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(last updated March 2024)

Richard Y. Zhang

Research

Optimization and machine learning, and applications in power and energy systems. Particularly interested in theoretical foundations and practical algorithms for *nonconvex low-rank matrix optimization* and *convex semidefinite programming*. Advances here can bring about radical, game-changing improvements to our ability to solve *power and energy problems*, with provable guarantees on cost, performance, efficiency, reliability, robustness, and safety.

Affiliation

2019– **Assistant Professor**, *Univ. of Illinois at Urbana-Champaign*, Urbana, IL, USA
Department of Electrical and Computer Engineering.
Coordinated Science Laboratory.

2017–2019 **Postdoctoral Scholar**, *University of California*, Berkeley, CA, USA
Department of Industrial Engineering and Operations Research.

2014 **Research Intern**, *ISO New England*, Holyoke, MA, USA
Business Architecture & Technology.

Education

2017 **Ph. D.**, *Massachusetts Institute of Technology*, Cambridge, MA, USA
Department of Electrical Engineering and Computer Science.

2012 **S. M.**, *Massachusetts Institute of Technology*, Cambridge, MA, USA
Department of Electrical Engineering and Computer Science.

2009 **B. E. (Hons)**, *University of Canterbury*, Christchurch, New Zealand
Department of Electrical and Computer Engineering. *First class honours.*

Select Awards and Honors

2021 National Science Foundation CAREER Award.

List of Teachers Ranked as Excellent, Spring semester 2021.

2017 Best Reviewer Award, *IEEE Transactions on Smart Grid*.

2015 IEEE APEC Outstanding Presentation Award (with Yiou He), poster track: *System Design Considerations for Power Electronics*.

2014 IEEE APEC Outstanding Presentation Award, oral track: *Magnetic Components, Design and Characterization*.

2012 MIT-Imperial College Global Fellow.

2010 William Georgetti Scholarship. Awarded by the Chief Justice of the Supreme Court of New Zealand, the Prime Minister of New Zealand, and the Governor General of New Zealand.

MIT EECS Great Educators Fellowship.

2008 University of Canterbury Senior Scholar, 25 awarded university-wide out of 13,718 undergraduates.

2007 Brian Morrison Memorial Scholarships in Engineering, awarded to one student "likely in their future lives to promote and foster racial tolerance, co-operation, and understanding".

Research Grants

2022 **Co-PI**, C3 AI Digital Transformation Institute: *High Performance Provably Robust AI methods for Cybersecurity Tasks on the Critical Infrastructure*. (May 2022–Feb 2025; PI Zico Kolter, CMU; Total $257k)

2021 **PI**, NSF Award ECCS-2047462: *CAREER: Structure-Exploiting Optimization for Power Systems and Applications to Large-Scale Networks*. (Feb 2021–Jan 2026; Total $500k)

2018 **Co-PI**, NSF Award ECCS-1808859: *Low-Complexity Algorithms for Sparse Conic Optimization with Applications to Energy Systems and Machine Learning*. (Aug 2018–Jul 2022; PI Somayeh Sojoudi, UC Berkeley; Total $360k)

Preprints

1 R. Y. Zhang, Parameterized Complexity of Sparse Semidefinite Programs with Small Treewidth, Jun 2023. [arxiv:2306.15288]

2 R. Y. Zhang, Improved Global Guarantees for the Nonconvex Burer–Monteiro Factorization via Rank Overparameterization, Jul 2022. [arxiv:2207.01789]

3 G. Liang, G. Zhang, S. Fattahi, R.Y. Zhang, Simple Alternating Minimization Provably Solves Complete Dictionary Learning, Apr 2023. [arxiv:2210.12816]

Peer-Reviewed Journal Articles

1 G. Zhang, S. Fattahi, R. Y. Zhang, Preconditioned Gradient Descent for Overparameterized Nonconvex Burer–Monteiro Factorization with Global Optimality Certification. *Journal of Machine Learning Research*, 24.163 (2023): pp. 1-55. [http://jmlr.org/papers/v24/22-0882.html]

