Modelling lane changing behavior at freeway weaving sections

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Abstract:

A freeway weaving section is a section of freeway where an on-ramp is closely followed by an off-ramp. By 'closely' it is implied that the distance is not long enough for the merge and diverge to operate independently. As a result, the merging and diverging maneuvers interact with each other forming a weaving pattern on the freeway section - hence the name weaving section. Weaving sections may cause bottlenecks on the freeway and might reduce its capacity. The lane changing behavior in the conflicting traffic streams from the merging and diverging flows is generally considered as the main source of the problem. Therefore, there is a need to carefully investigate the lane changing behavior at freeway weaving sections in order to understand how it differs from the usual lane changing behavior described by the recognized lane changing models.

This research is based on measurements from a weaving section at Hagnau-Gellert near Basel city in Switzerland. Measurement of this weaving section was carried out over five days between 15:30-19:30, which covered the evening peak period. Two kinds of technology were used to collect data. The first was the camera. Four cameras were installed on two tall buildings near the weaving section to record activities along the whole segment of the weaving section. The second technology was a new type of advanced radar from SmartMicro, which tracked the trajectories of vehicles detected. The radars covered the merging and diverging sections, each 100 meters long at the beginning and end of the weaving section. By examining the empirical data, two characteristics of lane changing behavior specific to the weaving section were identified.

The first behavior characteristic is the preference of the F-R and R-F drivers on where to make the weaving lane change along the weaving section. A weaving lane change is a compulsory lane change in the lane changing models. A compulsory lane change is usually modelled with a destination route choice, where the driver will look out for a suitable lane changing opportunity during the journey. When the car arrives at the last opportunity to make this compulsory lane change, it will stop to wait for such a lane changing opportunity. Therefore, when the traffic becomes more congested, we expect to see more cars stop to make the weaving lane changes near the end of the weaving section, because these cars cannot find a suitable opportunity earlier on the weaving section. However, empirical data contradicts this hypothesis which implies that the usual lane changing models do not adequately describe the compulsory lane changes at weaving sections. The position to make the weaving lane change is mostly determined by the drivers' preference rather than the traffic condition. This preference is probably country specific depending on both local driving habits and the weaving site configuration. However, for a specific weaving site, this preference is consistent over different days and traffic conditions. For example, in the weaving section near Basel, Switzerland, our empirical data shows that consistently more than 70% of the weaving lane changes take place within the first 20% (100 meters) of the weaving section. This behavior is consistent over days

and different periods in each day with different traffic conditions.

The second behavior characteristic is the preference of F-F drivers to avoid R-F cars by merging into the fast lane. Such a maneuver is a discretionary lane change in the lane changing models. In these models, the decision on whether to make this discretionary lane change mostly depends on the possibility to make this maneuver. Therefore, we expect the prevalence of such discretionary lane changes would depend on the traffic condition. However, empirical data contradicts this hypothesis which implies that the usual lane changing models do not adequately describe the discretionary lane changes at weaving sections. In the first 100 meters of the measured weaving section, there is a strong correlation of R-F lane changes and induced lane changes of the F-F cars from the middle lane onto the fast lane. Most surprisingly, there are many periods during which the fast lane is more congested than the middle lane resulting from the F-F cars changing into the fast lane to avoid the R-F cars. This suggests that the preference of the F-F drivers to avoid cars making weaving lane changes could have a stronger impact than the traffic condition in determining the discretionary lane change at freeway weaving sections.

The purpose of this paper is twofold. Firstly, empirical data is analyzed to demonstrate the importance of incorporating the above two additional factors to correctly model traffic behavior at freeway weaving sections. It is shown that freeway weaving sections exhibit these two special characteristics and the usual lane changing models are inadequate. Secondly, specific methods are proposed to incorporate these two extra factors into lane changing models for freeway weaving sections. As an example, a micro-simulation model was built with VISSIM to model the measured weaving site near Basel, Switzerland. The preference of the F-R and R-F drivers on where to make the weaving lane change along the weaving section is modelled with an extra parameter which describes the distribution of route choices. The preference of the F-F drivers to avoid cars making weaving lane changes by merging into the fast lane is modelled by changing a set of parameters related to gap acceptance. The simulation model is calibrated and validated with empirical data. It is demonstrated that by incorporating these two extra factors into the lane changing model, the lane changing behavior at the weaving section could be correctly modelled.

The importance of these two additional factors in modelling driving behavior at freeway weaving sections suggests the importance of the two identified characteristics in determining the performance of the weaving section. The paper eventually proposes a mechanism of how these two characteristics of lane changes at freeway weaving sections could affect capacity of the freeway section and cause bottlenecks.