Sungho Shin

Assistant Professor
Department of Chemical Engineering, Massachusetts Institute of Technology
77 Massachusetts Avenue 66-554, Cambridge, MA 02139, USA
Email: sushin@mit.edu | Cell: +1-617-715-5740 | Web: shin.mit.edu | Github: @sshin23

Education and Training

Argonne National Laboratory, Lemont, IL — 2021-2024
Postdoctoral Appointee in Mathematics and Computer Science Division
Supervisor: Mihai Anitescu

University of Wisconsin-Madison, Madison, WI — 2021
Ph.D. in Chemical Engineering
Minor in Industrial Engineering
Thesis: *Graph-Structured Nonlinear Programming: Properties and Algorithms*
Thesis Advisor: Victor M. Zavala

Seoul National University, Seoul, South Korea — 2016
B.S. in Chemical Engineering
B.S. in Mathematics
Thesis Advisors: Jong Min Lee (Chemical Engineering) and Seng Yeal Ha (Mathematics)
Summa Cum Laude

Research Interests

nonlinear optimization; control theory; energy systems

Appointments

Assistant Professor — 2024–Present
Massachusetts Institute of Technology, Cambridge, MA
Department of Chemical Engineering

Postdoctoral Appointee — 2021–2024
Argonne National Laboratory, Lemont, IL
Mathematics and Computer Science Division
Supervisor: Mihai Anitescu

Research Assistant — 2016–2021
University of Wisconsin-Madison, Madison, WI
Department of Chemical and Biological Engineering
Supervisor: Victor M. Zavala

Research Intern — 2020
Los Alamos National Laboratory, Los Alamos, NM
Advanced Network Science Initiative
Supervisor: Carleton Coffrin and Kaarthik Sundar

Research Intern — 2018
Argonne National Laboratory, Lemont, IL
Mathematics and Computer Science Division
Supervisor: Mihai Anitescu

Research Intern — 2016
Seoul National University, Seoul, South Korea
Department of Chemical and Biological Engineering
Supervisor: Jong Min Lee.

Honors and Awards

James W. Swan Outstanding Faculty Award, Department of Chemical Engineering, MIT — 2025

COIN-OR Cup, Computational Infrastructure for Operations Research 2023

W. David Smith, Jr. Graduate Publication Award, AIChE 2023

Young Author Award, IFAC Conference on Nonlinear Model Predictive Control 2021

Young Author Award, IFAC International Symposium on Advanced Control of Chemical Processes 2021

CAST Directors' Student Presentation Award, AIChE 2020

Grainger Wisconsin Distinguished Graduate Fellowship, University of Wisconsin-Madison 2020–2021

Kwanjeong Scholarship, Kwanjeong Educational Foundation 2016–2020

Korea Presidential Science Scholarship, Korea Student Aid Foundation 2010–2016

Grants

PI. Data-Driven Modeling of the Dynamics of Battery Degradation Process for Degradation-Aware Decision-Making in Grid-Scale Storage Systems. Research Support Committee. Total $90,000. 2025-2026.

PI. Characterizing the Trade-Off between CO2 Capture Rate and Energy Efficiency in Amine-Based Carbon Capture under Variable Feed Conditions. MIT Energy Initiative. Total $250,000. 2025-2027.

PI. Optimal Utilization Strategies of Utility-Scale Battery Storage: Slowing Down Degradation in the Face of Complex Physics and Uncertainties. MIT Energy Initiative. Total $150,000. 2024-2026.

PI. Multi-Scale Production Cost Modeling for Optimal Storage Investment. MIT Energy Initiative. Total $100,000. 2024-2025.

PI. Analyzing the Ripple Effect of Consumer Flexibility on Utility Scale Energy System Investments. EQUINOR. Total $304,524. 2024-2025.

Co-PI. Optimal Design of Carbon Capture Units under Uncertainties in Feed Compositions and Operational Conditions. Department of Energy. $175,000 allocation. (expected to start in 2025).

Co-PI. Digital Twins for Sustainable Low-Cost EV Batteries: Real-Time Monitoring and Charging Optimization. Tata-MIT Alliance. Total $200,000 allocation. (expected to start in 2025).

Co-PI. Watts v/s Bytes: Energy Storage Impact Analysis on Flexible Computing Loads. MIT Energy Initiative. 2025-2026.

