Editorial: Software Reliability and Dependability Engineering

Zheng Zheng, *Senior Member, IEEE*, Lorenzo Strigini, *Senior Member, IEEE*, Nuno Antunes, *Member, IEEE*, and Kishor Trivedi, *Life Fellow, IEEE*

As software plays an increasingly important role in our lives, it is essential to maintain its reliability, and generally dependability. Software bugs can cause huge financial losses and dangerous accidents; the safety risks from software are underscored these days to even the non-technical public by the emergence of autonomous software-based systems. Thus, it is important to explore principled approaches to reduce the harm from defects in software, preferably by removing them as early as possible, but also by fault tolerance and by predicting their effects so as to inform mitigation actions.

Large sectors of academia and industry have long recognized the potential of software reliability and dependability engineering. Yet, in spite of decades of research and methodological advances, challenging research questions persist and new ones keep emerging, due to the complexity, heterogeneity and distributed nature of software products, and to continuing innovation - e.g. the emerging of machine learning techniques and of new critical application domains. This Special Issue on Software Reliability and Dependability Engineering was prepared to report recent advances in areas of this vast topic including the assessment, prediction and improvement of dependability attributes of software products. It was also aimed at reporting compelling results from industrial experience and "real-world" case studies in critical domains.

All the manuscripts received went through a rigorous review process. Each was evaluated typically by three reviewers and the reviews discussed among guest editors. The reviewers' suggestions to authors led to many improvements. This process resulted, in the end, in the acceptance of 9 very interesting papers, out of the 43 submitted. The selected papers show the intensive use of empirical and statistical evidence in Software Reliability Engineering research. Most are motivated by challenges arising from comparatively new technologies (machine learning, service architectures) or applications (e.g. self-driving vehicles); others address ever-present questions, like the dependability evolution of long-lived products.

The first two articles focus on machine learning systems.

The paper *"Fault Injection for TensorFlow Applications"* starts from the premise that improving error resilience requires detailed understanding of an application's resilience. The paper presents two high-level fault injection frameworks for TensorFlow-based applications, TensorFI 1 and TensorFI 2, for injecting hardware and software faults into programs. Both are flexible and portable so as be integrated into existing TensorFlow programs. Examples application to evaluating resilience of machine learning programs are reported, with the insight gained for improving it.

The paper *"Empirical Study of Fault Triggers in Deep Learning Frameworks"* is the first comprehensive empirical study on fault-triggering conditions in deep learning frameworks such as TensorFlow, MXNET and PaddlePaddle. Bugs in 3,555 reports are classified, based on fault triggering conditions. Analyses follow that cover: the frequency distribution of different bug types and evolution features; correlations between bug types and fixing time; root causes and consequences of Bohrbugs and Mandelbugs. Finally, an analysis of regression bugs was performed. The results of the study were systematized in 12 findings and 10 implications.

The next two articles focus address cyber-physical intelligence systems.

Autonomous Driving Systems (ADSs) are complex systems with strict requirements of safety and compliance. The paper *"An Incremental Approach for Understanding Collision Avoidance of an Industrial Path Planner"* presents a method to analyze the relation between ADS configurations and the levels of hazard in particular traffic situations. The approach first tries to understand whether the hazard is caused by single weights, and eventually extends the analysis to sets of multiple weights. It was applied to an industrial path planner, showing that different driving situations require the use of different weights values to maintain safety. This type of analysis can be used to re-engineer the solution and increase its safety.

The paper *"RGB cameras failures and their effects in autonomous driving applications"* studies the failure modes of a type

- *Zheng Zheng is with the School of Automation Science and Electrical Engineering, Beihang University, Beijing 100191, China. E-mail: zhengz@buaa.edu.cn.*
- *Lorenzo Strigini is with the Department of Computer Science at City, University of London, WC1E 7HU London, U.K. E-mail: L.Strigini@city.ac.uk.*
- *Nuno Antunes is with the CISUC, DEI, University of Coimbra, 3030-290 Coimbra, Portugal. E-mail: nmsa@dei.uc.pt.*
- *Kishor Trivedi is with the Department of Electrical and Computer Engineering, Duke University, Durham, NC 27708 USA. E-mail: ktrivedi@duke.edu.*

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of cameras important for self-driving vehicles, their effects and possible mitigations, using a FMEA method and resuts from the literature. The authors built a library for generating images taht cpould arise from camera failures, and fed them to six object detectors for mono and stereo cameras, and to one self-driving agent. The results add detail to our knowledge of effects of these failures and underscore the need for consider them in reliability engineering.

The next two articles focus on the localization of anomalies and faults.

The paper *"Locating Anomaly Clues for Atypical Anomalous Services: An Industrial Exploration"* builds on top of ImpAPTr, a tool to identify the combination of multiple dimensional attributes as clues about the root causes of service anomalies. While this paper is dedicated to solve the problems incurred by the threshold driven mechanism therein and that of identification of a suitable threshold. A method called ImpAPTr+ is proposed in which the constraint of 0.05%' threshold is removed. In comparative evaluation against two other typical methods, ImpAPTr+ is found to be: (1) far more accurate than the others; (2) one of two methods that give proper clues within seconds; (3) more suitable for near real-time monitoring.

The anomaly detection and localization technique proposed in *"SwissLog: Robust Anomaly Detection and Localization for Interleaved Unstructured Logs"* works based on anomalies manifested in sequence order changes and log time interval. For this, the technique parses logs and recognizes entities across different logs, embed them using BERT, and perform anomaly detection with Bi-LSTM.

The next article is on software analysis for reliability.

