INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Modeling of Inter-Vehicular Gaps and Driver Behavior in Heterogeneous Traffic Stream with Weak Lane Discipline

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SHORT ABSTRACT

The traffic stream of developing countries like India is different than that of the developed world, due to two peculiar phenomena- (i) Weak lane-discipline (random placement of vehicles over entire width of the road) and (ii) Presence of heterogeneous or mixed traffic; or large number of vehicle types. In such traffic conditions, reaction of drivers is not just in the form of acceleration or deceleration but also simultaneous veering or lateral movement. Thus, lateral and longitudinal gap-maintaining become important parameters in such traffic stream. Previous studies on such traffic have not incorporated the lateral and longitudinal gap-maintenance behavior in their proposed simulation models extensively. The studies on gap-maintenance need to incorporate (i) weak lane-discipline, (ii) vehicle variability; and (iii) driver variability. Therefore, a comprehensive simulation model incorporating the realistic lateral and longitudinal gap-maintaining behavior of heterogeneous traffic is required.

Thus, the goal of this work is to develop a simulation model, which can replicate real world traffic conditions in heterogeneous urban, mid-block traffic stream, incorporating the models of inter-vehicular gaps and driver behavior of such a stream. To achieve this goal, initially, a detailed analysis of lateral and longitudinal gaps and their relationship with speeds and vehicle types is presented. Moreover, factors affecting the decision to overtake are also presented. Thereafter, these developed models are incorporated in the developed simulation model, in addition to set of algorithms governing driver behavior in mixed traffic stream.

For this purpose, an accurate data-collection is also required for development of inter-vehicular gap-maintaining models. The lateral gaps are estimated accurately by an instrumented vehicle equipped with ultrasonic sensors (on its both sides) and high accuracy GPS along with a camera is developed to measure lateral clearances and vehicle speeds. More than 6,000 lateral interactions are observed across six different cities with different instrumented vehicle types. On the other hand, study of longitudinal gap-maintaining behavior is conducted by extracting vehicle

trajectories from video images of a recorded traffic stream. The variation of longitudinal gap with speeds and staggering (centerline separation) is obtained for more than 14,000 interactions are across 12 different sections located in different cities of India.

On the analysis of these collected data, inter-vehicular lateral and longitudinal gaps are observed to increase with speed, while longitudinal gaps are observed to decrease with increase in staggering. The variation of lateral clearance with speeds is modeled as a linear regression equation (deterministic part) with positive slope, and Beta-distributed homoscedastic residuals (stochastic part). The variation is different for different vehicle pairs, and it is observed that similar vehicle pairs maintain lesser lateral clearance than dissimilar pairs. Similarly, the variation of longitudinal gaps with speed and centerline separation consists of single degree regression equations (deterministic part) having positive slope with speed and negative slope with centerline separation, and Burr-distributed heteroskedastic residuals (stochastic part). Further, when vehicle interacts (either laterally or longitudinally) with multiple vehicles simultaneously, it is observed that there is significant compromise in gap-maintaining behavior, especially at higher speeds. A categorical

model for decision of overtaking in mixed traffic conditions is developed (using logistic regression), which is used for prediction of overtaking decision, if inter-vehicular gaps and speeds are known.

A rule-based simulation model is developed incorporating lateral and longitudinal gap-maintaining models and overtaking behavioral model, in addition to free-flowing and vehicle following behavioral model. The stochastic nature of various inter-vehicular gap-maintaining relationships is assimilated into the model by means of a risk factor, which is considered as a measure of driver aggressiveness. All vehicle positions are updated simultaneously at discrete intervals of time, using different models mentioned above. Developed model is well-calibrated using genetic algorithms, validated with field conditions, and compared with the commercial simulation software VISSIM (calibrated in the similar way). The validation is conducted for macroscopic properties (speed-flow relationship) and microscopic properties (time headway distribution, speed distribution, average lateral shifts, lateral and longitudinal gap-maintaining behavior, etc). It is observed that for most cases, the developed model can perform better than VISSIM. The developed model is also used for generating specific cases to test its applicability. The capacity of simulated road section can be estimated based on fitting of a generalized model for speed-density relationship. This capacity is observed to increase with increase in desired speed and road width, but capacity per unit road width decreases with increase in road width. The simulation model is also used to study the impact of segregation of buses from other vehicles.

Thus, the simulation model developed on the basis of inter-vehicular gaps can have large contribution to the traffic engineering community, especially for designing road capacity at given desired speeds, widths and compositions; effect of traffic segregation, safety analysis, development of simulators, etc.