Zachary Nolan Sunberg

Ann and H. J. Smead Aerospace Engineering Sciences
University of Colorado Boulder

720-933-7799 • zachary.sunberg@colorado.edu • zachary.sunberg.net

Academic Appointments

Assistant Professor [January 2020 – Present]
University of Colorado, Boulder, CO
Ann and H. J. Smead Aerospace Engineering Sciences Department

Postdoctoral Research Scholar [October 2018 – October 2019]
University of California, Berkeley, CA
Supervisor: Claire Tomlin, Hybrid Systems Laboratory

Education

Doctor of Philosophy in Aeronautics and Astronautics [2018]
Stanford University, Stanford, CA
Advisor: Mykel Kochenderfer | Thesis: "Safety and Efficiency in Autonomous Vehicles through Planning with Uncertainty"

Master of Science in Aerospace Engineering [2013]
Texas A&M University, College Station, TX
Advisor: Jonathan Rogers | Thesis: "A Real Time Expert Control System for Helicopter Autorotation"

Bachelor of Science in Aerospace Engineering [2011]
Texas A&M University, College Station, TX
Summa cum Laude, Minor in Mathematics

Peer Reviewed Journal Publications

[1] Benjamin W. Blonder, **Michael H. Lim**, **Zachary Sunberg**, and Claire Tomlin. "Navigation between initial and desired community states using shortcuts". In: *Ecology Letters* (2023). URL: .

[2] **Zachary Sunberg** and Mykel Kochenderfer. "Improving Automated Driving through Planning with Human Internal States". In: *IEEE Transactions on Intelligent Transportation Systems* (2022). URL: .

[3] Shakeeb Ahmad, **Zachary N. Sunberg**, and J. Sean Humbert. "End-to-End Probabilistic Depth Perception and 3D Obstacle Avoidance using POMDP". In: *Journal of Intelligent & Robotic Systems* 103.2 (2021).

[4] **Patrick Slade**, **Zachary Sunberg**, and Mykel J. Kochenderfer. "Estimation and Control Using Sampling-Based Bayesian Reinforcement Learning". In: *IET Cyber-Physical Systems: Theory and Applications* 5 (1 2020). URL: .

[5] Maxim Egorov, **Zachary N. Sunberg**, Edward Balaban, Tim A. Wheeler, Jayesh K. Gupta, and Mykel J. Kochenderfer. "POMDPs.jl: A Framework for Sequential Decision Making under Uncertainty". In: *Journal of Machine Learning Research* 18.26 (2017). URL: .

[6] **Zachary Sunberg**, Suman Chakravorty, and Richard Scott Erwin. "Information Space Receding Horizon Control for Multisensor Tasking Problems". In: *IEEE Transactions on Cybernetics* 46.6 (2016). URL: .

[7] **Zachary N. Sunberg**, Nathaniel R. Miller, and Jonathan D. Rogers. "A Real-Time Expert Control System For Helicopter Autorotation". In: *Journal of the American Helicopter Society* 60.2 (2015). DOI: 10.4050/JAHS.60.022008. URL: .

[8] **Zachary Sunberg**, Suman Chakravorty, and Richard Scott Erwin. "Information Space Receding Horizon Control". In: *IEEE Transactions on Cybernetics* 43.6 (2013). URL: .

[9] **Zachary Sunberg** and Jonathan Rogers. "A Belief Function Distance Metric for Orderable Sets". In: *Information Fusion* 14.4 (2013). DOI: 10.1016/J.INFFUS.2013.03.003. URL: .

Journal-Equivalent Peer Reviewed Conference Publications

[10] **Himanshu Gupta**, Bradley Hayes, and **Zachary Sunberg**. "Intention-Aware Navigation in Crowds with Extended-Space POMDP Planning". In: *Autonomous Agents and Multi-Agent Systems (AAMAS)*. 2022. URL: .