Mentoring Experience

Massachusetts Institute of Technology, Cambridge, MA

Yeongwoo Son (Visiting Student; Seoul National University) (Spring 2025–)
Geunseo Song (Visiting Student; Ewha Womans University) (Spring 2025–)
Natalie Chung (UROP) (Spring 2025–)
Boxun Huang (PhD Student) (Spring 2025–)
Sanjay Johnson (PhD Student) (Spring 2025–)
Xiaomian Yang (PhD Student) (Spring 2025–)
David Jin (PhD Student) (Fall 2024–)
Wallace Tan Gian Yion (PhD Student) (Fall 2024–)
Flemming Holtorf (Postdoctoral Associate) (Fall 2024–)
Dirk Lauinger (Postdoctoral Associate) (Fall 2024–)
Shaohui Liu (Postdoctoral Associate) (Fall 2024–)
Chun Wai Fung (Visiting Student; Imperial College London) Summer 2024

Argonne National Laboratory, Lemont, IL

Alexis Montoison (Polytechnique Montréal) Fall 2023
Runxin Ni (University of Chicago) Summer 2023
Miao Li (Predoctoral Appointee) Fall 2022–Summer 2023
Anthony Spyros Degleris (Stanford University) Summer 2022
David Cole (University of Wisconsin-Madison) Summer 2022

Rishabh Gupta (University of Minnesota) Spring 2022

University of Wisconsin-Madison, Madison, WI

Sang-il Kwon (University of Wisconsin-Madison) Fall 2017

Teaching Experience

Massachusetts Institute of Technology, Cambridge, MA

10.551 Systems Engineering, Instructor Spring 2025

10.34 Numerical Methods Applied to Chemical Engineering, Instructor Fall 2024

University of Wisconsin-Madison, Madison, WI

Statistics for Chemical Engineers, Teaching Assistant Spring 2019

Process Dynamics and Control, Teaching Assistant Fall 2018, Fall 2017

Seoul National University, Seoul, South Korea

Process Control and Design, Undergraduate Tutor Fall 2015

Process Fluid Mechanics, Undergraduate Tutor Spring 2015

Basic Chemistry, Undergraduate Tutor Spring 2015

Services

Academic Services

Associate Editor, American Control Conference 2024

Associate Editor, IFAC Conference on Nonlinear Model Predictive Control 2024

Session Organizer INFORMS Annual Meeting 2024

Session Chair INFORMS Annual Meeting 2022

Session Chair AIChE Annual Meeting 2022, 2024

Reviewer AIChE Annual Meeting CAST Division (10B, 10E) 2022, 2024

Co-Chair, Summer Argonne Students Symposium, 2022

Peer Review

Proposals: NSF CBET (panel), DoE Office of Science (panel), NSF SES (ad hoc)

Journals: AIChE Journal; IEEE Transactions on Automatic Control; Automatica; Computers & Chemical Engineering; IEEE Open Journal of Control Systems; IEEE Control Systems Letters; IEEE Transactions on Control Systems Technology; Industrial & Engineering Chemistry Research; INFORMS Journal on Computing; Journal of Physical Chemistry; Journal of Optimization Theory and Applications; Optimization Methods and Software; SIAM Journal on Optimization

Conferences: American Control Conference; IFAC Conference on Nonlinear Model Predictive Control; IFAC International Symposium on Advanced Control of Chemical Processes

Professional Affiliations

- **American Institute of Chemical Engineers** (AIChE)
- **Institute of Electrical and Electronics Engineers** (IEEE) – Control Systems Society
- **Institute for Operations Research and the Management Sciences** (INFORMS)
- **Society for Industrial and Applied Mathematics** (SIAM)

Publications

Preprints

[P4] R. Ni, S. Na, S. Shin, and M. Anitescu. Distributed sequential quadratic programming with overlapping graph decomposition and exact augmented Lagrangian, 2024, 2402.17170. Under Review.

[P3] F. Pacaud, S. Shin, A. Montoison, M. Schanen, and M. Anitescu. Condensed-space methods for nonlinear programming on GPUs, 2024, 2405.14236. Under Review.

[P2] S. Shin and M. Anitescu. Improved approximation bounds for moore-penrose inverses of banded matrices with applications to continuous-time linear quadratic control, 2024, 2411.04400. Under Review.

[P1] F. Pacaud and S. Shin. GPU-accelerated nonlinear model predictive control with ExaModels and MadNLP, 2024, 2403.15913. Under Review.

