Tomoki Koike

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Research Interests

My research interests encompass model reduction, control theory, extreme data analysis, scientific machine learning (SciML), and network information systems, exploring the intersection of data-driven techniques and control systems.

Education

Georgia Institute of Technology, Atlanta, GA   Aug 2021 – *Present*
   Ph.D. in Aerospace Engineering & **M.S.** in Computational Science and Engineering
   Cumulative Gpa: 3.89 / 4.0
   Advisor: Dr. Elizabeth Qian
   Topic: Model reduction in extreme data settings with considerations of stability and controls.

Purdue University, West Lafayette, IN   Aug 2018 – May 2021
   B.S. in Aeronautical & Astronautical Engineering
   Cumulative Gpa: 3.89 / 4.0
   Undergrad Research Advisor: Dr. Carolin Frueh, Research Field: Space Debris Data Analysis
   Thesis Project: VTOL Aircraft Design: Proof-of-concept

Research/Experience

Graduate Research Assistant

Present
Aug 2022

Aerospace Computational Engineering Laboratory, Georgia Institute of Technology, Atlanta, GA

❖ Researching model reduction techniques for extreme data scenarios – ROME Project.

❖ Developing the Energy-Preserving Operator Inference (EP-OpInf) method, incorporating constrained optimizations for stable physics-informed model reduction.

❖ Extending operator inference methods to ensure stability in various scenarios, including local and global asymptotic stability and attractor/limit cycle cases.

❖ Creating a data-driven Lyapunov Function Inference (LFI) method using Zubov's approach.

❖ Pioneering a recursive algorithm for monomial-based Lyapunov function discovery in large-scale non-linear dynamical systems.

❖ Constructing a trajectory optimization framework with Extended Dynamic Mode Decomposition (EDMD) and Linear Quadratic Regulator (LQR) for modified equinoctial element equations.

❖ Developing an iterative quadratic quadratic regulator (iQQR) for precise controller design.

❖ Discovering the latent space of large-scale dynamics such as neutron star smoothed-particle hydrodynamics (SPH) model via scientific machine learning and model reduction approaches.

Robotics Summer Intern

Aug 2022
Jun 2022

Nokia Bell Labs, New Providence, NJ

❖ Made contributions to validate performance enhancements in ROS2 for simulating multi-agent robots within a factory environment using Gazebo.

❖ Conducted comprehensive benchmarking assessments to evaluate the scalability of both ROS1 and ROS2, focusing on key performance indicators such as message drop ratio, latency, and jitter.

❖ Performed in-depth performance comparisons among ROS2 components, discovery servers, and data distribution service (DDS) to assess their scalability and efficiency.

UAV Capturing – Aerospace Engineering Masters Research

Aug 2021
May 2022

Advised by Dr. Jonathan Rogers, Georgia Institute of Technology, Atlanta, GA

❖ Developed fully animated simulation model of a quadcopter using MATLAB & Simulink for testing UAV chase simulations.

❖ Implemented a range of advanced control algorithms, including PID and Pure Pursuit, to enable precise target pursuit and capture capabilities, enhancing project performance and functionality.

LiDAR Data Processing Software Development Summer Intern

Aug 2021
May 2021

TerraDrone Corporation, Tokyo, Japan

❖ Contributed substantially by developing Python software to insource drone point cloud data strip adjustment reducing hours of manual work to 15 minutes for 500MB data.

❖ Development of tree detection software for point cloud data with tree crown delineation algorithm.

❖ Business idea development for American Drone Service Provider Market.

Undergraduate Research Assistant

May 2021
Feb 2020

Space Information Dynamics Laboratory, Purdue University, West Lafayette, IN

❖ Acquired data from Space-Track, Vimpel, etc. which is propagated with simplified general perturbation (SGP) 4 algorithm.

❖ Provided data to assess uncertainty with Mahalanobis distance used to refine the debris data.

Teaching Experience

Graduate Teaching Assistant

2022

AE2220 Dynamics, lecturer: Dr. Mayuresh Patil (Fall, $\sim$ 60 students)

❖ Designed the final project involving a cubic space robot. The students worked on their robot's kinematics, dynamics, and trajectory design.

❖ Graded and provided assistance to projects and assignments.

❖ Held regular office hours for additional help.

AE2220 Dynamics, lecturer: Dr. Mayuresh Patil (Spring, $\sim$ 60 students)

❖ Graded all assignments and assisted student learning with regular office hours.

❖ Created additional homework questions.

❖ Designed a final project that involved the dynamics of diving.

Talks & Seminars

2023

❖ **AIAA SciTech 2024 Presentation**, in Orlando, FL, for session MDO-08: Metamodeling, Reduced Order Models, and Approximation Methods I. Presentation on "Energy-Preserving Reduced Operator Inference for Efficient Design and Control."

❖ **Short & Sweet Seminar Series**, Georgia Institute of Technology. Talk on "Discovering Stable Reduced Order Models: Energy-Preserving Operator Inference." Hosted by the Computational Science and Engineering Department.

Publications

Conference Proceedings

2023

❖ **T. Koike** and E. Qian, "Energy-Preserving Reduced Operator Inference for Efficient Design and Control." In AIAA SciTech Forum 2024, January 8-12, Orlando, FL.

Skills

Programming Languages:	Julia, Python, MATLAB, C/C++, Bash, Lua
Software:	Git, Simulink, GMAT
OS, Libraries, Tools:	Linux, ROS1, ROS2, PyTorch, LaTeX, Arduino IDE, Raspberry PI
Languages:	English (fluent), Japanese (native)

Awards and Scholarships

Aug 2018 - May 2023	Semester Hours & Dean's list, Purdue University
Dec 2020	2020 FAA Smart Airport Student Competition Winner.
	(Developed trajectory planning algorithm)
Dec 2019	Sigma Gamma Tau, National Honor Society of AAE
May 2017	De Anza College (Cupertino, CA) – NIC International Japan Partnership Scholarship

Selected Coursework

Controls
    Linear Control, Nonlinear Control, Optimal Control, Kalman Filter, Advanced Dynamics
Mathematics
    Optimization, Linear Algebra, Numerical Linear Algebra, Real Analysis, Probability, PDE
Machine Learning
    Math foundations of ML, Scientific Machine Learning

References

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