



Delft University of Technology

Special issue on road safety and simulation 2017

Farah, Haneen; Hagenzieker, Marjan; Brijs, Tom

DOI

[10.1016/j.aap.2021.106384](https://doi.org/10.1016/j.aap.2021.106384)

Publication date

2021

Document Version

Final published version

Published in

Accident Analysis and Prevention

Citation (APA)

Farah, H., Hagenzieker, M., & Brijs, T. (2021). Special issue on road safety and simulation 2017. *Accident Analysis and Prevention*, 161, Article 106384. <https://doi.org/10.1016/j.aap.2021.106384>

Important note

To cite this publication, please use the final published version (if applicable).
Please check the document version above.

Copyright

Other than for strictly personal use, it is not permitted to download, forward or distribute the text or part of it, without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license such as Creative Commons.

Takedown policy

Please contact us and provide details if you believe this document breaches copyrights.
We will remove access to the work immediately and investigate your claim.

Green Open Access added to TU Delft Institutional Repository

'You share, we take care!' - Taverne project

<https://www.openaccess.nl/en/you-share-we-take-care>

Otherwise as indicated in the copyright section: the publisher is the copyright holder of this work and the author uses the Dutch legislation to make this work public.



Editorial

Special issue on road safety and simulation 2017

1. Introduction

This special issue originated from the Road Safety and Simulation International Conference 2017 held in the Netherlands and organized by the Delft University of Technology in collaboration with SWOV- Dutch National Scientific Institute for Road Safety Research. The present Special Issue on 'Road Safety and Simulation 2017' provides a synthesis of high-quality scientific papers that we have broadly categorized under four major themes within traffic safety: crash prediction models, surrogate safety measures, risk factors and the safety of vulnerable road users. Another special issue originating from the same conference and containing a selection of papers focussing on behavioural aspects of traffic safety is published in the journal of Transportation Research Part F: Traffic Psychology and Behaviour.

2. Brief overview on articles

This special issue contains 19 articles. Here we present a brief overview on each of the articles included in the Special Issue:

2.1. Crash prediction models

The development of crash prediction models has a long research history which led to the publication of the Road Safety Manual in 2010 (AASHTO, 2010). Traditionally these models relate the crash rates to infrastructure related factors, environmental factors and exposure. However, in recent years the advances in technology, computation and statistical methods have enabled the enrichment of these models with additional information as well as the development of models with higher prediction accuracy and power. Furthermore, models to predict the severity levels of crashes were also developed.

Dhahir and Hassan (2019) used Naturalistic driving data to enrich the horizontal curve collision prediction model by considering information on the speed reduction from the approach tangent to the curve. The developed models predict the curve collision frequency by relating the expected collision frequency on horizontal curves to the speed reduction from the approach tangent to the curve. The findings of this study showed that the speed reduction is directly related to the collision frequency on horizontal curves, and that it is more significant in predicting collision frequency than the curve geometric parameters. Gomes et al. (2019) demonstrate the potential improvements in spatial crash prediction model performance by enhancing the explanatory variables and modelling casualties with an appropriate exposure variable. Crash prediction models were developed within the framework of Geographically Weighted Regression with the Poisson distribution of errors. The

results show that by adding supplementary data, reductions of 20% and 25% were observed in the corrected Akaike Information Criterion (AICc) and the Mean Squared Prediction Error (MSPE), respectively for motorized transport, and a reduction of 25% in AICc and 35% in MSPE for active transport. Heqimi et al. (2018) used spatial interpolation to analyse the effects of annual snowfall on crash occurrence at non-interchange freeway segment locations in Michigan. The weather data were spatially matched with historical crash data and roadway inventory data. The authors developed a Negative Binomial regression model to quantify the effects of snowfall on crashes. Annual snowfall was found to have a statistically significant positive effect on winter crashes for all types of crashes analysed.

Gitelman et al. (2019) examined the impacts of shoulder width and shoulder type on crashes on two-lane roads. The study database combined information on crash numbers, traffic volumes and road infrastructure characteristics of 3594 road sections. The authors analysed the data using case-control and negative-binomial regression models. The authors found a consistent non-monotonous link between the shoulder width and crashes. Narrow shoulders, below 1 m, and wide ones, of 3 m or more, were found to be safer. Unpaved shoulders of over 0.9 m were associated with an increase in crash risk.

Chen and Qin (2019) addressed the temporal and spatial consistency issues associated with physical loop detectors using the Cell transmission model (CTM) to simulate traffic data in order to fill the spatial and temporal gaps inherent in the observed traffic data collected from physical loop detector stations. They have developed a real-time crash prediction model using data from a corridor of I-94 in Wisconsin. The findings of their study indicate that the developed real-time crash prediction models using simulated traffic data were found to outperform the model developed with actual traffic data. Diependaele et al. (2019) developed a tool which would improve the accuracy of the year-end forecasts by BAST, concerning various types of national accident/injury numbers. They have demonstrated the performance of the developed tool with a time-series modelling strategy that quantifies the impact of weather conditions on accident numbers in Germany. The authors conclude that their approach improve the accuracy of the predictions.