2 R. Y. Zhang and J. Lavaei, Sparse Semidefinite Programs with Guaranteed Near-Linear Time Complexity via Dualized Clique Tree Conversion. *Mathematical Programming* (2020). [10.1007/s10107-020-01516-y]

3 S.-W. Park, R. Y. Zhang, J. Lavaei, and R. Baldick, Uniqueness of Power Flow Solutions Using Monotonicity Between Phase Angles and Power Flow. *IEEE Transactions on Control of Network Systems*, 8.1 (2020): pp. 319-330. [10.1109/TCNS.2020.3027783]

4 R. Y. Zhang, S. Sojoudi, and J. Lavaei, Sharp Restricted Isometry Bounds for the Inexistence of Spurious Local Minima in Nonconvex Matrix Recovery. *Journal of Machine Learning Research*, 20.114 (2019): pp. 1-34. [http://jmlr.org/papers/v20/19-020.html]

5 R. Y. Zhang, J. Lavaei, and R. Baldick, Spurious Local Minima in Power System State Estimation. *IEEE Transactions on Control of Network Systems*, 6.3 (2019): pp. 1086-1096. [10.1109/TCNS.2019.2920586]

6 Y. Ouyang, R. Y. Zhang, J. Lavaei, and P. Varaiya, Large-Scale Traffic Signal Offset Optimization. *IEEE Transactions on Control of Network Systems* (2019). [10.1109/TCNS.2020.2966588]

7 R. Y. Zhang and J. K. White, GMRES-Accelerated ADMM for Quadratic Objectives. *SIAM Journal on Optimization*, 28.4 (2018): pp. 3025-3056. [10.1137/16M1059941]

8 R. Y. Zhang, C. Josz, and S. Sojoudi, Conic optimization for control, energy systems, and machine learning: Applications and algorithms. *Annual Reviews in Control*, 47 (2018): pp. 323-340. [10.1016/j.arcontrol.2018.11.002]

9 S. Fattahi, R. Y. Zhang, and S. Sojoudi, Linear Time Algorithms for Sparse Inverse Covariance Estimation. *IEEE Access*, 7 (2018): pp. 12658-12672. [10.1109/ACCESS.2018.2890583]

10 R. Y. Zhang and J. K. White, Toeplitz-Plus-Hankel Matrix Recovery for Green's Function Computations on General Substrates. *Proceedings of the IEEE*, 103.11 (2015): pp. 1970-1984. [10.1109/JPROC.2015.2461005]

11 R. Y. Zhang, J. K. White, and J. G. Kassakian, Fast simulation of complicated 3D structures above lossy magnetic media. *IEEE Transactions on Magnetics*, 50.10 (2014): 7027416. [10.1109/TMAG.2014.2323933]

Highly-Selective Conference Proceedings in Machine Learning

1 Y. Zhuang, Y. Yang, X. Chen, R. Y. Zhang, Statistically Optimal K-means Clustering via Nonnegative Low-rank Semidefinite Programming, *ICLR 2024*, May 7-11, 2024. Vienna, Austria. Selected for Oral (one of 85/7262 submissions). [arxiv:2305.18436]

2 G. Zhang, H.-M. Chiu, R.Y. Zhang, Fast and Minimax Optimal Estimation of Low-Rank Matrices via Non-Convex Gradient Descent, *AISTATS 2024*, May 2-4, 2024. Valencia, Spain. [arxiv:2305.17224]

3 H.-M. Chiu, R. Y. Zhang, Tight Certification of Adversarially Trained Neural Networks via Nonconvex Low-Rank Semidefinite Relaxations, *ICML 2023*, Jul 23-29, 2023. Honolulu, HI. [arxiv:2211.17244]

4 G. Zhang, H.-M. Chiu, R. Y. Zhang, Accelerating SGD for Highly Ill-Conditioned Huge-Scale Online Matrix Completion, *NeurIPS 2022*, Nov 28-Dec 9, 2022. New Orleans, LA. [arxiv:2208.11246]

5 G. Zhang, S. Fattahi, R. Y. Zhang, Preconditioned Gradient Descent for Over-parameterized Nonconvex Matrix Factorization, *NeurIPS 2021*, Dec 6-14, 2021. Virtual conference.

