A Review Paper on Assessment of Conflict Areas Using VISSIM and Surrogate Safety Assessment Model (SSAM)

Seema Bheemanaik, Harshad R. Parate, N. S. Chandanshree and Nikhil T. R

Faculty of Engineering and Technology, M. S. Ramaiah University of Applied Sciences, Bangalore 560058

*Contact Author E-mail: seema.bheemanaik@gmail.com

Abstract

A conflict can be defined as a scenario where two or maybe more road-users might probably end up colliding if no evasive manuever is taken by either of the road-users. Traffic conflicts are in focus and being studied since the early 1960's as a strategy to estimate safety-level and the knowledge on conflict frequency that directly relates with the threat of legitimate vehicular accident. In early days, the safety of traffic facilities like intersections, interchanges etc. were usually obtained by tracing and srcutinizing police reported crashes over a period of time. Occurance of crashes being random and infrequent in nature make the process slower in disclosing the remedial measures which could be putfort for the roadway design or maybe traffic flow techniques. This particular procedure thereby will not be relevant in evaluating safety-levels of the roadway designs which are to be built yet or maybe vehicular-flow techniques which are to be used in reality. This paper provides a methodology of figuring out the potential conflict point at the selected intersections by the utilizating traffic micro simulators. This paper presents the review work on assessing the conflicts that possess a high potential of turning into crash events, and also presenting feasible improvements in order to reduce the possible crash scenarios in the near future through analysis of data in VISSIM and Surrogate safety Assessment Model (SSAM)

KeyWords: Conflict, VISSIM, SSAM (Surrogate safety Assessment Model).

1. INTRODUCTION

Traffic conflicts are popularly being considered as surrogate measures of safety evaluation. A near crash scenario shall be described as an event in which two or more road-users are involved, where both or either road-user take avoidable action to stay away from colliding. The data on Traffic conflicts is often collected on site by trained observers, and this course of action of measuring conflicts is at times labor intensive and time consuming, thereby deliberately delaying the more prevalent utilization of traffic conflicts methodology in useful engineering implementation. This technique of conflict identification has been cross examined due the extreme participation of observer's judgment.

In the past years, the operational functionality of a new or improved transportation facility were examined by the transportation professional by using micro simulation methods. Lately, this method of using micro simulation tools are being utilized for the traffic safety assessment. As a solution to the concern a brand new approach titled Surrogate Safety Assessment Model (SSAM) has been introduced by SIEMENS research group, sponsored by the Federal Highway Administration (FHWA) of the USA (Douglas Gettman, 2008). Back in the year 2003 Gettman and Head studied the various possibilities of deriving surrogate safety measures from the widely available simulation tools, that resulted in the further improvement of the SSAM. In the SSAM a few algorithms are utilized to determine the conflicts by analyzing the vehicle trajectory file pot forth by the micro simulation tool like VISSIM, PARAMICS, TEXAS and AIMSUN.

The results of SSAM provide us with the number, type, locations and severity of simulated conflicts for traffic facilities, SSAM considers five surrogate safety parameters to assess the severity of a simulated conflict, that includes Time to Collision (TTC), Post Encroachment Time (PET), deceleration rate, the speed and maximum speed differential [1]. A conflict is captured in SSAM for each of vehicular interaction if the minimum PET and TTC values exceed the fixed threshold values, as well as the conflict type related with each conflict is actually identified based on the lane and the angle or link info between the two converging vehicles (Douglas Gettman, 2008). Safety assessment tools are actually a vital component in continuing to enhance road safety in India. With the social costs of crashes being extremely big, it is essential to reduce crashes events in reality. By utilizing surrogate safety measures, road safety improvements can be successfully evaluated before and after implementation.

2 CRITICAL REVIEW ON ASSESSING TRAFFIC CONFLICTS USING VISSIM AND SURROGATE SAFETY ASSESSMENT MODEL

Gettman et.al (2003) [2] stated that the research conducted by FHWA in regards to finding the surrogate measures that could be ascertained by the simulation through software for the safety analysis of alternative designs or existing facilities, required certain level of calibration in order to acquire every surrogate measure for every occurring conflict. The study later suggested the various surrogate measures of safety that could be utilized to evaluate the severity of the conflicts for DeltaS, DR MaxS, PET, and TTC. The study also suggested that a post-processing tool could be introduced that could help in calculating the statistics of various surrogate measures identified during a conflict, after all the required surrogate measures are identified with the aid of simulation for every occurring conflict. Eventually with these statistics, the safety of traffic facilities could

be evaluated by comparing 2 or more design alternatives at an instant.

