Headway Distribution on Urban Roads under Heterogeneous Traffic Condition

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Abstract

This study examines time headway distributions on urban roads in Sri Lanka, emphasizing the impact of heterogeneous traffic conditions. Headway, which refers to the temporal gaps or spacing between consecutive vehicles on the road, plays a pivotal role in shaping traffic flow, congestion, and road safety, making its understanding essential for effective traffic management and urban planning as a microscopic parameter offering insights into macroscopic traffic behaviors. This parameter finds application in capacity analysis, safety evaluations, accident investigations, car-following behavior models, and lane change propensity studies. The problem lies in the lack of comprehensive research on headway distribution in urban traffic settings marked by significant heterogeneity. The prevailing focus on homogeneous traffic conditions in conventional traffic research, often limited to low and medium flow situations within lane-based vehicle flow scenarios. However, urban road networks in Sri Lanka frequently encounter highly diverse traffic conditions due to the presence of diverse vehicle types like three-wheelers, motorbikes, mini-lorries, buses, and heavy vehicles, each with varying physical attributes, axle configurations, weight distributions, power ratios, varying driver behaviors, and multitude road users. Moreover, road discipline issues and truncated inter-vehicle distances due to aggressive driving further complicate traffic analysis. The primary aim is to determine appropriate distribution models for various traffic flow ranges and leader-follower pairs on different road segments and rigorously evaluate their statistical validity through a range of goodness-of-fit tests. The data collection involves videographic surveys to capture headway data from selected road sections. The selection process for these road sections involves considering several crucial factors, such as the absence of side hindrances (e.g., parking lots, gradients, bus stops, intersections), the straight and flat nature of the road, the availability of ample shoulder space, favorable weather conditions, good visibility, Optimal driving surface, geometric and functional homogeneity for at least 1 kilometer upstream and downstream. Selected road sections are A004 road at Pannipitiya, A001 road at Kegalla, Marine Drive at Wellawatta and AB -042 road at Hirasagala. For each road section videographic surveys were carried out at three peaks periods during the day, namely 7.00-9.00 am, 12.00-2.00 pm and 4.00-6.00 pm, which were identified during the initial observations of the road sections and also based on the findings of the literature review. Each time interval was sub divided into 15 min intervals in order to identify the variation of flow and calculate the flow rates. Sub-time intervals were defined in such a manner that sample size (number of headways) was large enough for all flow ranges. Time stamps during the entry of the front bumper, vehicle type and speed of each vehicle were extracted from video recordings manually by image processing using software “Traffic Extractor” developed by IIT Bombay to compute time headways. Accordingly, headways between successive vehicles were determined by the time gap between the entry times of front bumpers of successive vehicles. A total of 24,201time headways were collected through the data collection. The analytical framework encompasses two scenarios: studying headway variations across diverse traffic flow conditions and exploring headway data for different leader-follower pairs. The data is

categorized into three flow ranges—below 400 veh/hr indicating free-flowing conditions (Level of Service A and B), 400 to 1200 veh/hr representing moderate flow with some restrictions (Level C), and above 1200 veh/hr denoting highly congested conditions with reduced speeds and potential stoppages (Level D and E) based on computed flow rates. Frequency and cumulative frequency distributions are constructed for each flow range and road section. Distribution model selection relies on established empirical models, with goodness-of-fit assessments carried out using the K-S test, Anderson-Darling test, and chi-square test. Statistical tools such as Easy Fit, NCSS, and SPSS aid in these evaluations. The K-S and Anderson- Darling tests assess the fitness of theoretical distribution models to observed data by comparing cumulative distribution functions, with the chosen model yielding the least discrepancy as the best fit. Easy Fit software aids in conducting these tests, and rejection of the null hypothesis occurs if calculated statistics surpass critical values at a chosen significance level. The study examines various flow ranges across different road sections and tests the goodness-of-fit of several distributions, including Generalized Extreme Value, Johnson SU, Pearson, Generalized Gamma, Beta, and Burr. In conclusion, the research findings suggest that the "General Extreme Value" distribution consistently emerges as a strong and versatile candidate for describing traffic flow behavior in the flow range below 400 veh/h. For flow rates between 400 and 1200 veh/h, the Gen. Gamma (4P) distribution proves to be the most suitable choice. In the flow range above 1200 veh/h, the Gen. Gamma distribution also performs well. Moreover, the study reveals varying degrees of variability, skewness, and kurtosis in leader-follower relationships across different vehicle classes, indicating the need for tailored approaches to traffic management and safety analysis. The research contributes to a deeper understanding of headway behavior in diverse traffic scenarios, offering practical implications for transportation engineering and management, safety analysis, and infrastructure planning. It underscores the importance of tailoring headway distribution models to specific traffic conditions and vehicle relationships, providing valuable insights for traffic management and infrastructure planning in Sri Lanka and similar urban environments.

Keywords: *Time headway, Heterogeneous Traffic, Distribution Model, Flow range, Goodness of Fit*

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