Journal Publications

[J16] S. Shin, S. Na, and M. Anitescu. Near-optimal performance of stochastic model predictive control. *Mathematics of Operations Research*, 2024, 2210.08599. Accepted.

[J15] A. Engelmann, S. Shin, F. Pacaud, and V. M. Zavala. Scalable primal decomposition schemes for large-scale infrastructure networks. *IEEE Transactions on Control of Network Systems*, 2024, 2212.11571. Accepted.

[J14] S. Shin, M. Anitescu, and F. Pacaud. Accelerating optimal power flow with GPUs: SIMD abstraction of nonlinear programs and condensed-space interior-point methods. *Electric Power Systems Research*, 236:110651, 2024, 2307.16830. doi:10.1016/j.epsr.2024.110651.

[J13] F. Pacaud, M. Schanen, S. Shin, D. A. Maldonado, and M. Anitescu. Parallel interior-point solver for block-structured nonlinear programs on SIMD/GPU architectures. *Optimization Methods and Software*, 39(4):874–897, 2024, 2301.04869. doi:10.1080/10556788.2024.2329646.

[J12] F. Pacaud, S. Shin, M. Schanen, D. A. Maldonado, and M. Anitescu. Accelerating condensed interior-point methods on SIMD/GPU architectures. *Journal of Optimization Theory and Applications*, pages 1–20, 2023, 2203.11875. doi:10.1007/s10957-022-02129-5.

[J11] S. Shin, Y. Lin, G. Qu, A. Wierman, and M. Anitescu. Near-optimal distributed linear-quadratic regulator for networked systems. *SIAM Journal on Control and Optimization*, 61(3):1113–1135, 2023, 2204.05551. doi:10.1137/22M1489836.

[J10] S. Shin and V. M. Zavala. Diffusing-horizon model predictive control. *IEEE Transactions on Automatic Control*, 2023, 2002.08556. doi:10.1109/TAC.2021.3137100.

[J9] F. Pacaud, D. A. Maldonado, S. Shin, M. Schanen, and M. Anitescu. A feasible reduced space method for real-time optimal power flow. *Electric Power Systems Research*, 212:108268, 2022, 2110.02590. doi:https://doi.org/10.1016/j.epsr.2022.108268.

[J8] D. L. Cole, S. Shin, and V. Zavala. A julia framework for graph-structured nonlinear optimization. *Industrial & Engineering Chemistry Research*, 2022, 2204.05264. doi:https://doi.org/10.1021/acs.iecr.2c01253.

[J7] S. Na, S. Shin, M. Anitescu, and V. M. Zavala. On the convergence of overlapping schwarz decomposition for nonlinear optimal control. *IEEE Transactions on Automatic Control*, 2022, 2005.06674. doi:10.1109/TAC.2022.3194087.

[J6] J. Jalving, S. Shin, and V. M. Zavala. A graph-based modeling abstraction for optimization: Concepts and implementation in Plasmo.jl. *Mathematical Programming Computation*, 2022, 2006.05378. doi:10.1007/s12532-022-00223-3.

[J5] S. Shin, M. Anitescu, and V. M. Zavala. Exponential decay of sensitivity in graph-structured nonlinear programs. *SIAM Journal on Optimization*, 32(2):1156–1183, 2022, 2101.03067. doi:10.1137/21M1391079.

[J4] S. Shin, V. M. Zavala, and M. Anitescu. Decentralized schemes with overlap for solving graph-structured optimization problems. *IEEE Transactions on Control of Network Systems*, 7(3):1225–1236, 2020, 1810.00491. doi:10.1109/TCNS.2020.2967805.

[J3] S. Shin, P. Hart, T. Jahns, and V. M. Zavala. A hierarchical optimization architecture for large-scale power networks. *IEEE Transactions on Control of Network Systems*, 6(3):1004–1014, 2019, 2002.09796. doi:10.1109/TCNS.2019.2906917.

[J2] S. Shin, O. S. Venturelli, and V. M. Zavala. Scalable nonlinear programming framework for parameter estimation in dynamic biological system models. *PLoS Computational Biology*, 15(3):e1006828, 2019. doi:10.1371/journal.

pcbi.1006828.

[J1] D. S. Kim, S. Shin, G. B. Choi, K. H. Jang, J. C. Suh, and J. M. Lee. Diagnosis of partial blockage in water pipeline using support vector machine with fault-characteristic peaks in frequency domain. *Canadian Journal of Civil Engineering*, 44(9):707–714, 2017. doi:10.1139/cjce-2016-0615.