[11] John Mern, Anil Yildiz, **Zachary Sunberg**, Tapan Mukerji, and Mykel J. Kochenderfer. "Bayesian Optimized Monte Carlo Planning". In: *AAAI Conference on Artificial Intelligence (AAAI)*. 2021.

[12] **Michael H. Lim**, Claire J. Tomlin, and **Zachary N. Sunberg**. "Sparse Tree Search Optimality Guarantees in POMDPs with Continuous Observation Spaces". In: *International Joint Conference on Artificial Intelligence (IJCAI)*. 2020.

[13] **Lasse Peters**, David Fridovich-Keil, Claire Tomlin, and **Zachary Sunberg**. "Inference-Based Strategy Alignment for General-Sum Differential Games". In: *International Conference on Autonomous Agents and Multiagent Systems (AAMAS)*. 2020. URL: .

[14] **Zachary N. Sunberg** and Mykel J. Kochenderfer. "Online Algorithms for POMDPs with Continuous State, Action, and Observation Spaces". In: *International Conference on Automated Planning and Scheduling (ICAPS)*. 2018. URL: .

Peer Reviewed Conference Publications

[15] **Qi Heng Ho**, Roland B. Ilyes, **Zachary Sunberg**, and Morteza Lahijanian. "Automaton-Guided Control Synthesis for Signal Temporal Logic Specifications". In: *IEEE Conference on Decision and Control (CDC)*. 2022. URL: .

[16] **Qi Heng Ho**, **Zachary N. Sunberg**, and Morteza Lahijanian. "Gaussian Belief Trees for Chance Constrained Asymptotically Optimal Motion Planning". In: *2022 International Conference on Robotics and Automation (ICRA)*. 2022. DOI: 10.1109/ICRA46639.2022.9812343.

[17] **Zachary Nolan Sunberg**, Kathryn Anne Wingate, and Lara Buri. "Fair Senior Capstone Project Teaming based on Skills, Preferences, and Friend Groups". In: *ASEE Annual Conference*. 2021. URL: .

[18] **Michael H. Lim**, Claire J. Tomlin, and **Zachary N. Sunberg**. "Voronoi Progressive Widening: Efficient Online Solvers for Continuous Space MDPs and POMDPs with Provably Optimal Components". In: *Conference on Decision and Control (CDC)*. 2021. URL: .

[19] Shakeeb G. Ahmad, **Zachary Sunberg**, and Sean Humbert. "APF-PF: Probabilistic Depth Perception for 3D Reactive Obstacle Avoidance". In: *American Control Conference (ACC)*. 2021.

[20] Ekhlas Sonu, **Zachary Sunberg**, and Mykel J. Kochenderfer. "Exploiting Hierarchy for Scalable Decision Making in Autonomous Driving". In: *Intelligent Vehicles Symposium*. 2018.

[21] **Zachary N. Sunberg**, Christopher J. Ho, and Mykel J. Kochenderfer. "The Value of Inferring the Internal State of Traffic Participants for Autonomous Freeway Driving". In: *American Control Conference (ACC)*. 2017. URL: .

[22] Patrick Slade, Preston Culbertson, **Zachary Sunberg**, and Mykel J. Kochenderfer. "Simultaneous Active Parameter Estimation and Control using Sampling-based Bayesian Reinforcement Learning". In: *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2017. URL: .

[23] **Zachary Sunberg**, Mykel J. Kochenderfer, and Marco Pavone. "Optimized and Trusted Collision Avoidance for Unmanned Aerial Vehicles using Approximate Dynamic Programming". In: *IEEE International Conference on Robotics and Automation (ICRA)*. 2016. URL: .

[24] **Zachary Sunberg**, Suman Chakravorty, and Richard Erwin. "Information space sensor tasking for Space Situational Awareness". In: *American Control Conference (ACC)*. June 2014. DOI: 10.1109/ACC.2014.6858922.