Gettman et.al (2008) [1] worked on introduction of SSAM as a completely new methodology of evaluating the safety of traffic facilities with the utilization of various traffic-simulation software. In SSAM a conflicting event was recognized for every vehicle-to-vehicle interaction based on the threshold values of certain surrogate measures, and after analysis a catalog of all the events is presented. The author stated that for each of that event, SSAM likewise calculates various surrogate safety measures, including the following:

- Minimum time-to-collision (TTC).
- Minimum post encroachment (PET).
- Initial deceleration rate (DR).
- Maximum deceleration rate (MaxD).
- Maximum speed (MaxS).
- Maximum speed differential (DeltaS).
- Classification as lane change, back end, or possibly path crossing event type.
- Vehicle velocity change had the event proceeded to a crash (DeltaV)

This approach circumvents the need to hold out for "abnormally high" crashes to actually occur, allows assessments of hypothetical designs and control options, and is really acceptable to facilities where conventional, prediction models based on vehicular volume have not been established.

Fan et.al (2013) [3] studied the safety levels at freeway merge point by utilizing both VISSIM and SSAM. In order to validate, the author opted the method of comparing the software simulated conflicts with the real life conflicts that were observed by conducting the conventional conflicting measuring technique. The main intent here was to try improving the percentage of match of field observed conflicts with that of the simulated conflicts. In order to achieve consistency, VISSIM was calibrated to the field observed values and the threshold values of Surrogate measures of SSAM were altered and the transferability of the calibrated models was tested. The calibration process helped in deducing the MAPE value of total conflicts from 0.781 to 0.334, for rear-end conflicts from 0.766 to 0.335 and for lane change conflicts from 0.795 to 0.358. Finally from the developed linear regression model and Spearman rank correlation it was evident that there existed a sensible level of reliability between the VISSIM produced conflicts and conflicts observed on field.

Wang et.al (2013) [4] studied the test of reliability of VISSIM and SSAM by performing a comparison between the simulated conflicts obtained by VISSIM simulation and recognized by SSAM with those conflicts obtained by field conducted survey's. Study also focused on learning the correlation between simulated conflicts and the conflicts obtained by field survey could be enhanced by performing a two staged calibration process i.e. calibration of both VISSIM and SSAM. This two-stage calibration process had helped in enhancing the goodness-of-fit between the simulated conflicts and the field observed conflicts. The regression analysis revealed the existence of a fair amount of goodness–of-fit between the VISSIM produced conflicts and field identified conflicts. The study further revealed, simulated conflicts weren't of much help in case the conflict were produced during unexpected driving behaviors. They further analyzed the prediction functionality by considering simulated conflicts as independent variables in the prediction model, that revealed the prediction models provided fair enough prediction performance for the rear end and total conflicts with a MAPE value of 0.18 and 0.20 respectively. For crossing and lane change conflict was fairly moderate with MAPE value of 0.31 and 0.38 respectively.

Stevanovic et.al(2013) [5] made an attempt to study integration of VISSIM, SSAM, and VISSIM based Genetic Algorithm to Optimize Signal phase timings in order to reduce the surrogate values and hence decreasing the evident risk of real vehicular accidents. For this study a corridor on Glades Road with 12 intersections and 2 smaller artificial network in Boca Raton city, USA were considered. With signal optimization both safety and efficiency of the intersections were balanced and conflicts were cut down by 7%. Initially the signals were optimized considering efficiency as the priority, and 9% reduction in conflicts was observed with very less efficiency loss. The majority of the enhancements were obtained at a cost of worsening efficiency of traffic streams, which showed as an inevitable necessity for tradeoff between safety and efficiency. And hence confirming that cycle length and vehicular conflicts were inversely related.

Zhou et.al (2013) [6] studied the safety performance of a signalized intersection by utilizing the concept of simulated conflicts. Initially the signalized intersection was simulated in VISSIM along with all traffic operations collected on field. Subsequently SSAM was utilized in determining the statistics of simulated conflicts which were obtained by analyzing the vehicle trajectory data produced by VISSIM simulation. The field observed traffic conflicts were compared to the simulated conflicts, then with a two stage calibration process was performed to enhance the consistency between simulated conflicts and field observed conflicts. After the validation and calibration process, the speed limit that was earlier 60 km/h restricted to 50 km/h, as a remedial measure to reduce the conflicts. On comparing the initial model with the improved model it was evident that the safety functionally at this particular intersection was elevated with reduced speed limit.

Lorion A.(2014) [7] studied the viabilities of various prediction models involved in determining the safety of a two way stop controlled intersection by performing an investigation on the relationships between traffic volume, conflicts, intersection delay with crash frequencies. The study was conducted within the Greater Toronto city in Canada. Crash prediction models were designed and evaluated based on goodness of fit measures and CURE plots. Crash-volume, crash-delay, crash-conflict, conflict prediction models were developed and were compared in order to determine the most suitable one for two way stop controlled intersection. From the results it was evident that crash-conflict prediction model could effectively predict crashes for intersection groups.

