Development of Queue Estimation Algorithms for Urban Intersections in Mixed Traffic Conditions

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Declaration

I hereby declare that to the best of my knowledge, this submission is my own work and it neither contains direct material previously published nor written by another person or material, which to substantial extent, has been accepted for the award of any other academic qualification of a university or other institute of higher learning except where acknowledgement is made in the text.

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Abstract

Traffic congestion has increased globally due to rapid urbanization and expedited economic developments in many countries. Vehicle queues are a governing aspect of traffic congestion, studied over the past decades. Most of the existing queue estimation approaches are limited to homogeneous traffic conditions. However, the traffic conditions in many developing countries are heterogeneous and are heavily influenced by mixed vehicle composition, lane changing, and gap-filling behaviors. This study aims to estimate the queue length at signalized intersections having heterogeneous traffic conditions. The methodology employed in this study integrates both statistical and neural network analyses utilizing a time-series approach. A key innovation in this research lies in the incorporation of heterogeneity considerations, where Passenger Car Units (PCU) are assimilated into the measurements of traffic flow and lane-changing movements within the analyzed road section. The influential factors impacting queue length were examined, encompassing arrival flow, discharge flow, outbound lane change, inbound lane change, and signal configuration.

The statistical analysis was undertaken through an econometric approach, representing another novel contribution to queue estimation studies. Vector Auto Regression (VAR) models were developed to estimate queue lengths for signalized and unsignalized intersections. The VAR estimation results demonstrated heightened accuracy in queue estimation and practical applicability for prediction, capturing the traffic characteristics of the formed vehicle queue. However, limitations were identified, particularly in terms of lower prediction times, which impeded the practical utilization of the model for traffic management. Consequently, to address this limitation, neural network analysis using the Long Short-Term Method (LSTM) was incorporated to enhance queue predictions over longer time sequences. While the neural network exhibited promise, challenges in data collection contributed to lower accuracy in predictions. Notwithstanding the challenges, the methodological development in this thesis presents a promising direction for queue estimations under heterogeneous conditions. This advancement brings the scientific and research field one step closer to improved queue estimation methods within this specific scope.

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Abbreviations

ACF	Auto Correlation Function
ADF	Augmented Dickey Fuller
AR	Auto Regression
ARIMA	Auto Regressive Integrated Moving Average
FIFO	First-In-First-Out
HGV	Heavy Goods Vehicle
KF	Kalman Filter
LGV	Light Goods Vehicle
LIFO	Last-In-First-Out
LR	Likelihood Ratio
LSTM	Long Short-Term Method
LWR	Lighthill-Whitham-Richards
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error
MGV	Medium Goods Vehicle
MSE	Mean Squared Error
PACF	Partial Auto Correlation Function
PFIPFO	Probably-First-In-Probably-First-Out
ROW	Right of Way
RMSE	Root Mean Squared Error
SLIIT	Sri Lanka Institute of Information Technology
TIM	Tail Interval-based Method
VAR	Vector Auto Regression