



Artificial Intelligence for Robust Engineering & Science

AIRES 4: Machine Learning for Robust Digital Twins

In-Person Workshop

April 18-20, 2023

Overview

Robust engineering is the process of designing, building, and controlling systems to avoid or mitigate failures. Advances in digital twin and digital thread technologies are expected to enable robust engineering practices in a wide variety of scientific and industrial applications, providing the capability to manage the lifecycle of complex systems. Over the past decade, data availability, advances in computing, and streamlined data-driven methods and tools widened the opportunities for transferring digital twin technology at the edge to enable real-time system operation. The introductory Artificial Intelligence for Robust Engineering and Science (AIRES) workshop in January 2020 explored the foundations of AI for robust engineering while subsequent workshops in this series expanded on this theme. The next workshop in this series, AIRES 4, will build on the successes of previous workshops, and explore and develop the foundations of AI in digital engineering, with a focus on assured digital twins, lifecycle management of digital twins, and data management. Other related topics are also expected to be discussed.

The workshop will be a venue for knowledge sharing about upcoming advances in digital twin and digital thread technology for both engineered and natural systems, and for building collaborations between researchers across the spectrum of technologies and applications. While the focus of the workshop is on AI technologies, we recognize that applications are an important aspect driving the development of AI technologies and digital twins. Researchers developing and deploying solutions across a wide range of application domains, including areas defined by the US DOE Earthshot Initiatives, are invited to participate.

The workshop will comprise three tracks:

Assured Digital Twins: This track focuses on the technical challenges associated with developing and using robust digital models, such as

- Integrating physics or other knowledge into machine learning
- Methods for multi-scale prediction (especially multi-scale time-series prediction)
- Scaling issues associated with large models
- AI algorithms for control of complex systems
- Uncertainty quantification
- Assurance, including causal inference, explainability, and interpretability
- Verification, validation, and calibration

Digital Twin Model Development and Lifecycle

Management: This track focuses on the ecosystem and methods necessary for practical use of digital twins, such as:

- Real-time data integration, online and offline continuous learning on edge-based systems
- Edge deployment for real-time and power-efficient deployment of digital twins, and integrating HPC and edge systems
- Federated learning for privacy or for data reduction
- Security and resilience
- Human-machine interface design
- Interoperability of digital twins
- Standards needs, and the use of digital twin technologies in standards

Sensors and Data Management: This track focuses on all aspects of data relevant to digital twin technology, including

- AI supporting data acquisition, communication, data management, and data validation
- Novel experimental in-process and post-process characterization of systems



- Techniques for optimizing sensor selection and placement for digital twins
- Detecting and dealing with data bias
- Standards for data for digital twin technologies

In addition, topics associated with detecting and dealing with bias, and diversity, equity, and inclusion associated with the development and use of AI solutions are of interest and will need to be addressed to enable AI for robust digital twins.

Meeting format

AIRES 4 is planned as an in-person meeting from April 18-20, 2023. The meeting will be hosted on site at Oak Ridge National Laboratory (ORNL), in Oak Ridge, TN.

AIRES 4 is focused on user participation with the objectives of exploring current work in the use of artificial intelligence and machine learning for robust engineering and digital twins, identifying research challenges and investment areas, and developing collaborations among participants. The workshop will include

- *Invited talks*
- *Contributed talks* (15 minutes each). Participants may propose a talk during the registration process by submitting an abstract (1 page or less preferred; 2-page maximum). The program committee will select from the proposed talks for presentation during the workshop.
- *Breakout sessions* to address specific questions proposed by the program committee and by participants. A summary of each breakout session will be included in the workshop report. Interested participants may propose a topic during the registration process.
- *Networking opportunities* to enable attendees to identify opportunities for collaboration.

General Chair:

Pradeep Ramuhalli, Oak Ridge National Laboratory

Executive Committee

Sudip Seal, Oak Ridge National Laboratory

David Womble, Oak Ridge National Laboratory

Malachi Schram, Jefferson Lab

The workshop will comprise multiple sessions dedicated to each track, with additional breakout sessions for small-group interactions and brainstorming activities. A workshop report will be produced with input from attendees based on participation in breakout and brainstorming sessions. Extended abstracts submitted by attendees will be considered for inclusion in the workshop report. In addition, the workshop organizers expect to invite selected attendees (based on the submitted extended abstracts) to submit full technical papers for a special issue of a journal. Details of the journal submission and review timelines will be shared closer to the workshop dates.

How to participate

With the goal of increased collaborations, AIRES-4 participants will be expected to actively contribute in the workshop including small group interactions and breakout sessions. In addition to providing basic personal and contact information during registration, participants will also provide their research interests and be given the option to propose a contributed 15-minute talk, recommend breakout session topics, and volunteer to lead a breakout session. Registration is free.

Participation is by invitation only. Requests to participate can be emailed to AIRES@ornl.gov. The deadline to request an invitation is February 1, 2023. However, we ask that individuals who may be considering attending request an invitation as soon as possible to enable the organizing committee to meet the processing timelines for site access to ORNL.

Meeting organization

AIRES 4 will be hosted by Oak Ridge National Laboratory.

Logistics and Planning Chair:

Taylor Bullock, Oak Ridge National Laboratory

Nat Trask, Sandia National Laboratories

Draguna Vrabie, PNNL

For more information, please visit <https://AIRE.ORNL.gov>.