Methodology for the Calibration of VISSIM in Mixed Traffic

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ABSTRACT

Mixed traffic, characterized by diverse vehicles, changing composition, lack of lane discipline, etc. is best modeled by micro simulation. However, the majority of the leading micro simulation packages and their calibration methodologies have been developed considering less complex homogeneous traffic. Hence, a methodology for calibrating a micro simulation model for mixed traffic is proposed. Driver behavior in mixed traffic is observed and adjustments were made to represent in the simulation. Calibration parameters were identified using multi parameter sensitivity analysis, and the optimum values for these parameters were obtained by minimizing the error between the simulated and field delay using a genetic algorithm. Multiple criteria were included in the optimization formulation by constraint insertion. The proposed methodology is illustrated using VISSIM, a widely used micro simulation software. Signalized intersections with different traffic characteristics from Mumbai are taken as case study.

INTRODUCTION

Traffic micro simulation models are quickly becoming the standard for the evaluation and development of road traffic management and control systems worldwide. But skeptics often view simulation modeling as an inexact science at best and an unreliable “black-box” technology at worst (1). This skepticism usually results from unrealistic expectations of the capabilities of simulation models and use of poorly calibrated models. Due to the complexities of mixed traffic, not only are there difficulties in collecting and analyzing real world data but also there is a lack of readily available procedures to calibrate simulation models. It is a challenge to understand driver behavior in heterogeneous traffic and calibrate the micro simulators accordingly. The need for a reliable, calibrated model to assess various traffic operations and control in the heterogeneous traffic was the driving force behind this study.

The heterogeneous traffic is characterized by a mix of vehicles having diverse static (length, width, etc.) and dynamic (acceleration/deceleration, speed, etc.) properties. These vehicles include nonconventional motorized as well as nonmotorized vehicles, and their composition is highly transient. Another distinguishing aspect of such traffic is the absence of lane marking and lane discipline resulting in complex movement of vehicles especially at intersections. Often, the lane widths are not uniform. Characteristics and modeling issues of such traffic are well documented in the literature (2).

Most early literature of calibration of micro simulators were primarily confined to homogeneous traffic conditions where good lane discipline is observed. Earlier, researchers informally calibrated simulation models and often used default parameters resulting in large errors (3). Realizing its importance, Hellinga (1), Cohen (4), Dowling et al., (5), Zhang et al., (6) and others suggested general methodologies and techniques for calibration. Along with a set of guidelines Milam et al.,(7) implemented the calibration methodology in CORSIM. Toledo et al., (8) used O-D flow data to calibrate MITSIMLab.

Among the studies on calibration of VISSIM in particular, Fellendorfand Vortisch (9) provided a discussion of the car following and driver behavior logic that is incorporated in the VISSIM. The paper included a detailed analysis of the Wiedemann driver behavior model implemented in the VISSIM. Park and Schneeberger (3) used Latin Hypercube sampling along with a linear regression model to generate scenarios and solve to match the travel times in field and simulation.

Parameter optimization is one of the important calibration techniques, and various algorithms have been applied for solving this problem by obtaining the optimal values for the parameter sets used in calibration. Genetic algorithms (GA) are widely used for solving a wide variety of optimization problems including those related to the calibration of simulation models. GA was explored to determine a suitable combination of parameter values for PARAMICS by Lee et al., (10). Kim and Rilett (11) illustrated a GA-based approach to traffic simulation model calibration using ITS data. Two microscopic simulation models, CORSIM and TRANSIMS, were calibrated for two freeway segments in Houston, Texas. Menenni at al. (12) use a genetic algorithm to calibrate VISSIM based on speed-flow-data. Park and Qi (13) proposed a general methodology to calibrate micro simulation models for isolated intersections using VISSIM as well as CORSIM as an example. In this study, Latin Hyper Cube method was used to generate scenarios and the solution parameter set was obtained by use of GA. The same methodology was tested on a large scale network of co-ordinated signals by Park et al., (14). Mathew and Radhakrishnan (15), made a study on calibration of VISSIM with respect to heterogeneous traffic. A sensitivity analysis was conducted to select parameters and their ranges. An optimization formulation was introduced to find a solution parameter set so as to minimize the intersection delay. Both Wiedemann 74 and 99 models were calibrated at three intersections.
Lownes and Machemehl (16) considered link capacity as measure of effectiveness and conducted experiments with six different combinations of car following parameters of the Wiedemann-99 model in VISSIM. Two way Analysis of Variance (ANOVA) was conducted to find the individual parameters producing significant effect on the value of the capacity as well as the interaction among the parameters themselves. Most of the earlier calibration studies use a single measure of performance for the sake of simplicity. Recently, multi criteria approaches were adopted by Duong et al., (17) in VISSIM and Park and Kwak (18) in TRANSIMS respectively.

