Big Data-Theoretic Advancements for Probabilistic Risk Assessment

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Abstract

We continue to witness large-scale system failures resulting in injuries, fatalities, adverse environmental consequences, and economic losses. Preventing these catastrophic accidents requires advancements in multidisciplinary risk analysis supported by collaborative research among academia, industry, and national labs. It demands the development of a common vocabulary within diverse engineering and social science domains in order to address risks emerging from the interface of social and technical systems. These collaborations will lead to the improvement in socio-technical risk theories and the integration of deterministic and probabilistic techniques. The talk presents some of the speaker's on-going multidisciplinary research projects, focusing on the advancement of Probabilistic Risk Assessment (PRA) that provides input for risk-informed nuclear regulatory decision making. The theoretical contribution of these projects is the incorporation of two types of underlying phenomena into PRA: (1) physical failure mechanisms (e.g., to model fire risk, location-specific Loss of Coolant Accidents leading to Emergency Core Cooling System failure) and (2) social failure mechanisms (e.g., to model the effects of human and organizational factors on technical system failure). This incorporation helps identify and manage root causes of system failure and reduces unnecessary conservatism in nuclear power plant operation and design. The methodological contribution of these research projects relates to the integration of classical PRA techniques (i.e., Fault Trees and Event Trees) with simulation-based methods that enable the modeling of emergent risk behavior by depicting the dynamic interactions of risk contributing factors within their ranges of variability and uncertainty. These cutting-edge PRA models are quantified with state-of-the-art big data analytics to expand the classical approach of data extraction and execution for risk analysis by incorporating techniques such as text mining, network data analytics, and data curation. The *Big Data-Theoretic* advancements of PRA (1) utilize big data analytics to address wide-ranging, incomplete, and unstructured data for risk assessment of complex systems and (2) are founded on physical and social failure theories, avoiding the possibility to be misled by solely data-informed approaches. These theories support the completeness of contextual risk factors and the accuracy of their causal relationships. The talk will conclude by demonstrating the monetary value of PRA. Although the current projects focus on nuclear power applications, the newly developed theories and techniques can be implemented in other high-hazard industries such as oil and gas, aviation, and space.

Biography

ZAHRA MOHAGHEGH is currently an Assistant Professor in the Department of Nuclear, Plasma, and Radiological Engineering (NPRE) and an affiliate to the Department of Industrial and Enterprise Systems Engineering at the University of Illinois at Urbana-Champaign. She is a recipient of the George Apostolakis early-career award in risk assessment and the Zonta International Award for her contribution to modeling large-scale complex systems. Dr. Mohaghegh is the director of the Socio-Technical Risk Analysis (SoTeRiA) research group (http://soteria.npre.illinois.edu) at NPRE. She is the author of over thirty journal and conference papers on risk analysis and a member of the Society for Risk Analysis, American Nuclear Society, and American Society of Mechanical Engineers. Dr. Mohaghegh holds Master's and Ph.D. in Reliability Engineering from the Mechanical Engineering Department at the University of Maryland.

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