Vasconcelos et.al (2014) [8] studied the SSAM's approach of assessing the safety levels at urban intersections as an accident prediction tool. The study

considered three intersection layouts i.e. the prioritized four legged junction, staggered four legged junction and single lane roundabouts. The first validation stats obtained by SSAM were contrasted with the conflicts observed at the four junctions i.e. two priority ones and two roundabout. Another validation done based on Accident prediction model revealed strong correlation between regression models predicted crashes and conflicts predicted by the simulation models. It was also observed that the conflicts-accident ratio varied with respect to the intersection type, the entry flow, as well as the specific APM. A field validation was performed by comparing observed conflicts and later simulated in four kinds of intersections. SSAM had managed to reproduce the hourly development of conflicts as well as to determine the dangerous prone spots at each of these junctions. Nevertheless, the study concluded that SSAM examination was actually a rather promising approach to evaluating the safety of new facilities, of revolutionary layouts, or perhaps of traffic regulation schemes.

Vedagiri et.al (2015) [9] conducted a thorough examination on the effect of management measures on traffic safety at un-signalized junctions under mixed traffic conditions. A strategy was introduced, that helped in measuring the post encroachment time, gave exact outcomes that proved to become a dependable sign as traffic safety evaluator at junctions. In this study three types of management measures were examined, out of the three management measures, the rotary outperformed out of all the rest, followed by raised tables and speed bumps. The performance was checked for the combination of these facilities, raised table along with roundabout gave the best benefits. Nevertheless, this effect observed to be varying considerably depending on the change in traffic volume at the intersection. The research contribution of the proposed methodology had provided a reliable and accurate technique of determining unsafe junctions and then provide precautionary management measures to reduce the future crashes occurrence under the mixed traffic problems which prevail in developing countries.

Wu et.al (2018) [10] had tried to determine pedestrian-vehicle conflicts at signalized junctions with the aid of VISSIM and SSAM by evaluating the maximum time to collision and post encroachment time as indicators. The VISSIM models were calibrated in order to replicate the real life conflicts, helping in generating the trajectory file which was then read by SSAM to obtain pedestrian-vehicle near crash scenarios. The mean absolute percentage error utilized in figuring out the minimum PET and TTC limits for pedestrian-vehicle near crash scenario. From the linear regression model it was learnt that for relationship between the simulated and observed near crash scenarios at the set limits, there existed a highest correlation of simulated conflicts with observed conflicts if the TTC and PET values were set to 2.7 sec and 8 sec respectively. The last observation pointed out that VISSIM's underestimation of conflicts involving pedestrians under scenarios where the pedestrian behavior was unpredictable.

Astaritaa et.al (2019) [11] had tried to assess the safety of various intersection types i.e. a roundabout, signalized intersection and an un-signalized intersection; also thereby testing the utilization of simulation tool for safety evaluation. For this study the selected intersections were located in urban area where the potential of car interactions turning into a crash was high, the above considered intersection scenario were tested with three distinct micro simulation tools i.e. triton, VISSIM, and Aimsun along with one additional tool from FHWA, the SSAM. The outcomes from all the simulation models confirmed that a roundabout possess a much greater fraction of conflicts compared to the other 2 traffic facilities. This particular study had proven that in an evaluation of intersection planning it's feasible to make use of the SSAM methodology to lessen the points of conflict and look for greater solutions.

Ghanim et.al (2019) [12] had performed an investigation on the feasibility of using SSAM in determining and differentiating the pedestrian-vehicle conflicts by performing an analysis of trajectories files produced by simulation tool. The study was conducted on a signalized intersection of the Doha city. The onsite conditions of the intersection was modeled and calibrated in VISSIM and the trajectory file obtained from VISSIM was then analyzed in SSAM. The results of conflict data obtained from SSAM were compared to the real life conflicts depending on the TTC criteria. Obtained results indicated that there existed a certain correlation between simulated and observed conflicts, and overestimation the collision risks, particularly in the situation involving pedestrians. The outcome likewise suggested the method adopted was very much efficient in recognizing the near crash scenario at the merging and diverging maneuvers.

