Saber Jafarpour

INFORMATION

Research Assistant Professor
Department of Computer Science
University of Colorado Boulder,
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ACADEMIC POSITIONS

University of Colorado Boulder — 2023–present

Department of Computer Science
Research Assistant Professor

Georgia Institute of Technology — 2021–2023

Institute for Robotics and Intelligent Machines
Postdoctoral Research Fellow (Advisor: Samuel Coogan)

University of California Santa Barbara — 2016–2021

Center of Control, Dynamical Systems, and Computation
Postdoctoral Research Fellow (Advisor: Francesco Bullo)

EDUCATION

Queen's University, Canada — 2011–2016

Department of Mathematics and Statistics

Ph.D. in Applied Mathematics (Advisor: Andrew D. Lewis)
Dissertation: On the Role of Regularity in Mathematical Control Theory

Shiraz University, Iran — 2008–2011

Department of Mechanical Engineering

M.Sc. in Applied Mechanics (Advisor: Mojtaba Mahzoon)
Dissertation: Investigating Nonholonomic Constraints in Robotic Systems

Shiraz University, Iran — 2004–2008

Department of Mechanical Engineering

B.Sc. in Mechanical Engineering

RESEARCH INTERESTS

My research interests lie at the broad intersection of control theory, autonomy, and machine learning. I develop mathematically rigorous and computationally efficient tools for the safety, learning, and control of autonomous systems, with applications in robotics and cyber-physical systems. I have been conducting research in the following areas:

- Safety assurance for learning-enabled systems
- Uncertainty quantification in autonomous systems
- Resilience of large-scale multi-agent systems
- Geometric control of nonlinear systems

UNDER REVIEW PAPERS

[U4] Z. Liu, **S. Jafarpour**, and Y. Chen. Safety verification of nonlinear stochastic systems via probabilistic tube. *IEEE Transactions on Automatic Control*, 2025. URL https://arxiv.org/pdf/2503.03328. Submitted

[U3] F. Galarza-Jimenez, M. Zamani, and **S. Jafarpour**. Trajectory-based barrier certificates for monotone systems. In *64th IEEE Conference on Decision and Control*, 2025. Submitted

[U2] C. Xu, **S. Jafarpour**, C. Zhao, Z. Shi, and J. Chen. Geometric reachability for attitude control systems via contraction theory. *Automatica*, 2025. URL https://arxiv.org/abs/2502.20878. Submitted

[U1] Z. Liu, **S. Jafarpour**, and Y. Chen. Probabilistic reachability of discrete-time nonlinear stochastic system. *Automatica*, 2024a. URL https://www.arxiv.org/abs/2409.09334. Submitted

JOURNAL
PAPERS

[J25] A. Alavi, A. Nadali, M. Zamani, and **S. Jafarpour**. Neural barrier certificates for monotone systems. *IEEE Control Systems Letters*, 2025. DOI: 10.1109/LCSYS.2025.3579779. To apear

[J24] **S. Jafarpour***, Z. Liu*, and Y. Chen. Probabilistic reachability analysis of stochastic control systems. *IEEE Transactions on Automatic Control*, 2025. URL https://arxiv.org/abs/2407.12225. To apear

[J23] Z. Liu, **S. Jafarpour**, and Y. Chen. Safety verification of stochastic systems: A set-erosion approach. *IEEE Control Systems Letters*, 8:2859–2864, 2024b. DOI: 10.1109/LCSYS.2024.3518394

[J22] A. Davydov*, **S. Jafarpour***, A. V. Proskurnikov, and F. Bullo. Non-Euclidean monotone operator theory and applications. *Journal of Machine Learning Research*, 25(307):1–33, Dec. 2024. URL https://www.jmlr.org/papers/volume25/23-0805/23-0805.pdf

[J21] **S. Jafarpour***, A. Harapanahalli*, and S. Coogan. Efficient interaction-aware interval analysis of neural network feedback loops. *IEEE Transactions on Automatic Control*, 69(12):8706–8721, 2024. DOI: 10.1109/TAC.2024.3420968

[J20] **S. Jafarpour** and S. Coogan. Monotonicity and contraction on polyhedral cones. *IEEE Transactions on Automatic Control*, 70(2):1200–1207, 2025. DOI: 10.1109/TAC.2024.3454258