Traffic representation is considered important in literature and a visual check is generally suggested after the calibration process. The present study involves the identification and observation of unique features of mixed traffic and techniques to incorporate them in VISSIM. In principle, the work done in this study can be transferred to other micro simulators, as long as they support a continuous lateral movement of vehicles and support the calibration methods by the appropriate user interface, measures of performance output and the ability to interface and interact with an external application.

**METHODOLOGY**

Calibration of a micro simulation model for mixed traffic requires special procedures to address the unique characteristics of such traffic. Accordingly a methodology is proposed which includes representation of vehicles, geometry and traffic, followed by identification of calibration parameters by multi parameter sensitivity analysis, setting their ranges heuristically and determining the parameter values by an optimization model. The traffic representation addresses several distinct features of mixed traffic. The proposed methodology is presented in the form a flow chart in Figure 1. First, to ascertain the need for calibration, the model is to be simulated with the default setting (pre calibration) and the delay values are to be obtained. These values are compared with field values; if the error is insignificant (which is generally unlikely), then the model with default settings can be adopted without any further calibration. If the error is significant, the calibration steps are to be followed.

**Vehicle Representation**

Simulation models typically come with a set of standard types of vehicles such as car, bus, truck, and motorcycle. However, in the case of mixed traffic, several non standard vehicle types such as motorized and non motorized three wheelers exist and these can significantly affect the simulation results. Therefore, the first step in the simulation is to accurately define the static and dynamic characteristics of every vehicle type in terms of length, width, acceleration and deceleration, and speed ranges. For a more accurate modeling, one may consider parameters such as axle configuration, turning radius, etc., for each vehicle type.

**Geometric Representation**

The next step is to represent the intersection accurately. The foremost aspect is to accurately represent the geometry defined by the number of approaches, width of each approach, and turning space, the space occupied by each turning movement in the intersection. The second aspect is the representation of the signal control system. This is comparatively easier since most of the signal systems are similar to, or a simplified form of, the signal systems for homogeneous traffic. The representation includes the cycle time, green time, and red time for each movement group, amber time, and phase sequence.

**Traffic representation**

This phase involves identifying the local characteristics of the traffic and fine tuning the elements of networks so that the traffic in the simulation behaves similar to the one in the reality. One can observe different additional movements in terms of lane changes, smaller vehicles seeping through etc. The available parameters in the simulation model may not be sufficient to replicate certain special movements by the vehicles in mixed traffic, but depending on the flexibility of network modeling, one can try to bring the behavior in the simulation as close as possible to reality.

**Selection of parameters and their range**

Once the vehicle types and intersections are modeled, the next step is the identification of the calibration parameters. A multi-parameter sensitivity analysis is conducted with link capacity being the measure of sensitivity. Pairs of car-following parameters are considered and a two-way ANOVA is done to check for the significant parameters as well as significant interaction within the parameters.
Each parameter needs a lower and upper bound for the value it can take so that the optimization model needs to search in lesser space which makes the procedure computationally efficient. Such a range is necessary to ensure realistic performance of the simulation model. A heuristic method is proposed to determine the range of parameters for the subsequent use by optimization algorithms. If a parameter has a positive effect on delay, then its value is increased until the delay reaches a specified upper bound; this value is set as the upper limit for the parameter. In an analogous manner, the value of this parameter is reduced in steps until the delay reaches the lower limit. On the other hand, if the parameter has a negative influence on the delay, then an opposite procedure is adopted to get the lower and upper limits. This iterative process is continued, and a range is fixed. While doing this, care should be taken to see that the parameter limits do not result in unrealistic behavior (vehicle jumping red, for instance, vehicles stopping perpendicular to each other during red time, unrealistic long queues). During this process, if the search is able to yield delay values within the precision set, then calibration of the parameters can be considered completed.

