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# Transferability of calibrated microsimulation model parameters for safety assessment using simulated conflicts

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ABSTRACT

Several studies have investigated the relationship between field-measured conflicts and the conflicts obtained from micro-simulation models using the Surrogate Safety Assessment Model (SSAM). Results from recent studies have shown that while reasonable correlation between simulated and real traffic conflicts can be obtained especially after proper calibration, more work is still needed to confirm that simulated conflicts provide safety measures beyond what can be expected from exposure. As well, the results have emphasized that using micro-simulation model to evaluate safety without proper model calibration should be avoided. The calibration process adjusts relevant simulation parameters to maximize the correlation between field-measured and simulated conflicts.

The main objective of this study is to investigate the transferability of calibrated parameters of the traffic simulation model (VISSIM) for safety analysis between different sites. The main purpose is to examine whether the calibrated parameters, when applied to other sites, give reasonable results in terms of the correlation between the field-measured and the simulated conflicts. Eighty-three hours of video data from two signalized intersections in Surrey, BC were used in this study. Automated video-based computer vision techniques were used to extract vehicle trajectories and identify field-measured rear-end conflicts. Calibrated VISSIM parameters obtained from the first intersection which maximized the correlation between simulated and field-observed conflicts were used to estimate traffic conflicts at the second intersection and to compare the results to parameters optimized specifically for the second intersection. The results show that the VISSIM parameters are generally transferable between the two locations as the transferred parameters provided better correlation between simulated and field-measured conflicts than using the default VISSIM parameters. Of the six VISSIM parameters identified as important for the safety analysis, two parameters were directly transferable, three parameters were transferable to some degree, and one parameter was not transferable.



## 1. Introduction

Traditional traffic safety analysis, which usually relies on the use of historical collision data, is a reactive approach that offers an incomplete understanding of collision mechanisms and how safety measures work (Sayed and Zein, 1999; Sayed et al., 1994; Autey et al., 2012). The traditional approach is associated with several shortcomings. These include: poor collision data quality and availability, and an ethical dilemma as collisions, that are required to be prevented, have to occur and be recorded over an adequately long period in order to conduct a sound safety diagnosis (Sayed and Zein, 1999; Chin et al., 1997; Ismail et al., 2010). Therefore, there has been a growing interest in traffic safety analysis techniques that rely on other surrogate safety measures. One commonly used surrogate measures are traffic conflicts or near misses. The traffic conflict technique (TCT) involves recording and evaluating the frequency and severity of near misses at a location which enables the safety professionals to immediately observe unsafe driving maneuvers at road locations without waiting for collisions to occur (Amundsen and Hydén, 1977; Svensson et al., 2006). However, the TCT is commonly criticized for the high cost of data collection and the reliability of the manual collection of the conflict data. Recently, video-based automated computer vision techniques were shown to be useful automated traffic conflict detection and in conducting various safety analysis applications such as before and after safety evaluations and studying road user behavior (Autey et al., 2012; Sayed et al., 2012, 2013).

The use of traffic simulation models for conducting conflict-based safety evaluations has also been recently proposed (Gettman et al., 2003). There is a growing interest in using simulation models

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for the safety assessment of road facilities by analyzing simulated vehicle trajectories and estimating conflict indicators. The main advantages of this approach are: (1) the ability to evaluate the safety of various design and traffic management options of road facilities before actually making changes and (2) the ease of estimating simulated conflicts without actually observing them. The Surrogate Safety Assessment Model (SSAM) was recently developed to estimate traffic conflicts using simulated vehicle trajectories exported from four commonly used microscopic simulation models: VISSIM, AIMSUN, PARAMICS, and TEXAS. Several traffic conflict indicators can be calculated including the time to collision (TTC), post-encroachment time (PET), deceleration rate (DR), maximum speed (MaxS), and speed differential (DeltaS). In SSAM, conflicts are classified into three maneuver types: rear-end; lane-change; and crossing. Conflicts are identified based on conflict angle and specific thresholds for TTC and PET, which are predetermined by the user (Gettman et al., 2008). The SSAM approach has seen increasing use in safety evaluations recently (Shahdah et al., 2014; Wang et al., 2014; among others). However, several researchers raised two main concerns about using simulated conflicts in safety studies (Tarko et al., 2005; Saunier et al., 2007). First, vehicles in the simulation models follow specific rules which are aimed at avoiding collisions. Therefore, it is very difficult to represent unsafe vehicle interactions and near misses. Second, there are many model parameters in micro-simulation models. These parameters can have a significant impact on the estimated simulated conflicts. As well, there are usually several ways to model traffic in simulation models (road geometry, priority rules, conflicts areas, traffic distribution, etc.). Therefore, the results can vary significantly depending on the approach used in modeling.

