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Investigation of Headway Distribution of Traffic Dominated by Motorcycles

Hassan Shuaibu Abdulrahman*[1], Stephen Sunday Kolo [2], Mahmud Abubakar[3] Mohammed Shehu[4]

[1]*Federal University of Technology, Civil Engineering Department, Nigeria, abdul.hassan@futminna.edu.ng*
[2] *Federal University of Technology, Civil Engineering Department, Nigeria, s.kolo@futminna.edu.ng*
[3]*Federal University of Technology, Civil Engineering Department, Nigeria, mahmud1879@futminna.edu.ng*
[4]*Federal University of Technology, Civil Engineering Department, Nigeria, moh.shehu@futminna.edu.ng*

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Motorcycles; headway distribution, kernel distribution, goodness-of-fit, P-value, developing countries

Abstract

The use of lower class vehicles such as two or three wheelers have become the preferred urban transport in some developing countries. However, most of the traffic theories adopted are from developed countries where cars are prevalent. The headway probability distribution models can be used to describe vehicle-to-vehicle interactions. Most of these distributions are parametric and makes an underlining assumption about the data. A case study was conducted to investigate the performance of the different probability distributions that best describes the vehicle to vehicle interaction of motorcycle dominated road in Bida, Niger state Nigeria. The different parametric distributions and non-parametric distribution (Kernel) of the data were tested for the goodness-of-fit. The test results indicate that the kernel distribution fits best with improved P-values which in turn gives a better description for the headways than other distribution models considered. This study can serve as a foundation for developing generalized headway models in developing countries.

Introduction

Headway studies can be used to depict the individual vehicle-to-vehicle interaction in order to ascertain the safe operations of highways. The importance of carrying out such traffic analysis includes; analysis of road safety issues, estimation of road capacity and level of service, and the ease of data collection, etc. [1]. The probability distribution models can be used to describe headway data. These models are location dependent and sensitive to local conditions such as class of vehicles, driver behaviours etc. In some cities in Nigeria, the use of lower class vehicles such as two or three wheelers as personal and public transport is fast becoming the main stay in urban mobility. In 2016 alone, motorcycles form about 50% of all newly registered vehicles in Nigeria [2]. Previous studies on motorcycles in Nigeria concentrated on issues such as; their emergence as a public transportation mode, characteristics, education and road safety concerns [3,4,5]. Motorcycle traffic do not behave like conventional vehicles because they tend to be more aggressive, drive parallel to other vehicles, creating a near zero headways which might cause the risk of accidents [6]. Most important works pertaining to headway modelling are related to other vehicle interaction other than motor cycles [7]. While those relating to motorcycles have varying distributions representing this phenomenon especially for heterogeneous traffic where vehicles arrivals tend to be random in nature. This suggest a non-normal distribution which agrees with the probability distribution of homogeneous traffic [8- 9]. Furthermore, these distributions are parametric i.e.it is assumed that the observed data agrees with a particular distribution. These presumptions may affect the efficacy of the model especially under different circumstances of time, location and other human- induced factors [10]. Despite the persistent accidents recorded due to the proliferation of motorcycle use in some parts of Nigeria, only a few reports can be found in the literature on motorcycle headway models especially in Nigeria. This study is presents application of non-parametric distribution method in defining the headway data of motorcycle dominated traffic in Nigeria.

Material and Method

Due to high proportion of motorcycle in traffic flow, landzhu road in Bida LGA Niger state was selected based on pre-feasibility studies that was carried out on some selected roads. The selected road has more than 70% of motor cycle traffic, 28% of car traffic and very about 2% heavy vehicles. Landzhu road is 2 lanes 2-way. The road width of are 7.5m. The data was collected using a digital video recorder for morning, afternoon and evening peak hours 8.00-9.00 am, 1.00-2.00 pm and 5.00-6.00pm respectively. Only headway data involving motorcycles were collected. The data was analysed using the following process; Histogram (check for skewness of data), descriptive statistics, and determine best fit distribution (common parametric vs non-parametric).

Results

The results of descriptive statistics, hypothesis testing, and best distribution are thus presented