In many developing countries there is a lack of proper crash reporting and therefore the development and use of rigorous statistical techniques is still at an early stage. In their study, Mitra and Bhowmick (2020), investigate the effects of geometric, infrastructural, traffic control and land use parameters on the number of crashes and their severity across 52 signalized intersections of Kolkata, India. The authors identify based on their analysis the factors that significantly affect the frequency of crashes and those that affect the severity of crashes at signalized

<https://doi.org/10.1016/j.aap.2021.106384>

Available online 30 August 2021

0001-4575/© 2021 Elsevier Ltd. All rights reserved.

intersections of Kolkata.

Chiou et al. (2020) used generalized estimating equations (GEE) to identify the key factors contributing to the severity levels of two parties involved in a two-vehicle accident at signalized intersections in Taipei City while accommodating potential clustering correlation between them and avoiding the use of complex model settings of multivariate models. The findings indicate that the GEE ordered probit model with exchangeable working matrix performs best and the key contributing factors to crash severity were vehicle type (motorcycle) followed by speeding, angle impact, and alcohol use.

2.2. Surrogate safety measures

The limitations of safety analysis based on crashes have been repeatedly and widely described in the literature. Among these limitations are: under-reporting, the random nature of crashes, low counts, and lack of information regarding the process leading to the crash. For these reasons Surrogate Measures of Safety (SMoS) were proposed as an alternative pro-active and relatively quick approach for safety evaluation which enable an understanding of the process that led for the crashes. The following studies present applications of surrogate measures of safety in different driving context and the use of Extreme Value theory to predict crashes from near crashes. Kieć et al. (2019) investigated the impact of turbo-roundabouts raised lane dividers on road safety and driver's behaviour using two surrogate safety measures: speed and lane behaviour. Speed profiles were constructed from speed data obtained from video observations and floating car data. Lane behaviour data was gathered from video observations. The authors found that the lack of lane dividers was found associated with increase of accident frequency and speed profiles were influenced by the presence of lane dividers and drivers' behaviour. Xie et al. (2019) proposed in their study a time to collision with disturbance (TTCD) for risk identification in cases when the following vehicle's speed is slightly less than or equal to the leading vehicle's but the spacing between two vehicles is relatively small, overcoming the limitation of the traditional TTC. They have used the real-world connected vehicle pilot test data collected in Ann Arbor, Michigan to test the performance of the newly proposed surrogate safety measure. The results show that risk rate identified by TTCD can achieve a higher Pearson's correlation coefficient with rear-end crash rate than other traditional SSMs.

Finally, Cavadas et al. (2020) extend existing efforts on Extreme Value theory (EV) for accident probability estimation for two dependent surrogate measures. Using detailed trajectory data from a driving simulator, the authors model the joint probability of head-on and rear-end collisions in passing manoeuvres. The Block Maxima method was applied and several extremal univariate and bivariate models were estimated, including the logistic copula. In their estimation the authors account for driver specific characteristics and road infrastructure variables. Their findings indicate that accounting for these factors improve the collision probabilities estimation.

2.3. Risk factors

Several factors contribute to the increased risk of road crashes and can be broadly categorised into human, road, vehicle and environmental factors. Understanding the contribution of each of these factors to crashes is crucial to propose proper countermeasures and to prioritise them based on their contribution to crash reduction and cost-benefit analysis. A recent European effort led to the development of the European Road Safety Decision Support System on Risks and Measures. In Martensen et al. (2019) the scientific basis of this Decision Support System (DSS) is presented. This online tool provides evidence on a broad range of road risks and countermeasures and links them together and provides economic efficiency evaluation. Behaviour, infrastructure, as well as vehicle factors are covered. Within the framework of the same project Papadimitriou et al. (2019) reviewed and conducted a

comparative assessment of infrastructure related crash risk factors based on a total of 243 recent and high quality studies, with the explicit purpose of ranking the risk factors based on how detrimental they are towards road safety (i.e. crash risk, frequency and severity). Some of the risk factors which are apparent in Papadimitriou et al. (2019) are the focus of a number of other studies in this Special Issue:

Inattention and distraction are considered among the leading risk factors related to human factors. In their study, Sundfør et al. (2019) reviewed reports from in-depth studies of fatal crashes in Norway 2011–2015, and have found that inattention among drivers contributes to 29% of all fatal crashes. Failure to check for information is a typical form of inattention. Distraction by use of mobile phones contributes to 2–4 % of all fatal crashes. One of the most frequent type of inattention-related crashes is collision with pedestrians.

