

Nikolai Matni

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Academic Positions

- Aug 2019 – **Assistant Professor, Department of Electrical and Systems Engineering,**
Present *University of Pennsylvania*, Philadelphia, PA.
- Oct 2017 – **Postdoctoral Scholar, Department of Electrical Engineering and Computer Science,**
July 2019 *UC Berkeley*, Berkeley, CA.
Advisor: Benjamin Recht
Robust learning-based control, and learning and control of large-scale networked systems.
- Dec 2015 – **Postdoctoral Scholar, Department of Computing and Mathematical Sciences,**
Sep 2017 *California Institute of Technology*, Pasadena, CA.
Advisor: John C. Doyle
Cyber-physical system design with applications to power and networking.

Education

- 2010–2015 **Ph.D. in Control and Dynamical Systems, conferred June 2016,**
California Institute of Technology, Pasadena, CA.
Advisor: John C. Doyle
Thesis: *Distributed Optimal Control of Cyber-Physical Systems: Controller Synthesis, Architecture Design and System Identification*
- 2008–2010 **M. A.Sc. in Electrical and Computer Engineering,**
The University of British Columbia, Vancouver, Canada.
Advisor: Meeko M. Oishi
Thesis: *Stability of switched systems with switching delay: application to remote operation of aircraft under distributed control*
- 2004–2008 **B. A.Sc. in Electrical and Computer Engineering, with distinction,**
The University of British Columbia, Vancouver, Canada.

Honors and Awards

- 2017 **Keynote Speaker, The ACEMS Workshop on Challenges of Data and Control of Networks**
Invited to be a keynote speaker at the upcoming ACDCN workshop at the University of Adelaide. One of four keynote speakers, including Paul Barford, Walter Willinger and John C. Doyle.
- 2017 **Best Student Paper Award (as co-advisor), IEEE American Control Conference**
For the paper “System level parameterizations, constraints and synthesis” co-authored with Yuh-Shyang Wang and John C. Doyle. A major award recognizing the best paper written by a student at ACC 2017.
- 2016 **Everhart Lecture Series speaker, California Institute of Technology**
One of four graduate-student lecturers selected to present their work to a campus-wide audience based on dynamic speaking skills, ability to communicate their research field’s broader importance and impact on the scientific community. Presentation available on youtube (<http://youtube.com/watch?v=1S-Y5iVNQ-U>, **1600 views**) and iTunes U .

- 2013 **Best Student Paper Award, IEEE Conference on Decision and Control**
For the **sole-author** paper “Communication delay co-design in \mathcal{H}_2 decentralized control using atomic norm minimization.” A major award recognizing the best paper written by a student at CDC 2013. First ever sole-author award winner.
- Oct 2013 **Visiting student, LLLC at Lund University**
Invited by Anders Rantzer to visit Lund University for a month to work on distributed system identification and statistical methods in control.
- 2008–2010 **NSERC Alexander Graham Bell Canada Graduate Scholarship,**
Funding from the Canadian federal government to support graduate studies.
- 2009 **General Chairs’ Recognition Award for Interactive Papers, IEEE Conference on Decision and Control**
For the paper “Reachability analysis for continuous systems under shared control: Application to user-interface design.”
- 2008 **APEG BC Achievement Award in Engineering, University of British Columbia**
As selected by the faculty of engineering at the University of British Columbia for demonstrating great promise in electrical engineering in the final undergraduate year.
- 2004–2008 **Academic All Canadian, Canadian Inter-university Sport**
A recognition of student-athletes who achieve an academic standing of 80% or better while playing on one of their university’s varsity teams.

