Curriculum vitae: Piyush Grover

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Employment

08/19–	Assistant Professor, Mechanical and Materials Engineering, University of Nebraska-Lincoln, Nebraska, USA
04/19–06/19	Senior Principal Research Scientist, MERL
04/15–03/19	Principal Research Scientist, MERL
07/10–03/15	Research Scientist, Control and Dynamical Systems Group, Mitsubishi Electric Research Laboratories (MERL), Cambridge, MA, USA

Education

July 2010	PH.D. in Engineering Mechanics, Virginia Tech, Blacksburg, VA **Thesis**: Finding and exploiting structure in complex systems via geometric and statistical methods **Advisor**: Shane Ross
June 2005	B.TECH in Mechanical Engineering, Indian Institute of Technology (IIT), Guwahati, India

Publications, Presentations & Patents

*** denotes Ph.D. students, interns or postdoctoral researchers mentored by Piyush Grover**

Journal articles

Submitted

Accepted/Published

[1] K. Bakshi*, P. Grover, and E. Theodorou, "On mean-field games for agents with Langevin dynamics," *IEEE Transactions on Control of Network Systems*, 2019. DOI: 10.1109/TCNS.2019.2896975.

[2] M. A. Khodkar, P. Hassanzadeh, S. Nabi, and P. Grover, "Reduced-order modeling of fully turbulent buoyancy-driven flows using the green's function method," *Physical Review Fluids*, vol. 4, 1 2019, Chosen as Editor's Suggestion. DOI: 10.1103/PhysRevFluids.4.013801.

[3] S. Nabi, P. Grover, and C. Caulfield, "Nonlinear optimal control policies for buoyancy-driven flows in the built environment," *Computers and Fluids*, 2019.

[4] K. Berntorp and P. Grover, "Feedback particle filter with data-driven gain-function approximation," *IEEE Transactions on Aerospace and Electronic Systems*, 2018. DOI: 10.1109/TAES.2018.2807559.

[5] K. Elamvazhuthi* and P. Grover, "Optimal transport over nonlinear systems via infinitesimal generators on graphs," *Journal of Computational Dynamics*, 2018. DOI: 10.3934/jcd.2018001.

[6] K. Elamvazhuthi*, P. Grover, and S. Berman, "Optimal transport over discrete-time nonlinear systems using stochastic feedback laws," *IEEE Control Systems Letters*, 2018. DOI: 10.1109/LCSYS.2018.2855185.

[7] P. Grover, K. Bakshi*, and E. Theodorou, "A mean-field game model for homogeneous flocking," *Chaos: An Interdisciplinary Journal of Nonlinear Science*, 2018. DOI: 10.1063/1.5036663.

[8] A. Kuang, N. Cao, A. Creely, *et al.*, "Conceptual design study for heat exhaust management in the ARC fusion pilot plant," *Fusion Engineering and Design*, 2018. DOI: 10.1016/j.fusengdes.2018.09.007.

[9] P. Grover and K. Elamvazhuthi*, "Optimal perturbations for nonlinear systems using graph-based optimal transport," *Communications in Nonlinear Science and Numerical Simulation*, 2017. DOI: 10.1016/j.cnsns.2017.09.020.

[10] B. Kramer*, P. Grover, P. Boufounos, S. Nabi*, and M. Benosman, "Sparse sensing and DMD-based identification of flow regimes and bifurcations in complex flows," *SIAM Journal on Applied Dynamical Systems*, vol. 16, no. 2, pp. 1164–1196, 2017. DOI: 10.1137/15M104565X.

[11] S. Nabi*, P. Grover, and C. P. Caulfield, "Adjoint-based optimization of displacement ventilation flow," *Building and Environment*, 2017. DOI: 10.1016/j.buildenv.2017.07.030.

[12] A. Tripathi*, P. Grover, and T. Kalmár-Nagy, "On optimal performance of nonlinear energy sinks in multiple-degree-of-freedom systems," *Journal of Sound and Vibration*, vol. 388, pp. 272–297, 2016. DOI: 10.1016/j.jsv.2016.10.025.

[13] Y. Sato*, P. Grover, and S. Yoshikawa, "Design of low fuel trajectory in interior realm as a backup trajectory for Lunar exploration," *Transactions of Japan Society for Aeronautical and Space Sciences*, vol. 12, no. ists29, 2014. DOI: 10.2322/tastj.12.Pd_47.