6 G. Zhang, R. Y. Zhang, How Many Samples is a Good Initial Point Worth? *NeurIPS 2020*, Dec 6-12, 2020. Virtual conference. Selected for Spotlight (one of 280/9454 submissions). [arXiv:2006.06915]

7 R. Y. Zhang, On the Tightness of Semidefinite Relaxations for Certifying Robustness to Adversarial Examples. *NeurIPS 2020*, Dec 6-12, 2020. Virtual conference. [arXiv:2006.06759]

8 R. Y. Zhang, C. Josz, S. Sojoudi, and J. Lavaei, How Much Restricted Isometry is Needed In Nonconvex Matrix Recovery? *NeurIPS 2018*, Dec 3-8, 2018. Montreal, QC. Selected for Spotlight (one of 168/4856 submissions). [arXiv:1805.10251]

9 C. Josz, Y. Ouyang, R. Y. Zhang, J. Lavaei, and S. Sojoudi, A Theory on the Absence of Spurious Solutions for Nonconvex and Nonsmooth Optimization. *NeurIPS 2018*, Dec 3-8, 2018. Montreal, QC. [arXiv:1805.08204]

10 R. Y. Zhang, S. Fattahi, and S. Sojoudi, Large-Scale Sparse Inverse Covariance Estimation via Thresholding and Max-Det Matrix Completion. *ICML 2018*, Jul 10-15, 2018. Stockholm, Sweden. [arXiv:1802.04911]

NeurIPS = Advances in Neural Information Processing Systems. ICML = International Conference on Machine Learning. ICLR = International Conference on Learning Representations. AISTATS = Artificial Intelligence and Statistics

Peer-Reviewed Conference Proceedings

1 S.-W. Park, R. Y. Zhang, J. Lavaei, and R. Baldick, Monotonicity Between Phase Angles and Power Flow and Its Implications for the Uniqueness of Solutions. *HICSS 52*, Jan 8-11, 2019. Grand Wailea, HI.

2 Y. Ouyang, R. Y. Zhang, J. Lavaei, and P. Varaiya, Conic Approximation with Provable Guarantee for Traffic Signal Offset Optimization. *CDC 2018*, Dec 17-19, 2018. Miami Beach, FL.

3 R. Y. Zhang and J. Lavaei, Sparse Semidefinite Programs with Near-Linear Time Complexity. *CDC 2018*, Dec 17-19, 2018. Miami Beach, FL.

4 R. Y. Zhang and J. Lavaei, Efficient Algorithm for Large-and-Sparse LMI Feasibility Problems. *CDC 2018*, Dec 17-19, 2018. Miami Beach, FL.

5 S. Fattahi, R. Y. Zhang, and S. Sojoudi, Sparse Inverse Covariance Estimation for Chordal Structures. *ECC 2018*, Jun 12-15, 2018. Limassol, Cyprus.

6 R. Y. Zhang, C. Josz, and S. Sojoudi, Conic Optimization Theory: Convexification Techniques and Numerical Algorithms. *ACC 2018*, Jun 27-29, 2018. Milwaukee, WI.

7 R. Y. Zhang, J. Lavaei, and R. Baldick, Spurious Critical Points in Power System State Estimation. *HICSS 51*, Jan 3-6, 2018. Waikoloa Village, HI.

8 R. Y. Zhang and J. Lavaei, Modified Interior-Point Method for Large-and-Sparse Low-Rank Semidefinite Programs. *CDC 2017*, Dec 12-15, 2017. Melbourne, Australia.

9 R. Y. Zhang, J. Elizondo, J. L. Kirtley, and J. K. White, Small-Signal Stability Verification Issues for Transmission Systems with Distributed Renewables. *PESGM 2016*, July 17-21, 2016. Boston, MA, USA.

