Jake Buzhardt

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Education

Clemson University Clemson, SC
Ph.D. in Mechanical Engineering, GPA: 4.00/4.00 January 2018 –December 2023 (Expected)
Thesis: Controlled density transport with applications in Stokes flows and uncertain control systems

Clemson University Clemson, SC
B.S. in Mechanical Engineering, GPA: 3.75/4.00 August 2013–December 2017
Minor in Mathematical Sciences

Research Interests:

Nonlinear dynamics and control for locomotion, optimal control and trajectory optimization, uncertainty propagation and quantification, low Reynolds number hydrodynamics, offroad vehicle navigation and control, data-driven dynamical systems and reduced order modelling

Research and Work Experience

Applied Dynamical Systems Lab Clemson, SC
Graduate Research Assistant January 2018 –Present
Advisor: Dr. Phanindra Tallapragada

- Data-driven dynamical systems:
  - Applied existing methods and developed new methods based on the Perron-Frobenius and Koopman operators for data-driven modelling and control of dynamical systems involving complex environmental interactions including micro-scale swimming robots, offroad vehicle navigation on deformable terains, and hydrofoil stabilization in an unsteady flow.
  - Developed methods for propagating and controlling uncertainty in controlled dynamical systems based on the Perron Frobenius operator. Quantified uncertainty in Koopman-based modelling frameworks by using Gaussian processes as a feature map.
- Magnetically actuated artificial microswimmers
  - Developed simulation methods to model the dynamics of interacting groups of artificial microswimmers composed of rigidly linked magnetic spheres driven by an external magnetic field. Implemented the Stokesian dynamics algorithm, the method of regularized Stokeslets, and models based on singularity solutions of the Stokes equations.
  - Developed control strategies for steering microswimmers along a desired path, manipulating passive spherical particles, and steering distributions of fluid particles.
- Rolling, jumping mechanisms and robots
  - Developed a novel pendulum-driven rolling, jumping wheel robot in a compact, lightweight, 3D printed design based on Littlewood's classical model of a heavy eccentric mass on a light hoop leading to a loss of contact. The robot consists of a single actuator and can achieve jumps of up to 2.5 body lengths vertically, and clear horizontal distances of over 6 body lengths.

Virtual Prototyping of Ground Vehicle Systems Center (VIPR-GS) Greenville, SC
Graduate Research Assistant August 2020 –July 2022

- Implemented Koopman operator based data driven model predictive control for simultaneous path planning and stabilization of an offroad vehicle in simulation
- Analyzed effects of proprioceptive sensing on the capability to estimate unknown terrain parameters from onboard sensor measurements using a 5 degree-of-freedom vehicle model coupled with a Bekker-Wong deformable terrain model.
- Developed deep reinforcement learning algorithms for off-road navigation, estimation, and path planning. Studied the effects of offline, model-based training and online training using a tenth-scale vehicle platform.
- Derived lower-order models for simplified analysis of complex suspension systems within reinforcement learning framework.

Robert Bosch, LLC Anderson, SC
Manufacturing Engineering Co-op August 2015 –May 2017

- Managed and contributed to multiple long-term projects aimed at reducing scrap costs in production and improving product quality, including multiple projects utilizing Shainin problem solving strategies.
- Implemented digital entry forms and databases for collecting and storing production data, thereby replacing paper forms, developing interactive data visualizations, and implementing Industry 4.0 standards.
- Applied Solidworks and CAD skills to develop custom tooling and gain a broader knowledge of machine design.
- Completed manufacturing engineering apprenticeship program, recognized by the SC Department of Labor, gaining a knowledge of manufacturing topics including Bosch Production Systems, PLC programming, pneumatic systems, and electrical safety.

Teaching

Clemson University –Department of Mechanical Engineering Clemson, SC
Graduate Teaching Assistant January 2019–December 2020

- Instructed class of sophomore mechanical engineering students in ME 222: Mechanical Engineering Laboratory (class size typically 15-16 students).
- Facilitated hands-on learning through experimentation, group projects, and technical writing exercises.
- Developed video lectures for hybrid instruction and a new applied statistics and uncertainty course module.