[14] P. Grover, S. D. Ross, M. A. Stremler, and P. Kumar, "Topological chaos, braiding and bifurcation of almost-cyclic sets," *Chaos: An Interdisciplinary Journal of Nonlinear Science*, vol. 22, no. 4, p. 043 135, 2012. DOI: 10.1063/1.4768666.

[15] M. A. Stremler, S. D. Ross, P. Grover, and P. Kumar, "Topological chaos and periodic braiding of almost-cyclic sets," *Physical review letters*, vol. 106, no. 11, p. 114 101, 2011. DOI: 10.1103/PhysRevLett.106.114101.

[16] P. Grover and S. D. Ross, "Designing trajectories in a planet-moon environment using the controlled Keplerian map," *AIAA Journal of guidance, control, and dynamics*, vol. 32, no. 2, pp. 437–444, 2009. DOI: 10.2514/1.38320.

Peer-reviewed conference proceedings

[17] P. Grover, "Stability analysis in mean-field games via an Evans function approach," in *ASME Dynamic Systems and Control Conference (DSCC)*, 2018. DOI: 10.1115/DSCC2018-8926.

[18] N. G. Nilsson, P. Grover, and U. Kalabic, "Assignment and control of two-tiers of traffic," in *IEEE Conference on Decision and Control (CDC)*, IEEE, 2018.

[19] Y. Pan, A.-m. Farahmand, M. White, S. Nabi, P. Grover, and D. Nikovski, "Reinforcement learning with function-valued action spaces for partial differential equation control," in *Proceedings of the 35th International Conference on Machine Learning (ICML)*, ser. Proceedings of Machine Learning Research, vol. 80, PMLR, 2018, pp. 3986–3995. [Online]. Available: http://proceedings.mlr.press/v80/pan18a.html.

[20] M. Benosman, B. Kramer*, P. T. Boufounos, and P. Grover, "Learning-based reduced order model stabilization for partial differential equations: Application to the coupled burgers' equation," in *American Control Conference (ACC)*, IEEE, 2016, pp. 1673–1678. DOI: 10.1109/ACC.2016.7525157.

[21] K. Berntorp and P. Grover, "Data-driven gain computation in the feedback particle filter," in *American Control Conference (ACC)*, IEEE, 2016, pp. 2711–2716. DOI: 10.1109/ACC.2016.7525328.

[22] A.-m. Farahmand, S. Nabi*, P. Grover, and D. N. Nikovski, "Learning to control partial differential equations: Regularized fitted q-iteration approach," in *IEEE Conference on Decision and Control (CDC)*, IEEE, 2016, pp. 4578–4585. DOI: 10.1109/CDC.2016.7798966.

[23] C. Laughman, S. Nabi*, and P. Grover, "A numerical study of refrigerant dispersion in single and multiple connected spaces," in *ASHRAE Transactions*, vol. 122, 2016.

[24] V. Vikas, P. Grover, and B. Trimmer, "Model-free control framework for multi-limb soft robots," in *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, IEEE, 2015, pp. 1111–1116. DOI: 10.1109/IROS.2015.7353509.

Conference Presentations

[25] P. Grover, K. Bakshi*, and E. Theodorou, "Understanding and designing emergent behavior via stability analysis of mean field games," *SIAM Conference on Applications of Dynamical Systems*, 2019.

[26] U. Kalabic, A. Weiss, and P. Grover, "Low-thrust GTO-to-GEO Trajectory optimization and tracking," *AIAA/AAS Astrodynamics Conference*, 2018.

[27] P. Grover and K. Elamvazhuthi*, "Perron-Frobenius meet Monge-Kantorovich: A set-oriented graph-based approach to optimal transport," *SIAM Conference on Applications of Dynamical Systems*, 2017.

[28] P. Hassanzadeh, P. Grover, and S. Nabi*, "Reduced-Order Modeling of 3D Rayleigh-Benard Turbulent Convection," *American Physical Society, 70th Annual DFD meeting*, 2017.

[29] S. Nabi*, P. Grover, and C. P. Caulfield, "Nonlinear optimal control policies for buoyancy-driven flows in the built environment," *American Physical Society, 70th Annual DFD meeting*, 2017.

[30] ——, "Nonlinear optimization of buoyancy-driven ventilation flow," *American Physical Society, 69th Annual DFD meeting*, 2016.

[31] P. Grover, B. Kramer*, P. Boufounos, S. Nabi*, and M. Benosman, "Sparse sensing based detection of dynamical phenomena and flow transitions," *SIAM Conference on Applications of Dynamical Systems*, 2015.

