Alexander Davydov

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EDUCATION

University of California, Santa Barbara — Santa Barbara, CA
Ph.D. Mechanical Engineering (Advisor: Francesco Bullo) — *Expected* 2025
University of Maryland — College Park, MD
B.S. Mechanical Engineering, *Cum Laude, with Honors* — Aug. 2016 - May 2020
B.S. Mathematics, *Cum Laude* — Cumulative GPA: 3.92

RESEARCH INTERESTS

Reliable control of complex engineering systems; machine learning architectures and optimizers from a dynamical systems and control theory perspective; neural networks; time-varying optimization; adversarial robustness in machine learning; vehicle control; multi-agent robotics

RESEARCH EXPERIENCE

Graduate Student Researcher, *Department of Mechanical Engineering* — Santa Barbara, CA
Research on contraction theory and neural networks. Advisor: Francesco Bullo — Sep. 2020 - Present

- Developing control-theoretic tools for the analysis and control of nonlinear network systems using contraction theory, convex optimization, and monotone operator theory
- Applying these tools to continuous-time neural networks and implicit deep learning architectures

Undergraduate Research Assistant, *Collaborative Controls and Robotics Lab* — College Park, MD
Research on control of multi-robot systems. Advisor: Yancy Diaz-Mercado — Aug. 2018 - May 2020

- Provided novel sufficient conditions for optimality in multi-robot coverage control
- Developed a novel approach for wind turbine wake estimation via adaptive coverage control in teams of aerostats and validated the approach in MATLAB simulations

Summer Research Fellow, *Autonomous Unmanned Systems Lab* — College Park, MD
First-Year Innovation & Research Experience. Mentor: Derrick Yeo — June 2017 - Dec. 2017

- Developed a model for sensor fusion and static target detection using Minesweeper
- Developed a multi-robot simulation in Python for clearing all the mines

PUBLICATIONS

Journal Publications

1. Anand Gokhale, **Alexander Davydov**, and Francesco Bullo, "Proximal Gradient Dynamics: Monotonicity, Exponential Convergence, and Applications," *IEEE Control Systems Letters*, Dec. 2024, URL: https://arxiv.org/abs/2409.10664. **To Appear**

2. **Alexander Davydov**, Saber Jafarpour, Anton V. Proskurnikov, and Francesco Bullo, "Non-Euclidean Monotone Operator Theory with Applications," *Journal of Machine Learning Research*, vol. 25, no. 307, pp. 1-33, 2024, URL: https://jmlr.org/papers/v25/23-0805.html.

3. **Alexander Davydov** and Francesco Bullo, "Perspectives on Contractivity in Control, Optimization, and Learning," *IEEE Control Systems Letters*, vol. 8, pp. 2087-2098, 2024, doi: 10.1109/LCSYS.2024.3436127

4. **Alexander Davydov**, Anton V. Proskurnikov, and Francesco Bullo, "Non-Euclidean Contraction Analysis of Continuous-Time Neural Networks," *IEEE Transactions on Automatic Control*, 2024, doi: 10.1109/TAC.2024.3422217, URL: https://arxiv.org/abs/2110.08298. **To Appear**

5. **Alexander Davydov** and Francesco Bullo, "Exponential Stability of Parametric Optimization-Based Controllers via Lur'e Contractivity," *IEEE Control Systems Letters*, vol. 8, pp. 1277-1282, 2024, doi: 10.1109/LCSYS.2024.3408110, URL: https://arxiv.org/abs/2403.08159.

6. Veronica Centorrino, **Alexander Davydov**, Anand Gokhale, Giovanni Russo, and Francesco Bullo, "On Weakly Contracting Dynamics for Convex Optimization," *IEEE Control Systems Letters*, vol. 8, pp. 1745-1750, 2024, doi: 10.1109/LCSYS.2024.3414348, URL: https://arxiv.org/abs/2403.07572.

7. Veronica Centorrino, Anand Gokhale, **Alexander Davydov**, Giovanni Russo, and Francesco Bullo, "Positive Competitive Networks for Sparse Reconstruction," *Neural Computation*, vol. 36, no. 6, pp. 1163–1197, 2024, doi: 10.1162/neco_a_01657, URL: https://arxiv.org/abs/2311.03821.