10 R. Y. Zhang, J. Elizondo, J. L. Kirtley, and J. K. White, Certifying Microgrid Stability Under Large-Signal Intermittency. *COMPEL 2016*, June 27-30, 2016. Trondheim, Norway.

11 J. Elizondo, R. Y. Zhang, P.-H. Huang, and J. K. White, J. L. Kirtley, Inertial and Frequency Response from Microgrids with Induction Motors. *COMPEL 2016*, June 27-30, 2016. Trondheim, Norway.

12 R. Y. Zhang, A.-T. Avestruz, J. K. White, and S.B. Leeb, Design of Resonance Damping via Control Synthesis. *PESGM 2015*, Jul 12-15, 2015. Vancouver, BC, Canada.

13 J. Elizondo, R. Y. Zhang, J. L. Kirtley, and J. K. White, Robust Small Signal Stability for Microgrids under Uncertainty. *PEDG 2015*, Jun 22-25, 2015. Aachen, Germany.

14 Y. He, R. Y. Zhang, and J. G. Kassakian, An Energy-Based Method for the Assessment of Battery and Ultracapacitor in Pulse Load Applications. *APEC 2015*, Mar 15-19, 2015. Charlotte, NC, USA. Outstanding presentation award (poster track).

15 C. R. Sullivan and R. Y. Zhang, Analytical Model for Effects of Twisting on Litz-wire Losses. *COMPEL 2014*, Jun 22-25, 2014. Santander, Spain.

16 R. Y. Zhang, J. K. White, J. G. Kassakian, and C. R. Sullivan, Characterization of Realistic Litz Wires using Fast Simulations. *APEC 2014*, Mar 16-20, 2014. Ft. Worth, TX, USA. Outstanding presentation award (oral track).

17 C. R. Sullivan and R. Y. Zhang, Simplified Design Method for Litz Wire. *APEC 2014*, Mar 16-20, 2014. Ft. Worth, TX, USA.

18 B. Heffernan, R. Duke, R. Zhang, P. Gaynor, and M. Cusdin, A go-cart as an electric vehicle for undergraduate teaching and assessment. *AUPEC 2010*, Dec 5-8, 2010. Christchurch, New Zealand.

HICSS = Hawaii International Conference on System Sciences. CDC = IEEE Conference on Decision and Control. ACC = American Control Conference. ECC = European Control Conference. PESGM = IEEE Power & Energy Society General Meeting. PEDG = International Symposium on Power Electronics for Distributed Generation Systems. COMPEL = Workshop on Control and Modeling for Power Electronics. APEC = Applied Power Electronics Conference & Exposition. AUPEC = Australasian Universities Power Engineering Conference.

Invited Talks

Student speaker speaking on my behalf indicated in *.

2024 R.Y. Zhang, *25th International Symposium on Mathematical Programming (ISMP)*, Montreal, Canada. Jul 21-26, 2024. (Host: F. Permenter, Toyota Research Institute.)

G. Zhang*, R.Y. Zhang, *25th International Symposium on Mathematical Programming (ISMP)*, Montreal, Canada. Jul 21-26, 2024. (Host: A. Wang, Purdue U.; L. Ding, Texas A&M.)

H.-M. Chiu*, R.Y. Zhang, *25th International Symposium on Mathematical Programming (ISMP)*, Montreal, Canada. Jul 21-26, 2024. (Host: M. Kočvara, U. Birmingham)

R.Y. Zhang, *SIAM Conference on Applied Linear Algebra (LA24)*, Paris, France. May 13-17, 2024. (Hosts: A. Uschmajew, U. Augsburg; B. Vandereycken, U. Geneva.)

R.Y. Zhang, *Johns Hopkins University Data Science Seminar*, Baltimore, MD. May 1, 2024. (Host: F. Lu, JHU; Mauro Maggioni, JUH; Xiong Wang, JHU.)

R.Y. Zhang, *Georgia Institute of Technology*, Atlanta, GA. Mar 11, 2024. (Host: S.T. Maguluri, Georgia Tech.)