[J19] M. Pirani* and **S. Jafarpour***. Network critical slowing down: Data-driven detection of critical transitions in nonlinear networks. *IEEE Transactions on Control of Network Systems*, 11(2):573–585, 2024. DOI: 10.1109/TCNS.2023.3332730

[J18] **S. Jafarpour**, A. Davydov, and F. Bullo. Non-Euclidean contraction theory for monotone and positive systems. *IEEE Transactions on Automatic Control*, 68(9):5653–5660, 2023. DOI: 10.1109/TAC.2022.3224094

[J17] A. Davydov, **S. Jafarpour**, and F. Bullo. Non-Euclidean contraction theory for robust nonlinear stability. *IEEE Transactions on Automatic Control*, 67(12):6667–6681, 2022. DOI: 10.1109/TAC.2022.3183966

[J16] **S. Jafarpour**, P. Cisneros-Velarde, and F. Bullo. Weak and semi-contraction for network systems and diffusively-coupled oscillators. *IEEE Transactions on Automatic Control*, 67(3):1285–1300, 2022a. DOI: 10.1109/TAC.2021.3073096

[J15] **S. Jafarpour**, V. Purba, S. V. Dhople, B. Johnson, and F. Bullo. Singular perturbation and small-signal stability for inverter networks. *IEEE Transactions on Control of Network Systems*, 9(2):979–992, 2022c. DOI: 10.1109/TCNS.2021.3084444

[J14] P. Cisneros-Velarde, **S. Jafarpour**, and F. Bullo. A contraction analysis of primal-dual dynamics in distributed and time-varying implementations. *IEEE Transactions on Automatic Control*, 67(7):3560–3566, 2022. DOI: 10.1109/TAC.2021.3103865

[J13] K. D. Smith, **S. Jafarpour**, and F. Bullo. Transient stability of droop-controlled inverter networks with operating constraints. *IEEE Transactions on Automatic Control*, 67(2):633–645, 2022a. DOI: 10.1109/TAC.2021.3053552

[J12] K. D. Smith, **S. Jafarpour**, A. Swami, and F. Bullo. Topology inference with multivariate cumulants: The Möbius inference algorithm. *IEEE/ACM Transactions on Networking*, 30(5):2102–2116, 2022b. DOI: 10.1109/TNET.2022.3164336

[J11] **S. Jafarpour***, A. Davydov*, A. V. Proskurnikov, and F. Bullo. Robust implicit networks via non-Euclidean contractions. In *Advances in Neural Information Processing Systems (NeurIPS)*, volume 34, pages 9857–9868, Dec. 2021. URL https://openreview.net/forum?id=SwfsoPuGYku

[J10] **S. Jafarpour**, E. Y. Huang, K. D. Smith, and F. Bullo. Flow and elastic networks on the n-torus: Geometry, analysis and computation. *SIAM Review (Research Spotlight)*, 64(1):59–104, 2021. DOI: 10.1137/18M1242056

[J9] A. Silva, F. Kocayusufoglu, **S. Jafarpour**, A. Swami, F. Bullo, and A. K. Singh. Combining physics and machine learning for network flow estimation. In *International Conference on Learning Representations*, Online, May 2021. URL https://openreview.net/forum?id=l0V53bErniB

[J8] X. Duan, **S. Jafarpour**, and F. Bullo. Graph-theoretic stability conditions for Metzler matrices and monotone systems. *SIAM Journal on Control and Optimization*, 59(5):3447–3471, 2021. DOI: 10.1137/20M131802X

[J7] **S. Jafarpour**. On small-time local controllability. *SIAM Journal on Control and Optimization*, 58(1):425–446, 2020. DOI: 10.1137/16M1068797

[J6] V. Purba, B. Johnson, **S. Jafarpour**, F. Bullo, and S. V. Dhople. Dynamic aggregation of grid-tied three-phase inverters. *IEEE Transactions on Power Systems*, 35(2):1520–1530, 2020. DOI: 10.1109/TPWRS.2019.2942292

[J5] V. Purba, B. Johnson, M. Rodriguez, **S. Jafarpour**, F. Bullo, and S. V. Dhople. Reduced-order aggregate model for parallel-connected single-phase inverters. *IEEE Transactions on Energy Conversion*, 34(2):824–837, 2019. DOI: 10.1109/TEC.2018.2881710