[32] P. Grover and S. Nabi*, "Near-optimal source placement in forced convection," *American Physical Society, 68th Annual DFD meeting*, 2015.

[33] P. Grover and Y. Song*, "Optimal transport of diffusive scalar from the boundary," *American Physical Society, 67th Annual DFD meeting*, 2014.

[34] S. Naik* and P. Grover, "Thermal coherent sets and heat transfer in chaotic laminar flows," *American Physical Society, 66th Annual DFD meeting*, 2013.

[35] P. Grover, "Topological chaos and braiding of almost-cyclic sets," *9th International Conference on Flow Dynamics (ICFD), Sendai, Japan*, 2012.

[36] P. Grover and C. Andersson*, "Optimized Three-Body Gravity Assists and Manifold Transfers in End-to-End Lunar Mission Design," *22nd AAS/AIAA Space Flight Mechanics Meeting*, 2012.

[37] P. Grover and Y. Sato*, "Efficient estimation and uncertainty quantification in space mission dynamics," *AIAA/AAS Astrodynamics Conference*, 2012.

[38] Y. Sato*, P. Grover, and S. Yoshikawa, "Probability Representation of Spacecraft Orbit Error for Robust Trajectory Design," *22nd JAXA Workshop on Astrodynamics and Flight Mechanics*, 2012.

[39] P. Grover, S. Ross, M. Stremler, and P. Kumar, "Characterizing changes in topological entropy via break-up of almost-invariant sets," *American Physical Society, 63rd Annual DFD meeting*, 2010.

[40] M. Stremler, S. Ross, P. Grover, and P. Kumar, "Almost-invariant sets as "ghost rods" for fluid stirring," *American Physical Society, 63rd Annual DFD meeting*, 2010.

[41] P. Grover and S. Ross, "Noise Induced Chaos and Calculation of Noisy Lyapunov Exponent in Complex Systems," *SIAM Conference on Applications of Dynamical Systems*, 2009.

[42] ——, "Designing trajectories in a Planet-Moon environment using a controlled Keplerian Map," *AAS/AIAA Space Flight Mechanics Meeting*, 2008.

[43] S. Ross and P. Grover, "Fuel-optimal trajectories in a planet-moon environment using multiple gravity assists," *20th International Symposium on Space Flight Dynamics (ISSFD)*, 2007.

Patents

[44] M. Benosman, P. Boufounos, B. Kramer, and P. Grover, "System and method for controlling operations of air-conditioning system," pat., US Patent 9,976,765, 2018.

[45] A.-m. Farahmand, S. Nabi, P. Grover, and D. N. Nikovski, "Method for data-driven learning-based control of HVAC systems using high-dimensional sensory observations," pat., US Patent Application 15,290,038, 2018.

[46] P. Grover and K. Elamvazhuthi, "Multi-agent control system and method," pat., US Patent Application 15,340,015, 2018.

[47] P. Boufounos, P. Grover, B. Kramer, and M. Benosman, "System and method for controlling operations of air-conditioning system," pat., US Patent Application 14,714,428, 2015.

[48] P. Grover, "System and method for estimating states of spacecraft in planet-moon environment," pat., US Patent 9,114,893, 2015.

[49] P. Grover and C. Andersson, "System and method for controlling motion of spacecrafts," pat., US Patent 8,655,589, 2014.

Honors

2017, 2012 Director's award for excellence in research at MERL

2014 Invited talk at Fields Institute for Research in Mathematical Sciences, Univ. of Toronto, Canada

2012 Invited talk at 9th International Conference on Flow Dynamics (ICFD), Sendai, Japan

2010 Invited talk at UCSD Physics Department

Service

Session Chair: *ASME Dynamic Systems and Controls Conference*, 2018

Reviewer
Journals: *Journal of Nonlinear Science*, *Communications in Nonlinear Science and Numerical Simulation*, *Celestial Mechanics and Dynamical Astronomy*, *IEEE Control Systems Letters*, *AIAA Journal of Guidance, Control and Dynamics*, *ASME Journal of Computational and Nonlinear Dynamics*, *Journal of Astronautical Sciences*, *ASME Journal of Dynamic systems, measurement and control*, *Journal of Physics A: Mathematical and Theoretical*

Conferences: *Control and Decision Conference (CDC), American Control Conference (ACC), ASME Dynamic Systems and Control Conference (DSCC), Hybrid Systems: Computation and Control Conference* (HSCC)