Conference Publications

[C9] S. Shin, V. Rao, M. Schanen, D. A. Maldonado, and M. Anitescu. Scalable multi-period AC optimal power flow utilizing GPUs with high memory capacities. In *Open Source Modelling and Simulation of Energy Systems*, 2024, 2405.14032. Accepted.

[C8] S. Shin, F. Pacaud, E. Contantinescu, and M. Anitescu. Constrained policy optimization for stochastic optimal control under nonstationary uncertainties. In *2023 American Control Conference (ACC)*, 2023, 2209.13050.

[C7] D. Cole, S. Shin, F. Pacaud, V. M. Zavala, and M. Anitescu. Exploiting GPU/SIMD architectures for solving linear-quadratic MPC problems. In *2023 American Control Conference (ACC)*, 2023, 2209.13049.

[C6] S. Shin and V. M. Zavala. Controllability and observability imply exponential decay of sensitivity in dynamic optimization. In *7th IFAC Conference on Nonlinear Model Predictive Control*, volume 54, pages 179–184, 2021, 2101.06350. doi:10.1016/j.ifacol.2021.08.542. Young Author Award.

[C5] S. Shin, C. Coffrin, K. Sundar, and V. M. Zavala. Graph-based modeling and decomposition of energy infrastructures. In *11th IFAC International Symposium on Advanced Control of Chemical Processes*, volume 54, pages 693–698, 2021, 2010.02404. doi:10.1016/j.ifacol.2021.08.322. Keynote Paper, Young Author Award.

[C4] S. Shin, M. Anitescu, and V. M. Zavala. Overlapping Schwarz decomposition for constrained quadratic programs. In *2020 59th IEEE Conference on Decision and Control (CDC)*, pages 3004–3009, 2020, 2003.07502. doi:10.1109/CDC42340.2020.9304139.

[C3] Q. Lu, S. Shin, and V. M. Zavala. Characterizing the predictive accuracy of dynamic mode decomposition for data-driven control. In *21th IFAC World Congress*, volume 53, pages 11289–11294, 2020, 2003.01028. doi:https://doi.org/10.1016/j.ifacol.2020.12.373.

[C2] S. Shin, T. Faulwasser, M. Zanon, and V. M. Zavala. A parallel decomposition scheme for solving long-horizon optimal control problems. In *2019 IEEE 58th Conference on Decision and Control (CDC)*, pages 5264–5271, 2019, 1903.01055. doi:10.1109/CDC40024.2019.9030139.

[C1] S. Shin, A. D. Smith, S. J. Qin, and V. M. Zavala. On the convergence of the dynamic inner PCA algorithm. In *Foundations of Process Analytics and Machine Learning*, 2019, 2003.05928.

Book Chapters, Technical Reports, and Others

[B5] M. Anitescu, K. Kim, Y. Kim, A. Maldonado, F. Pacaud, V. Rao, M. Schanen, S. Shin, and A. Subramanian. Targeting Exascale with Julia on GPUs for multiperiod optimization with scenario constraints. *SIAG/OPT Views and News*, 2021. URL http://wiki.siam.org/siag-op/images/siag-op/e/e8/ViewsAndNews-29-1.pdf.

[B4] P. F. Lang, S. Shin, and V. M. Zavala. SBML2Julia: interfacing SBML with efficient nonlinear Julia modeling and solution tools for parameter optimization. 2020, arXiv:2011.02597.

[B3] S. Shin, Q. Lu, and V. M. Zavala. Unifying theorems for subspace identification and dynamic mode decomposition. 2020, arXiv:2003.07410.

[B2] S. Shin and V. M. Zavala. Computing economic-optimal and stable equilibria for droop-controlled microgrids. 2018, arXiv:2002.09802.

[B1] S. Shin and V. M. Zavala. Multi-grid schemes for multi-scale coordination of energy systems. In *Energy Markets and Responsive Grids*, pages 195–222. Springer, 2018, arXiv:2002.10680. doi:10.1007/978-1-4939-7822-9_9.

Thesis

[T1] S. Shin. *Graph-Structured Nonlinear Programming: Properties and Algorithms*. The University of Wisconsin-Madison, 2021.

Invited Presentations

[I23] S. Shin. Scalable computing and ai for energy transition. CJ CheilJedang, 2025.

[I22] S. Shin. Scalable computing for energy transition. LG Chem, 2025.

