a high traffic (constrained traffic). Al-Ghamdi[4] performed a similar study on uninterrupted sections of 13 freeways and seven arterial in Riyadh, Saudi Arabia and found that Negative Exponential is fit for low levels of traffic flow ($<$ 400 veh/h), Shifted Exponential and Gamma models for intermediate traffic state (400 to 1200 veh/h) and Erlang model for high traffic state ($>$1200 veh/h). Ha et al.[5] did an extensive study of headway models on uninterrupted sections (RN118 and A6 motorway) on south Paris using simple, combined and mixed models to eventually find that Gamma based Semi-Poisson model and Gamma based Generalized Queuing model (Gamma-GQM) are statistically equivalent and provide the best fits in a wide range of TH samples. The TH also has been studied to compare the models in different traffic contexts[6]. However, these studies are done on uninterrupted freeways and arterial sections of road and also on a homogeneous traffic. Jang[7] on the other hand analyzed TH on a suburban arterial and divided the data to five traffic flows (5-9, 10-14, 15-19, 20-24, 25-29 veh/min).

He found that Johnson SB model was best fitting a traffic flow of 10-14 veh/min, and Johnson SU for the other remaining flows. Log-Normal and Log-logistic were also accepted for high flows. Suresh et al.[8] analyzed the TH of ten uninterrupted four-lane roads (two lanes on either side) on Chennai city with a heterogeneous traffic. They found that three models best represent the TH data of these roads (Log-Normal, Inverse Gaussian and Exponential models), which also led to a capacity estimation study on the concerned roads[9]. Other distributions have been used in the last years (generalized Gamma[10], Log-logistic[11], Weibull[12] and others[8]). The Pareto family was proposed as a promising family of models to describe TH by Greenberg[13] and was tested on 751 consecutive vehicles of the same type gathered by the Port of New York Authority in the Holland tunnel. It was found that a Paretian law may be useful as an approximation of the TH variable.

In this paper, we analyze TH data from four urban roads preceded by signalized intersection under heterogeneous traffic conditions in the city of Marrakesh. A periodicity analysis of the arriving vehicles on each road is used and lead to a decomposition of the data based on signal phases of the preceding intersection. The samples are then divided into sub-samples representing different traffic flow levels. Six TH models are used to see the most suitable model in different traffic flow levels. The parameter estimation is done using an aggregation of the Moments Estimation (ME) method and the Maximum Likelihood Estimation method (MLE). The comparison is done using a non-parametric Kolmogorov-Smirnov (K-S) goodness of fit test with a random sampling approach and a threshold variable we call the non-rejection rate measuring the number times the model is not rejected divided by the number of times the parameter estimation process is done.

In Section 2, we present the case study on the traffic in Marrakesh describing the traffic infrastructure and behavior of motorists. Section 3 describes the TH analysis process consisting of processing the data, sampling, Time Headway models parameter estimation and the comparison of the models to empirical data. Section 4 is dedicated to the discussion of the results.

2. Traffic in Marrakesh

The traffic in the city of Marrakesh is heterogeneous. Two-wheelers and four-wheelers are the most common, but there are also buses and even chariots (horse drawn carriages, used commonly by tourists). Heavy trucks are more used in the peripheral roads and the industrial zones.

The driving behavior of two-wheelers is opportunistic and non-lane based. Two-wheelers drivers prefer using the right available lane on a road, but they change lane quickly either by right or left overtaking to avoid being stuck in traffic jams. At a stop or a signalized intersection, they overtake to the front of lines of waiting cars. Due to this behavior, a platoon of two-wheelers is observed in the front of the queue discharging when the light is green.