Mentoring

Dissertation Committee

- Kaivalya Bakshi, Ph.D. candidate in Aerospace Engineering, Georgia Tech
  2017-present
  Thesis title: PDE Based Stochastic Control: Sampling Algorithms, Optimality Principles and Stability Analysis

Ph.D. Student Interns and postdocs mentored at MERL

03/19-06/19 Mandy Huo, Ph.D. student (Control and Dynamical Systems), Caltech
Topic: Stability analysis and bifurcations in Mean-Field Games

05/18-08/18 Francisco Gonzales, Ph.D. student (Mech. Eng.), Univ. Illinois at Urbana Champaign
Topic: Sensor Placement and Flow Estimation in Buildings

05/17-08/17 Mithu Debnath, Ph.D. student (Mech. Eng.), Univ. Texas at Dallas
Topic: Adjoint-based Data Assimilation of Flow over Complex Terrains using Wind-LiDAR measurements

05/17-08/17 & 01/18-04/18 Kaivalya Bakshi, Ph.D. student (Aero. Eng.), Georgia Tech
Topic: Low-order Modeling and Bifurcations in Mean-Field Games

04/16-08/16 Karthik Elamvazhuthi, Ph.D. student (Mech. Eng.), Arizona State Univ.
Topic: Optimal Transport in Nonlinear Systems : Control of Collective Dynamics

05/15-08/15 Peter Mueller, Ph.D. student (Applied Math), Univ. Wisconsin at Madison
Topic: Optimal Microchannel Heat Exchanger Design

09/14- Saleh Nabi (Postdoctoral Fellow/Visiting Researcher, Ph.D. Univ. Alberta, Canada)
Topic: Nonlinear Adjoint Approach to Design and Control of Indoor Airflow

08/14-06/15 Boris Kramer, Ph.D. student (Applied Math), Virginia Tech
Topic: Dynamic Mode Decomposition and Sparse Sensing of Complex Fluid Flow

05/15-08/14 Yunfei Song, Ph.D. student (Applied Math), Lehigh Univ.
Topic: Topic: Optimal Mixing in Microchannel Heat Exchangers

04/14-08/14 Astitva Tripathi, Ph.D. student (Mech. Eng.), Purdue Univ.
Topic: Nonlinear Energy Transfers in High-DoF Systems with Nonlinear Energy Sinks

05/13-12/13 Shibabrat Naik, Ph.D. student (Eng. Mechanics), Virginia Tech
Topic: Transfer Operator Approach to Finding Coherent Sets in Microchannel Heat Exchangers

05/12-08/12 Ashuman Mishra, Ph.D. student (Mech. Eng.), Univ. Illinois at Urbana Champaign
Topic: Model Reduction in Navier-Stokes and Boussinesq Flows

05/11-08/11 Guanqing Xue, M.S. student (Mech. Eng.), Purdue Univ.
Topic: Modeling of Convective Flows in Indoor Environment

01/11-05/11 Christian Andersson, Ph.D. student (Computational Math), Lund Univ., Sweden
Topic: Merging Optimal Control and Dynamical Systems Methods in Low-Fuel Mission Design

Teaching

At UNL

Fall 2019 MECH450/850: Mechanical Engineering Control Systems Design

Before UNL

Spring 2016 Guest instructor for graduate level system-design class at MIT Nuclear Engineering department

Fall 2009 Lab Instructor for freshmen engineering design class at Virginia Tech

Summer 2009 Recitation instructor for *Introduction to Dynamics* at Virginia Tech

Summer 2009 Instructor for Graduate Record Examination (GRE) preparatory math class for gifted students from under-represented backgrounds at Virginia Tech

Workshop Attendance

Particulate and Granular Networks (Max Planck Institute, Dresden, Germany July 2019), Crowds: Models and Control Workshop (CIRM, France June 2019), IPAM workshop on mean field games (UCLA, 2017), IMA workshop on Computational Methods for Control of Infinite-dimensional Systems (Univ. Minnesota, 2016), Summer school on Transport, Fluids and Mixing (Univ. Trento, Italy, 2015), CRM workshop on Planetary Motions, Satellite Dynamics, and Spaceship Orbits (Univ. Montreal, Canada, 2013), IMA workshop on Algebraic Topology in Dynamics, Differential Equations, and Experimental Data (Univ. Minnesota, 2013), Workshop on Coherent Structures in Dynamical Systems (Univ. Lieden, Netherlands, 2011)