**Measures of Effectiveness and Parametric Optimization**

The measures of effectiveness can be any number of, and any combination of, travel times, flows, capacities, delay values, and queue lengths. Measures of effectiveness should be selected such that effects on individual parts of the network, such as intersections or ramps, and effects on the entire network are captured. Multiple measures of effectiveness can be adopted by weighting each of them based on certain criteria or making one of them as the objective for optimization and others as constraints (17). The HCM also suggests suitable measures according to the type of facility. For signalized intersection control delay is the suggested measure of effectiveness by the HCM.

In this study, the estimation of the parameter values is formulated as an optimization problem which minimizes the cumulative absolute error between the observed and simulated delays for all the intersections. The link capacities are fixed within a range and they are the measure introduced by constraint insertion technique.

The formulation is given in the form of a mathematical program:

Minimize \[ e_{ob} = \sum_{i=1}^{n} |d_{i}^s - d_{i}^l| \] (1)

Subjected to \[ \beta_{i}^l \leq \beta_{i}^l \leq \beta_{i}^u \text{ for all } j \] (2)

\[ e_{c} \leq 10 \] (3)

Where, \( d_{i}^s \) = average delay obtained from the simulation model for intersection i;
According to the terminology of Dowling et al. (5), this formulation can be called a global calibration. Local calibration is a special case of the above formulation when \( n = 1 \). The different algorithms to search for the parameter set satisfying the conditions in the optimization formulation are iterative averaging, Genetic Algorithm (GA), Simultaneous Perturbation Stochastic Approximation (SPSA) etc. GA is proposed as the solver for the above formulations.

**Calibration**

First the GA code produces candidate solution sets randomly (initial chromosomes), then these values are fed into simulator via an interaction interface and the feedback is received in the form of Measure of Effectiveness (MOE, in this case is delay. See Figure 2). Based on the feedback, the value of the fitness function is calculated. The new set of chromosomes will produced will depend on the fitness function. After iteration, the value of the fitness function improves till the convergence. More literature on this can be found at Deb (19).

**Validation**

A new data set corresponding to different traffic and, preferably, geometric conditions should be used for validating the simulation model. The absolute error in the values of the measures of effectiveness is estimated. The model can be used confidently if this error is within certain limits. Field measured and simulated delays are compared and generally a variation of simulation results within 15% of the field measured delay is considered acceptable.

**IMPLEMENTATION**

The methodology is evaluated by implementation in the traffic simulator VISSIM. The traffic flow model in VISSIM is a discrete, stochastic, time step based microscopic model, with driver-vehicle-units as single entities. The model contains a psycho-physical car following model for longitudinal vehicle movement and a rule-based algorithm for lateral movement. The model is based on the continued work of Wiedemann (20). The basic idea of the Wiedemann model is the assumption that a driver can be in one of four driving modes: Free Driving, Approaching, Following, and Braking. VISSIM implements two variants of this model, the so called Wiedemann-74 and Wiedemann-99 models. The models differ in the way they define the thresholds or action-points where the driver changes his driving behavior and in the amount of stochasticity in the driver model. Owing to the advantages and flexibilities Wiedemann-99 model offers, it is used in the present study. Also, due to varying characteristics of different vehicle types in mixed traffic, the values of the car following parameter set are defined separately for each individual vehicle type.

Apart from car following parameters, the behavior of traffic in simulation of mixed traffic depends mainly on two other factors: Lateral distances and speed-acceleration profiles of the vehicle types (21). Lateral safety distances are assumed to be linearly dependent on speed and are defined in VISSIM by setting the values for speeds of 0 km/h and 50 km/h. The lateral distances can be specified separately for any pair of vehicle types. A separate speed-acceleration curve is defined for each vehicle type. Field measurements with utmost care and accuracy are necessary to define these parameters in VISSIM, as a little variation in these can result in a varied output in simulation (Figure 3a and 3b).
FIGURE 2a,2b: Variation of simulation output with change in lateral distances

Figure 2a shows the variation of simulation output (in terms of delay) with change in lateral distances for two different sets of maneuverability. Maneuverability is indirectly achieved through three VISSIM parameters: the collision time gained by lateral decision, the minimum speed to make that decision and the time between successive direction changes. Figure 2b shows the variation of simulation output (in terms of delay) with change in lateral distances for two different sets of driver aggressiveness. Driver aggressiveness is changed by altering speed-acceleration profiles of the vehicles. In the next section, some of the significant features of the mixed traffic are studied along with the attempts to simulate the same in VISSIM.