Road and weather conditions also contribute to crashes. Malin et al. (2019) investigated the relative accident risk of different road weather conditions and combinations of conditions by applying the notion of Palm probability. The authors calculated the Palm distribution of different conditions and compared it with the distribution of the same conditions as seen by the accidents. The authors found that the relative accident risks are higher for poor road weather conditions. Moreover, the risk in poor weather and road conditions was higher on motorways compared to two-lane and multiple-lane roads.

Yet another risk factor that is investigated in this group of articles relates to the interaction between control design parameters and vehicle dynamics. Mavromatis et al. (2019) assessed in their study critical safety concerns in terms of vehicle skidding, and examined the motion of a passenger car over a range of design speed values paired with control design elements from AASHTO 2011 Design Guidelines as well as certain values of poor pavement friction coefficients. They have found that control alignments on steep upgrades consisting of low design speed values and combined with poor friction pavements are critical in terms of safety.

2.4. Safety of vulnerable road users

In the last few decades there has been a growing attention towards the safety of vulnerable road users, such as walking and cycling, and new forms of transport such as all-terrain vehicles, golf carts, and micro-mobility. These road users are considered vulnerable and their safety is greatly affected by the interaction with the infrastructure and other road users. Davide et al. (2019) in their study focus on light mopeds (LM) in the Netherlands and the implications of moving them to the carriageway due to the increased traffic density on bicycle paths as well as concerns about the safety of cyclists. To this end, 36 light moped crashes on bicycle paths in the Netherlands were investigated in an in-depth study and six types of crashes were identified and described in prototypical scenarios. These scenarios give leads for measures to improve the safety of both light moped riders and cyclists.

Russo and Smaglik (2019) Riders or occupants of All-Terrain Vehicles (ATVs) as well as golf carts are particularly vulnerable to injury, not only due to the lack of protection and safety equipment offered by their vehicles, but also the propensity for ejection in the event of a crash. To understand the factors which may affect injury severity and to plan effective countermeasures the authors analysed 1,769 drivers/passengers of these vehicle types involved in police-reported crashes. In their paper the authors explain the person- vehicle- roadway- and environmental-related variables which were found to significantly affect the injury severity of riders or occupants of ATVs and golf carts.

Gitelman et al. (2019) observed child and teen pedestrian behaviours on crosswalks of urban junctions. Crossing behaviours during leisure hours, were video-recorded at 29 crosswalks, on signalized and unsignalized intersections situated on collector roads. Risk-taking behaviours were found to be higher as the child age increased. A fifth of the children over age nine crossed by riding a bicycle or wheeled device. Crossing on red and non-checking traffic was higher for children who

were riding. Finally, non-checking traffic was higher for children distracted by a mobile phone or a gadget.

3. Conclusions

This special issue presented a collection of scientific papers introducing advancements in four major themes within traffic safety: Crash prediction models, surrogate safety measures, risk factors and the safety of vulnerable road users. Within the theme of crash prediction models the availability of rich data and advancements in statistical methods have shown improvements in the ability to predict crashes on different road facilities. Within the theme of surrogate safety measures the presented studies demonstrate the usefulness of these measures to evaluate safety, their applicability in different driving contexts, and the possibility to predict crashes from near crashes by applying the Extreme Value theory. It has also been shown that some traditional surrogate safety measures can still be improved. Within the theme of risk factors the presented studies discuss the contribution of human related factors such as inattention and distraction, a range of infrastructural factors, vehicle related factors and environmental factors to road crashes. Furthermore, these risk factors are ranked based on how detrimental they are towards road safety. Finally, within the theme of safety of vulnerable road users the safety of light mopeds, all-terrain vehicles and golf carts, as well as child and teen pedestrian behaviour are being discussed.

Acknowledgement

The Guest Editors would like to thank: the authors for contributing to this Special Issue; the reviewers for their constructive evaluation in the peer review process; and the Editor in Chief of the Accident Analysis & Prevention journal, Prof. Dr. Mohamed Abdel-Aty, who made this Special Issue contribution possible.