Featured Publications

1. S. Dean, H. Mania, **N. Matni**, B. Recht and S. Tu, “On the Sample Complexity of the Linear Quadratic Regulator,” *Journal of Foundations of Computational Mathematics (FoCM)*, 2019.
Describes a contemporary approach that merges techniques from statistical learning theory and robust/optimal control, providing baselines delineating the possible control performance achievable given a fixed amount of data collected about an unknown system.
2. S. Dean, H. Mania, **N. Matni**, B. Recht and S. Tu, “Regret Bounds for the Robust Adaptive Control of the Linear Quadratic Regulator,” *32nd Conference on Neural Information Processing Systems (NeurIPS)*, 2018.
Defines and analyzes the first model-based reinforcement learning algorithm that is poly-time computable for the linear quadratic regulator guaranteeing (a) robust and stable execution throughout, (b) identification of the true model parameters, and (c) sub-linear regret of $O(T^{2/3})$.
3. Y.-S. Wang, **N. Matni** and J. C. Doyle, “A System Level Approach to Controller Synthesis,” *IEEE Transactions on Automatic Control*, 2018. Accepted.
Describes a novel convex parameterization of stabilizing controllers that enables, among other things, convex synthesis of large-scale robust and optimal controllers. The conference version of this paper was awarded the **IEEE ACC 2017 Best Student Paper Award**.
4. N. Wu, Y. Bi, N. Michael, A. Tang, J. C. Doyle and **N. Matni**, A Control-Theoretic Approach to In-Network Congestion Management, *IEEE Transactions on Networking*, 2018.
Describes a novel software-defined networking based approach to in-network congestion management wherein network-scale coordination of buffer egress rates is achieved using distributed optimal control. Includes experimental validation of the proposed method in a custom experimental testbed, a production WAN, and a Mininet emulation of a backbone network.
5. **N. Matni** and V. Chandrasekaran, “Regularization for Design,” *IEEE Transactions on Automatic Control*, 2016.
Describes a convex programming based approach to controller architecture design for distributed optimal controllers. By drawing connections to the structured inference and statistics literature, we provide conditions under which our convex approach identifies optimally structured controllers. A precursor to this paper was awarded the **IEEE CDC 2013 Best Student Paper Award**.

Invited Talks (excluding conference presentations)

- Feb 2019 *Safety and Robustness Guarantees with Learning in the Loop*, ESE Seminar, U Penn
- Feb 2019 *Safety and Robustness Guarantees with Learning in the Loop*, SILO Seminar, UW-Madison
- Aug 2018 *Robustness Guarantees with Learning in the Loop*, ME Seminar, USC
- Apr 2018 *A System Level Approach to Robust Autonomy*, EE Seminar, USC
- Mar 2018 *A System Level Approach to Distributed and Adaptive Control*, ME Seminar, UCSB
- Mar 2018 *A System Level Approach to Distributed and Adaptive Control*, ECE Seminar, U of Minnesota
- Feb 2018 *A System Level Approach to Distributed and Adaptive Control*, ECE Seminar, UIUC
- Jan 2018 *A System Level Approach to Distributed and Adaptive Control*, EE Seminar, UCLA
- Jan 2018 *A System Level Approach to Distributed and Adaptive Control*, ECE Seminar, U of Michigan
- Dec 2017 *A System Level Approach to Controller Synthesis with Applications to Software Defined Networking*, **Keynote Speaker**, ACDCN Workshop, U of Adelaide
- Sep 2017 *On the Sample Complexity of the Linear Quadratic Regulator*, EE Seminar, USC
- Aug 2017 *A System Level Approach to Controller Synthesis*, Guest Lecturer, USC
- July 2017 *New Math for Living Machines*, Living Machines 2017 Workshop, Stanford University
- June 2017 *A System Level Approach to Controller Synthesis*, EECS Seminar, UC Berkeley
- May 2017 *A System Level Approach to Controller Synthesis*, EE Seminar, U Washington
- Apr 2017 *A System Level Approach to Controller Synthesis*, EECS LIDS Seminar, MIT
- Apr 2017 *A System Level Approach to Controller Synthesis*, EE Seminar, Harvard
- Mar 2017 *A System Level Approach to Controller Synthesis*, ECE ISS Seminar, McGill University
- Feb 2017 *A System Level Approach to Controller Synthesis*, CommNets Seminar, USC
- Jan 2017 *A System Level Approach to Controller Synthesis*, CCDC Seminar, UCSB
- Nov 2016 *Layering, Dynamics, Optimization and Control in SDNs*, Huawei Future Network Theory Lab, Hong Kong
- June 2016 *Layering, Dynamics, Optimization and Control in SDNs*, NSF AiTF Workshop on Algorithms for SDN, DiMACS (Rutgers)
- May 2016 *A Theory of Architecture and Co-Design for Cyber-Physical Systems*, ECE Seminar, UCSD
- Apr 2016 *Building and Controlling Complex Interconnected Systems*, Caltech Everhart Lecture Series, Caltech
- Mar 2016 *A Theory of Architecture and Co-Design for Cyber-Physical Systems*, EECS/IDSS Seminar, MIT
- Mar 2016 *A Theory of Architecture and Co-Design for Cyber-Physical Systems*, ECE Seminar, Cornell University
- Feb 2016 *A Theory of Architecture and Co-Design for Cyber-Physical Systems*, EE Seminar, Stanford University
- Jan 2016 *Regularization for Design*, ECE/ISN Seminar Series, Cornell University
- Dec 2014 *Tutorial on Distributed Control and Optimization*, Caltech CDS@20 workshop at IEEE CDC
- Oct 2014 *Regularization for Design: Connections Between Distributed Control and Sparse Reconstruction Theory*, University of Minnesota
- Aug 2014 *Tutorial Session on Distributed Control and Optimization*, CDS@20 celebration at Caltech
- Aug 2014 *A Convex Approach to Visual Pose Estimation*, UCLA
- Nov 2013 *Delay Pattern Design in Decentralized H2 Optimal Control Using Convex Optimization*, Linkoping University
- Nov 2013 *Delay Pattern Design in Decentralized H2 Optimal Control Using Convex Optimization*, Lund University