Clemson University –Department of Mechanical Engineering Clemson, SC
Graduate Grading Assistant January 2018–December 2022 (Intermittent)

- Served as a point of contact for students, professors, and the grading team on course grading matters.
- Managed the course web-page, regulate assignments, and arrange regular grading team meetings
- Courses Graded:
  - ME 2010: Statics & Dynamics (Lead Grader –Spring 2018)
  - ME 6930: Nonlinear Dynamics & Chaos (Fall 2018)
  - ME 6930: Mechanical Vibrations (Fall 2022)

Clemson University - General Engineering Department Clemson, SC
Undergraduate Teaching Assistant August 2014 - May 2015

- Attended class meetings of freshman level general engineering courses and assisted course instructors in creating an active learning environment through lab activities and group learning exercises.
- Hosted three-hour study sessions each week to facilitate group learning and assist students in learning course concepts.

Graduate Coursework

at Clemson University

2022	Asymptotics and Perturbation Methods in Engineering Science
2021	Autonomy: Science and Systems , Multibody and Robot Dynamics
2020	Hydrodynamic Stability, Advanced Nonlinear Dynamics
2019	Foundations of Fluid Mechanics Advanced Estimation , Theory of Elasticity , Advanced Nonlinear Control
2018	Intermediate Dynamics , Applied Optimal Control Modern Control Engineering , Structural Vibration , Autonomous Driving Technology
2017	Nonlinear Dynamics & Chaos (as an undergraduate)

Honors and Awards

2023	Awarded Clemson University Doctoral Dissertation Completion grant (Fall 2023)
2023	Awarded Graduate Travel Grant from Clemson Graduate Student Government to attend IROS 2023
2022	Award of Excellence – Doctoral Student. (Clemson Department of Mechanical Engineering)
2020	Figure from Buzhardt & Tallapragada, Phys. Rev. E. 2019 featured in Annual Calendar of American Physical Society (APS)
2019	Departmental Master's Student Award (Clemson University Department of Mechanical Engineering)
2019	Figure from Buzhardt & Tallapragada, Phys. Rev. E. 2019 featured in PRE Kaleidoscope online.
2019	Finalist for Best Student Paper at the 2019 ASME Dynamic Systems and Controls Conference (DSCC)
2018	Awarded Graduate Travel Grants from Clemson Graduate Student Government to attend 2018 ASME DSCC and 2018 APS Division of Fluid Dynamics meeting.

Publications

1. **Buzhardt, J.**, Chivkula, P., and Tallapragada, P. A Pendulum-Driven Legless Rolling Jumping Robot. Accepted by IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2023. Preprint: arXiv:2304.11527

2. Loya, K., **Buzhardt, J.** and Tallapragada, P. "Koopman operator based predictive control with a data archive of observables" ASME Letters in Dynamic Systems and Control, Oct 2023. 3:1-7 DOI: 10.1115/1.4063604

3. **Buzhardt, J.** and Tallapragada, P. "Controlled density transport using Perron Frobenius generators." Accepted by IEEE Conference on Decision and Control (CDC), 2023. Preprint: arXiv:2304.13829

4. Rodwell, C., **Buzhardt, J.** and Tallapragada, P. "A Koopman operator approach for the pitch stabilization of a hydrofoil in an unsteady flow field." In 2023 American Control Conference (ACC) (pp. 1453-1458). IEEE. DOI: 10.23919/ACC55779.2023.10156189

5. Salvi, A., Coleman, J., **Buzhardt, J.**, Krovi, V., and Tallapragada, P.. "Stabilization of vertical motion of a vehicle on bumpy terrain using deep reinforcement learning." Proceedings of the Modeling, Estimation and Control Conference, 2022. DOI: 10.1016/j.ifacol.2022.11.197

6. **Buzhardt, J.** and Tallapragada, P. "A Koopman operator approach for the vertical stabilization of an off-road vehicle." Proceedings of the Modeling, Estimation and Control Conference, 2022. DOI: 10.1016/j.ifacol.2022.11.260

7. **Buzhardt, J.** and Tallapragada, P. "Terrain parameter estimation from proprioceptive sensing of the suspension dynamics in offroad vehicles. In 2022 American Control Conference (ACC), pp. 2437-2442. IEEE, 2022. DOI: 10.23919/ACC53348.2022.9867793

8. **Buzhardt, J.** and Tallapragada, P. "Magnetically actuated microswimmers as mobile microparticle manipulators" ASME Letters in Dynamic Systems and Control. 2021. DOI: 10.1115/1.4046581. Extended version: arXiv:1909.05646

9. **Buzhardt, J.** and Tallapragada, P. "Optimal trajectory tracking for a magnetically driven microswimmer" In 2020 American Control Conference (ACC), pp. 3211-3216. IEEE, 2020. DOI: 10.23919/ACC45564.2020.9147973