8. Anand Gokhale, **Alexander Davydov**, and Francesco Bullo, "Contractivity of Distributed Optimization and Nash Seeking Dynamics," *IEEE Control Systems Letters*, vol. 7, pp. 3896-3901, 2023, doi: 10.1109/LCSYS.2023.3341987, URL: https://arxiv.org/abs/2309.05873.

9. Saber Jafarpour, **Alexander Davydov**, and Francesco Bullo, "Non-Euclidean Contraction Theory for Monotone and Positive Systems," *IEEE Transactions on Automatic Control*, vol. 68, no. 9, pp. 5653-5660, 2023, doi: 10.1109/TAC.2022.3224094, URL: https://arxiv.org/abs/2104.01321.

10. Veronica Centorrino, Anand Gokhale, **Alexander Davydov**, Giovanni Russo, and Francesco Bullo, "Euclidean Contractivity of Neural Networks with Symmetric Weights," *IEEE Control Systems Letters*, vol. 7, pp. 1724-1729, 2023, doi: 10.1109/LCSYS.2023.3278250, URL: https://arxiv.org/abs/2302.13452.

11. Anton V. Proskurnikov, **Alexander Davydov**, and Francesco Bullo, "The Yakubovich S-Lemma Revisited: Stability and Contractivity in Non-Euclidean Norms," *SIAM Journal on Control and Optimization*, vol. 61, no. 4, pp. 1955-1978, July 2023, doi: 10.1137/22M1512600, URL: https://arxiv.org/abs/2207.14579.

12. **Alexander Davydov**, Saber Jafarpour, and Francesco Bullo, "Non-Euclidean Contraction Theory for Robust Nonlinear Stability," *IEEE Transactions on Automatic Control*, vol. 67, no. 12, pp. 6667-6681, 2022, doi: 10.1109/TAC.2022.3183966, URL: https://arxiv.org/abs/2103.12263.

13. **Alexander Davydov**, Phillip Rivera-Ortiz, and Yancy Diaz-Mercado, "Pursuer Coordination in Multi-Player Reach-Avoid Games through Control Barrier Functions," *IEEE Control Systems Letters*, vol. 5, no. 6, pp. 1910-1915, 2021, doi: 10.1109/LCSYS.2020.3044549.

14. **Alexander Davydov** and Yancy Diaz-Mercado, "Sparsity Structure and Optimality of Multi-Robot Coverage Control," in *IEEE Control Systems Letters*, vol. 4, no. 1, pp. 13-18, 2020, doi: 10.1109/LCSYS.2019.2921513.

Conference Publications

1. Sean Jaffe, **Alexander Davydov**, Deniz Lapsekili, Ambuj K. Singh, and Francesco Bullo, "Learning Neural Contracting Dynamics: Extended Linearization and Global Guarantees," *NeurIPS*, 2024, URL: https://openreview.net/forum?id=YYnP3Xpv3y.

2. **Alexander Davydov**, Sean Jaffe, Ambuj K. Singh, and Francesco Bullo, "Retrieving k-Nearest Memories with Modern Hopfield Networks," *NeurIPS workshop on Associative Memory and Hopfield Networks in 2023*, 2023, URL: https://openreview.net/forum?id=bNBMnQXRJU **(Oral Presentation)**

3. Xiaotian Xu, **Alexander Davydov**, and Yancy Diaz-Mercado, "On the Equivalence of Multi-Agent 2D Coverage Control and Leader-Follower Consensus Network," *American Control Conference (ACC)*, pp. 503-508, 2023, doi: 10.23919/ACC55779.2023.10156475.

4. **Alexander Davydov**, Saber Jafarpour, Anton V. Proskurnikov, and Francesco Bullo, "Non-Euclidean Monotone Operator Theory with Applications to Recurrent Neural Networks," *IEEE Conference on Decision and Control*, pp. 6332-6337, 2022. doi: 10.1109/CDC51059.2022.9993197.

5. **Alexander Davydov**, Saber Jafarpour, Matthew Abate, Francesco Bullo, and Samuel Coogan, "Comparative Analysis of Interval Reachability for Robust Implicit and Feedforward Neural Networks," *IEEE Conference on Decision and Control*, pp. 2073-2078, 2022. doi: 10.1109/CDC51059.2022.9993217.

