Diego Mandelli

R&D Scientist at Idaho National Laboratory

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Professional Interest: Develop and apply methods and algorithms to analyze, model, and manage complex systems

CORE COMPETENCIES

Reliability Modeling	Optimization Methods	Machine Learning
Methods Development	System Modeling	Causal reasoning

PROFESSIONAL EXPERIENCE

Idaho National Laboratory: R&D Scientist August 2011 - Present

- PI of the LWRS "Risk Informed Asset Management" project. In collaboration with multiple nuclear utilities, I lead and develop advanced data analytics tools that synthesize system equipment reliability data from a plurality of sources to improve nuclear power plant operations. The developed centralized data analysis platform captures the system architecture and full performance history of plant systems and assets. This integration enables system engineers to identify connections between events, build a narrative for identified anomalies, and associate historical patterns with current observations. This platform has the potential to cut costs by scheduling maintenance operations only when required, troubleshoot sources of abnormal behaviors, and improve overall system/equipment performance.
- PI of the LWRS "Plant Outage Optimization" project. In collaboration with different nuclear utilities, I focus on the development of methods to co-pilot plant outage managers to create outage schedule and manage outage execution with the goal of reducing the risk of outage delays. The developed methods rely on: 1) AI/ML algorithms to analyze plant outage data and inform outage managers on past outage performance, and 2) optimization methods that integrate plant resource availability (e.g., time, crews, space) to assess resilience and robustness of an outage schedule.
- PI of the LWRS "Digital Architecture for an Automated Plant" project. In collaboration with different nuclear utilities and private companies, the goal of this project is to reduce plant operations and maintenance (O&M) costs by automating plant's work management process (currently heavily relying on human decision-making) by leveraging AI's ability to handle large and complex amounts of data to make the same decisions. I focus on finalizing the development of the MIRACLE software which contains several AI functions that can automate several steps of plant work management such as: screening of unexpected events, scoping to define the nature of the work, planning and assembling a work package, scheduling work and resources, executing the work, and documenting.
- Project manager and developer of the RAVEN statistical analysis platform for uncertainty quantification, regression analysis, data analysis, and model optimization. I provide direction and contribution on the development and deployment of RAVEN capabilities for several use cases ranging from model optimization, data mining, and model response exploration.
- Co-PI of the "Build-to-Replace" project in collaboration with EPRI and MIT with the goal of reexamining underlying assumptions of O&M approaches and practices of advanced reactors. I investigated scenarios whether more frequent and predictable replacement of advanced reactor assets result in an improved O&M cost, as a result of avoiding a variety of possible costs associated with longer service life (e.g., monitoring, periodic maintenance).
- Co-PI of the "Reliability Integrity Management" (RIM) project in collaboration with U.S. NRC and advanced reactor developers. I contributed to the: 1) estimation of system and equipment reliability targets based on regulatory constraints, and 2) integration of performance (i.e., condition-based) data into equipment reliability. I have been leading the development of first-of-its-kind:
  - Optimization methods designed to analytically determine system and equipment reliability targets that minimize costs and satisfy regulatory safety requirements.
  - Analytical methods designed to assess equipment reliability based on monitoring/maintenance strategy and observed performance data.
- PI for the INL LDRD project "A Causal Approach to Model Validation and Calibration". I led and developed AI/ML methods that move away from currently employed purely data-driven methods for validation and calibration toward more robust model-driven methods based on causal inference. Such methods capture the causal relationships between data elements (e.g., simulated and experimental data) rather than looking at their associations, and they employ these relationships to measure differences between simulated and measured data. These causal differences directly inform the calibration process rather than relying on the analyst educated guess.