Traffic Representation

The unique features of mixed traffic are identified and observed. Some of them are difference in lane behavior, maneuverability of smaller vehicles and stop line violation, ineffective free left turn etc. Techniques to incorporate the mentioned features in micro simulation are also discussed. Although VISSIM was developed for western traffic, the flexibilities provided by the simulator in defining the network elements can be taken advantage of, to simulate the peculiarities of the driver behavior in mixed traffic condition.

Lane behavior

When a vehicle joins the queue, the main stimulus is the front gap irrespective of the lane in which it is available. As a result, it has been observed that straight ahead vehicles occupy any position across the link based on the available space.

Unlike lane based system, where lane changing is a continuous process i.e. when a driver needs to change lane in order to overtake a slow leader, he takes lane changing decision only if it is possible to perform complete maneuver in one attempt. On the contrary, in mixed traffic and non-lane based operation as there is no restriction on positioning a vehicle at any place across the link width and therefore the driver who would like to change lane does not bother about completing the maneuver in one attempt. From the field observation it is seen that a driver changes lane gradually according to the available opportunity. Though this behavior is not possible to replicate completely in the simulation, the vehicles can be made to look for newer options quickly using “Collision time gain”, “minimum longitudinal speed” for lateral movement and “time between direction changes” parameters. Though the right side must be used for overtaking according to the traffic rules, vehicles approaching a queue use both left and right sides depending on the available front gaps. VISSIM has an “overtake on both sides” option to simulate the kind of behavior.

Maneuverability of smaller vehicles and Stop line violation

Two-wheelers use inter-vehicular space to come in front of the queue. The “seepage” of two-wheelers can be simulated in VISSIM by giving appropriate lateral distances to be maintained at rest and 50 km/h respectively and setting the parameters collision time gain, minimum longitudinal speed for lateral movement and time between direction changes. The parameter values are changed based on vehicle types. Also, the vehicles stop 2 to 4 meters ahead of the stop line during the red signal. This gives the motivation for two-wheelers to seep through inter-vehicular gaps. This behavior has a significant effect on how the different vehicle types position themselves in the queue. This can be simulated by having two stop lines in VISSIM, the first one only for buses and cars and the second for all vehicle types.
Ineffective free left turn

When a “free left turn” is allowed at an intersection the vehicles turning left proceed along their route accordingly. But several seconds into the red phase, through and right turning vehicles exhibit a “greedy” behavior by occupying the lanes reserved for left turning traffic. Several seconds into the red, this behavior makes the concept of “free left turn” ineffective. (The bus in the extreme right in Figure 3 is a part of through traffic and it has made the free left ineffective). Though there are no specific parameters available to simulate such behavior, using the flexibilities in VISSIM in defining the network elements through links, connectors and stop lines this can be achieved.

![FIGURE 3: Ineffective Free Left in Simulation and in Reality](image)

Resolution requirement

Resolution is the simulation time step; to adequately model the complex movements in mixed traffic, the calculations have to be at smaller time steps. VISSIM offers simulation at different time steps according to the need from 1 time step per second to 10 time steps per second. A resolution of 10 time steps per second is adopted in the case of mixed traffic, which requires more computational effort.

Data requirements

The data required for the proposed methodology are intersection geometry, signal timing and phasing, vehicle types, traffic inflow, proportion of turning traffic, traffic composition, and delay at intersections and link capacity of approach under study. Field delay is measured using the technique recommended by the highway capacity manual (22). In this technique, the vehicles in queue are counted from the start of red until the last vehicle in the queue clears the stop line. The counting is done for intervals of 20 s. The cumulative vehicle-in-queue count is obtained and averaged over the total number of vehicles passing through the intersection during the observation period to get the delay. The link capacity of approach under study is obtained by taking the vehicle count at saturated/over saturated cycles and converting it into hourly flow. While the simulation capacity is estimated using the VISSIM traffic counting tool available in the simulation immediately downstream of the stop line. This definition of capacity is supported by the guidelines adopted by FHWA (5).