3 MAJOR ENCOUNTERS FROM THE LITERATURE REVIEW

1. SSAM methodology can be employed to analyze an intersection during its initial stage of planning itself in order to minimize conflict points; thereby helps in predicting unsafe road sections for the vehicle maneuver and finding better solutions. [2] [3]
2. With the aid of micro-simulation model, it is possible to estimate safety levels for every planning solution and also helps in evaluating alternative time plans and geometric changes without creating any disturbance to the existing traffic also saving large resources, which would be otherwise wasted when done practically. [2] [3]
3. Simulation models like Aimsun, Tritone and VISSIM provide similar reliable outputs. [1] [2]
4. The accident prediction models using surrogate measures is more effective than with traditional crash volume prediction model approach which would effect in prolongation of road safety design or the flow control strategy. [1] [4][5]
5. The correlation between the simulated and field obtained conflicts could be enhanced by calibrating VISSIM simulation models and by adjusting threshold values in SSAM.[1][9]

6. Modified PET has proven to be a dependable gauge for determining safety levels at traffic junctions.[6]
7. SSAM indicate similarities between simulated and observed conflicts[3][7][8][12]
8. SSAM tends to overestimate conflicts risk in scenarios were pedestrians are involved and VISSIM shall underrate conflicts involving pedestrians [7][8][9]
9. VISSIM and SSAM provide unreliable outcomes of near crash scenarios produced by unpredicted driving behaviors. [9]
10. Signal time optimized using VISSIM and SSAM reduce risks of potential real world crashes. [12]
11. The safety levels of the newly proposed or already existing traffic facility can be evaluated beforehand. [11]

4. CONCLUSION

The traditional method of determining conflicts are both time consuming, labor intensive and also the judgments involved by the observer are questionable, that resulted in collections on infrequent and random data. Therefore, the method of using micro-simulation in determining the probabilistic conflicts in various traffic scenarios have been studied and proven to show comparable results to the real life conflicts thereby possessing potential in traffic safety analysis.

Intersections are one such traffic location were the percentage of conflict occurring, possess a higher potential of turning into accident is much greater when compared to various other traffic situations. Hence it becomes one of the outmost importance to try and providing safe scenario at the intersection to the drivers.

In safety performance the most crucial point is representative driver behavior that provides suitable levels of variance and relative safety indicators that need to be derived from the simulation models. Here SSAM comes as a tool that helps determining the conflict points that would turn in to an accident. SSAM records a conflict when the required minimum value for TTC and PET exceed the predetermined threshold values. The conflict type associated with each conflict is then determined based on the provided link information and converging angle of the two vehicles. In SSAM, by using the trajectory data from the simulation models and with the aid of obtained potent conflict points, improved measures can be applied to high risked road sections in order to reduce impending fatality beforehand.

REFERENCES

[1] Gettman, D., Pu, L., Sayed, T., Shelby, S. and Siemens, I.T.S., 2008. Surrogate safety assessment model and validation (No. FHWA-HRT-08-051). United States. Federal Highway Administration. Office of Safety Research and Development.

[2] Gettman, D. and Head, L., 2003. Surrogate safety measures from traffic simulation models. Transportation Research Record, 1840(1), pp.104-115.

[3] Fan, R., Yu, H., Liu, P. and Wang, W., 2013. Using VISSIM simulation model and Surrogate Safety Assessment Model for estimating field measured traffic conflicts at freeway merge areas. IET Intelligent Transport Systems, 7(1), pp.68-77.

[4] Huang, F., Liu, P., Yu, H. and Wang, W., 2013. Identifying if VISSIM simulation model and SSAM provide reasonable estimates for field measured traffic conflicts at signalized intersections. Accident Analysis & Prevention, 50, pp.1014-1024.

[5] Stevanovic, A., Stevanovic, J. and Kergaye, C., 2013. Optimization of traffic signal timings based on surrogate measures of safety. Transportation research part C: emerging technologies, 32, pp.159-178.

[6] Zhou, H. and Huang, F., 2013. Development of traffic safety evaluation method based on simulated conflicts at signalized intersections. Procedia-Social and Behavioral Sciences, 96, pp.881-885.

[7] Lorion, A., 2014. Investigation of Surrogate Measures for Safety Assessment of two-way stop controlled intersections, Ryerson University.

[8] Vasconcelos, L.; Neto, L.; Seco, Á.; Silva, A (2014), Validation of the surrogate safety assessment model for assessment of intersection safety. Transp. Res. Rec. J. Transp. Res. Board 2432, 1–9.

[9] Vedagiri, P. and Killi, D.V., 2015. Traffic safety evaluation of uncontrolled intersections using surrogate safety measures under mixed traffic conditions. Transportation research record, 2512(1), pp.81-89.

[10] Wu, J., Radwan, E. and Abou-Senna, H., 2018. Determination if VISSIM and SSAM could estimate pedestrian-vehicle conflicts at signalized intersections. Journal of Transportation Safety & Security, 10(6), pp.572-585.

[11] Astarita, V., Festa, D.C., Giofrè, V.P. and Guido, G., 2019. Surrogate safety measures from traffic simulation models a comparison of different models for intersection safety evaluation. Transportation research procedia, 37, pp.219-226.

DFHB hanim, M.S. and Shaaban, K., 2019. A Case study for surrogate safety assessment model in predicting real-life conflicts. Arabian Journal for Science and Engineering, 44(5), pp.4225-4231