[25] **Zachary Sunberg**, Nathaniel Miller, and Jonathan Rogers. "A Real Time Expert Control System for Helicopter Autorotation". In: *70th Forum of the American Helicopter Society*. 2014.

[26] **Zachary Sunberg**, Suman Chakravorty, and Richard Erwin. "Information Space Receding Horizon Control for MultiAgent Systems". In: *American Control Conference (ACC)*. 2012. URL: .

Conference Publications with Abstract-only Review

[27] Johnathan Tucker, Jackson Wagner, and **Zachary Sunberg**. "Adaptive Stress Testing Applied To Space Domain Awareness Systems". In: *Advanced Maui Optical and Space Surveillance Technologies (AMOS)*. 2022. URL: .

[28] **Tyler Becker** and **Zachary Sunberg**. "Imperfect Information Games and Counterfactual Regret Minimization in Space Domain Awareness". In: *Advanced Maui Optical and Space Surveillance Technologies (AMOS)*. 2022. URL: .

[29] Hunter M. Ray, Nicholas Conlon, **Zachary Sunberg**, and Nisar R. Ahmed. "User Preference Elicitation for Unmanned Aircraft System Collaborative Search". In: *AIAA SCITECH Forum*. 2022.

[30] **Zachary Sunberg** and Jonathan Rogers. "A Fuzzy Logic-Based Controller for Helicopter Autorotation". In: *AIAA Aerospace Sciences Meeting*. 2013.

Forthcoming Publications

[31] **Michael H. Lim**, **Tyler J. Becker**, Mykel J. Kochenderfer, Claire J. Tomlin, and **Zachary N. Sunberg**. "Optimality Guarantees for Particle Belief Approximation of POMDPs". Under Review for the *Journal of Artificial Intelligence Research*. 2022. URL: .

[32] Prashin Sharma, **Benjamin Kraske**, Joseph Kim, **Zakariya Laouar**, Ella Atkins, and **Zachary Sunberg**. "Investigation of risk-aware MDP and POMDP contingency management autonomy for UAS". In preparation. 2022.

[33] Sampada Deglurkar, **Michael H. Lim**, **Johnathan Tucker**, **Zachary N. Sunberg**, Aleksandra Faust, and Claire J. Tomlin. "Compositional Learning-based Planning for Vision POMDPs". Under Review for the *Learning for Dynamics & Control (L4DC)*. 2022. URL: .

Open Source Software

POMDPs.jl [2015 – present]

`https://github.com/JuliaPOMDP/POMDPs.jl`

Interface for defining continuous and discrete, fully and partially observable Markov decision processes along with a suite of state-of-the art solvers written in Julia and C++.

ProjectAssigner.jl [2020]

`https://github.com/zsunberg/ProjectAssigner.jl`

Software for optimally assigning student teams to projects based on preferences, friend groups, and skills [17]. Used to assign senior project groups in the AES department since 2020.

Research Funding

Awarded

Co-I: IUCRC Phase I: Center for Autonomous Air Mobility and Sensing (CAAMS) [2022 – 2027]

National Science Foundation

$2,210,225 (PI: Eric Frew) | Co-Is: Nisar Ahmed, Morteza Lahijanian, Sriram Sankaranarayanan | This grant establishes the IUCRC and pays for administrative costs; sub-awards funded through industry contributions will be listed separately.

Co-I: Dispersed Autonomy for Marsupial Aerial Robot Teams [2022 – 2025]

National Science Foundation | National Robotics Institute (Collaborative Research)

$1,045,429 (PI: Eric Frew) | My share: $300,000 (approx.) | Co-Is: Brian Argrow, Adam Houston (University of Nebraska, Lincoln)

PI: HIPPO (Human-Informed Planning with Probabilistic Observations) [2022-2023]
NSF Center for Autonomous Air Mobility and Sensing (CAAMS) Sub-award
$68,000 | PI share: full amount