Dec 2012 *Some recent results in decentralized optimal H2 control subject to delays*, Southern California Control Workshop, USCD

Teaching and Advising

Teaching Activities

- Fall 2019 **Instructor: ESE 680-004: Learning and Control**,
An advanced topics course on the emerging research area at the intersection of learning control.
- Apr–Jun 2014 **Teaching Assistant: ACM/CMS/EE 218 Statistical Inference**,
taught by V. Chandrasekeran at Caltech
- Jan–Mar 2014 **Co-Instructor: CDS 110b Introduction to Control Theory**,
co-taught with J. C. Doyle at Caltech
This was an unofficial position in which I taught approximately 90% of the lectures and helped develop the syllabus.

Advising Activities

- 2013 – **PhD student mentor**, *Caltech*
- Present **Students:** Yuh-Shyang Wang (System Level Approach to Controller Synthesis, thesis successfully defended Dec 2016, now at GE Research), Yorie Nakahira (Robust networked control with applications to sensorimotor control) and Dimitar Ho (System identification, learning and adaptive control of CPS). Co-advised with J. C. Doyle. Total of 12 referred publications.

Theses

- [T1] **N. Matni**, “Distributed optimal control of cyber-physical systems: Controller synthesis, architecture design and system identification,” Ph.D. dissertation, California Institute of Technology, 2015.
- [T2] **N. Matni**, “Stability of switched systems with switching delay: application to remote operation of aircraft under distributed control,” Master’s thesis, University of British Columbia, 2010.

Journal Publications

- [J1] J. Anderson, J. C. Doyle, S. H. Low, and **N. Matni**, “System level synthesis,” *Annual Reviews in Control*, 2019. [Online]. Available: <http://www.sciencedirect.com/science/article/pii/S1367578819300215>
- [J2] S. Dean, H. Mania, **N. Matni**, B. Recht, and S. Tu, “On the sample complexity of the linear quadratic regulator,” *Foundations of Computational Mathematics*, Aug 2019. [Online]. Available: <https://doi.org/10.1007/s10208-019-09426-y>
- [J3] N. Wu, Y. Bi, N. Michael, A. Tang, J. C. Doyle, and **N. Matni**, “A control-theoretic approach to in-network congestion management,” *IEEE/ACM Transactions on Networking*, pp. 1–14, 2018.
- [J4] Y. Wang, **N. Matni**, and J. C. Doyle, “A system level approach to controller synthesis,” *IEEE Transactions on Automatic Control*, pp. 1–1, 2019.
- [J5] Y. Wang, **N. Matni**, and J. C. Doyle, “Separable and localized system-level synthesis for large-scale systems,” *IEEE Transactions on Automatic Control*, vol. 63, no. 12, pp. 4234–4249, Dec 2018.
- [J6] **N. Matni**, “Communication delay co-design in \mathcal{H}_2 -distributed control using atomic norm minimization,” *IEEE Transactions on Control of Network Systems*, vol. 4, no. 2, pp. 267–278, June 2017.
- [J7] **N. Matni** and V. Chandrasekaran, “Regularization for design,” *IEEE Transactions on Automatic Control*, vol. 61, no. 12, pp. 3991–4006, Dec 2016.