[J4] **S. Jafarpour**, E. Y. Huang, and F. Bullo. Synchronization of Kuramoto oscillators: Inverse Taylor expansions. *SIAM Journal on Control and Optimization*, 57(5):3388–3412, 2019. DOI: 10.1137/18M1216262

[J3] **S. Jafarpour** and F. Bullo. Synchronization of Kuramoto oscillators via cutset projections. *IEEE Transactions on Automatic Control*, 64(7):2830–2844, 2019. DOI: 10.1109/TAC.2018.2876786

[J2] M. George, **S. Jafarpour**, and F. Bullo. Markov chains with maximum entropy for robotic surveillance. *IEEE Transactions on Automatic Control*, 64(4):1566–1580, 2019. DOI: 10.1109/TAC.2018.2844120

[J1] **S. Jafarpour** and A. D. Lewis. Locally convex topologies and control theory. *Mathematics of Control, Signals and Systems*, 28(4):1–29, 2016b. DOI: 10.1007/s00498-016-0179-0

REFEREED
CONFERENCE
PAPERS

[C15] D. Ajeyemi, **S. Jafarpour**, and E. Dall'Anese. Neural network-assisted interval reachability for systems with control barrier function-based safe controllers. In *Proceedings of The 5th Annual Learning for Dynamics and Control Conference*, Proceedings of Machine Learning Research. PMLR, 6-8 Jun 2025. URL https://arxiv.org/abs/2504.08249. To apear

[C14] A. Harapanahalli, **Jafarpour, S.**, and S. Coogan. immrax: A parallelizable and differentiable toolbox for interval analysis and mixed monotone reachability in JAX. *IFAC-PapersOnLine*, 58 (11):75–80, 2024. DOI: 10.1016/j.ifacol.2024.07.428. 8th IFAC Conference on Analysis and Design of Hybrid Systems ADHS 2024

[C13] **S. Jafarpour** and S. Coogan. A contracting dynamical system perspective toward interval markov decision processes. In *IEEE Conf. on Decision and Control*, pages 2918–2924, Marina Bay Sands, Singapore, Dec. 2023. DOI: 10.1109/CDC49753.2023.10383575

[C12] A. Harapanahalli, **S. Jafarpour**, and S. Coogan. Contraction-guided adaptive partitioning for reachability analysis of neural network controlled systems. In *IEEE Conf. on Decision and Control*, pages 6044–6051, Marina Bay Sands, Singapore, Dec. 2023b. DOI: 10.1109/CDC49753.2023.10383360

[C11] **Jafarpour, S.**, A. Harapanahalli, and S. Coogan. Interval reachability of nonlinear dynamical systems with neural network controllers. In *Proceedings of The 5th Annual Learning for Dynamics and Control Conference*, volume 211 of *Proceedings of Machine Learning Research*, pages 12–25. PMLR, 2023. URL https://proceedings.mlr.press/v211/jafarpour23a.html

[C10] A. Harapanahalli, **Jafarpour, S.**, and S. Coogan. A toolbox for fast interval arithmetic in numpy with an application to formal verification of neural network controlled system. In *ICML workshop on Formal Verification of Machine Learning (WFVML 2023)*, 2023a. URL https://arxiv.org/abs/2306.15340

[C9] **S. Jafarpour**, A. Davydov, M. Abate, F. Bullo, and S. Coogan. Robust training and verification of implicit neural networks: A non-Euclidean contractive approach. In *ICML Workshop on Formal Verification of Machine Learning*, July 2022b. DOI: 10.48550/arXiv.2208.03889

[C8] **S. Jafarpour***, M. Abate*, A. Davydov*, F. Bullo, and S. Coogan. Robustness certificates for implicit neural networks: A mixed monotone contractive approach. In *Learning for Dynamics and Control Conf.*, volume 168, pages 917–930, June 2022. URL https://proceedings.mlr.press/v168/jafarpour22a. **(Oral Presentation: Top 10 percent of submitted papers)**

[C7] A. Davydov*, **S. Jafarpour***, M. Abate, F. Bullo, and S. Coogan. Comparative analysis of interval reachability for robust implicit and feedforward neural networks. In *IEEE Conf. on Decision and Control*, Cancun, Mexico, Dec. 2022. URL https://arxiv.org/abs/2204.00187. To appear

