A Microscopic Investigation into the Capacity Drop: Impacts of Bounded Accelerations and Reaction time

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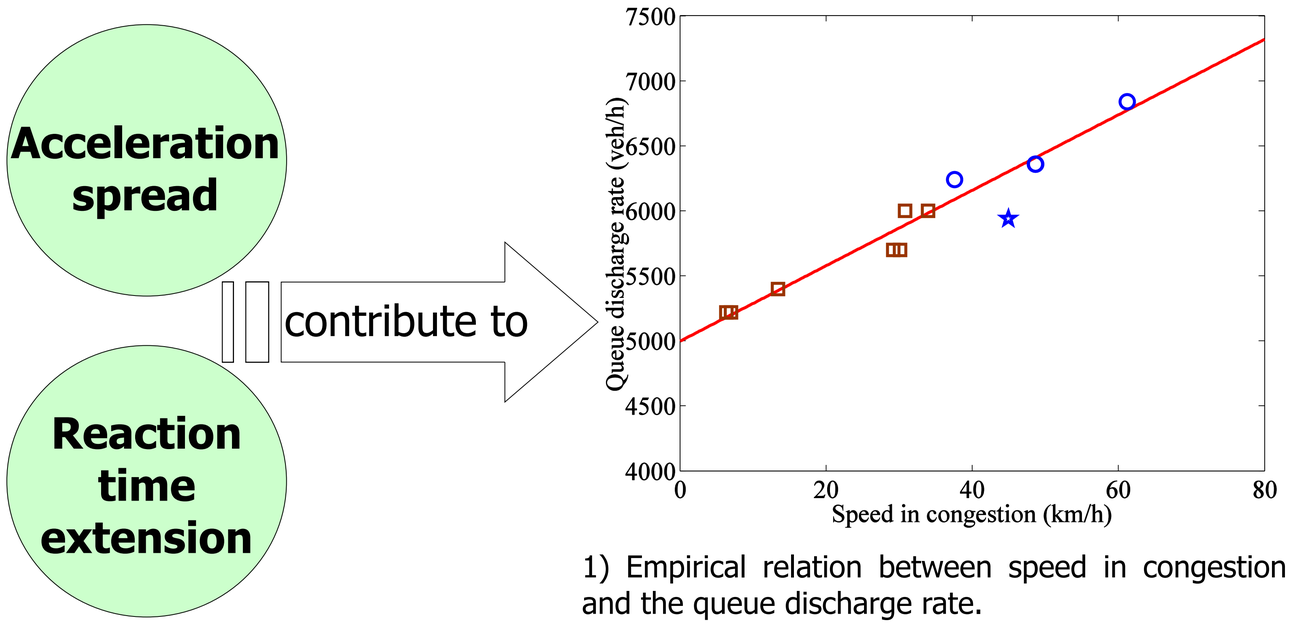
Abstract

The capacity drop indicates that the queue discharge rate is lower than the free-flow capacity. Empirical data show that the queue discharge rate increases as the speed in congestion increases. Insights into the underlying behavioral mechanisms that cause these variable queue discharge rates can help minimize traffic delays and eliminate congestion. However, to the best of the authors' knowledge, few efforts have been devoted to testing impacts of traffic behaviors on the queue discharge rate. This paper tries to fill this gap. We investigate to what extent the acceleration spread and reaction time can influence the queue discharge rate. It is found that the (inter-driver) acceleration spread does not reduce the queue discharge rates as much as found empirically.

Research question

To what extent



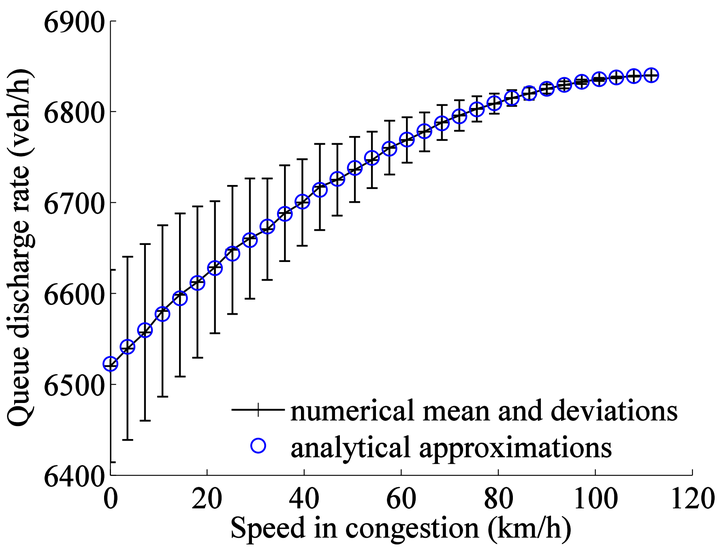
1) Empirical relation between speed in congestion and the queue discharge rate.

