ASME Journal of Dynamic Systems, Measurement, and Control
Online journal at:
https://asmedigitalcollection.asme.org/dynamicsystems

Journal of Dynamic Systems, Measurement, and Control

Guest Editorial

Special Issue on Data-Driven Modeling and Control of Dynamical Systems

Advances in data-driven modeling and control techniques have revolutionized the field of dynamical systems, leading to significant advances in broad domains, including engineering, robotics, finance, biology, and environmental sciences. By leveraging data-driven methods, researchers and practitioners are developing novel models to capture observed behavior and designing novel strategies for efficient, robust, and resilient performance. This special issue brings together leading experts to showcase the latest developments in this exciting area.

The breadth of topics addressed in this issue reflects the fundamental advances enabled by data-driven methods from multi-agent tracking and localization, cyber-physical security, human motor control, decentralized control of robot swarms, and precision motion systems to the prediction and control of complex nonlinear dynamic systems. Additionally, the issue covers advancements in electric vehicle operation, aircraft dynamic modeling, underwater robotic sensing, and material microstructure optimization, illustrating a range of novel applications benefiting from these techniques. The specific highlights of the issue are discussed below.

Addressing challenges in precision motion systems, Yang et al. combine data-driven feedforward control with gradient descent to avoid unstable plant inversion. This innovative method achieves optimal point-to-point tracking performance without extensive model identification, showcasing significant advancements in feedforward control.

Olsen et al. introduce an information-theoretic Bayesian inference approach for multi-agent tracking and localization of a dynamically moving radio frequency emitter with an unknown waveform. The paper demonstrates the efficacy of utilizing mutual information to coordinate mobile sensors in both simulations and physical experiments involving micro-aerial vehicles.

Exploring human motor control mechanisms, Yu et al. compare methods for inferring control intent using inverse linear quadratic regulators. The study illustrates that using output penalty in inverse linear quadratic regulators significantly improves the goodness of fit, providing new insights into human control strategies through physical human–robot interaction experiments.

Tsolovikos et al. extend dynamic mode decomposition to high-dimensional uncertain nonlinear systems by combining it with Gaussian process (GP) regression methods. The proposed method yields hybrid parametric/nonparametric reduced-order models for prediction and control tasks. The proposed methods show superior performance in controlling nonlinear fluid flows, highlighting the potential of combining dynamic mode decomposition with GP regression in such complex scenarios.

Focusing on the operational challenges of electric trucks, Ahn et al. introduce a data-driven model using a gated recurrent unit and maximum entropy Markov model to predict velocity and energy consumption. The approach utilizes real-world electric vehicle data to demonstrate high accuracy in fleet route planning, addressing critical issues in sustainable transportation.

Lochrie et al. present an antiwindup adaptive look-up table algorithm for engine control systems, addressing system variations due to aging and faults. The study demonstrates robust adaptation techniques crucial for maintaining emissions control in engines.

Srinath and Dey focus on the cyber-physical security of modern battery systems, presenting a machine learning-based method to detect, estimate, and mitigate adversarial attacks. This approach enhances resilience against false data injection attacks by integrating adaptive boosting, long short-term memory neural networks, and corrective control.

Benyamen et al. employ data-driven machine learning and reinforcement learning to improve flight controller performance. This method outperforms traditional controllers in flight tests, showing significant improvements in lateral tracking and adaptability under challenging conditions.

Omotuyi and Kumar present a novel approach for decentralized control of large-scale heterogeneous robot swarms using graph neural networks. This method demonstrates efficiency and scalability, achieving performance comparable to centralized controllers in both simulation and hardware implementations.

Sharma et al. investigate the optimal control of material microstructures utilizing phase field models and reinforcement learning algorithms. This data-based approach demonstrates feasibility in achieving desired material properties, offering new insights into the control of complex material systems.

Han and Yi propose GP-based learning controllers for underactuated balance robots, addressing uncontrolled motion issues in external and internal convertible-based designs. This method ensures tracking and balancing tasks and is validated in experimental setups, advancing the field of robotic control.

Finally, utilizing Koopman operator techniques, Rodwell and Tallapragada advanced algorithms for underwater robots to extract information from vortex wakes. This approach improves estimation accuracy compared to convolutional neural networks, enabling efficient obstacle localization and enhancing underwater robotic capabilities.

This special issue highlights the transformative potential of data-driven approaches in the modeling and control of dynamical systems. We hope these contributions inspire further research and collaboration in this dynamic and rapidly evolving field.

Efstathios Bakolas
Aerospace Engineering and Engineering Mechanics,
The University of Texas at Austin,
Austin, TX 78712
e-mail: bakolas@austin.utexas.edu

Suman Chakravorty
Aerospace Engineering,
Texas A&M University,
College Station, TX 77843
e-mail: schakrav@tamu.edu

Santosh Devasia
Mechanical Engineering,
University of Washington,
Seattle, WA 98195
e-mail: devasia@uw.edu

Vaibhav Srivastava
Electrical and Computer Engineering,
Michigan State University,
East Lansing, MI 48824
e-mail: vaibhav@egr.msu.edu