Saber Jafarpour

Contact Information

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Research Experience

School of Electrical and Computer Engineering — Sept. 2021–present
Georgia Institute of Technology
Postdoctoral Research Fellow (Advisor: Samuel Coogan)

Center of Control, Dynamical Systems, and Computation — Aug. 2016–Aug. 2021
University of California, Santa Barbara
Postdoctoral Research Fellow (Advisor: Francesco Bullo)

Education

Department of Mathematics and Statistics, — Aug. 2011–July 2016
Queen's University
Ph.D. in Applied Mathematics (Advisor: Andrew D. Lewis)
Dissertation: On the Role of Regularity in Mathematical Control Theory

Department of Mechanical Engineering, — Aug. 2008–May 2011
Shiraz University
M.Sc. in Applied Mechanics (Advisor: Mojtaba Mahzoon)

Department of Mechanical Engineering, — Aug. 2004–Aug. 2008
Shiraz University
B.Sc. in Mechanical Engineering

Research Interests

My research interests focus on the safety and autonomy of learning-enabled inerconnected systems with applications to power grids, transportation networks, and robotic systems. Topics of interest:

- Stability, resilience, and control of power grids
- Reachability and robustness of learning-based systems
- Congestion and multistability in flow networks

Journal/ CS-Conference Papers

[J1] **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

[J2] **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

[J3] **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

[J4] **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

[J5] **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

[J6] **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

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

[J8] **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

[J9] A. Davydov, **S. Jafarpour**, and F. Bullo. Non-Euclidean contraction theory for robust nonlinear stability. *IEEE Transactions on Automatic Control*, 2022. DOI: 10.1109/TAC.2022.3183966

[J10] 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

[J11] 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

[J12] 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

[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

[J14] 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

[J15] 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

[J16] 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

[J17] K. D. Smith, **S. Jafarpour**, A. Swami, and F. Bullo. Topology inference with multivariate cumulants: The Möbius inference algorithm. *IEEE/ACM Transactions on Networking*, 2022b. DOI: 10.1109/TNET.2022.3164336. To appear

Refereed Conference papers

[C1] **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. **(Oral Presentation: Top 10 percent of submitted papers)**

[C2] **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 (WFVML)*, 2022b

[C3] 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

[C4] 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*, Cancun, Mexico, Dec. 2022. To appear

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

[C6] 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*, Dec. 2021. To appear (Invited Tutorial Session)

[C7] 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

[C8] **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

[C9] **S. Jafarpour** and A. D. Lewis. Real analytic control systems. In *IEEE Conf. on Decision and Control*, pages 5618–5623, Dec. 2014a. DOI: 10.1109/CDC.2014.7040268

[C10] V. Purba, **S. Jafarpour**, B. B. Johnson, F. Bullo, and S. V. Dhople. Reduced-order structure-preserving model for parallel-connected three-phase grid-tied inverters. In *18th Workshop on Control and Modeling for Power Electronics*, July 2017. DOI: 10.1109/COMPEL.2017.8013389

Under review Papers

[U1] **S. Jafarpour**, A. Davydov, and F. Bullo. Non-Euclidean contraction theory for monotone and positive systems. *IEEE Transactions on Automatic Control*, Apr. 2021. URL https://arxiv.org/abs/2104.01321. Submitted

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

[T1] Robustness of Neural Networks via Non-Euclidean Contraction Thepry, *Indian Institute of Technology Delhi (virtual)*, Control Colloquium, Jun. 2022.

[T2] Safety and Resilience of Large-scale Networks via Contraction Theory, *Uinversity of California, Riverside, Mechanical Engineering Department*, Mar. 2022.

[T3] Frequency synchronization and multistability in power grids, *RSRG Virtual Seminar*, Department of Electrical Engineering, California Institute of Technology, May 2021.

[T4] Non-Euclidean contraction and its extensions with applications to network systems, *Control Seminar*, School of Electrical and Computer Engineering, Georgia Institute of Technology, May 2021.

[T5] Weak and Semi-Contraction for Network Systems, *Mathematical Biology Seminar*, Department of Mathematics, University of Iowa, Apr. 2021.

[T6] Stability and Control of Large-scale Nonlinear Networks, *Queen's University Control Seminar*, Department of Mathematics, Queen's University, Apr. 2021.

[T7] Synchronization and Multistability in Complex Networks and Power Grids, *Control Theory Seminar*, Peking University, May 2020.

[T8] Synchronization in Oscillator Networks and Power Grids, 35th *Southern California Control Workshop*, UCLA, Nov. 2018.

[T9] Real Analytic Control Systems, *ISS Seminar Series, Center for Intelligent Machines*, McGill University, Feb. 2014.

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 Assistant 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

Conference organizer

Summer 2022 Organizer of the **Whiteboard Seminars** for Decison and Control Lab at Georgia Institute of Technology.

July 2017 Session Chair for **Controlled Networks and System Controllability** at the 14th SIAM Conference on Control & Its Applications, Pittsburgh

Workshops

Sept. 2021	Autonomous Energy Systems, NREL (Virtual workshop)
Aug. 2020	Autonomous Energy Systems, NREL (Virtual workshop)
Apr. 2019	Innovative Optimization and Control Methods for Autonomous Systems, NREL
July 2012	Focus Program on Geometry, Mechanics and Dynamics, Fields Institute, Toronto

Mentoring

Sept. 2022 - present	Akash Harapanahalli (Ph.D. student, ECE Georgia Tech)
Sept. 2021 - Jun 2022	Matthew Abate (Ph.D. student, ME Georgia Tech)
Sept. 2020 - Mar 2022	Alexander Davydov (Ph.D. student, ME UCSB)
Sept. 2018 - Aug. 2021	Kevin D. Smith (Ph.D. student, ECE, UCSB)
Sept. 2019 - Jul. 2021	Pedro Cisneros-Velarde (Ph.D. student, ECE, UCSB)
May 2017 - Sept. 2018	Elizabeth Y. Huang (Ph.D. student, ME, UCSB)

Teaching Experience

UCSB

Summer	2018	Instructor, Engineering Mechanics: Dynamics (ME 16)
Fall	2018	Guest Lecturer, Nonlinear Network Systems

Queen's University

Winter	2015	Instructor, Introduction to Control Theory (MATH 332)
Winter	2014	Instructor, Lagrangian Mechanics, Dynamics, and Control (MATH 439/836)
Winter	2016	Teaching assistant, Application of Numerical Methods (MATH 272)
Fall	2012	Teaching assistant, Differential Equations (MATH 232)

Honors and Awards

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
2008	Ranked 26th in M.Sc. Entrance Exam for Iranian Universities
2004	Ranked 288th in B.Sc. Entrance Exam for Iranian Universities
2003	Awarded Silver Medal in the 23th Iranian Student Mathematical Olympiad

Review Activity

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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