Parameter Estimation and Statistical Inference of a Two-regime Car-following Model

Tu Xu

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Directed by Dr. Jorge Laval

This thesis presents the formulation of a family of two-regime car-following models where both free-flow and congestion regimes obey random processes. This formulation generalizes previous efforts based on Brownian and geometric Brownian acceleration processes, each reproducing a different feature of traffic instabilities.

We show that the unified model is able to capture virtually all types of traffic instabilities consistently with empirical data, including oscillations, speed-capacity relationship, and the concave growth pattern of vehicle speeds along a platoon.

The probability density of vehicle positions turns out to be analytical in our model, and therefore parameters can be estimated using maximum likelihood. This allows us to test a wide variety of hypotheses using statistical inference methods, such as the homogeneity of the driver/vehicle population and the statistical significance of the impacts of roadway geometry.

Using data from two controlled car-following experiments and one uncontrolled car-following dataset, we find that (i) model parameters are similar across repeated experiments within the same dataset but different across datasets, (ii) the acceleration error process is closer to a Brownian motion, and (iii) drivers press the gas pedal harder than usual when they come to an upgrade segment. The model is flexible so that newer vehicle technologies can be incorporated to test such hypotheses as differences in the car-following parameters of automated and regular vehicles, when data becomes available.