Co-I: SURP: Fast planning under uncertainty with operational and safety guarantees [2022-2023]
NASA Jet Propulsion Laboratory
$60,000 (PI: Federico Rossi, JPL) | My share: $50,000 | Co-Is: Martin Feather (JPL), Morteza Lahijanian

PI: Elektra: Naval Defensive Resource Allocation through POMDP Optimization [2021 – 2023]
Office of Naval Research (Subcontract of Johns Hopkins University Applied Physics Lab)
$169,805 | PI share: full amount

Co-I: L3Harris Modern Analytics for Mission Applications (LMA2) [2021-2023]
L3-Harris Technologies
$1,495,048 (PI: Marcus Holzinger) | My share: $350,000 (approx.)

Co-PI: Full Stack Planning and Control under Uncertainty [2021 – 2022]
NSF Center for Unmanned Aircraft Systems (C-UAS) Sub-award
$130,000 (with Co-PI Ella Atkins, Univ. of Michigan) | My share: $65,000

PI: POMDP Algorithms for In-flight Learning in Emergencies [2020 – 2021]
NSF Center for Unmanned Aircraft Systems (C-UAS) Sub-award
$60,000 | PI share: full amount

Declined

In the moment (ITM): Aligned Algorithmic Aide (ALAI) [2022]
Defence Advanced Research Projects Agency
$6,200,000 (approx., PI: Brett Israelson, Raytheon) | My share: $450,000 (approx.) | CU subcontract Co-I: Nisar Ahmed

Co-I: Multi-Phenomenological, Autonomous ... Decision Support [2021]
Air Force Office of Scientific Research
$5,000,000 (approx., PI: Marcus Holzinger) | My share: $500,000 (approx.) | Co-Is: K. Terry Alfriend (TAMU), Scott Palo, Kyle DeMars (TAMU), John Junkins (TAMU), Karen Feigh (Georgia Tech) | Full title: Multi-Phenomenological, Autonomous, and Understandable SDA and XDA Decision Support

PI: CAREER: Active competence through online Bayesian reasoning [2021]
National Science Foundation
$599,341 | PI share: full amount | Full title: CAREER: Towards reliable autonomy in open environments: active competence through online Bayesian reasoning

Co-I: RACER-Sim [2021]
Defence Advanced Research Projects Agency
Budget details are controlled unclassified information (CUI) | PI: Christoffer Heckman; Co-I: Zachary Manchester (CMU)

PI: Hazard mitigation for self-piloted vehicles... [2020]
National Aeronautics and Space Administration
$806,411 | PI share: $400,000 (approx.) | Full title: Hazard mitigation for self-piloted vehicles through POMDP planning and formal controller synthesis | Co-I: Majid Zamani

PI: Enabling rapid and flexible medical planning research with POMDPs.jl [2020]
Chan Zuckerberg Initiative
$91,053 | PI share: full amount

Co-I: AVATAR-ACE (AViator-Agent Trusted AI for Real-time Air Combat Engagements) [2020]
Defence Advanced Research Projects Agency
$5,000,000 (approx., PI: Krishna Kalyanam, Palo Alto Research Center) | My share: $660,000 (approx.)

Research Positions

Autonomous Decision and Control Laboratory (ADCL) [January 2020 – Present]
Director
University of Colorado, Boulder, CO

Hybrid Systems Laboratory [October 2018 – October 2019]
Postdoctoral Research Scholar
University of California, Berkeley, CA

Stanford Intelligent Systems Laboratory (SISL) [2015 – 2018]
Graduate Research Assistant
Stanford University, Stanford, CA

Autonomous Systems Laboratory (ASL) [2014 – 2016]
Graduate Research Assistant
Stanford University, Stanford, CA

Hansen Experimental Physics Lab [2013 – 2014]
Graduate Research Assistant
Stanford University, Stanford, CA

Helicopters and Unmanned Systems Laboratory (HUSL) [2011 – 2013]
Graduate Research Assistant
Texas A&M University, College Station, TX

Air Force Research Lab Summer Faculty Program [Summer 2011]
Research Assistant
Kirtland AFB, Albuquerque, NM

Industry Experience

Google, Inc., Mountain View, CA [Summer 2014]
Software Engineering Intern
Wrote software to evaluate and optimize a NASA collision avoidance program for use with Google self-piloted air vehicles.