The paper *"Does OpenBSD and Firefox's Security Improve with Time"* addresses its title's question by studying vulnerability reports for these two open source software project over many years (22 for OpenBSD). The study is based on a framework for analysing software vulnerabilities data, a contribution in its own right. The authors derive interesting insights, for instance that as these products matured, they became more secure, but not because of developers producing less vulnerable code; and that although developers' mistakes are similar in both projects, Firefox vulnerabilities are more numerous, easier to exploit, but also fixed more quickly.

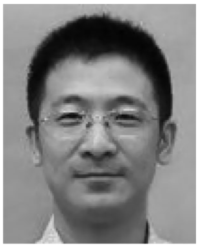
The next article addresses automated software correction.

The paper *"Sorald: Automatic Patch Suggestions for SonarQube Static Analysis Violations"* proposes a solution to automatically suggest fixes for Java code that violates the coding rules of the sonarqube platform. The approach is meant to reduce developers' effort to respond to warning, and thus help to increase software reliability. These fixes are ready to me merged into the code base if approved by the code's authors. The approach can be integrated in a software development lifecycle, as the authors prepared a bot ready to continuously monitor for changes in the Git repository. When evaluated on 161 popular GitHub repositories, Sorald was able to fix 65% of the violations that met the repair preconditions.

The final article of this special issue focuses on the impact of aging on software reliability.

In *"Impact of Service Function Aging on the Dependability for MEC Service Function Chain"*, a semi-Markov model is developed to investigate transient availability and steady-state dependability of MEC-SFC services, with any number of service functions, and capture complex time-dependent behaviors of aging, failure, and recovery. Approximate accuracy is evaluated by simulation; bottlenecks for MEC-SFC systems are detected through sensitivity analysis; the impact of event-time interval distributions on steady-state dependability is analyzed; transient behavior of MEC-SFC services with varying system parameters is investigated.

We wish to thank again all authors who submitted their work for this special issue, as well as the about 100 reviewers from all over the world, who helped to evaluate and select these 9 papers: we are very grateful to all of them for their timely and high-quality reviews. Finally, we wish to thank the Editor-in-Chief, Dr. Jaideep Vaidya and the Administrator, Mr. Ashutosh Rawat of IEEE Transactions on Dependable and Secure Computing for their constant and valuable support.



Zheng Zheng (Senior Member, IEEE) is a professor with Beihang University and the deputy dean with the School of Automation Science and Electrical Engineering. His research work is primarily concerned with software reliability and testing. Recently, He paid more attention on the intelligent software reliability engineering. He has co-authored more than 100 journal and conference publications, including *IEEE Transactions on Dependable and Secure Computing*, *IEEE Transactions on Information Forensics and Security*, *IEEE Transactions on Software Engineering*, *IEEE Transactions on Reliability*, *IEEE Transactions on Services Computing*, JSS and so on. He serves for IEEE PRDC2019, IEEE DASC 2019, IEEE ISSRE 2020, IEEE QRS 2021 as PC Co-Chairs, as well as WoSAR 2019, DeIS 2020 and DeIS 2021 as General Co-Chairs. He is the editor-in-chief of Atlantis Highlights in Engineering (Springer Nature), associate editor of *IEEE Transactions on Reliability* (2021-), Elesvier KBS (2018-) and Springer IJCIS (2012-) and guest editor of *IEEE Transactions on Dependable and Secure Computing* (2021). He is IEEE CIS Emerging Technologies TC member.

Lorenzo Strigini (Senior Member, IEEE) received the Laurea degree cum laude from the University of Pisa, Italy, in 1980. He is a professor and the director with the Centre for Software Reliability, City, University of London, which he joined in 1995. He previously worked with the National Research Council of Italy . His research area is dependability of software and systems, focusing on quantitative assessment, diversity for fault tolerance, human-machine systems. He has published widely. On these topics, led national and international research projects and acted as a consultant. He is an associate editor in chief of TDSC and has served as an associate editor for the *IEEE Transactions on Software Engineering*. He is a member of IFIP Working Group 10.4 on Dependable Computing and Fault Tolerance; the European Workshop on Industrial Systems Reliability, Safety and Security; the ACM; the IEEE Computer Society.

Nuno Antunes (Member, IEEE) received the PhD degree in information science and technology, in 2014. He is an assistant professor with the University of Coimbra. He has been with the Centre for Informatics and Systems of the University of Coimbra (CISUC) since 2008. His expertise includes testing, fault injection, vulnerability injection and benchmarking, which are applied to the assessment of the dependability and security of intelligent systems, virtualized environments, intrusion detection systems, web services, web and mobile applications, and data management systems. He is a member of the IEEE Computer Society.

Kishor Trivedi (Life Fellow, IEEE) received the BTech degree in electrical engineering from IIT Mumbai, and the MS and PhD degrees in computer science from the University of Illinois at Urbana-Champaign. He holds the Fitzgerald Hudson chair with the Department of Electrical and Computer Engineering, Duke University, Durham, NC. He has been on the Duke faculty since 1975. He is the author of a well-known text entitled, Probability and Statistics with Reliability, Queuing and Computer Science Applications, originally published in 1982 by Prentice-Hall which was published as an inexpensive Indian edition by PHI. A thoroughly revised second edition of this book has been published by John Wiley that is also available as an inexpensive Asian edition. The book was recently translated into Chinese. He has also published several other books: Performance and Reliability Analysis of Computer Systems, published by Kluwer Academic Publishers (1996), Queueing Networks & Markov Chains, John Wiley (1998 and 2006) and Reliability and Availability Engineering, Cambridge University Press (2017). He is a Golden Core Member of IEEE Computer Society. He is the recipient of IEEE Reliability Society's Life Time Achievement Award. His h-index is 110. He is the recipient of IEEE Computer Society's Technical Achievement Award for his research on Software Aging and Rejuvenation.