

# Saber Jafarpour

## CONTACT INFORMATION

Decision and Control Laboratory  
Georgia Institute of Technology  
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## RESEARCH EXPERIENCE

**School of Electrical and Computer Engineering  
Georgia Institute of Technology**

Sept. 2021–present

Postdoctoral Research Fellow (Advisor: Samuel Coogan)

**Center of Control, Dynamical Systems, and Computation  
University of California, Santa Barbara**

Aug. 2016–Aug. 2021

Postdoctoral Research Fellow (Advisor: Francesco Bullo)

## EDUCATION

**Department of Mathematics and Statistics,  
Queen's University**

Aug. 2011–July 2016

Ph.D. in Applied Mathematics (Advisor: Andrew D. Lewis)

Dissertation: On the Role of Regularity in Mathematical Control Theory

**Department of Mechanical Engineering,  
Shiraz University**

Aug. 2008–May 2011

M.Sc. in Applied Mechanics (Advisor: Mojtaba Mahzoon)

**Department of Mechanical Engineering,  
Shiraz University**

Aug. 2004–Aug. 2008

B.Sc. in Mechanical Engineering

## RESEARCH INTERESTS

My research interests center around safety, autonomy, and learning in large-scale network systems with applications to power grids, transportation networks, artificial neural networks, and robotic systems. Topics of interest include:

- Stability, resilience, and control of networks
- Reachability and robustness of learning-based systems
- 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)*, 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](https://doi.org/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](https://doi.org/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](https://doi.org/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, 2022b. DOI: [10.1109/TCNS.2021.3084444](https://doi.org/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](https://doi.org/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](https://doi.org/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](https://doi.org/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](https://doi.org/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=10V53bErniB>
- [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](https://doi.org/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](https://doi.org/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](https://doi.org/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](https://doi.org/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](https://doi.org/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](https://doi.org/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](https://doi.org/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*, July 2022. DOI: [10.48550/arXiv.2208.03889](https://doi.org/10.48550/arXiv.2208.03889)
- [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 2022a. DOI: [10.23919/ACC53348.2022.9867237](https://doi.org/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. DOI: [10.1109/CDC45484.2021.9682883](https://doi.org/10.1109/CDC45484.2021.9682883)

		<p>[C7] E. Y. Huang, <b>S. Jafarpour</b>, and F. Bullo. Synchronization of coupled oscillators: The Taylor expansion of the inverse Kuramoto map. In <i>IEEE Conf. on Decision and Control</i>, pages 5340–5345, Miami, USA, Dec. 2018. DOI: <a href="https://doi.org/10.1109/CDC.2018.8619559">10.1109/CDC.2018.8619559</a></p> <p>[C8] <b>S. Jafarpour</b> and A. D. Lewis. The classical and tautological orbit theorems. In <i>22<sup>nd</sup> International Symposium on Mathematical Theory of Networks and Systems</i>, July 2016a</p> <p>[C9] <b>S. Jafarpour</b> and A. D. Lewis. Real analytic control systems. In <i>IEEE Conf. on Decision and Control</i>, pages 5618–5623, Dec. 2014a. DOI: <a href="https://doi.org/10.1109/CDC.2014.7040268">10.1109/CDC.2014.7040268</a></p>
UNDER REVIEW PAPERS		<p>[U1] <b>S. Jafarpour</b>, A. Davydov, and F. Bullo. Non-Euclidean contraction theory for monotone and positive systems. <i>IEEE Transactions on Automatic Control</i>, Apr. 2021. URL <a href="https://arxiv.org/abs/2104.01321">https://arxiv.org/abs/2104.01321</a>. Submitted</p> <p>[U2] M. Pirani and <b>S. Jafarpour</b>. Network critical slowing down: Data-driven detection of critical transitions in nonlinear networks. <i>IEEE Transactions on Control of Network Systems</i>, 2022. URL <a href="https://arxiv.org/abs/2208.03881">https://arxiv.org/abs/2208.03881</a>. Submitted</p> <p>[U3] <b>S. Jafarpour</b> and S. Coogan. Monotonicity and contraction on polyhedral cones. <i>IEEE Transactions on Automatic Control</i>, 2022b. URL <a href="http://arxiv.org/abs/2210.11576">http://arxiv.org/abs/2210.11576</a>. Submitted</p>
BOOKS		<p>[B1] <b>S. Jafarpour</b> and A. D. Lewis. <i>Time-Varying Vector Fields and Their Flows</i>. SpringerBriefs in Mathematics. Springer International Publishing, 2014b. DOI: <a href="https://doi.org/10.1007/978-3-319-10139-2">10.1007/978-3-319-10139-2</a></p>
INVITED TALKS		<p>[T1] Robustness of Neural Networks via Non-Euclidean Contraction Theory, <i>Indian Institute of Technology Delhi (virtual)</i>, Control Colloquium, Jun. 2022.</p> <p>[T2] Safety and Resilience of Large-scale Networks via Contraction Theory, <i>University of California, Riverside, Mechanical Engineering Department</i>, Mar. 2022.</p> <p>[T3] Frequency synchronization and multistability in power grids, <i>RSRG Virtual Seminar</i>, Department of Electrical Engineering, California Institute of Technology, May 2021.</p> <p>[T4] Non-Euclidean contraction and its extensions with applications to network systems, <i>Control Seminar</i>, School of Electrical and Computer Engineering, Georgia Institute of Technology, May 2021.</p> <p>[T5] Weak and Semi-Contraction for Network Systems, <i>Mathematical Biology Seminar</i>, Department of Mathematics, University of Iowa, Apr. 2021.</p> <p>[T6] Stability and Control of Large-scale Nonlinear Networks, <i>Queen’s University Control Seminar</i>, Department of Mathematics, Queen’s University, Apr. 2021.</p> <p>[T7] Synchronization and Multistability in Complex Networks and Power Grids, <i>Control Theory Seminar</i>, Peking University, May 2020.</p> <p>[T8] Synchronization in Oscillator Networks and Power Grids, 35<sup>th</sup> <i>Southern California Control Workshop</i>, UCLA, Nov. 2018.</p>
GRANT WRITING EXPERIENCE	<p>2021</p> <p>2018</p>	<p>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</p> <p>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</p>
CONFERENCE ORGANIZER	<p>Summer 2022</p> <p>July 2017</p>	<p>Organizer of the <b>Whiteboard Seminars</b> for Decision and Control Lab at Georgia Institute of Technology.</p> <p>Session Chair for <b>Controlled Networks and System Controllability</b> at the 14<sup>th</sup> SIAM Conference on Control &amp; Its Applications, Pittsburgh</p>