Lockheed Martin Autonomous Systems, Littleton, CO [Summer 2009]
Intern
Helped in testing of autonomous SMSS allterrain military transport vehicle navigation system; wrote rough terrain navigation program in C++ based on the A* search algorithm; wrote software in C++ for analyzing the performance of an advanced video analysis tool.

Invited and Contributed Talks and Panels

2022

University of Illinois Urbana-Champaign (UIUC): Safe and efficient autonomy in the face of uncertainty.

University of Texas at Austin: Safe and efficient autonomy in the face of uncertainty.

Korea Advanced Institute of Science and Technology (KAIST): Safe and efficient autonomy in the face of state and interaction uncertainty.

2021

AIAA Rocky Mountain Annual Technical Symposium: "Machine Learning in Aerospace Systems" (panel)

JuliaCon 2021: POMDPs.jl and Interactive Assignments in Julia

NASA Jet Propulsion Lab, *Pasadena, CA*: Scalable online POMDP planning for safe and efficient autonomy

Johns Hopkins University Applied Physics Lab, *Laurel, MD*: Some Recent Advances in Online POMDP Algorithms

2019

SRI International, *Palo Alto, CA*: Safety and Efficiency for Autonomous Vehicles through Online Learning

Washington State University, *Pullman, WA*: Safety and Efficiency for Autonomous Vehicles through Online Learning

University of Colorado, *Boulder, CO*: Safety and Efficiency for Autonomous Vehicles through Online Learning

2018

Renault-Nissan Research, *Sunnyvale, CA*: Safety and Efficiency in Autonomous Vehicles through POMDP Planning

Lyft Level 5, *Palo Alto, CA*: Safety and Efficiency in Autonomous Vehicles through Planning with Uncertainty

Makani, *Alameda, CA*: Algorithms for Uncertain, Non-convex Control Problems in the Real World

Indeed, *San Francisco, CA*: Safety and Efficiency in Autonomous Vehicles through Planning with Uncertainty

2017
Julia in Controls Workshop, ***ACC, Seattle, WA***: POMDPs.jl
Open Source Software for Decision Making (OSS4DM), ***Stanford, CA***: POMDPs.jl - Challenges and Lessons Learned

Teaching

ASEN 3128 Aircraft Dynamics [2022 – Present]
University of Colorado Boulder

ASEN 5264 Decision Making under Uncertainty [2020 – present]
University of Colorado Boulder
Developed new entry-level graduate course about decision making under uncertainty.
Open-source course materials: `https://github.com/zsunberg/CU-DMU-Materials`
Open-source companion software package: `https://github.com/zsunberg/DMUStudent.jl`

ASEN 6519 Advanced Survey of Sequential Decision Making [2021]
University of Colorado Boulder
Developed new advanced graduate course that surveys recent advances in decision making under uncertainty.

ASEN 4018/4028 Senior Design Project [2020 – 2021]
University of Colorado Boulder
Advised senior design project teams, created new optimization-based approach (see Open Source Software) for fairly creating teams based on student preferences [17].

Army High Performance Computing Summer Institute [June 2017]
Stanford University, Stanford, CA
Developed and taught a 5 lecture course about decision making under uncertainty for college students.

Stanford Artificial Intelligence Lab OutReach Summer (SAILORS, now AI4ALL) [2015-2017]
Stanford University, Stanford, CA
Developed and taught a 2 week course and project for high school students that included programming robots for optical line following and using Dijkstra's algorithm to find the shortest path on a road network; only project mentor to serve all three years of the program. `http://ai-4-all.org/`

AA-228/CS-238 Decision Making Under Uncertainty [Autumn 2016]
Stanford University, Stanford, CA
Head course assistant for a class of around 200; developed problems for midterm project; gave guest lectures on the POMDPs.jl framework and autonomous driving research; project software was reused in a course at Iowa State University.

