Saber Jafarpour

Contact Information

Decision and Control Laboratory
Georgia Institute of Technology
Technology Square Research Building
Webpage: engineering.ucsb.edu/∼saber.jafarpour

Email: saber@gatech.edu
Orcid ID: 0000-0002-7614-2940
Google Scholar: Saber Jafarpour

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 robustness of large-scale interconnected systems motivated by applications in power grids, transportation networks, and neural networks. Topics of interest include:

- Stability, control, and optimization in network systems
- Safety and robustness of learning algorithms
- Congestion and multistability in flow networks
- Geometric control and controllability of systems

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)*, Dec. 2021. URL http://arxiv.org/abs/2106.03194. To appear

[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*, Jan. 2021. URL https://arxiv.org/pdf/1901.11189.pdf. To appear

[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*, May 2021a. DOI: 10.1109/TAC.2021.3073096. To appear

[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*, 2019b. DOI: 10.1109/TCNS.2021.3084444. To appear

[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, 2019a. 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. 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

[J10] P. Cisneros-Velarde, **S. Jafarpour**, and F. Bullo. Distributed and time-varying primal-dual dynamics via contraction analysis. *IEEE Transactions on Automatic Control*, Jan. 2020. DOI: 10.1109/TAC.2021.3103865. To appear

[J11] 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

[J12] K. D. Smith, **S. Jafarpour**, and F. Bullo. Transient stability of droop-controlled inverter networks with operating constraints. *IEEE Transactions on Automatic Control*, 2021. DOI: 10.1109/TAC.2021.3053552. To appear

[J13] 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

[J14] 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

[J15] 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

Under review Papers

[U1] **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 Conference*, Nov. 2022. URL https://sites.engineering.ucsb.edu/~saber.jafarpour/2021y_ImplicitNeural.pdf. Submitted

[U2] **S. Jafarpour** and S. Coogan. Resilience of input metering in dynamic flow networks. In *American Control Conference*, 2022. URL https://sites.engineering.ucsb.edu/~saber.jafarpour/FlowNetwork_2021.pdf. Submitted

[U3] **S. Jafarpour**, A. Davydov, and F. Bullo. Non-Euclidean contraction theory for monotone and positive systems. *IEEE Transactions on Automatic Control*, Apr. 2021b. URL https://arxiv.org/abs/2104.01321

[U4] A. Davydov, **S. Jafarpour**, and F. Bullo. Non-Euclidean contraction theory via semi-inner products. *IEEE Transactions on Automatic Control*, Mar. 2021. URL https://arxiv.org/abs/2103.12263

[U5] K. D. Smith, **S. Jafarpour**, A. Swami, and F. Bullo. Topology inference with multivariate cumulants: The Möbius inference algorithm. *IEEE/ACM Transactions on Networking*, May 2020. URL https://arxiv.org/pdf/2005.07880.pdf. 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

Refereed Conference papers

[C1] 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)

[C2] 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

[C3] V. Purba, S. V. Dhople, **S. Jafarpour**, F. Bullo, and B. Johnson. Network-cognizant model reduction of grid-tied three-phase inverters. In *Allerton Conf. on Communications, Control and Computing*, Oct. 2017a. DOI: 10.1109/ALLERTON.2017.8262732

[C4] 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 2017b. DOI: 10.1109/COMPEL.2017.8013389

[C5] **S. Jafarpour** and A. D. Lewis. The classical and tautological orbit theorems. In 22$^{\text{nd}}$ *International Symposium on Mathematical Theory of Networks and Systems*, July 2016a

[C6] **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

Invited Talks

[T1] Frequency synchronization and multistability in power grids, *RSRG Virtual Seminar*, Department of Electrical Engineering, California Institute of Technology, May 2021.

[T2] 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.

[T3] Weak and Semi-Contraction for Network Systems, *Mathematical Biology Seminar*, Department of Mathematics, University of Iowa, Apr. 2021.

[T4] Stability and Control of Large-scale Nonlinear Networks, *Queen's University Control Seminar*, Department of Mathematics, Queen's University, Apr. 2021.

[T5] Synchronization and Multistability in Complex Networks and Power Grids, *Control Theory Seminar*, Peking University, May 2020.

[T6] Synchronization in Oscillator Networks and Power Grids, 35$^{\text{th}}$ *Southern California Control Workshop*, UCLA, Nov. 2018.

[T7] On Small-time Local Controllability, 7$^{\text{th}}$ *Biennial meeting on Systems and Control Theory*, Queen's University, May 2016.

[T8] Real Analytic Control Systems, *ISS Seminar Series, Center for Intelligent Machines*, McGill University, Feb. 2014.

Grant Writing Experience

2021 Collaboration in writting 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

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

Workshops

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

Mentoring

Sept. 2021 - present	Matthew Abate (PhD student, ME Georgia Tech)
Sept. 2020 - present	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)
Jan. 2019 - Jan. 2020	Xiaoming Duan (Ph.D. student, ME, 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)
2014	Queen's Graduate Conference Travel Award, Queen's University
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

Francesco Bullo
Department of Mechanical Engineering
University of California, Santa Barbara
bullo@engineering.ucsb.edu

Andrew D. Lewis
Department of Mathematics and Statistics
Queen's University
andrew@mast.queensu.ca

Florian Dörfler
Department of Information Technology and Electrical Engineering
ETH Zürich
dorfler@ethz.ch

Sam Coogan
School of Electrical and Computer Engineering
Georgia Institute of Technology
sam.coogan@gatech.edu

Bahman Gharesifard
Department of Electrical and Computer Engineering
University of California, Los Angeles
gharesifard@ucla.edu

Mario di Bernardo
Department of Automatic Control
University of Naples Federico II, Italy
mario.dibernardo@unina.it