ASCE-ASME J. Risk Uncertainty Part B

Guest Editorial

Special Section: Risk, Reliability, and Uncertainty Quantification in Automotive Applications

Risk, reliability, and uncertainty quantification (RR&UQ) are important research topics in automotive engineering including among others, vehicle design, vehicle safety analysis, automotive market analysis, and durability. RR&UQ methods, such as reliability, safety and quality analysis, reliability-based design optimization, model bias quantification, model verification and validation, and surrogate modeling, are deemed essential in improving the reliability and quality of automotive systems. The design of highly reliable, high-quality, and high-efficiency automotive systems poses new challenges in recent years due to the increased complexity of the automotive systems and the development of emerging automotive technologies, such as electrical vehicles, connected vehicles, autonomous vehicles (AVs), and new vehicle materials. New RR&UQ methods are desired to address the safety, reliability, and quality issues in the emerging automotive technologies and thus move the automotive industry forward. This special section issue covers various recent advances in the field of RR&UQ and their applications in automotive systems.

The idea for the special section issue was initiated by the managing Editor, Professor Sankaran Mahadevan, who expressed the need to highlight the importance of RR&UQ in the automotive sector. Located in the "Motor City" and as organizers of SAE International World Congress and ASME Design Automation Conference on sessions related to RR&UQ, we were enthusiastically responsive to Professor Mahadevan's initiative. The idea was also supported by the Editor, Professor Bilal M. Ayyub and then was approved by the journal editorial board. We would like to express our sincere gratitude to Professors Ayyub and Mahadevan, and the editorial board for their support.

The Call for Papers was announced in April, 2018 with a submission deadline of Aug. 15, 2018. The 11 full papers that are presented in this special section issue highlight recent advances in uncertainty quantification, reliability analysis, reliability of repairable system, global sensitivity analysis, multidisciplinary design optimization, reliability-based design optimization, design for resilience, failure prognosis, and their applications in various emerging automotive techniques and challenges, such as AVs, lithium-ion batteries, and vehicle accident reconstruction, among others. Below are highlights of all papers in this special section issue.

Drignei, Mourelatos, and Hu presented a new sensitivity analysis approach for time-dependent computer models. They proposed new sensitivity measures for dynamic computer models whose outputs are time-dependent. The developed measures were applied to the safety of restraint systems in light tactical vehicles. The results show that the chest deflection curves are sensitive to the addition of pretension and load limiters.

Wu and Wang presented a comparative study of control strategies for disruption management in engineering design for resilience. This is an important topic related to the resilience of connected vehicles and autonomous vehicles. The commonly used proportional-integral-derivative control, model predictive control, and adaptive control strategy, are compared in this paper using an electricity transmission system.

Zhang, Zhang, Yang, and Hou developed a traffic accident reconstruction approach based on occupant trajectories and trace identification. They accounted for the uncertainty in the vehicle parameters before the accident and used Kriging surrogate modeling to reduce the required computational effort.

A new approach to estimate the expected number of failures for the generalized renewal process was proposed in a paper co-authored by Koutsellis, Mourelatos, and Hu. It focused on an important topic related to the reliability of repairable systems. Without solving the complicated g-renewal equation directly, the authors developed a data-driven numerical estimation procedure. The good accuracy of the proposed method was demonstrated using a locomotive braking grids problem.

To tackle the challenging issues caused by the mixed interval and probabilistic uncertainty sources, Xia and Li proposed a new sequential approach for robust multidisciplinary design optimization. In the sequential approach, the robust design optimization in a single discipline is first solved. After that, a multidisciplinary design optimization under mixed uncertainty is performed. The developed novel approach was applied to a speed reducer problem with double objectives in each subsystem.

Another paper, co-authored by Liu, Zhao, Hu, Mourelatos, and Papadimitriou concentrated on the reliability analysis of AVs based on an adaptive surrogate modeling approach. The authors showed that the required number of tests in the collision-avoidance reliability analysis of AVs can be substantially reduced by employing an adaptive surrogate modeling approach, which refines the surrogate model through refinements in the region of interest.

Another paper by Xu and Liu proposed a new formulation of a control variate estimator to predict the variance and perform sensitivity analysis of mesostructure–structure systems by leveraging data from both low-fidelity and high-fidelity models. The mesostructure–structure system, manufactured by additive manufacturing, was used to demonstrate the advantages of the proposed new approach.

Ding, Wang, and Dai proposed a clustering-based framework using supervised models and multiple physical signals to estimate the remaining useful life of low-speed and heavy-load slewing bearings. Experimental data were used to validate the effectiveness of the proposed method.

Another paper, co-authored by Dahmardeh and Xi focused on the state-of-charge estimation of lithium-ion battery packs considering cell-to-cell variability from manufacturing tolerances. The one-state hysteresis model is used in conjunction with the extended Kalman filter approach to conduct the state-of-charge estimation for a serially connected battery pack.

Hu and Du co-authored a paper on system reliability prediction with outsourced components. The developed approach enables accurate system reliability predictions without requiring proprietary information from component suppliers. This covers a realistic scenario in automotive and other industries.

Yu, Wang, and Wang proposed a new time-dependent reliability-based robust design optimization approach which similarly to the paper by Hu and Du above has important applications in automotive and other industries. The accuracy of the proposed method was demonstrated with an automotive torsion bar example.

We hope everyone enjoys reading these papers. We also hope that the papers stimulate further advances in the area of RR&UQ in the automotive industry. We sincerely thank all the authors who responded to our call for papers and contributed excellent research articles. We would also like to thank all the reviewers for spending time to review papers. Last but not least, we would like to thank Ms. Deena Ziadeh who helped us with many logistical details.

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