10. **Buzhardt, J.** and Tallapragada, P. "Dynamics of groups of magnetically driven artificial microswimmers." Physical Review E 100.3 (2019): 033106. DOI: 10.1103/PhysRevE.100.033106

11. Tallapragada, P., **Buzhardt, J.**, and Seney, R. "A passive jumping mechanism" Proceedings of the ASME Dynamic Systems and Control Conference (DSCC), 2019. DOI: 10.1115/DSCC2019-9194

12. **Buzhardt, J.**, Fedonyuk, V., and Tallapragada, P. "Pairwise controllability and motion primitives for micro-rotors in a bounded Stokes flow." International Journal of Intelligent Robotics and Applications. 2018. DOI:10.1007/s41315-018-0075-5

13. **Buzhardt, J.**, Fedonyuk, V., Sudarsanam, S., and Tallapragada, P. "Controllability of a pair of swimming microrotors in a bounded domain at low Reynolds number." Proceedings of the ASME Dynamic Systems and Control Conference (DSCC), 2018. DOI: 10.1115/DSCC2018-9013

Presentations and Posters

1. Controlled density transport in nonlinear systems with applications in Stokes flows and uncertain control systems. Center for Nonlinear Studies, Los Alamos National Lab. Virtual. 14 September 2023.
2. Controlled density transport in nonlinear systems with applications in Stokes flows and uncertain control systems. Clemson Mechanical Engineering Graduate Student Research Seminar Series. 18 September 2023.
3. "Reinventing the wheel: a pendulum-driven robot that can roll and jump" Clemson Mechanical Engineering Mechatronics Forum. Clemson, SC. 21 April 2023.
4. "Control strategies for magnetically driven artificial microswimmers" Annual Meeting of the APS Division of Fluid Dynamics. Indianapolis, IN. 22 November 2022.
5. "Embodied Sensing and Control for Agile Motion of Unmanned Ground Vehicles." Poster at 2022 Automotive Research Center (ARC) Annual Program Review. Ann Arbor, MI. 21 June 2022.
6. "Embodied Sensing and Control for Agile Motion of Unmanned Ground Vehicles." Mechanical Engineering Graduate Student Research Seminar Series. Clemson, SC. 27 September 2021.
7. "Deep reinforcement learning for simultaneous path planning and stabilization of offroad vehicles." 2021 NDIA Ground Vehicle System Engineering and Technology Symposium (GVSETS). Novi, MI. 10 August 2021.
8. "Agile Modular Cyber-Physical Vehicle Platforms" Poster and lightning talk at 2021 Automotive Research Center (ARC) Annual Program Review. Virtual. 10 May 2021.
9. "Modeling of magnetically driven micro-robots." ME Graduate Student Government Research Poster Competition. Clemson, SC. October 29 – 2 November 2018.
10. "A singularity model for the dynamics of externally driven microswimmers." Annual Meeting of the APS Division of Fluid Dynamics. 19 November 2018.
11. "Modeling of externally driven magnetic micro-robots." Clemson Mechanical Engineering Graduate Student Research Seminar Series. 8 October 2018.

Other Project and Leadership Experience

ME 4010: Capstone Design Clemson, SC

Design of a Six-Rotor Drone June 2017–August 2017

- Worked with a team of five other senior engineering students to redesign an Eagle Pro Six Rotor drone to meet additional requirements and have added functionality, as part of the mechanical engineering capstone design program.
- Modified the drone to meet a smaller size constraint, land and launch from water, retrieve and carry a payload, and deliver this payload to a receptacle.
- Carried out a thorough design process, including conceptualization, functional analysis, design, prototyping, requirement validation, and documentation.

Clemson University Undergraduate Student Government Clemson, SC

Freshman Council Member September 2013 –May 2014

- Served as a member of a group of Clemson University freshmen that places an emphasis on leadership and community involvement, while focusing on issues within the Clemson University community.
- Met weekly to discuss issues concerning the Clemson University student body while organizing events on campus, such as Clemson's annual High School Leadership Conference

South Carolina Junior Civitan District Newberry, SC

Area Lieutenant Governor June 2011–July 2013

- Monitored and motivated Junior Civitan clubs in district by serving as a line of communication between clubs and organizing joint projects to ensure a stronger district by maintaining regular contact throughout the year

Technical Skills

Programming Languages	MATLAB, Python, Julia
Software	Mathematica, Maple, TensorFlow, PyTorch, Solidworks, ROS
Simulation Softwares	MSC Adams, Project Chrono, Gazebo, CoppeliaSim

Professional references are available upon request.
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