

# Sungho Shin

Assistant Professor

Department of Chemical Engineering, Massachusetts Institute of Technology

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## Education and Training

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**Argonne National Laboratory**, Lemont, IL 2021  
Postdoctoral Appointee in Mathematics and Computer Science Division  
Supervisor: Mihai Animescu

**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

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control theory; model predictive control; nonlinear optimization; stochastic optimization; energy systems

## Appointments

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**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 Animescu

**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 Animescu

**Research Intern**

2016

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

**Honors and Awards**


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<b>COIN-OR Cup</b> , Computational Infrastructure for Operations Research	2023
<b>W. David Smith, Jr. Graduate Publication Award</b> , AIChE	2023
<b>Young Author Award</b> , IFAC Conference on Nonlinear Model Predictive Control	2021
<b>Young Author Award</b> , IFAC International Symposium on Advanced Control of Chemical Processes	2021
<b>CAST Directors' Student Presentation Award</b> , AIChE	2020
<b>Grainger Wisconsin Distinguished Graduate Fellowship</b> , University of Wisconsin-Madison	2020–2021
<b>Kwanjeong Scholarship</b> , Kwanjeong Educational Foundation	2016–2020
<b>Korea Presidential Science Scholarship</b> , Korea Student Aid Foundation	2010–2016

**Mentoring Experience**


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<b>Argonne National Laboratory</b> , Lemont, IL	
<b>Alexis Montoisson</b> (Polytechnique Montréal)	Fall 2023
<b>Runxin Ni</b> (University of Chicago)	Summer 2023
<b>Miao Li</b> (Predoctoral Appointee)	Fall 2022–Summer 2023
<b>Anthony Spyros Degleris</b> (Stanford University)	Summer 2022
<b>David Cole</b> (University of Wisconsin-Madison)	Summer 2022
<b>Rishabh Gupta</b> (University of Minnesota)	Spring 2022
<b>University of Wisconsin-Madison</b> , Madison, WI	
<b>Sang-il Kwon</b> (University of Wisconsin-Madison)	Fall 2017

**Teaching Experience**


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<b>University of Wisconsin-Madison</b> , Madison, WI	
<b>Statistics for Chemical Engineers</b> , Teaching Assistant	Spring 2019
<b>Process Dynamics and Control</b> , Teaching Assistant	Fall 2018, Fall 2017
<b>Seoul National University</b> , Seoul, South Korea	
<b>Process Control and Design</b> , Undergraduate Tutor	Fall 2015
<b>Process Fluid Mechanics</b> , Undergraduate Tutor	Spring 2015
<b>Basic Chemistry</b> , Undergraduate Tutor	Spring 2015

## Professional Services

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### Academic Services

<b>Session Chair</b> INFORMS Annual Meeting	2022
<b>Session Co-Chair</b> AIChE Annual Meeting	2022
<b>Reviewer</b> AIChE Annual Meeting CAST Division (10B, 10E)	2022
<b>Co-Chair</b> , Summer Argonne Students Symposium,	2022
<b>Judge</b> , Research Presentation Sessions, Argonne Postdoctoral Research and Career Symposium	2021

### Peer Review

**Proposals:** NSF

**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

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- **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

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### Preprints

- [P6] 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.
- [P5] F. Pacaud, **S. Shin**, A. Montoisson, M. Schanen, and M. Anitescu. Condensed-space methods for nonlinear programming on GPUs, 2024, [2405.14236](#). Under Review.
- [P4] **S. Shin** and M. Anitescu. Improved perturbation bounds for graph-induced banded systems and application to optimal control. In Preparation.
- [P3] **S. Shin**, S. Na, and M. Anitescu. Near-optimal performance of stochastic predictive control, [arXiv:2210.08599](#). Under Review.
- [P2] F. Pacaud and **S. Shin**. GPU-accelerated nonlinear model predictive control with ExaModels and MadNLP, 2024, [2403.15913](#). Under Review.
- [P1] A. Engelmann, **S. Shin**, F. Pacaud, and V. M. Zavala. Scalable primal decomposition schemes for large-scale infrastructure networks, 2022, [arxiv:2212.11571](#). Under Review.

### Journal Publications

- [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*, 2023, [arXiv:2301.04869](#). Accepted.

- [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, [arXiv: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, [arXiv:2204.05551](#). doi:10.1137/22M1489836.
- [J10] **S. Shin** and V. M. Zavala. Diffusing-horizon model predictive control. *IEEE Transactions on Automatic Control*, 2023, [arXiv: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, [arXiv: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, [arXiv: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, [arXiv:2005.06674](#). doi:10.1109/TAC.2022.3194087. \*Equal contribution.
- [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, [arXiv: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, [arXiv: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, [arXiv: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, [arXiv: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

- [C10] **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.
- [C9] **S. Shin**, F. Pacaud, and M. Anitescu. Accelerating optimal power flow with GPUs: SIMD abstraction of nonlinear programs and condensed-space interior-point methods. In *XXIII Power Systems Computation Conference*, [arXiv:2307.16830](#). 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, [arXiv: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, [arXiv: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, [arXiv: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 infras-

- tructures. In *11th IFAC International Symposium on Advanced Control of Chemical Processes*, volume 54, pages 693–698, 2021, [arXiv: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, [arXiv: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, [arXiv: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, [arXiv: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, [arXiv: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/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.

