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Sheng Cheng

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EDUCATION

Ph.D. in Electrical Engineering, Control 08/2021
University of Maryland, College Park, MD Advisor: Derek Paley

M.S. in Electrical Engineering, Control 08/2018
University of Maryland, College Park, MD Advisor: Nuno Martins

B.Eng. in Control Science and Engineering, Automation 07/2014
Harbin Institute of Technology, Harbin, China

RESEARCH INTERESTS

Safe learning for control; aerial robotics; optimization; adaptive control; distributed parameter systems

SELECTED PUBLICATIONS

Journal articles

1. Z. Wu*, **S. Cheng***, P. Zhao, A. Gahlawat, K. A. Ackerman, A. Lakshmanan, C. Yang, J. Wu, N. Hovakimyan "$\mathcal{L}_1$Quad: $\mathcal{L}_1$ Adaptive Augmentation of Geometric Control for Agile Quadrotors with Performance Guarantees," under review (preprint: https://arxiv.org/abs/2302.07208).
2. Q. Chen, **S. Cheng**, N. Hovakimyan, "Simultaneous Spatial and Temporal Assignment for Fast UAV Trajectory Optimization using Bilevel Optimization," under review (preprint: https://arxiv.org/abs/2211.15902).
3. **S. Cheng** and D. A. Paley, "Cooperative estimation and control of a diffusion-based spatiotemporal process using mobile sensors and actuators," under review.
4. **S. Cheng** and D. A. Paley, "Optimal guidance and estimation of a 2D diffusion-advection process by a team of mobile sensors," Automatica, vol. 137, p. 110112, March 2022.
5. **S. Cheng** and D. A. Paley, "Optimal control of a 2D diffusion-advection process with a team of mobile actuators under jointly optimal guidance," Automatica, vol. 133, p. 109866, August 2021.
6. **S. Cheng** and N. C. Martins, "An optimality gap test for a semidefinite relaxation of a quadratic program with two quadratic constraints," SIAM Journal on Optimization, vol. 31, no. 1, pp. 866-886, March 2021.
7. A. Wolek, **S. Cheng**, D. Goswami, and D. A. Paley, "Cooperative mapping and target search over an unknown occupancy graph using mutual information," IEEE Robotics and Automation Letters, vol. 5, no. 2, pp. 1071-1078, 2020.

Conference papers

8. **S. Cheng**, M. Kim*, L. Song*, Z., S. Wang, N. Hovakimyan, "An Auto-Tuning Framework for Controllers using Auto-Differentiation," orally presented at RoboAdapt Workshop in the Conference on Robot Learning, 2022.
9. **S. Cheng**, L. Song, M. Kim, S. Wang, N. Hovakimyan, "DiffTune+: Hyperparameter-Free Auto-Tuning using Auto-Differentiation," accepted by the 5th L4DC Conference (preprint: https://arxiv.org/abs/2212.03194).
10. H. Lee, **S. Cheng**, Z. Wu, N. Hovakimyan, "Geometric Tracking Control of Omnidirectional Multirotors in the Presence of Rotor Dynamics," under review (preprint: https://arxiv.org/abs/2209.10024).
11. **S. Cheng**, M. Kim*, L. Song*, Z., S. Wang, N. Hovakimyan, "DiffTune: Auto-Tuning through Auto-Differentiation," under review (preprint: https://arxiv.org/abs/2209.10021).
12. Z. Wu, **S. Cheng**, K. A. Ackerman, A. Gahlawat, A. Lakshmanan, P. Zhao, and N. Hovakimyan, "$\mathcal{L}_1$ Adaptive Augmentation for Geometric Tracking Control of Quadrotors," 2022 International Conference on Robotics and Automation, pp. 1329–1336, Philadelphia, PA, 2022.
13. **S. Cheng** and D. A. Paley, "Optimal guidance of a team of mobile actuators for controlling a 1D diffusion process with unknown initial conditions," 2021 American Control Conference, pp. 1497-1502, New Orleans, LA, 2021.

14. **S. Cheng** and D. A. Paley, "Optimal guidance and estimation of a 1D diffusion process by a team of mobile sensors," 2020 IEEE Conference on Decision and Control, pp. 1222-1228, Jeju Island, South Korea, 2020.
15. **S. Cheng** and D. A. Paley, "Optimal control of a 1D diffusion process with a team of mobile actuators under jointly optimal guidance," American Control Conference, pp. 3449-3454, Denver, CO, 2020.
16. **S. Cheng** and N. C. Martins, "Reaching a target in a time-costly area using a two-stage optimal control method," American Control Conference, pp. 4903-4910, Philadelphia, PA, 2019.