[C6] A. Davydov*, **S. Jafarpour***, A. V. Proskurnikov, and F. Bullo. Non-Euclidean monotone operator theory with applications to recurrent neural networks. In *IEEE Conf. on Decision and Control*, Cancún, México, Dec. 2022. DOI: 10.1109/CDC51059.2022.9993197

[C5] **S. Jafarpour** and S. Coogan. Resilience of input metering in dynamic flow networks. In *American Control Conference*, pages 126–131, Atlanta, USA, June 2022. DOI: 10.23919/ACC53348.2022.9867237

[C4] F. Bullo, P. Cisneros-Velarde, A. Davydov, and **S. Jafarpour**. From contraction theory to fixed point algorithms on Riemannian and non-Euclidean spaces. In *IEEE Conf. on Decision and Control*, Austin, USA, Dec. 2021. DOI: 10.1109/CDC45484.2021.9682883. Invited Tutorial Session

[C3] E. Y. Huang, **S. Jafarpour**, and F. Bullo. Synchronization of coupled oscillators: The Taylor expansion of the inverse Kuramoto map. In *IEEE Conf. on Decision and Control*, pages 5340–5345, Miami, USA, Dec. 2018. DOI: 10.1109/CDC.2018.8619559

[C2] **S. Jafarpour** and A. D. Lewis. The classical and tautological orbit theorems. In 22nd *International Symposium on Mathematical Theory of Networks and Systems*, July 2016a

[C1] **S. Jafarpour** and A. D. Lewis. Real analytic control systems. In *IEEE Conf. on Decision and Control*, pages 5618–5623, Los Angeles, USA, Dec. 2014a. DOI: 10.1109/CDC.2014.7040268

BOOKS

[B1] **S. Jafarpour** and A. D. Lewis. *Time-Varying Vector Fields and Their Flows*. SpringerBriefs in Mathematics. Springer International Publishing, 2014b. DOI: 10.1007/978-3-319-10139-2

INVITED TALKS

[T22] Safety Assurance in Neural Network Controlled Systems: A Mixed Monotone Approach, *ACC workshop on formal methods for systems with neural components*, July 2025 [Slides]

[T21] Mixed Monotone Reachability in Dynamical Systems with application to safety of learning-enabled systems, *Louisiana State University, Department of Mathematics*, March 2025 (Host: Michael Malisoff) [Slides]

[T20] Non-Euclidean Monotone Operator Theory for Robustness of Implicit Neural Networks, *Vector Institute for Artificial Intelligence, Toronto, Canada*, Feb 2025 (Host: Anastasis Kratsios) [Slides]

[T19] Safety Assurance in Learning-enabled Autonomous Systems: A Mixed Monotone Apporach *Robotic Seminar Series, University of Colorado Boulder*, Oct 2025 [Slides]

[T18] Reachability Analysis of Dynamical Systems: A Mixed Monotone Contracting Approach, *Allerton Conference on Communication, Control, and Computing*, Sep. 2024 (Host: Daniel Liberzon) [Slides]

[T17] Mixed-monotone Theory for Verification of Autonomous System, *Guest Lecturer in UIUC Verification of Embedded & Cyber-physical systems*, Apr. 2024 (Host: Huan Zhang) [Slides]

[T16] Safety Assurance in Learning-enabled Autonomous Systems, *Waterloo Data and Artificial Intelligence Institute*, Mar. 2024. [Slides]

[T15] Safety of Autonomous Systems with Learning-enabled Feedbacks, *Reliable Autonomous System Lab, Massachusetts Institute of Technology (MIT)*, Nov. 2023, (Host: Chuchu Fan) [Slides]

[T14] Reachability Analysis of Control Systems: A Mixed Monotone Approach, *ECEE Department Seminar, University of Colorado Boulder*, Oct. 2023, [Slides]

[T13] Interaction-aware interval reachability of neural network controlled systems, *2023 Allerton Conference on Communication, Control, and Computing*, Oct. 2023. [Slides] [Link]