A recent study (Essa and Sayed, 2015) investigated the relationship between field-measured and simulated rear-end conflicts using microsimulation model (VISSIM) and the SSAM tool. Automated video-based computer vision techniques were used to extract vehicle trajectories and identify field-measured rear-end conflicts. A two-step calibration procedure was proposed to enhance the correlation between field-measured and simulated rear-end conflicts at a signalized intersection. The correlation between field and simulated conflicts was determined at 21 different TTC thresholds. The first calibration step consists of matching actual field conditions (desired speed and arrival type) to ensure that VISSIM gives accurate average delay values. The second step was to use sensitivity analysis followed by a Genetic Algorithm (GA) procedure to calibrate VISSIM parameters. Six parameters, which have the biggest effect on the simulated conflicts, were selected from the sensitivity analysis. A Genetic Algorithm (GA) procedure was applied to find the best values of these parameters which give the highest correlation between simulated and field-measured conflicts. The two-step calibration procedure was validated using another dataset that was not used in the calibration process.

The results showed that the calibration of the VISSIM model to match the existing traffic conditions (e.g. arrival pattern and platoon ratio) and to calibrate the driver behavior parameters is very important. This first calibration step has been generally ignored by researchers but shown to have significant impact. Good correlation between simulated and field-measured conflicts was obtained after the two-step calibration step especially at higher TTC values. However, the spatial distribution of simulated and field-measured conflicts showed major differences which may indicate the simulation did not really capture the vehicles interaction (conflict) mechanism. Therefore, while the results show good correlation between simulated and real rear-end conflicts especially after proper calibration, more work is still needed to confirm that simulated conflicts provide safety measures beyond what can be expected from exposure. Also, using SSAM to evaluate safety without proper calibration of simulation models should be avoided (Essa and Sayed, 2015).

Practically, the calibration process can be relatively complicated, time consuming, and need real traffic conflict data to be collected. In addition, the main advantage of using the VISSIM and SSAM models is the evaluation of the safety of changes to design and traffic control that have not been implemented. Therefore, the transfer of the calibrated parameters of simulation models for use in safety studies between different locations (with comparable traffic conditions and geometric characteristics) can help in eliminating or reducing the need for the complex calibration process. Therefore, there is a need to investigate and confirm the transferability of the calibrated simulation model parameters for use at different sites.

The main objective of this study is to investigate the transferability of calibrated parameters of microscopic simulation model (VISSIM) for safety analysis between two different sites. The study investigates whether the transferred parameters, when applied to other sites, give reasonable results in terms of the relationship (correlation) between the field-measured and the simulated rear-end conflicts.

Eighty-three hours of recorded video data at two signalized intersections at the same corridor in Surrey, BC were selected for analysis (60 h at the first intersection and 23 h at the second intersection). At both intersections, automated video-based computer vision techniques were used to extract vehicle trajectories and identify field-measured rear-end conflicts. The simulated rear-end conflicts were estimated from VISSIM trajectories using the Surrogate Safety Assessment Model (SSAM) tool. The two-step micro-simulation model calibration procedure, which has been proposed and validated in a recent study (Essa and Sayed, 2015), was applied to enhance the correlation between simulated and field-measured conflicts. At the first intersection, the two-step calibration procedure was carried out and resulted in the calibrated values of 6 VISSIM parameters which give the highest correlation between simulated and field-measured conflicts. At the second intersection, the correlation between simulated and field-measured conflicts was calculated for VISSIM model with default and transferred parameters, with and without the calibration process. Furthermore, the calibrated values of the VISSIM parameters from the two intersections were compared and their transferability was determined. Finally, the spatial distributions of the field-measured and the simulated conflicts were compared using conflict heat maps.

## 2. Previous work

Several previous studies have examined the calibration and validation of microsimulation models for use in traffic safety evaluations. Gettman et al. (2008) conducted theoretical and field validation to assess the use of SSAM. The theoretical validation was conducted to evaluate the relative safety of pairs of design alternatives in 11 case studies that include intersections and interchanges. The results found that SSAM could recognize statistically significant differences in the total number of conflicts, the number of conflicts by type, and conflict severity indicators for both design alternatives under equivalent traffic conditions. The field validation was also conducted to evaluate the use of SSAM as a surrogate safety assessment tool. For the field validation, 83 signalized intersections, modeled in VISSIM and assessed with SSAM, were used. The simulated conflicts of these intersections were compared to the actual crash data using 5 statistical tests. The results found a statistically significant correlation between the simulation conflicts data provided by SSAM and the field crash data. However, it should be noted that this correlation maybe expected due to both simulated conflicts and crashes being correlated with traffic volume.