INVITED WORKSHOPS	July 2023	Geometry, Topology and Control System Design, Banff Research Station, Canada
	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	<b>UCSB</b>	
	Summer 2018	Instructor, Engineering Mechanics: Dynamics ( <a href="#">ME 16</a> )
	Fall 2018	Guest Lecturer, Nonlinear Network Systems
	<b>Queen's University</b>	
	Winter 2015	Instructor, Introduction to Control Theory ( <a href="#">MATH 332</a> )
HONORS AND AWARDS	Winter 2014	Instructor, Lagrangian Mechanics, Dynamics, and Control ( <a href="#">MATH 439/836</a> )
	Winter 2016	Teaching assistant, Application of Numerical Methods ( <a href="#">MATH 272</a> )
	Fall 2012	Teaching assistant, Differential Equations ( <a href="#">MATH 232</a> )
	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 1 <sup>st</sup> in the M.Sc. Mechanical Engineering program, Shiraz University
REVIEW ACTIVITY	2008	Ranked 26 <sup>th</sup> in M.Sc. Entrance Exam for Iranian Universities
	2004	Ranked 288 <sup>th</sup> in B.Sc. Entrance Exam for Iranian Universities
	2003	Awarded Silver Medal in the 23 <sup>th</sup> Iranian Student Mathematical Olympiad
	Journals	<input type="checkbox"/> Nature Communications <input type="checkbox"/> IEEE Transactions on Automatic Control
		<input type="checkbox"/> Automatica <input type="checkbox"/> SIAM Journal on Control and Optimization <input type="checkbox"/> IEEE Transactions on Control of Network Systems <input type="checkbox"/> IEEE Transactions on Power Systems <input type="checkbox"/> IEEE Transactions on Circuits and Systems I: Regular Papers <input type="checkbox"/> IEEE Control Systems Letters <input type="checkbox"/> IEEE Transactions on Control Systems Technology <input type="checkbox"/> IEEE Transactions on Network Science and Engineering <input type="checkbox"/> Nonlinearity <input type="checkbox"/> IEEE Transactions on Energy Conversion
	Conferences	<input type="checkbox"/> IEEE Conference on Decision and Control (CDC) <input type="checkbox"/> American Control Conference(ACC) <input type="checkbox"/> European Control Conference (ECC)
REFERENCES	<b>Francesco Bullo</b>	
	Department of Mechanical Engineering University of California, Santa Barbara <a href="mailto:bullo@engineering.ucsb.edu">bullo@engineering.ucsb.edu</a>	
	<b>Samuel Coogan</b>	
	School of Electrical and Computer Engineering Georgia Institute of Technology <a href="mailto:sam.coogan@gatech.edu">sam.coogan@gatech.edu</a>	
	<b>Bahman Gharesifard</b>	
	Department of Electrical and Computer Engineering University of California, Los Angeles <a href="mailto:gharesifard@ucla.edu">gharesifard@ucla.edu</a>	
	<b>Andrew D. Lewis</b>	
	Department of Mathematics and Statistics Queen's University, Canada <a href="mailto:andrew@mast.queensu.ca">andrew@mast.queensu.ca</a>	