RESEARCH EXPERIENCE

University of Illinois Urbana-Champaign

Autonomous Quadrotor with Safety Guarantees 09/2021--present

Advisor: Dr. Naira Hovakimyan

- Leading the development of DiffTune: a novel auto-tune scheme using auto-differentiation.
- Leading the theoretical development and experimentation of a safe and agile quadrotor control framework that applies the $\mathcal{L}_1$ adaptive augmentation to a geometric controller.
- Leading the ACRL multirotor team (19 students) to integrate the low-level safe and agile quadrotor control framework with vision-based perception and planning for safe and autonomous quadrotor flights.
- Lead proposal development on integrating vision-based perception with the $\mathcal{L}_1$ adaptive augmentation on a quadrotor, with specific focuses on establishing a novel, uncertainty-aware, and robust framework for integrated perception, planning, and control (collaboration with Prof. Shenlong Wang from UIUC).

University of Maryland, College Park

Distributed Estimation and Control of a Spatiotemporal Process with Multiple Aerial Vehicles 02/2019–08/2021

Advisor: Dr. Derek Paley

- Built and maintained an outdoor quadrotor swarm testbed with six quadrotors.
- Proposed a jointly optimal guidance and actuation/sensing strategy for a team of mobile actuators/sensors to efficiently control/estimate a 2D diffusion-advection process.
- Wrote a proposal to Northrop Grumman-UMD seed grant on the topic of optimal estimation and control of a 2D spatiotemporal process and won the grant.
- Validated the jointly optimal guidance and actuation/sensing strategies in hardware-in-the-loop simulations with the outdoor quadrotor swarm testbed.

Cooperative Mapping, Searching, and Tracking in an Uncertain Urban Environment 09/2018–06/2019

Advisor: Dr. Derek Paley

- Proposed an efficient mapping strategy that drives agents to follow waypoints generated from frontier nodes and unexplored regions.
- Proposed a path planning method that generates conflict-free and locally optimal paths over a graph-based map.
- Validated a cooperative mapping and search algorithm on the outdoor quadrotor swarm testbed.

Reaching a Target within a GPS-denied or Costly Area: a Two-stage Optimal Control Approach 08/2016–08/2018

Advisor: Dr. Nuno Martins

- Formulated a two-stage optimization problem and transformed it into a quadratic program with two quadratic constraints (QC2QP).
- Proposed a necessary and sufficient test to determine whether a globally optimal solution for a general QC2QP can be computed from that of a specific convex semidefinite relaxation.
- Implemented a controller that steers a quadrotor to reach a target within a denied area in experiments.
- Analyzed data from bat experiments (conducted by Comparative Neural Systems and Behavior Lab at JHU) and

investigated bat's strategy on reaching a target within a man-made denied area.

PRESENTATIONS, TALKS, AND WORKSHOPS

Invited seminar, Secure Learning Lab, University of Illinois Urbana-Champaign 02/2023

Invited seminar, Robotics and Controls Seminar, University of North Carolina at Charlotte 02/2023

Organized a one-day lab workshop for hosting Dr. Kevin Wise *(Vice President and Distinguished Senior Technical Fellow at Boeing)*, Advanced Controls Research Laboratory, University of Illinois Urbana-Champaign 09/2022

Job talk, Advanced Controls Research Laboratory, University of Illinois Urbana-Champaign 05/2021

Oral presentation, SIAM Conference on Applications of Dynamical Systems 05/2021

Oral presentation, American Control Conference 05/2021

Oral presentation, IEEE Conference on Decision and Control 12/2020

Oral presentation, American Control Conference 07/2020

Oral presentation, American Control Conference 07/2019

SELECTED HONORS AND AWARDS

Excellent Reviewer, AIAA Journal of Guidance, Control, and Navigation. 12/2022

Student Travel Support Award, 2020 IEEE Conference on Decision and Control. 12/2020

Student Travel Award, 2020 American Control Conference. 06/2020

Future Faculty Fellow, A. James Clark School of Engineering, University of Maryland. 12/2018

George Corcoran Award, Department of Electrical and Computer Engineering, University of Maryland. 09/2016

International Teaching Fellowship, University of Maryland. 10/2015

Distinguished Teaching Assistant Award, ECE Department, University of Maryland. 05/2015

Outstanding Undergraduate Thesis Award, Harbin Institute of Technology. 07/2014

WORK EXPERIENCE

Postdoctoral Research Associate, MechSE Department, Univ. of Illinois Urbana-Champaign 09/2021–present