Advising and Mentoring

Ph.D. Thesis Advisees

Hyun Jae (Michael) Lim (Co-advised with Claire Tomlin at U.C. Berkeley) [Spring 2020 – Present]
Tyler Becker [Fall 2020 – Present]
Qi Heng Ho [Fall 2020 – Present]
Ben Kraske (Received NSF GRFP under my direction) [Fall 2020 – Present]
Himanshu Gupta [Fall 2020 – Present]
Zakariya Laouar [Fall 2021 – Present]

M.S. Thesis Advisees

William Pope [Spring 2022 – Fall 2022]
Jackson Wagner [Summer 2022 – Present]

Independent Study Advisees

Johnathan Tucker (Received NSF GRFP under my direction) [Fall 2020 – Summer 2022]
Saurabh Mishra [Spring 2020]

Ph.D. Comprehensive Exam and Defense Committees

Sangwoo Moon
Charles (Luke) Burks
Neha Garg (Nat. Univ. of Singapore, External Examiner)
Ramya Kanlapuli
Katherine Glasheen
Andrew Mills
Chandrakanth Venigalla
Sam Fedeler
John Jackson
Prashin Sharma (Univ. of Michigan)
Shakeeb Ahmad
John Mern (Stanford Univ.)
Aastha Acharya
Shohei Wakayama
Marcus Lapeyrolerie (Univ. of California, Berkeley, Quals)

M.S. Thesis Committees

Lasse Peters (TU Hamburg)
Wyatt Raich
Cody Charland
Akash Ratheesh
Jamison Mcginley
Rio McMahon

Department Service and Outreach

Graduate Program Committee [2020–present]
Autonomous Systems Lead
Served on Preliminary Exam Subcommittee

Rising Stars in Aerospace organizing committee member [2022]
Speaker for Tuskegee Airmen outreach event at CU [2021, 2022]
Invited Speaker for AIAA Movie Night & Technical Discussion: 2001: A Space Odyssey [2021]

Conference and Workshop Organization

Strategic multi-agent interactions: game theory for robot learning and decision making [2022]
Workshop at the Conference on Robotic Learning (CoRL)
Co-organizer with David Fridovich-Keil (Univ. of Texas) and Negar Mehr (Univ. of Illinois)

Academic Peer Review and Editing

Guest editor for the AIAA Journal of Aerospace Information Systems [2020 – 2022]

Reviewer: I have reviewed manuscripts for the following journals and conferences:

Journal of Artificial Intelligence Research
AIAA Journal of Guidance, Control, and Dynamics
IEEE Robotics and Automation Letters
IEEE Transations on Cybernetics
IEEE Transactions on Intelligent Transportation Systems
IEEE Transactions on Intelligent Vehicles
Journal of Aerospace Information Systems
Autonomous Robots
Intl. Journal of Robotics Research
Journal of the American Helicopter Society
International Symposium on Robotics Research
Intl. Conference on Robotics and Automation (ICRA)
Intl. Joint Conference on Artificial Intelligence (IJCAI)
AAAI Conference on Artificial Intelligence
American Control Conference (ACC)
Intelligent Transportation Systems Conference (ITSC)
Robotics, Science and Systems (RSS)
Learning for Decision and Control Conference (L4DC)

Fellowships and Awards

AIAA Journal of Guidance, Control, and Dynamics Excellent Reviewer [2021,2022]
Association for the Advancement of Artificial Intelligence Doctoral Consortium [February 2018]
IJCAI 2019 Distinguished Program Committee member [2019]
American Control Conference Student Travel Award [May 2017]

National Science Foundation Graduate Research Fellowship [2012-2016]