2023 R.Y. Zhang, Overparameterization and Global Optimality in Nonconvex Low-Rank Matrix Estimation and Optimization. *University of Michigan Communications and Signal Processing Seminar*, Ann Arbor, MI. Nov 2, 2023. (Host: J. Fesler, U. Michigan.)

R.Y. Zhang, Improved Global Guarantees for the Nonconvex Burer--Monteiro Factorization via Rank Overparameterization. *10th International Congress on Industrial and Applied Mathematics*, Tokyo, Japan. Aug 20–25, 2023. (Hosts: C. Kümmerle, UNCC; J. Maly, LMU Munich; D. Stüger, KU Eichstätt-Ingolstadt)

R.Y. Zhang, Improved Global Guarantees for the Nonconvex Burer--Monteiro Factorization via Rank Overparameterization. *SIAM Conference on Optimization (OP23)*, Seattle, WA. May 31–Jun 3, 2023. (Hosts: E. Levin, Caltech; J. Kileel, U. Texas at Austin; N. Boumal, EPFL.)

G. Zhang*, R.Y. Zhang, Preconditioned Gradient Descent for Algebraic and Geometric Optimization. *SIAM Conference on Optimization (OP23)*, Seattle, WA. May 31–Jun 3, 2023. (Hosts: O. Leung, Caltech; M. Diaz, Caltech; E. O'Reilly, Caltech.)

H.-M. Chiu*, R.Y. Zhang, Neural Network Verification via Nonconvex Low-Rank Semidefinite Relaxations. *SIAM Conference on Optimization (OP23)*, Seattle, WA. May 31–Jun 3, 2023. (Host: X. Jiang, Lehigh.)

2022 R.Y. Zhang, Improved Adversarial Attacks and Certified Defenses via Nonconvex Relaxations. *C3.ai Digital Transformation Institute (DTI) Colloquium Series*, virtual, Dec 1, 2022. (Host: G. Joshi, CMU.)

G. Zhang*, S. Fattahi, R.Y. Zhang, Preconditioned Gradient Descent for Overparameterized Nonconvex Burer-Monteiro Factorization with Global Optimality Certification. *INFORMS Annual Meeting*, Indianapolis, IN, 2022. (Hosts: S. Fattahi, U. Michigan; C. Josz, Columbia U.)

2021 R.Y. Zhang, Nonconvexity in Power System Optimization: Are Local Minima Really So Bad? *PSERC Webinar Series*, virtual, Feb 16, 2021. (Host: A. Dominguez–Garcia, U. Illinois at U-C.)

R.Y. Zhang, J.K. White, GMRES-Accelerated ADMM for Quadratic Objectives: Eigenvalues of the Iteration Matrix and Optimal Acceleration. *SIAM Conference on Computational Science and Engineering (CSE21).* Virtual, Mar 1-5, 2021. (Hosts: A.M.-S. Ang, U. Waterloo; H. de Sterck, U. Waterloo.)

2020 R.Y. Zhang, Scalable and Guaranteed Computation: Optimization and Machine Learning for the Future Electric Grid*, Power and Energy Conference at Illinois (PECI) Invited Lecture*, 2020. (Hosts: PECI organizing committee.)

2017 R.Y. Zhang, J. Lavaei, The Dangers of Local Search Algorithms for Power System State Estimation. *Federal Energy Regulatory Commission (FERC) Conference "Increasing Market and Planning Efficiency through Improved Software"*, Jun 2017. (Hosts: FERC conference organizing committee.)

2014 R.Y. Zhang, J.K. White, A Perspective on Adapting VLSI Techniques for Power System Simulations, *ISO New England*, Sep 2014. (Host: E. Litvinov, ISO-New England.)

Service & Synergistic Activities

2023 Organizer & Session Chair, Recent Advances in Optimization. *59th Annual Allerton Conference on Communication, Control, and Computing (Allerton)*, Monticello, IL. Sep 26-29, 2023. (Co-organizer: S. Fattahi, U. Michigan.)

