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Intersection Queue Length Estimation Using Connected Vehicles

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INTRODUCTION

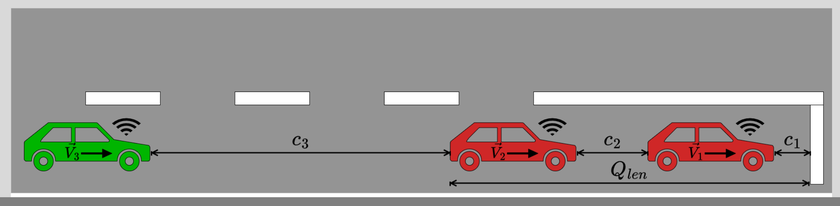
Traffic congestion and safety challenges in urban areas are key issues for today‘s societies, creating a need for more efficient traffic control systems. Such advanced control system require accurate data in real-time to function.

With the rise of Connected and Autonomous vehicles (CAVs) new opportunities for real-time data collection emerge. Of particular interest is the estimation of queue lengths on signalized intersection, as this data are important for the estimation of traffic network state used for adaptive traffic signal control

Objective of this research is to create a methodology for estimation of queue lenghts by processing data collected from CAVs. The obtained estimate will be compared to ground truth values with various levels of CAV penetration rates.

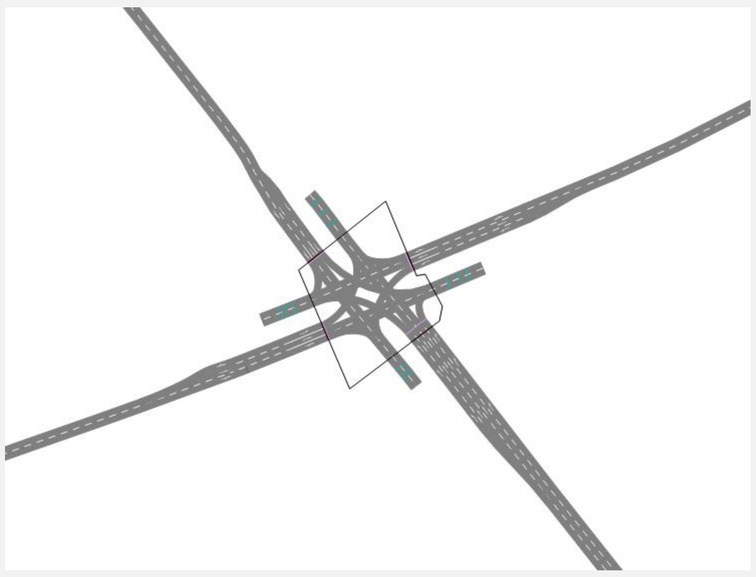
MATERIALS, METHODS & IMPLEMENTATION

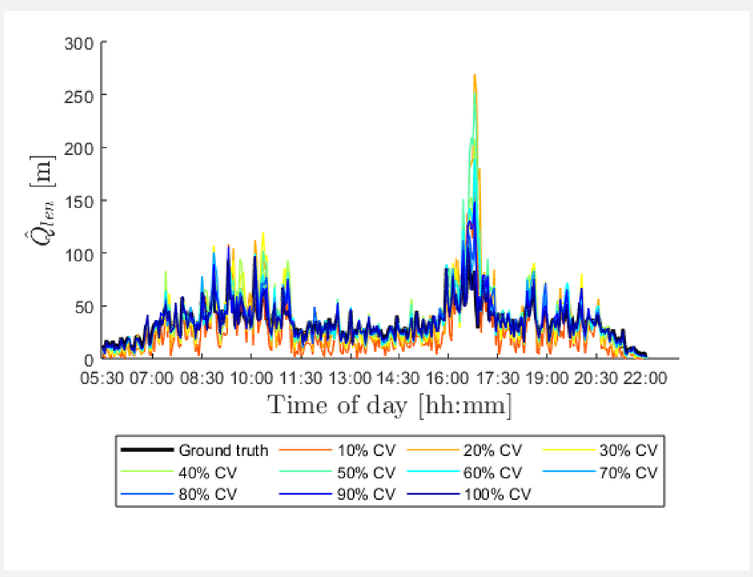
The determination of the queue length is illustrated in the figure below. The red vehicles in the figure meet the queue criteria, thus, the total queue length is equal to the distance of the last red vehicle to the stop line with the added vehicle length. The green vehicle does not meet the queue criteria due to the large distance from the vehicle in front. If CVs are used as a data source, the accuracy of the queue length estimation will depend on the penetration of CVs into the traffic flow. The queued status of vehicles is determined using the measured vehicle speed and clearence to the vehicle in front. To test the validity of the proposed methodology, a simulation model in PTV VISSIM including various CV penetration rates will be used to obtain CV data and ground truth queue length values.