Multi Parameter Sensitivity Analysis

Once the network is created and model inputs are provided from the data, the model is run with default parameter set. The default set usually fails to provide results to provide results closer to the reality. Hence the next steps to choose parameters and their ranges for calibration have to be undertaken. Multi parameter Sensitivity Analysis is done in this step. Apart from the individual effects of the driver behavior parameters on the capacity of the link in simulation, their combined effect is also sometimes significant (16). Parameters with Significant effect in current study were found to be CC0, CC1, CC2, CC7 and CC8. There was no significant interaction among each of them at an alpha level of 0.05. After observing the effect of each parameter on the capacity of the link, the selection of parameter and its range is done. A total of 13 variables are used in algorithm.

Tuning of Parameters

The interaction module feeds the GA populations into VISSIM simulation via COM interface and sends the received delay output to GA as feedback. The GA parameters like cross over and mutation probabilities are chosen heuristically. A general roulette wheel technique is used in selection of parameters. Currently, VISSIM COM interface does not have access to all network elements, which can limit the range of parameters used in the calibration.
CASE STUDY

The methodology proposed in the previous chapter is implemented for two signalized intersections in Mumbai. The aim of this case study is to evaluate the effectiveness of the calibration methodology. The intersection details are collected along with the video; data is extracted from the video later.

Vehicle Representation

VISSIM needs inputs for vehicle characteristics in terms of geometry as well as desired speed, and accelerations (23). The video is seen in frames and while queue discharges or builds up, vehicle trajectories are extracted and speed, acceleration and lateral distances are then calculated. The vehicle characteristics given as an input to VISSIM is listed in Table 1.

### TABLE 1: Vehicle Characteristics and Intersection Details

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Length (m)</th>
<th>Breadth (m)</th>
<th>Min. Lateral Distance (m)</th>
<th>Desired Speed (knph)</th>
<th>Traffic Composition(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two Wheeler</td>
<td>1.8</td>
<td>0.6</td>
<td>0.3</td>
<td>0.7</td>
<td>Powai: 30, Vashi: 22</td>
</tr>
<tr>
<td>Rickshaw/3W</td>
<td>2.6</td>
<td>1.4</td>
<td>0.4</td>
<td>0.8</td>
<td>Powai: 30, Vashi: 11</td>
</tr>
<tr>
<td>Car</td>
<td>4.0</td>
<td>1.6</td>
<td>0.5</td>
<td>0.9</td>
<td>Powai: 43, Vashi: 32</td>
</tr>
<tr>
<td>LCV</td>
<td>5.0</td>
<td>1.9</td>
<td>0.5</td>
<td>0.9</td>
<td>Powai: 6, Vashi: 3</td>
</tr>
<tr>
<td>Bus/HCV</td>
<td>10.3</td>
<td>2.5</td>
<td>0.6</td>
<td>1.0</td>
<td>Powai: 10, Vashi: 5</td>
</tr>
</tbody>
</table>

Volume(vph): 16002150

Analysis of Results

The resultant calibrated data set and the convergence of Genetic Algorithm is shown in Table 2 and Figure 4 respectively. As the first step of evaluation, the performance of a default and calibrated parameter set needs to be compared. As stated in the earlier, this calibration procedure is necessary when a simulation model with a default parameter set does not reproduce the field condition. For the same intersection in Vashi, the data was collected on a different day and the data was used for validating the calibrated model. The traffic composition and input volume were changed in the simulation input, rest remaining the same. The new data was taken on during less saturated flow and hence the delay time is lesser. The result from calibrated model was found close to the one in the field. (Table 3)
### TABLE 2: Calibrated Parameter Set