References

- AASHTO. (2010). Highway Safety Manual. Washington, DC, 529.
- Cavadas, J., Azevedo, C.L., Farah, H., Ferreira, A., 2020. Road safety of passing maneuvers: a bivariate extreme value theory approach under non-stationary conditions. *Accid. Anal. Prev.* 134, 105315. <https://doi.org/10.1016/j.aap.2019.105315>.
- Chen, Z., Qin, X., 2019. A novel method for imminent crash prediction and prevention. *Accid. Anal. Prev.* 125, 320–329.
- Chiou, Y.-C., Fu, C., Ke, C.-Y., 2020. Modelling two-vehicle crash severity by generalized estimating equations. *Accid. Anal. Prev.* 148, 105841. <https://doi.org/10.1016/j.aap.2020.105841>.
- Davidse, R.J., van Duijvenvoorde, K., Boele-Vos, M.J., Louwerse, W.J.R., Stelling-Konczak, A., Duivenvoorden, C.W.A.E., Algera, A.J., 2019. Scenarios of crashes involving light mopeds on urban bicycle paths. *Accid. Anal. Prev.* 129, 334–341.
- Dhahir, B., Hassan, Y., 2019. Using horizontal curve speed reduction extracted from the naturalistic driving study to predict curve collision frequency. *Accid. Anal. Prev.* 123, 190–199.
- Diependaele, K., Martensen, H., Lerner, M., Schepers, A., Bijleveld, F., Commandeur, J.J.F., 2019. Forecasting German crash numbers: The effect of meteorological variables. *Accid. Anal. Prev.* 125, 336–343.
- Gitelman, V., Doveh, E., Carmel, R., Hakkert, S., 2019a. The influence of shoulder characteristics on the safety level of two-lane roads: A case-study. *Accid. Anal. Prev.* 122, 108–118.
- Gitelman, V., Levi, S., Carmel, R., Korchatov, A., Hakkert, S., 2019b. Exploring patterns of child pedestrian behaviors at urban intersections. *Accid. Anal. Prev.* 122, 36–47.
- Gomes, M.M., Pirdavani, A., Brijs, T., Souza Pitombo, C., 2019. Assessing the impacts of enriched information on crash prediction performance. *Accid. Anal. Prev.* 122, 162–171.
- Heqimi, G., Gates, T.J., Kay, J.J., 2018. Using spatial interpolation to determine impacts of annual snowfall on traffic crashes for limited access freeway segments. *Accid. Anal. Prev.* 121, 202–212. <https://doi.org/10.1016/j.aap.2018.09.014>.
- Kieć, M., Ambros, J., Bąk, R., Gogólin, O., 2019. Evaluation of safety effect of turbo-roundabout lane dividers using floating car data and video observation. *Accid. Anal. Prev.* 125, 302–310.
- Malin, F., Norros, I., Innamaa, S., 2019. Accident risk of road and weather conditions on different road types. *Accid. Anal. Prev.* 122, 181–188.
- Martensen, H., Diependaele, K., Daniels, S., Van den Berghe, W., Papadimitriou, E., Yannis, G., Van Schagen, I., Weijermars, W., Wijnen, W., Filtiness, A., Talbot, R., Thomas, P., Machata, K., Aigner Breuss, E., Kaiser, S., Hermitte, T., Thomson, R., Elvik, R., 2019. The European road safety decision support system on risks and measures. *Accid. Anal. Prev.* 125, 344–351.
- Mavromatis, S., Laiou, A., Yannis, G., 2019. Safety assessment of control design parameters through vehicle dynamics model. *Accid. Anal. Prev.* 125, 330–335.
- Mitra, S., Bhowmick, D., 2020. Status of signalized intersection safety—a case study of Kolkata. *Accid. Anal. Prev.* 141, 105525. <https://doi.org/10.1016/j.aap.2020.105525>.
- Papadimitriou, E., Filtiness, A., Theofilatos, A., Ziakopoulos, A., Quigley, C., Yannis, G., 2019. Review and ranking of crash risk factors related to the road infrastructure. *Accid. Anal. Prev.* 125, 85–97.
- Russo, B.J., Smaglik, E.J., 2019. Analysis of factors affecting injury severity for riders or occupants of all-terrain vehicles and golf carts involved in police-reported crashes. *Accid. Anal. Prev.* 133, 105289. <https://doi.org/10.1016/j.aap.2019.105289>.
- Sundfør, H.B., Sagberg, F., Høye, A., 2019. Inattention and distraction in fatal road crashes—Results from in-depth crash investigations in Norway. *Accid. Anal. Prev.* 125, 152–157.
- Xie, K., Yang, D.i., Ozbay, K., Yang, H., 2019. Use of real-world connected vehicle data in identifying high-risk locations based on a new surrogate safety measure. *Accid. Anal. Prev.* 125, 311–319.

Haneen Farah^{a,*}, Marjan Hagenzieker^a, Tom Brijs^b

^a Department of Transport and Planning, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Stevinweg 1, P.O. Box 5048, 2600 GA Delft, Netherlands

^b School of Transportation Sciences, UHasselt—Hasselt University, Agoralaan, 3590 Diepenbeek, Belgium

* Corresponding author.

E-mail address: h.farah@tudelft.nl (H. Farah).