[T12] Reachability Analysis of Neural Network Controlled Systems: A Mixed Monotone Contracting Approach, *Workshop on Geometry, Topology and Control System Design, Banff Centre for Arts and Creativity, Canada*, June 2023. [Slides] [Video]

[T11] Weak and Semi-Contraction for Large-Scale Network Systems, *LANS Seminar Talk, Argonne National Laboratory*, Apr. 2023. (Host: Adrian Maldonado) [Slides]

[T10] Exploiting Structure in Feedback Systems with Learning-based Components, *ECEE Seminar Talk, University of Colorado Boulder*, Feb. 2023. [Slides]

[T9] Exploiting Structure in Analysis and Design of Feedback Systems with Learning-Based Components, *Coordinated Science Laboratory, University of Illinois, Urbana Champaign (UIUC)*, Jan. 2023. (Host: Mohamed-Ali Belabbas) [Slides]

[T8] Robustness Certificates for Implicit Neural Networks: A Mixed Monotone Contractive Approach, *Learning for Dynamics and Control (L4DC), Stanford University*, Jun. 2022. [Slides]

[T7] Robustness of Neural Networks via Non-Euclidean Contraction Theory, *Indian Institute of Technology Delhi (virtual)*, Control Colloquium, Jun. 2022. [Slides]

[T6] Safety and Resilience of Large-scale Networks via Contraction Theory, *University of California, Riverside, Mechanical Engineering Department*, Mar. 2022. [Slides]

[T5] Frequency synchronization and multistability in power grids, *RSRG Virtual Seminar, California Institute of Technology*, May 2021. (Host: Steven Low) [Slides]

[T4] Non-Euclidean Contraction and its Extensions with Applications to Network Systems, *Georgia Institute of Technology*, May 2021. (Host: Samuel Coogan) [Slides]

[T3] Weak and Semi-Contraction for Network Systems, *Mathematical Biology Seminar, Department of Mathematics, University of Iowa*, Apr. 2021. (Host: Zahra Aminzare) [Slides]

[T2] Stability and Control of Large-scale Nonlinear Networks, *Queen's University Control Seminar, Department of Mathematics, Queen's University*, Apr. [Slides] 2021.

[T1] Synchronization and Multistability in Complex Networks and Power Grids, *Control Theory Seminar, Peking University*, May 2020. [Slides]

MENTORING	Students:	
	2024 - present	Amirreza Alavi (Ph.D. student, CU Boulder – jointly with Majid Zamani)
	2024 - present	Felipe Galarza-Jimenez (Ph.D. student, CU Boulder – jointly with Majid Zamani)
	2025 - present	Onkar Apte (M.Sc. Student, CU Boulder)
	Mentees:	
	2022 - 2024	Akash Harapanahalli (Ph.D. student, ECE, Georgia Tech)
	2021 - 2022	Matthew Abate (Ph.D. student, ME, Georgia Tech)
	2020 - 2022	Alexander Davydov (Ph.D. student, ME UCSB)
	2018 - 2021	Kevin D. Smith (Ph.D. student, ECE, UCSB)
	2019 - 2021	Pedro Cisneros-Velarde (Ph.D. student, ECE, UCSB)

FUNDING & GRANTS

Grants Submitted:

2025 **NSF-Cyber Physical Systems** (total amount: $600K, my share: $300K)
Title: *Reachability Analysis for Nonlinear Cyber-Physical Systems.* (Role: PI)

Other PI: Sriram Sankaranarayanan (University of Colorado Boulder)

2025 **NSF-Cyber Physical Systems** (total amount: $600K, my share: $300K)
Title: *Toward A Principled Framework for Verification and Control of Dynamical Systems under Stochastic Uncertainty* (Role: PI)

Other PI: Yongxin Chen (Georgia Tech)

2024	**NSF-Software and Hardware Foundations** (total amount: \$1.2M, my share: \$210K)

Title: *Certifiable Correctness in Neural Network Feedback Loops* (Role: PI)

Other PIs: Samuel Coogan (Georgia Tech), Lillian Ratliff (University of Washington), Shreyas Kousik (Georgia Tech)

Grant Writing Experience:

2021   Collaboration in writing the proposal for grant AFOSR FA9550-22-1-0059 (2021-2024)
Title: *Contraction Theory for Network Systems: Stability, Control and Optimization*
PI: Francesco Bullo