- [J8] V. Jonsson, C. Blakely, ..., **N. Matni**, ..., and T. Bivona, "Novel computational method for predicting polytherapy switching strategies to overcome tumor heterogeneity and evolution," *Nature Scientific Reports*, 2016.
- [J9] M. M. Oishi, **N. Matni**, A. Ashoori, and M. J. McKeown, "Switching restrictions for stability despite switching delay: Application to switched tracking tasks in parkinson's disease," *Journal of Nonlinear Systems and Applications*, vol. 16, p. 25, 2011.

Refereed Conference Publications

- [C1] **N. Matni**, A. Proutiere, A. Rantzer, and S. Tu, "From self-tuning regulators to reinforcement learning and back again," in *2019 IEEE Conference on Decision and Control (CDC), Tutorial Paper*. IEEE, 2019.
- [C2] **N. Matni** and S. Tu, "A tutorial on concentration bounds for system identification," in *2019 IEEE Conference on Decision and Control (CDC), Tutorial Paper*. IEEE, 2019.
- [C3] S. Fattahi, **N. Matni**, and S. Sojoudi, "Learning sparse dynamical systems from a single sample trajectory," in *2019 IEEE Conference on Decision and Control (CDC), Accepted*. IEEE, 2019.
- [C4] S. Dean, S. Tu, **N. Matni**, and B. Recht, "Safely learning to control the constrained linear quadratic regulator," *2019 Annual American Control Conference (ACC), to appear.*, 2019.
- [C5] S. Dean, H. Mania, **N. Matni**, B. Recht, and S. Tu, "Regret bounds for robust adaptive control of the linear quadratic regulator," in *Advances in Neural Information Processing Systems*, 2018, pp. 4188–4197.
- [C6] R. Boczar, **N. Matni**, and B. Recht, "Finite-data performance guarantees for the output-feedback control of an unknown system," in *2018 IEEE Conference on Decision and Control (CDC)*. IEEE, 2018, pp. 2994–2999.
- [C7] D. Ho, **N. Matni**, and J. C. Doyle, "Passive-aggressive learning and control," in *2018 Annual American Control Conference (ACC)*, June 2018, pp. 1887–1894.
- [C8] J. Anderson and **N. Matni**, "Structured state space realizations for sls distributed controllers," in *2017 55th Annual Allerton Conference on Communication, Control, and Computing (Allerton)*, Oct 2017, pp. 982–987.
- [C9] N. Wu, Y. Bi, N. Michael, A. Tang, J. Doyle, and **N. Matni**, "HFTraC: High-frequency traffic control," in *Proceedings of the 2017 ACM SIGMETRICS / International Conference on Measurement and Modeling of Computer Systems*, ser. SIGMETRICS '17 Abstracts. New York, NY, USA: ACM, 2017, pp. 43–44. [Online]. Available: <http://doi.acm.org/10.1145/3078505.3078557>
- [C10] **N. Matni**, Y. Wang, and J. Anderson, "Scalable system level synthesis for virtually localizable systems," in *2017 IEEE 56th Annual Conference on Decision and Control (CDC)*, Dec 2017, pp. 3473–3480.
- [C11] J. C. Doyle, **N. Matni**, Y. Wang, J. Anderson, and S. Low, "System level synthesis: A tutorial," in *2017 IEEE 56th Annual Conference on Decision and Control (CDC)*, Dec 2017, pp. 2856–2867.
- [C12] Y. S. Wang, **N. Matni**, and J. C. Doyle, "System level parameterizations, constraints and synthesis," in *2017 American Control Conference (ACC)*, May 2017, pp. 1308–1315.
- [C13] **N. Matni**, "Optimal zero-queue congestion control using admm," in *2017 American Control Conference (ACC)*, May 2017, pp. 5598–5604.