6. Saber Jafarpour, **Alexander Davydov**, Matthew Abate, Francesco Bullo, and Samuel Coogan, "Robust training and verification of implicit neural networks: A non-Euclidean contractive approach," *ICML Workshop on Formal Verification of Machine Learning*, 2022, URL: https://arxiv.org/abs/2208.03889

7. Saber Jafarpour, Matthew Abate, **Alexander Davydov**, Francesco Bullo, and Samuel Coogan, "Robustness Certificates for Implicit Neural Networks: A Mixed Monotone Contractive Approach," *Learning for Dynamics and Control*, pp. 917-930, 2022, URL: https://arxiv.org/abs/2112.05310. **(Oral Presentation)**

8. **Alexander Davydov**, Anton V. Proskurnikov, and Francesco Bullo, "Non-Euclidean Contractivity of Recurrent Neural Networks," *American Control Conference (ACC)*, pp. 1527-1534, 2022, doi: 10.23919/ACC53348.2022.9867357. **(O. Hugo Schuck Best Paper Award and Best Student Paper Award Finalist)**

9. Saber Jafarpour, **Alexander Davydov**, Anton V. Proskurnikov, and Francesco Bullo, "Robust Implicit Networks via Non-Euclidean Contractions," *NeurIPS*, 2021, URL: https://arxiv.org/abs/2106.03194

10. Francesco Bullo, Pedro Cisneros-Velarde, **Alexander Davydov**, and Saber Jafarpour, "From Contraction Theory to Fixed Point Algorithms on Riemannian and non-Euclidean Spaces," *IEEE Conference on Decision and Control*, 2021, pp. 2923-2928. doi: 10.1109/CDC45484.2021.9682883 **(Invited Tutorial Paper)**

11. **Alexander Davydov**, Derrick W. Yeo, and Yancy Diaz-Mercado, "Low-Mobility Atmospheric Sensing via Multi-Vehicle Adaptive Coverage Control," in *AIAA AVIATION Forum*, 2020, doi: 10.2514/6.2020-2821.

Publications Under Review

1. **Alexander Davydov**, Franck Djeumou, Marcus Greiff, Makoto Suminaka, Michael Thompson, John Subosits, and Thomas Lew, "First, Learn What You Don't Know: Active Information Gathering for Driving at the Limits of Handling," *IEEE Int. Conf. on Robotics and Automation*, Sept. 2024, URL: https://arxiv.org/abs/2411.00107, **Submitted**

2. **Alexander Davydov**, Veronica Centorrino, Anand Gokhale, Giovanni Russo, and Francesco Bullo, "Time-Varying Convex Optimization: A Contraction and Equilibrium Tracking Approach," *IEEE Transactions on Automatic Control*, June 2023, URL: https://arxiv.org/abs/2305.15595. **Conditionally Accepted**

Professional Experience

ML & Control Research Intern, *Toyota Research Institute* Los Altos, CA
Human Interactive Driving; Extreme Performance Intelligent Control Team. June 2024 - Sep. 2024
- Leveraged Bayesian machine learning to enable reliable vehicle control at the limits of handling
- Drafted and submitted results to IEEE ICRA

Technical Intern, *The Johns Hopkins University Applied Physics Lab* Laurel, MD
Guidance, Navigation, and Control Group; Advanced Concepts Section. June 2020 - Aug. 2020
- Developed and tested decentralized multi-agent algorithms for coordinated capture of a fast evader
- Drafted and submitted manuscript detailing results for IEEE journal publication

Summer Research Program Intern, *MIT Lincoln Laboratory* Lexington, MA
Structural & Thermal-Fluids Engineering Group. June 2019 - Aug. 2019
- Performed testing and characterization of optomechanical components for space flight
- Designed optomechanical systems in SolidWorks and analyzed them in SolidWorks Simulation

Mechanical Engineering Intern, *ATA Aerospace, LLC* Greenbelt, MD
Contractor at NASA Goddard in the Mechanical Systems Division. May 2018 - Aug. 2018
- Modified flight hinge design for the Wide-Field Infrared Survey Telescope (WFIRST) sun shield
- Designed and modeled a 1/3 scale model of the WFIRST door in Creo Parametric

Mentoring Experience and Outreach

Fellowship Writing Consultant, *UC Santa Barbara Graduate Division*   Fall 2021 - 2023
- Aided students applying for NSF Graduate Research Fellowship in writing their statements
- Several students I have helped have been awarded NSF fellowships or honorable mentions