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default</th>
<th>2W</th>
<th>3W</th>
<th>Car/LCV</th>
<th>Bus/HCV</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCO (Standstill distance)</td>
<td>1.50</td>
<td>0.47</td>
<td>1.00</td>
<td>1.20</td>
<td>2.00</td>
</tr>
<tr>
<td>CC1 (Headway Time)</td>
<td>0.90</td>
<td>0.43</td>
<td>1.2</td>
<td>0.81</td>
<td>0.94</td>
</tr>
<tr>
<td>CC2 (Following Variation)</td>
<td>4.00</td>
<td>4.42</td>
<td>4.42</td>
<td>6.84</td>
<td>6.84</td>
</tr>
<tr>
<td>CC3 (Threshold for entering following)*</td>
<td>-8.00</td>
<td>-8.00</td>
<td>-8.00</td>
<td>-8.00</td>
<td>-8.00</td>
</tr>
<tr>
<td>CC4 (Negative following threshold)*</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
</tr>
<tr>
<td>CC5 (Positive following threshold)*</td>
<td>-0.35</td>
<td>-0.35</td>
<td>-0.35</td>
<td>-0.35</td>
<td>-0.35</td>
</tr>
<tr>
<td>CC6 (Speed dependency of Oscillation)*</td>
<td>-11.44</td>
<td>-11.44</td>
<td>-11.44</td>
<td>-11.44</td>
<td>-11.44</td>
</tr>
<tr>
<td>CC7 (Oscillation acceleration)</td>
<td>0.25</td>
<td>0.20</td>
<td>0.20</td>
<td>0.77</td>
<td>0.77</td>
</tr>
<tr>
<td>CC8 (Standstill acceleration)</td>
<td>3.50</td>
<td>2.30</td>
<td>2.30</td>
<td>2.30</td>
<td>2.30</td>
</tr>
<tr>
<td>CC9 (Acceleration at 80km/h)*</td>
<td>1.50</td>
<td>1.50</td>
<td>1.50</td>
<td>1.50</td>
<td>1.50</td>
</tr>
</tbody>
</table>

*Insignificant parameters left at Default values

### TABLE 3: Results of the Calibration

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Type</th>
<th>Simulated Delay(s)</th>
<th>Observed Delay(s)</th>
<th>Absolute Error(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powai</td>
<td>Default</td>
<td>130</td>
<td>51</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Globally Calibrated</td>
<td>50</td>
<td>51</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Default</td>
<td>160</td>
<td></td>
<td>59</td>
</tr>
<tr>
<td>Vashi</td>
<td>Globally Calibrated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Calibration Data Set</td>
<td>103</td>
<td>101</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Validation Data Set</td>
<td>46</td>
<td>51</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Locally Calibrated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Calibration Data Set</td>
<td>102</td>
<td>101</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Validation Data Set</td>
<td>47</td>
<td>51</td>
<td>4</td>
</tr>
</tbody>
</table>

### Global and Local Calibration

When the formulation in (1) to (3) is solved for only one network, i.e. when n=1, then it is called local calibration. The modules were adjusted for a single intersection and the Genetic Algorithm code is run again to get a new solution considering only the Vashi network. The comparison between globally and locally calibrated models in terms of delay can be seen in Table 4. Though there is a slight improvement in the estimated delay in the locally calibrated model, it is not significant. The delay values of both globally and locally calibrated models and the parameter sets obtained as solutions are similar. This might be due to similarities in the driver behavior at both the intersections.

### CONCLUSIONS

The study involved the identification and observation of unique features of mixed traffic and techniques to incorporate them in micro simulation. The multi parameter sensitivity analysis was found to be an effective way of finding the significant parameters and the interactions between them. The methodology was implemented in VISSIM with Genetic Algorithm for solving the optimization formulation and was shown to produce reliable results. The flexibility VISSIM offers in defining the network elements allows the users to model some of the complex maneuvers commonly adopted by the drivers in mixed traffic. The similarities in the results obtained by local and global calibration suggest the similarity in driver behavior at both the intersections and a significant improvement was seen in delay times from that of the default parameter set. Both lateral and longitudinal clear spaces were found to be lower than the default values, reflecting the compactness of the mixed traffic in the intersections under...
study. Beyond the flexibilities that present micro simulators offer, their ability to simulate the mixed traffic is still limited, additional parameters are required to accurately model some of the behavior in mixed traffic.

The calibration can be further carried out for a corridor and network level; the methodology and measures of effectiveness can be suitably modified. Implementation of the observations of this study can be made in different micro simulators based on their traffic model, user interface, measures of performance output and the ability to interface and interact with an external application. A model representing mixed traffic accurately can be built on the lines of the observations made in the present study and can be either incorporated in an existing simulation package, for example as an external driver behavior model in VISSIM or in a custom-made simulation environment.

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