- PI of the LWRS "Methods Development" project. I led and developed dynamic Probabilistic Risk Assessment (PRA) methods based on simulation models with the goal of accurately identifying the impact of sequence and timing of events on accident scenarios using physics-based simulation models. Simulation models included: plant dynamic simulators, human reliability models, and external events simulation tools. Developed methods included algorithms to generate accident sequences using simulation models coupled with AI/ML models and to analyze such scenarios using data mining methods.
- Co-PI of the NEUP "Integration of dynamic and classical PRA" in collaboration with The Ohio State University and ORNL. I led and developed approaches to improve the fidelity of plant PRA models by reducing conservative assumptions behind such models using simulation tools. This was performed by developing methods designed to link classical PRA models with system simulation models, and to integrate simulation-based data into event trees and fault trees.
- Co-Pi of the NEUP "OFBGT" project in collaboration with The Ohio State University and ORNL. I led and developed methods designed to solve the "inverse problem" applied to reactor systems, i.e., assess reactor core 3D power distribution based on limited sensor data and simulation models. This was performed by integrating sensor data with simulation data to predict core power using machine learning, optimization, and Bayesian inference algorithms.
- PI for the INL LDRD project: "Exploratory Nuclear Reactor Safety Analysis and Visualization via Integrated Topological and Geometric Techniques". I led and developed methods to assist system analysts to analyze complex (i.e., multi-dimensional) datasets. This was performed by developing software for visualization and analysis multi-dimensional data using topological decomposition methods (based on Morse-Smale regression) in collaboration with Scientific Computing and Imaging Institute (University of Utah).

Idaho National Laboratory: Instructor at U.S. Nuclear Regulatory Commission (NRC) 2018 - Present

- Instructor for the "P-102 Bayesian Inference in Risk Assessment" and "P-502 Bayesian Inference in Risk Assessment - Advanced Topics" courses. Topics covered: probability theory, computational Bayesian inference, uncertainty propagation on reliability models

Idaho State University: Adjunct Professor 2016

- Instructor for the "Reliability and Risk Assessment" class. Topics covered: computational statistical analysis, numeric reliability modeling, integration of machine learning methods with reliability models

EDUCATION

Ph.D Nuclear Engineering, The Ohio State University *June 2011*
M.S. Nuclear Engineering, The Ohio State University *March 2008*
Laurea Nuclear Engineering, Politecnico di Milano *October 2004*

SELECTED HONORS AND AWARDS

- R&D100 Award for the RAVEN code (2023)
- Scientific Achievement Award - System Safety Society (2023)
- INL Award: In recognition of top-notch technical research, presentation of research, quality of products and contribution to project management on the RISMC pathway methods development

PUBLICATIONS

Approximately 200 publications have been authored or co-authored to date, including journal papers, conference proceedings, book chapters, and technical reports. A complete list can be provided upon request. A list of selected publications is as follows:

- D. Mandelli, C. Wang, and S. Hess, "On the language of reliability: A system engineer perspective," *Nuclear Technology*, 2023
- D. Mandelli, C. Wang, A. Alfonsi, Z. Ma, C. Smith, C. Parisi, R. Youngblood, and T. Aldemir, "Mutual integration of classical and dynamic PRA," *Nuclear Technology*, vol. 207, pp. 363–375, 2021
- D. Mandelli, C. Wang, C. Parisi, D. Maljovec, A. Alfonsi, Z. Ma, and C. Smith, "Linking classical PRA models to a dynamic PRA," *Annals of Nuclear Energy*, vol. 149, 2020
- D. Mandelli, C. Parisi, A. Alfonsi, D. Maljovec, R. Boring, S. Ewing, S. S. Germain, C. Smith, and C. Rabiti, "Multi-unit dynamic PRA," *Reliability Engineering & System Safety*, vol. 185, pp. 303–317, 2019
- T. Aldemir, S. Guarro, J. Kirschenbaum, D. Mandelli, L. Mangan, P. Bucci, M. Yau, B. Johnson, C. Elks, M. Stovsky, D. Miller, X. Sun, S. Arndt, Q. Nguyen, and J. Dion, *NUREG/CR-6985: A Benchmark Implementation of Two Dynamic methodologies for the reliability modeling of Digital Instrumentation and Control Systems.* Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC, 2009