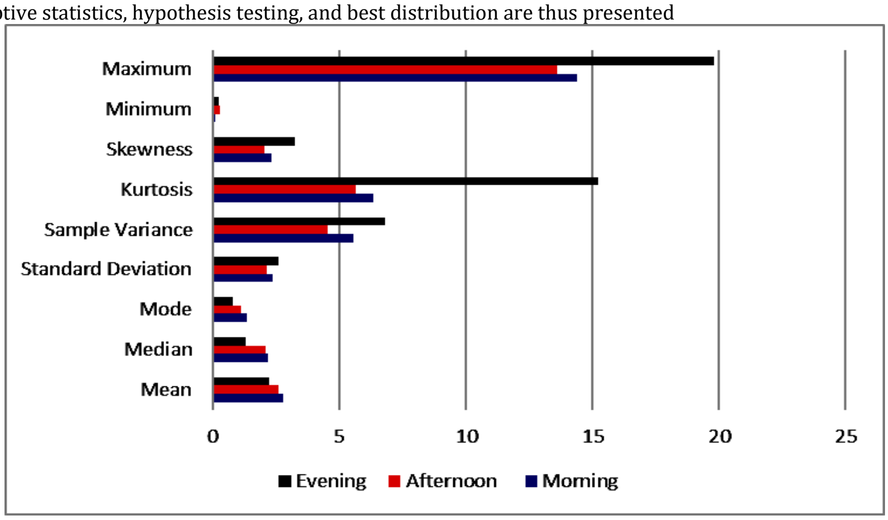

Figure 1. Quantitative description of the data set

Discussion

Figure 1 Shows the descriptive statistics for the headway data sets. The headway data for all times is right skewed which implies that the higher headway values are fewer and more vehicles drive at shorter headways. This represents a non-normal distribution. Similarly, the kurtosis values are non-zero strengthening the earlier argument. The degree to which these descriptive statistics values vary can be attributed to the different times the data was collected. In all statistics, the modal headway during the evening peak is lower than for other peaks. This implies a dangerous attitude of the motor cycles riders riding at shorter headways where there is poor visibility and a potential for accidents. Even though its standard deviation is higher which shows the presence of outliers. This may not be unconnected with the fact little or no enforcement exists during the evenings.

Table 1. Hypothesis Testing and Best Fit based on P-value

SN	Distributions	Morning		Afternoon		Evening	
		P values	Chi^2	P values	Chi^2	P values	Chi^2
1	Weibull	0.0003	1	0.0054	0	0.1029	1
2	Inverse Gaussian	0.0516	0	0.0724	0	0.5194	0
3	Gamma	0.0125	1	0.0014	0	0.2763	1
4	Lognormal	0.2388	0	0.0316	0	0.6162	1
5	Log-logistic	0.5506	0	0.028	0	0.6832	1
6	Burr	0.3099	0	0.0663	0	0.4557	0
7	Generalized Extreme Value	0.2693	0	0.0517	0	0.4717	0
8	Kernel	0.6809	0	0.9589	0	0.8532	0

One of the simpler methods of modelling data with a smooth function is the parametric polynomial trend line equations. It fits a polynomial function of a certain degree to the data the degree of the polynomials determines number bends. The trend line equations were fitted to probability density functions and the following equations ensued for morning, afternoon, and evening data respectively with high R^2. The high variations in headway data resulted high degree of the polynomial equations which may not necessarily capture the true relationships especially for complex. However, it may be necessary to confirm the nature of the distribution by using Chi-square distribution to test a more powerful non-parametric method. Table 1 shows the result of hypothesis test as regards

$$y = -0.00006x^6 + 0.0025x^5 - 0.0408x^4 + 0.3269x^3 - 1.346x^2 + 2.5594x - 1.4592 \quad R^2 = 0.99 \quad (1)$$

$$y = -0.00004x^6 + 0.0018x^5 - 0.0283x^4 + 0.226x^3 - 0.93x^2 + 1.77x - 0.95 \quad R^2 = 0.99 \quad (2)$$

$$y = -0.00006x^6 + 0.0023x^5 - 0.0435x^4 + 0.2692x^3 - 1.06x^2 + 1.88x - 976 \quad R^2 = 0.96 \quad (3)$$

whether the distribution belongs to a known distribution. "0" and "1" represents acceptance or rejection of hypothesis. The null hypothesis is that the data comes from same distribution and the alternative is that it does not. From the Table 1 it can be seen that the headway data agrees with the null hypothesis with only a few. Considering the P-value in Table 1, it can be seen the kernel distribution has the highest P-values for all cases. Although some parametric models performed well at different time periods, the kernel distribution still out performs them. This is because the kernel distribution tends to conform with the given data and this may lead to the problem of overfitting. Another point why the non-parametric distribution fits best can be attributed to randomness of the headway distribution associated with motorcycles. This makes it difficult to have realistic assumptions about the underlying distributions. The results indicate some unique characteristics for the different time periods. Moreover, the uncertainties associated with traffic flows and the human induced vehicle interactions, makes it difficult to have a parametric distribution model that represents headway data adequately. This result strengthens the need for site and condition specific distribution models to represent headways.

Conclusion

This study models the headway distribution of motorcycle dominated traffic. The descriptive statistics points to a non-normal distribution of the headways. Polynomial equations were also generated to ascertain the nature and all equations had high degrees (6) with high R^2. The performance of the different non-parametric distributions was assessed using the Chi-square statistics. The test results indicate that, the kernel distribution improved the P-values and showed a much better fit which in turn gives a better description for the headways than other parametric distribution models. This study can serve as a foundation to a generalized kernel model for traffic patterns of site specific locations especially where motorcycle dominates.

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