Lecturer, "Advanced Dynamics of Aerospace Systems" (co-teaching with Dr. Derek Paley) 01/2021–05/2021

Research Assistant, AE Department, University of Maryland. 09/2018–08/2021

Research Assistant, ECE Department, University of Maryland. 08/2016–08/2018

Teaching Assistant Training & Development Fellow, ECE Department, University of Maryland. 08/2015–05/2016

International Teaching Fellow Mentor, University of Maryland. 10/2015–05/2016

Teaching Assistant, ECE Department, University of Maryland. 08/2014–05/2016

Undergraduate Research Assistant, ME Department, University of Victoria. 06/2013–08/2013

PROFESSIONAL ACTIVITIES AND AFFILIATIONS

Journal Reviewer: Automatica; Journal of Guidance, Control, and Dynamics; IEEE Transactions on Control Systems Technology; IEEE Transactions on Industrial Informatics; IEEE Control Systems Letters; Robotics; Sensors.

Conference Reviewer: CoRL; ICRA; IFAC WC; CDC; ACC; and DARS-SWARM.

Member: IEEE CSS Technical Committee on Intelligent Control.

SKILLS

Proficient in LaTeX and C/C++ and simulation software, including MATLAB and Simulink.

Intermediate in ROS, Python, and Shell script.

MENTORED STUDENTS

Ph.D. students

Yuliang Gu (Mechanical Engineering, University of Illinois Urbana-Champaign) 09/2022–present

John Bullock (Mechanical Engineering, University of Illinois Urbana-Champaign) 07/2022–present

Lin Song (Mechanical Engineering, University of Illinois Urbana-Champaign) 07/2022–present

Chuyuan Tao (Mechanical Engineering, University of Illinois Urbana-Champaign) 03/2022–present
Minkyung Kim (Mechanical Engineering, University of Illinois Urbana-Champaign) 02/2022–present
Masamichi Kosuge (Visiting student from Keio University) 12/2021–03/2022
Hyungyu Lee (Mechanical Engineering, University of Illinois Urbana-Champaign) 12/2021– present
Michael Aramyan (Mechanical Engineering, University of Illinois Urbana-Champaign) 10/2021– present
Zhuohuan Wu (Mechanical Engineering, University of Illinois Urbana-Champaign) 09/2021–present

Master students

Koushik Udayachandran (Aerospace Engineering, University of Illinois Urbana-Champaign) 03/2023–present
Rong Wang (Mechanical Engineering, University of Illinois Urbana-Champaign) 09/2022–02/2023
Charlie Ray (Aerospace Engineering, University of Illinois Urbana-Champaign) 06/2022–present
Chengyu Yang (Mechanical Engineering, University of Illinois Urbana-Champaign) 05/2022–present
Jiahao Yu (Mechanical Engineering, University of Illinois Urbana-Champaign) 05/2022–12/2022

Undergraduate students

Yiquan Jin (Mechanical Engineering, University of Illinois Urbana-Champaign) 03/2023–present
Chenhao Xu (Computer Science, University of Illinois Urbana-Champaign) 10/2022–present
Di Liang (Computer Science, University of Illinois Urbana-Champaign) 10/2022–present
Donggu Lee (Mechanical Engineering, University of Illinois Urbana-Champaign) 09/2022–present
Jae Lee (Mechanical Engineering, University of Illinois Urbana-Champaign) 08/2022–present
Casey Li (Mechanical Engineering, University of Illinois Urbana-Champaign) 05/2022–present
Zhongchun Yu (Mechanical Engineering, University of Illinois Urbana-Champaign) 05/2022–present
Youyou Yu (Computer Engineering, University of Illinois Urbana-Champaign) 05/2022–present
Qianzhong Chen (Mechanical Engineering, University of Illinois Urbana-Champaign) 01/2022–present
Simon Ge (Computer Engineering, University of Illinois Urbana-Champaign) 01/2022–present
Albert Kwan (Aerospace Engineering, University of Illinois Urbana-Champaign) 12/2021–05/2022
Clive Chung (Mechanical Engineering, University of Illinois Urbana-Champaign) 09/2021–present
Ezra Bregin (Aerospace Engineering, University of Maryland) 09/2020–05/2021
Charles Flanagan (Aerospace Engineering, University of Maryland) 09/2019–05/2020
Joshua Yuan (Summer Research Student, University of Maryland) 05/2019–08/2019
Aniket Goel (Aerospace Engineering, University of Maryland) 09/2018–05/2019