- [C14] J. Doyle, Y. Nakahira, Y. P. Leong, E. Jenson, A. Dai, D. Ho, and **N. Matni**, "Teaching control theory in high school," in *2016 IEEE 55th Conference on Decision and Control (CDC)*, Dec 2016, pp. 5925–5949.
- [C15] **N. Matni** and J. C. Doyle, "A theory of dynamics, control and optimization in layered architectures," in *2016 American Control Conference (ACC)*, July 2016, pp. 2886–2893.
- [C16] Y. S. Wang, **N. Matni**, and J. C. Doyle, "Localized LQR control with actuator regularization," in *2016 American Control Conference (ACC)*, July 2016, pp. 5205–5212.
- [C17] Y. S. Wang and **N. Matni**, "Localized LQG optimal control for large-scale systems," in *2016 American Control Conference (ACC)*, July 2016, pp. 1954–1961.
- [C18] **N. Matni**, A. Tang, and J. C. Doyle, "A case study in network architecture tradeoffs," in *Proceedings of the 1st ACM SIGCOMM Symposium on Software Defined Networking Research*, ser. SOSR '15. New York, NY, USA: ACM, 2015, pp. 18:1–18:7.
- [C19] S. You and **N. Matni**, "A convex approach to sparse h-infinity analysis and synthesis," in *2015 54th IEEE Conference on Decision and Control (CDC)*, Dec 2015, pp. 6635–6642.
- [C20] Y. Nakahira, **N. Matni**, and J. C. Doyle, "Hard limits on robust control over delayed and quantized communication channels with applications to sensorimotor control," in *2015 54th IEEE Conference on Decision and Control (CDC)*, Dec 2015, pp. 7522–7529.
- [C21] Y.-S. Wang, S. You, and **N. Matni**, "Localized distributed kalman filters for large-scale systems," *NECSYS, IFAC-PapersOnLine*, vol. 48, no. 22, pp. 52 – 57, 2015.
- [C22] **N. Matni** and M. B. Horowitz, "A convex approach to consensus on $so(n)$," in *Communication, Control, and Computing (Allerton), 2014 52nd Annual Allerton Conference on*, Sept 2014, pp. 959–966.
- [C23] **N. Matni**, "Distributed control subject to delays satisfying an \mathcal{H}_∞ norm bound," in *Decision and Control (CDC), 2014 IEEE Annual Conference on*, Dec 2014, pp. 4006–4013.
- [C24] **N. Matni** and V. Chandrasekaran, "Regularization for design," in *Decision and Control (CDC), 2014 IEEE 53rd Annual Conference on*, Dec 2014, pp. 1111–1118.
- [C25] Y.-S. Wang, **N. Matni**, and J. C. Doyle, "Localized LQR optimal control," in *Decision and Control (CDC), 2014 IEEE 53rd Annual Conference on*, Dec 2014, pp. 1661–1668.
- [C26] V. Jonsson, **N. Matni**, and R. Murray, "Synthesizing combination therapies for evolutionary dynamics of disease for nonlinear pharmacodynamics," in *Decision and Control (CDC), 2014 IEEE 53rd Annual Conference on*, Dec 2014, pp. 2352–2358.
- [C27] Y.-S. Wang and **N. Matni**, "Localized distributed optimal control with output feedback and communication delays," in *Communication, Control, and Computing (Allerton), 2014 52nd Annual Allerton Conference on*, Sept 2014, pp. 605–612.
- [C28] **N. Matni**, A. Lamperski, and J. C. Doyle, "Optimal two player LQR state feedback with varying delay," in *IFAC World Congress*, vol. 19, no. 1, 2014, pp. 2854–2859.
- [C29] Y.-S. Wang, **N. Matni**, S. You, and J. C. Doyle, "Localized distributed state feedback control with communication delays," in *The IEEE American Control Conference (ACC), 2014*. IEEE, 2014, pp. 5748–5755.
- [C30] M. Horowitz, **N. Matni**, and J. Burdick, "Convex relaxations of SE(2) and SE(3) for visual pose estimation," in *Robotics and Automation (ICRA), 2014 IEEE International Conference on*, May 2014, pp. 1148–1154.