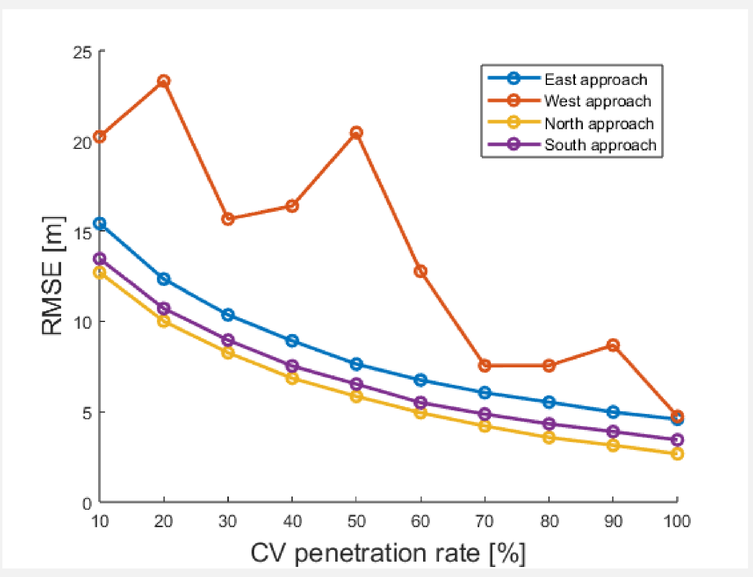


RESULTS

The methodology used to estimate queue lenghts from CVs data shows that even with low CV penetration rates a reasonable queue length can be estimated. Moreover, even with some introduced error the general trend of the estimate closely correlates with the ground truth values. This shows that even low CV penetration rates (10%-30%) could be used to obtained a general insight into traffic trends. For adaptive traffic signal control a more precise estimate (above 30%) is needed. Analysis with respect to individual intersection approaches indicates that the methodology performs well when the number of left turn movements is low, but can strugle when the number is higher.







CONCLUSION & IMPLEMENTATION PATH

This paper introduces a methodology for assessing the traffic states of intersections by utilizing data derived from CVs. The findings indicate that even with a low penetration rate of CVs within the traffic stream, it is feasible to accurately estimate queue lengths despite an unknown penetration rate of CVs. The proposed methodology offers an efficient approach for estimating traffic states at intersections amidst mixed traffic flows comprising CVs and conventional non-connected vehicles. This state estimation could subsequently be employed for real-time traffic signal management in zones devoid of other traffic measurements, or to supplement existing data collection efforts.

Future research efforts on queue length estimation should prioritize the identification of gaps within queues attributable to shock waves, thereby, enhancing the understanding of traffic dynamics at intersections. It is imperative to integrate estimated queue lengths with real-time traffic control systems to evaluate the system's performance under varying conditions of CV penetration rates. Furthermore, the scope of the study can be expanded by augmenting the traffic network to include more interconnected intersections. This expansion allows for the analysis of specific instances of queue overflow that affect preceding intersections.

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