Studied mechanisms

- Acceleration spread

Voids can be created between a low-acceleration vehicle and its high-acceleration predecessor.

√ Acceleration follows uniform distribution bounded by 0.5m/s^2 and 2m/s^2.
√ Analytically studied.
√ Examined in numerical experiments.
√ The acceleration spread hardly contributes to the capacity drop.

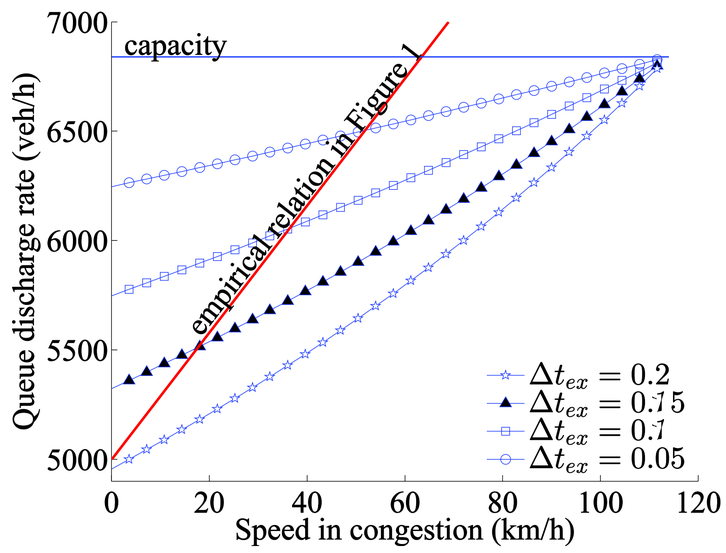


2) Capacity drop due to the acceleration spread

- Reaction time extension

Voids can also be created if the followers reaction time is longer than Newells reaction time.

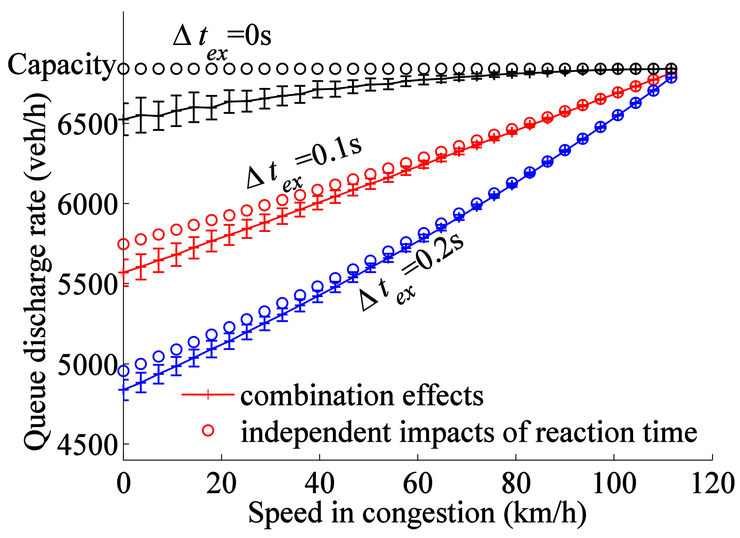
√ Analytically studied.
√ Reaction time extensions can influence capacity drop considerably.
√ To give empirical results, the reaction time should decrease as the speed in congestion increases.



3) Capacity drop due to the reaction time extension

- Combination effects of acceleration spread and reaction time extensions

√ Examined in numerical experiments.
√ The acceleration spread hardly contributes to the capacity drop.
√ To give empirical results, the reaction time extension decreases as the speed in congestion increases.



4) Capacity drop due to the combination effect

Conclusions

This paper reveals the impacts of bounded accelerations and reaction time on the queue discharge rate.

- The impact of inter-driver acceleration spread on the queue discharge rate is rather small.
- No matter whether the reaction time is considered or not, the acceleration spread does not decrease the queue discharge rate as much as found empirically.
- A speed-dependent reaction time extension mechanism, that is the reaction time decreases as the speed in congestion increases, yields a similar relation between the speed in congestion and the queue discharge rate as found in empirical observations.

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Project: there is plenty of room in the other lane

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