- [C31] **N. Matni**, Y. P. Leong, Y. S. Wang, S. You, M. B. Horowitz, and J. C. Doyle, "Resilience in large scale distributed systems," *Procedia Computer Science*, vol. 28, pp. 285 – 293, 2014.
- [C32] **N. Matni** and J. Doyle, "Optimal distributed LQG state feedback with varying communication delay," in *Decision and Control (CDC), 2013 IEEE 52nd Annual Conference on*, Dec 2013, pp. 5890–5896.
- [C33] **N. Matni**, "Communication delay co-design in \mathcal{H}_2 decentralized control using atomic norm minimization," in *Decision and Control (CDC), 2013 IEEE 52nd Annual Conference on*, Dec 2013, pp. 6522–6529.
- [C34] V. Jonsson, **N. Matni**, and R. Murray, "Reverse engineering combination therapies for evolutionary dynamics of disease: An H_∞ approach," in *Decision and Control (CDC), 2013 IEEE 52nd Annual Conference on*, Dec 2013, pp. 2060–2065.
- [C35] **N. Matni** and J. C. Doyle, "A dual problem in \mathcal{H}_2 decentralized control subject to delays," in *The IEEE American Control Conference (ACC), 2013*. IEEE, 2013, pp. 5772–5777.
- [C36] **N. Matni** and J. C. Doyle, "A heuristic for sub-optimal H_2 decentralized control subject to delay in non-quadratically-invariant systems," in *The IEEE American Control Conference (ACC), 2013*, 2013.
- [C37] **N. Matni**, "A projection framework for near-potential polynomial games," in *Decision and Control (CDC), 2012 IEEE 51st Annual Conference on*. IEEE, 2012, pp. 6507–6512.
- [C38] **N. Matni** and M. Oishi, "Stability of switched block upper-triangular linear systems with switching delay: Application to large distributed systems," in *American Control Conference (ACC), 2011*, June 2011, pp. 1440–1445.
- [C39] **N. Matni** and M. Oishi, "Reachability analysis for continuous systems under shared control: Application to user-interface design," in *Decision and Control, 2009 held jointly with the 2009 28th Chinese Control Conference. CDC/CCC 2009. Proceedings of the 48th IEEE Conference on*, Dec 2009, pp. 5929–5934.
- [C40] M. Oishi and **N. Matni**, "Towards provably safe control for smart wheelchairs." in *AAAI Fall Symposium: AI in Eldercare: New Solutions to Old Problems*, 2008, pp. 67–69.
- [C41] **N. Matni** and M. Oishi, "Reachability-based abstraction for an aircraft landing under shared control," in *American Control Conference, 2008*, June 2008, pp. 2278–2284.

Patents

- [P1] V. Jonsson, **N. Matni**, A. Rantzer, and B. Bernhardsson, "Designing combinations therapies of non-interacting drugs for evolutionary dynamics of disease using optimal control," USA Patent 20 150 278 485, CIT 14-135, Oct. 1, 2015.
- [P2] **N. Matni** and J. C. Doyle, "Data network controlled and optimized using layered architectures," USA Patent CIT 7323, 2016.

Professional Activities

Peer Review

Journals IEEE Transactions on Computational Social Systems, IEEE Transactions on Networking, IEEE Signal Processing Letters, Proceedings of the National Academy of Science, Automatica, IEEE Transactions on Automatic Control, SIAM Journal of Optimization and Control, and IEEE Transactions on Control of Networked Systems

Conferences IEEE Conference on Decision and Control, IEEE American Control Conference, IEEE European Control Conference, IEEE Multi-Conference on Systems and Control, IEEE Mediterranean Conference on Automation and Control

[Session Chair/Organizer](#)

- CDC 19 Co-organizer of tutorial session on Self-Tuning Control and Reinforcement Learning
- ACC 18 Co-organizer of invited session on Identification, Learning, and Adaptation in Control
- ACC 17 Chair of Control of Networks II
- CDC 14 Co-chair of Optimization II
- CDC 13 Co-chair of Decentralized control I