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Final Report

Project Title:

Modeling Cooperative Driving Behavior in Freeway Merges

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Background:
Merging locations are major sources of freeway bottlenecks and are therefore important for freeway operations analysis. Microscopic simulation tools have been successfully used to analyze merging bottlenecks and to design optimum geometric configurations and control strategies for such locations. In congested situations, acceptable gaps for merging are often not available and freeway mainline drivers often cooperate with the on-ramp drivers and create gaps for the merge. This is usually done either by decelerating or by changing to an inner freeway lane. Also, in some cases the merging driver may become impatient and decide to force in, which compels the lag driver in the freeway to decelerate. The lane-changing and acceleration decisions of the freeway mainline driver are therefore not only based on his present situation, but also influenced by the anticipated intention of the merging driver (e.g. whether or not the merging driver is executing a forced merge). Consequently, the merging models developed for a particular freeway may not be applicable to other freeways.

Objective:
The objective of the model was to develop a merging model for freeway conditions and explore transferability of such models across multiple locations. The model was estimated with trajectory data collected as part of the NGSIM project from I-80, CA and US-101, CA. The estimated models used a utility based framework and accounted for the unobserved heterogeneity among the drivers.

Methodology:
The model was developed using a two stage process. In the model estimation, the parameters of the model most likely to have generated the observed vehicle trajectories were estimated with disaggregate trajectory data using the maximum likelihood (MLE) technique.

For testing the model transferability in the disaggregate level, the likelihood-ratio test methodology estimated ‘unrestricted’ and ‘restricted’ models using ‘pooled’ data from the two networks. The goodness-of-fit statistics of these models (represented by log-likelihood) were compared. In the unrestricted model, the parameters were allowed to vary between the two datasets (i.e. parameters were assumed to be non-transferable). In the restricted model, the parameters were assumed to be exactly the same for the two datasets (i.e. parameters were assumed to be transferable).

Since users are primarily concerned with aggregate results (e.g. travel times, speeds, queue lengths etc.) in the application of simulation tools, transferability of models in an aggregate level is often of greater interest. Therefore, the estimated models were implemented in the microscopic traffic simulation tool MITSIMLab and tested for aggregate level transferability using relative error measures like Root Mean Square Error (RMSE) and Root Mean Square Percent Error (RMSPE) as indicators of accuracy in aggregate prediction. The following ratio, often termed as ‘Transferability Score’ (used by Koppelman and Wilmot, 1982, for travel demand model transferability), was used as an indicator to test aggregate transferability:

Transferability Score= $\frac{RMSPE_{Transferred}}{RMSE_{Local}}$

Where,

$RMSPE_{Transferred} = RMSPE$ of transferred model

$RMSPE_{Local} = RMSPE$ of model re-estimated with local data

$$RMSPE = \sqrt{\frac{1}{N}\sum_{n=1}^{N}\left(\frac{Y_n^{sim} - Y_n^{obs}}{Y_n^{obs}}\right)^2}$$

Y_n^{obs} and Y_n^{sim} are the averages of observed and simulated measurements at space-time point n, calculated from all available data (i.e. several days of observations and/or multiple simulation replications). It may be noted that unlike the likelihood-ratio test, aggregate transferability is simulator dependent.

Findings:

The results of the likelihood-ratio test on the developed merging models indicated that an estimated merging model may not be directly applied to all congested situations. The selected case study found that to apply the estimated model in a different network with largely different characteristics, at least six parameters should be adjusted. These include location-specific constants, standard deviations, and coefficients of driver-specific random terms (both for lead and lag gaps).

For testing transferability in an aggregate level, transferability scores were used. The findings revealed that after aggregate calibration, it is possible to get a reasonably close match between the local and the transferred model. However, it may be noted that the aggregate transferability is simulator dependent (unlike disaggregate transferability).

Conclusions:

It must be noted that though this research provides a rigorous framework for testing transferability of merging models across networks, both in disaggregate and aggregate levels, and demonstrates the methodologies through empirical case-studies, the case-studies are not sufficient to generalize the results. For this, more empirical studies with more diverse networks, merging situations and traffic mixes need to be executed.

References:

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