2018   Collaboration in writing the proposal for grant HDTRA1-19-1-0017 (2019-2022).
Title: *Inferring Network Structure and Flows Using Partial Observations*
PIs: Ambuj K. Singh, Francesco Bullo, and Ananthram Swami

TEACHING

CU Boulder

Spring	2025	**Linear Programming** (CSCI 5654)	Course Lecturer
Spring	2024	**Control System Analysis** (ECEN 5138)	Course Lecturer
Fall	2023/24	**Advanced Linear Systems** (ECEN 5448)	Course Lecturer

UCSB

Aug.	2018	**Engineering Mechanics: Dynamics** (ME 16)	Course Lecturer
Fall	2018	**Nonlinear Network Systems**	Guest Lecturer

Queen's University

Winter 2015	**Introduction to Control Theory** (MATH 332)	Course Lecturer
Winter 2014	**Lagrangian Mechanics and Control** (MATH 439/836)	Course Lecturer

HONORS AND AWARDS

2024	Outstanding Reviewer, IEEE Control Systems Letters (L-CSS)
2018	Outstanding Reviewer, IEEE Control Systems Letters (L-CSS)
2011-2015	Queen's International Tuition Award, Queen's University
2011-2012	Huntly Macdonald Sinclair Tuition Fellowship, Queen's University
2011	Ranked 1st in the M.Sc. Mechanical Engineering program, Shiraz University
2003	Awarded Silver Medal in the 23rd Iranian Student Mathematical Olympiad

PROFESIONAL SERVICE

PhD and M.Sc. Committee:

2025   Sara Kamali, *Doctoral Comprehensive Exam*, University of Colorado Boulder.

2025   Rameez Wajid, *Doctoral Comprehensive Exam*, University of Colorado Boulder.

2024   Hari Krishna Hari Prasad, *Geometric nonslip contact-switching systems: gait design, analysis, and applications to tiny legged robots*, University of Colorado Boulder.

2024   Sai Abhishek Aravind, *Influence of Discretization on Hypersampled Model Predictive Control*, University of Colorado Boulder.

Organizer/Chair:

2024   Co-organizer of the workshop *"From Formal Methods to Data-Driven Verification and Control"* in 63rd IEEE Conference on Decision and Control, Milan, Italy (with Abolfazl Lavaei, Chuchu Fan, and Lars Lindemann).

2024   Finance Chair for the *"8th IFAC Conference on Analysis and Design of Hybrid Systems"* (ADHS 2024), Boulder, Colorado.

2017   Session Chair for *"Controlled Networks and System Controllability"* at the 14th SIAM Conference on Control & its Applications, Pittsburgh, Pennsylvania.

Program Committee/Editorial:

2025   Associate Editor handling 5 papers in 2025 IEEE International Conference on Intelligent Transportation Systems (ITSC 2025)

2024   Associate Editor handling 6 papers in 2024 IEEE International Conference on Intelligent Transportation Systems (ITSC 2024)

University Committee:

2024   Engagement & Community (EC) committee, CU Boulder Department of Electrical and Computer Engineering

2023   Diversity, Equity, and Inclusion (DEI) Committee, CU Boulder Department of Electrical and Computer Engineering

2023   Faculty and Staff Recruitment, Retention, and Retirement (FSR^3) committee, CU Boulder Department of Electrical and Computer Engineering

Outreach Activity:

2023   Mentor for Georgia Intern-Fellowships for Teachers (GIFT)

REVIEW ACTIVITY

Grants   ❏ Panelist for three NSF programs

Journals   ❏ Nature Communications ❏ IEEE Transactions on Automatic Control ❏ Automatica ❏ SIAM Journal on Control and Optimization ❏ IEEE Transactions on Control of Network Systems ❏ IEEE Transactions on Power Systems ❏ IEEE Transactions on Circuits and Systems I: Regular Papers ❏ IEEE Control Systems Letters ❏ IEEE Transactions on Control Systems Technology ❏ IEEE Transactions on Network Science and Engineering ❏ Nonlinearity ❏ IEEE Transactions on Energy Conversion

Conferences   ❏ IEEE Conference on Decision and Control (CDC) ❏ American Control Conference(ACC) ❏ European Control Conference (ECC)

REFERENCES

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