Organizer & Session Chair, Recent Advances in Nonconvex Optimization. *SIAM Conference on Optimization (OP23)*, Seattle, WA. May 31–June 3, 2023. (Co-organizer: S. Fattahi, U. Michigan.)

2022 Organizer, Adversarial Machine Learning and Distributed and Federated Learning, *C3.ai Digital Transformation Institute (DTI) Colloquium Series*, weekly virtual seminar series, Aug 25–Dec 8, 2022. (Co-organizer: G. Joshi, CMU.)

Attendee & Discussion Record Keeping Team, Grid at the Edge: Towards the Zero-Carbon Power Grid with Improved Visibility, Safety, and Reliability. *NSF-sponsored Joint US-European Workshop*, Split, Croatia. May 23-24, 2022. (Workshop Chairs: Mladen Kezunovic, Texas A&M; Christian Rehtanz, TU Dortmund.)

Organizer & Session Chair, Recent Advances in Nonconvex Optimization I & II (two sessions). *INFORMS Annual Meeting*, Indianapolis, IN, USA. Oct 16–Oct19, 2022. (Co-organizers: S. Fattahi, U. Michigan; C. Josz, Columbia U.)

2018 Organizer & Session Chair, Sparse Semidefinite Programs with Machine Learning Applications. *INFORMS Annual Meeting 2018*, Phoenix, AZ, USA. Nov 4–Nov 7, 2019. (Co-organizer: J. Lavaei, UC Berkeley.)

Organizer & Session Chair, Algorithms for power systems. *INFORMS Annual Meeting 2018*, Phoenix, AZ, USA. Nov 4–Nov 7, 2019. (Co-organizer: J. Lavaei, UC Berkeley.)

2017 Organizer & Session Chair, Control and Optimization Techniques for Power Systems I. *INFORMS Annual Meeting 2017*, Houston, TX, USA. Oct 22–Oct 25, 2017. (Co-organizer: J. Lavaei, UC Berkeley.)

Conferences Area Chair, Neural Information Processing Systems (NeurIPS) 2021, 2022, 2023.

Area Chair, International Conference on Machine Learning (ICML) 2023, 2024.

Area Chair, International Conference on Learning Representations (ICLR) 2024.

Associate Editor, IEEE Control Systems Society Conference Editorial Board 2019.

Journal Reviewing SIAM Journal on Optimization, Mathematical Programming, Journal on Machine Learning Research, IEEE Transactions on Automatic Control, IEEE Transactions on Control of Network Systems, IEEE Transactions on Power Systems, IEEE Transactions on Smart Grid, IEEE Transactions on Power Electronics, IET Generation, Transmission & Distribution.

Grant Reviewing US National Science Foundation, US Office of Naval Research.

Teaching

ECE 530 *Analysis Techniques for Large-Scale Electrical Systems.* Instructor: Fall 2020, Fall 2022, Fall 2024

ECE 330 *Power Circuits and Electromechanics*. Instructor: Fall 2019, Spring 2020, Spring 2021, Fall 2021, Spring 2022, Spring 2023, Fall 2023, Spring 2024.

Outreach

2019 Faculty Mentor, *Rising Stars in EECS 2019*. Held at the University of Illinois at Urbana–Champaign.

2012–2013 Co-President, *MIT Energy Club*.

2011–2012 Content Co-Director, *MIT Energy Conference 2012*.

2011–2012 Executive Committee, *MIT Graduate Student Council*. Orientation co-chair.

2011–2012 Legislative Actions Subcommittee, *MIT Graduate Student Council*.

2010–2011 Workshop Lead, *MIT Energy Conference*. Led team of 4 to organize panel "Grid 101".

2006–2009 Tutor, *Univ. of Canterbury International Student Support*. Tutoring services for international students, primarily those from East Asia, but also South Asia and the Middle East.

2006–2009 Tutor, *Univ. of Canterbury Pacific Academic Student Support*. Intensive tutoring and academic support for Pasifika students, either of native New Zealand Maori descent, or from Tonga, Samoa, Fiji, the Cook Islands, or another Pacific island.