Research Mentor, *UC Santa Barbara's Summer Research Academies*   Summer 2023
- Mentored high school students on topics at the intersection of machine learning and mechanical engineering
- Students worked in teams and gave final presentations and wrote final research papers

Teaching Experience

Teaching Assistant, *University of California, Santa Barbara*   Santa Barbara, CA

Machine Learning (ME 107).	Fall 2023
Control System Design (ME 155A).	Spring 2023
Engineering Mechanics: Dynamics (ME 16).	Spring 2021
Engineering Mechanics: Vibrations (ME 163).	Winter 2021
Design and Analysis of Structures (ME 154).	Fall 2020

Teaching Assistant, *University of Maryland*   College Park, MD

Calculus II (MATH 141).	Spring 2020
Calculus I (MATH 140).	Fall 2020
Engineering Dynamics (ENES 221).	Winter/Spring 2019

Tutor, *University of Maryland*   College Park, MD

Differential Equations (MATH 246).	Fall 2017/Spring 2018

Awards

First Place – UCSB Mechanical Engineering Grad Slam	Oct. 2024
IEEE Control Systems Letters Outstanding Paper Award	Sept. 2024
AACC O. Hugo Schuck Best Paper Award	June 2023
American Control Conference Best Student Paper Award Finalist	Jan. 2022
IEEE Control Systems Society Student Travel Grant	Sept. 2021
NSF Graduate Research Fellowship	March 2021
NSF Graduate Research Fellowship — Honorable Mention	March 2020
University of California, Santa Barbara, Chancellor's Fellowship	Feb. 2020
Strauss Teaching Assistantship	April 2019
First-Year Innovation and Research Experience Summer Fellowship	March 2017

Invited Talks

1. "Contraction Theory as Guiding Principles for Design of Engineering Systems," D2C2S2 Seminar Series at the University of Maryland, College Park, MD, Nov. 2024.

2. "Contraction Theory as Guiding Principles for Design of Engineering Systems," Semiautonomous Seminar Series at UC Berkeley, Berkeley, CA, Oct. 2024.

3. "Contracting Dynamics for Time-Varying Convex Optimization," Online Optimization Methods for Data-driven Feedback Control workshop at the 2023 American Control Conference, San Diego, CA, May 2023.

4. "Contraction of Continuous-Time Proximal Gradient Dynamics," Contraction Theory for Systems, Control, and Learning workshop at the 2023 American Control Conference, San Diego, CA, May 2023.

5. "Contracting Dynamics for Time-Varying Convex Optimization," 41st Southern California Control Workshop, Santa Barbara, CA, April 2023.

Professional Affiliations and Services

Student Member of:

  □ IEEE, □ IEEE Control Systems Society, □ SIAM.

Reviewer for Journals:

  □ IEEE Transactions on Automatic Control, □ Automatica, □ IEEE Transactions on Control of Network Systems, □ SIAM Journal on Mathematics of Data Science, □ IEEE Control Systems Letters, □ European Journal of Control.

Reviewer for Conferences:

  □ IEEE Conference on Decision and Control, □ American Control Conference, □ IEEE International Conference on Robotics and Automation, □ Modeling, Estimation and Control Conference.

Skills

Programming Languages: Python, MATLAB, Java

Python Libraries: PyTorch, JAX, TensorFlow, NumPy, CVXPY, Matplotlib, scikit-learn, SciPy

Technical Software: GitHub, Simulink, LaTeX

Relevant Coursework: Deep Learning, Theoretical Machine Learning, Stochastic Processes, Nonlinear Control Systems, Robust Control Theory, Applied Dynamical Systems

Hobbies

Chess   Jan. 2012 - Present

- United States Chess Federation Expert and Candidate Master with a rating of 2162
- Organized a collegiate chess team that was awarded Best Division III Chess School at the Pan-American Intercollegiate Chess Championships 2017 in Columbus, OH
- 2016 Maryland High School Chess Champion
- 2014 World Open Under 2000 3rd place

Ultramarathon Running   Mar. 2022 - Present

- Completed the Marin Ultra Challenge, a 50 mile race with 11,000 feet of elevation gain
- Training and planning on running a 100 mile race