### Presentations

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#### Invited Talks

- [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**, M. Anitescu, and V. M. Zavala. Graph-structured nonlinear programming: Properties and algorithms. ALOP colloquium, Trier University (Virtual), 2021.
- [I3] **S. Shin**, M. Anitescu, and V. M. Zavala. Graph-structured nonlinear programming: Properties and algorithms. Rigorous Systems Research Group, Caltech (Virtual), 2021.
- [I2] **S. Shin** and V. M. Zavala. Graph-structured optimization for energy infrastructures. Department of Chemical and Biological Engineering Seminar, University of Wisconsin-Madison (Virtual), 2021.
- [I1] **S. Shin**, M. Anitescu, and V. M. Zavala. Exponential decay of sensitivity in graph-structured nonlinear programs. University of Bayreuth (Virtual), 2020.

#### Conference Talks

- [M18] **S. Shin**, S. Na, and M. Anitescu. On the performance of stochastic predictive control. AIChE Annual Meeting,

Pheonix, AZ, 2022.

- [M17] **S. Shin**, Y. Lin, G. Qu, A. Wierman, and M. Anitescu. Near-optimal distributed linear-quadratic regulator for networked systems. AICHE Annual Meeting, Pheonix, AZ, 2022.
- [M16] **S. Shin**, S. Na, and M. Anitescu. On the performance of stochastic predictive control. INFORMS Annual Meeting, Indianapolis, IN, 2022.
- [M15] **S. Shin**, S. Na, and M. Anitescu. Graph-structured nonlinear programming: Properties and algorithms. International Conference on Continuous Optimization, Lehigh, PA, 2022.
- [M14] **S. Shin**. MadNLP.jl: A mad nonlinear programming solver. JuliaCon2021.
- [M13] **S. Shin** and V. M. Zavala. Controllability and observability imply exponential decay of sensitivity in dynamic optimization. 7th IFAC Conference on Nonlinear Model Predictive Control (Virtual), 2021.
- [M12] **S. Shin**, C. Coffrin, K. Sundar, and V. M. Zavala. Graph-based modeling and decomposition of energy infrastructures. 11th IFAC International Symposium on Advanced Control of Chemical Processes (Virtual), 2021.
- [M11] **S. Shin**, M. Anitescu, and V. M. Zavala. Overlapping schwarz decomposition for constrained quadratic programs. 58th IEEE Conference on Decision and control (Virtual), 2020.
- [M10] **S. Shin**, V. M. Zavala, and M. Anitescu. Unifying theorems for subspace identification and dynamic mode decomposition. AICHE Annual Meeting (Virtual), 2020.
- [M9] **S. Shin** and V. M. Zavala. Diffusing-horizon model predictive control. AICHE Annual Meeting (Virtual), 2020.
- [M8] **S. Shin**, M. Anitescu, and V. M. Zavala. Overlapping domain decomposition schemes for solving graph-structured optimization problems. AICHE Annual Meeting (Virtual), 2020.
- [M7] **S. Shin**, T. Faulwasser, M. Zanon, and V. M. Zavala. A parallel decomposition scheme for solving long-horizon optimal control problems. 58th IEEE Conference on Decision and control, Nice, France, 2019.
- [M6] **S. Shin**, V. M. Zavala, and M. Anitescu. Overlapping domain decomposition schemes for solving graph-structured optimization problems. AICHE Annual Meeting, Orlando, FL, 2019.
- [M5] **S. Shin** and V. M. Zavala. Low-rank system identification from high-dimensional data. Computing in Engineering Forum, Madison, WI, 2019.
- [M4] **S. Shin**, A. D. Smith, S. J. Qin, and V. M. Zavala. Optimization algorithms for dynamic latent variable problems. MLSE, Atlanta, GA, 2019.
- [M3] **S. Shin** and V. M. Zavala. Stability-preserving economic optimization of microgrids. AICHE Annual Meeting, Pittsburgh, PA, 2018.
- [M2] **S. Shin** and V. M. Zavala. Multi-grid (hierarchical) control of power networks. AICHE Annual Meeting, Minneapolis, MN, 2017.
- [M1] **S. Shin**, O. S. Venturelli, and V. M. Zavala. Large-scale estimation techniques for dynamic microbial community networks. TWCCC Fall Meeting, Madison, WI, 2017.

## Software Products

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- [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/sshin23/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] **BlockNLPAgorithms.jl** (Contributor)

- a decomposition solver for BlockNLPMODELS
- <https://github.com/exanauts/BlockNLPAgorithms.jl>

[S7] **SBML2Julia** (Contributor)

- a tool for estimating parameters of biological system models in SBML format
- <https://github.com/paulflang/SBML2Julia>

## References

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Provided upon request.

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