[I21] S. Shin. Solving ac optimal power flow problems on gpus: State of the art and future prospects. Korea Power Exchange, the 1st Global AI Grid Optimization Workshop, 2025.
[I20] S. Shin. Scalable computing for energy transition. Ewha Woment's University, 2025.
[I19] S. Shin. Scalable computing for energy transition. Korea University, 2025.
[I18] S. Shin. Scalable computing for energy transition. Seoul National University, 2025.
[I17] S. Shin. Large-scale nonlinear programming on GPUs. Seoul National University, 2025.
[I16] S. Shin. Large-scale nonlinear programming on GPUs. Hitachi Energy, 2024.
[I15] S. Shin. Large-scale nonlinear programming on GPUs. AIChE Computing & Systems Technology Division webinar, 2024.
[I14] S. Shin. Large-scale nonlinear programming on GPUs. Process Systems Engineering seminar, Purdue University, 2024.
[I13] S. Shin. Harnessing the power of parallel and accelerated computing for scalable decision-making in energy systems. Department of Chemical Engineering Seminar, University of Oklahoma, 2024.
[I12] S. Shin. Accelerated nonlinear programming on GPUs: Implementing solver and automatic differentiation. Center for Nonlinear Studies Seminar, Los Alamos National Laboratory, 2024.
[I11] S. Shin. Scalable decision-making for energy infrastructures: Theory, algorithms, and software. SNU EPEL Seminar, Seoul National University (Virtual), 2022.
[I10] S. Shin. Scalable decision-making for energy systems: A graph-structured optimization approach. Department of Chemical Engineering Seminar, Massachusetts Institute of Technology, 2023.
[I9] S. Shin. Scalable decision-making for energy systems: A graph-structured optimization approach. Department of Chemical Engineering Seminar, University of Texas at Austin, 2023.
[I8] S. Shin. Scalable decision-making for energy systems: A graph-structured optimization approach. Department of Chemical Engineering Seminar, University of Washington, 2023.
[I7] S. Shin. Scalable decision-making for energy systems: A graph-structured optimization approach. Department of Industrial Engineering Seminar, University of Minnesota Twin Cities, 2023.
[I6] S. Shin. Scalable decision-making for energy systems: A graph-structured optimization approach. Grid Science Winter School and Conference, Santa Fe, NM, 2023.
[I5] S. Shin. Scalable decision-making for energy infrastructures: Theory, algorithms, and software. Young Researcher Symposium, Seoul National University (Virtual), 2022.
[I4] S. Shin. Graph-structured nonlinear programming: Properties and algorithms. ALOP colloquium, Trier University (Virtual), 2021.
[I3] S. Shin. Graph-structured nonlinear programming: Properties and algorithms. Rigorous Systems Research Group, Caltech (Virtual), 2021.
[I2] S. Shin. Graph-structured optimization for energy infrastructures. Department of Chemical and Biological Engineering Seminar, University of Wisconsin-Madison (Virtual), 2021.
[I1] S. Shin. Exponential decay of sensitivity in graph-structured nonlinear programs. University of Bayreuth (Virtual), 2020.

Software Products

[S1] **MadNLP.jl** (Main developer)
- a nonlinear programming solver
- allows for exploiting problem structures via abstract KKT system feature
- allows for solving dense nonlinear optimization problems on GPU efficiently
- https://github.com/MadNLP/MadNLP.jl

[S2] **ExaModels.jl** (Main developer)
- a sparse automatic differentiation and algebraic modeling tool
- https://github.com/exanauts/ExaModels.jl

[S3] **Plasmo.jl** (Contributor)
- a graph-based algebraic modeling framework
- https://github.com/plasmo-dev/Plasmo.jl

[S4] **DynamicNLPModels.jl** (Contributor)
- a GPU-friendly modeling tool for dynamic optimization problems
- https://github.com/MadNLP/DynamicNLPModels.jl

[S5] **BlockNLPModels.jl** (Contributor)
- a data structure for block nonlinear programming models
- https://github.com/exanauts/BlockNLPModels.jl

[S6] **BlockNLPAlgorithms.jl** (Contributor)
- a decomposition solver for BlockNLPModels
- https://github.com/exanauts/BlockNLPAlgorithms.jl

[S7] **SBML2Julia** (Contributor)
- a tool for estimating parameters of biological system models in SBML format
- https://github.com/paulflang/SBML2Julia

References

Provided upon request.

Last updated: July 24, 2025