

# Sungho Shin

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## Education

### University of Wisconsin-Madison.

*Ph.D. in Chemical Engineering with Minor in Industrial Engineering* (2021)

Thesis Advisor: Victor M. Zavala

Thesis Title: Graph-Structured Nonlinear Programming: Properties and Algorithms

### Seoul National University.

*B.S. in Chemical Engineering and Mathematics* (2016)

Thesis Advisors: Jong Min Lee (Chemical Engineering) and Seng Yeal Ha (Mathematics)

## Research Interests

control theory; sequential decision making; model predictive control; nonlinear optimization; numerical optimization; distributed optimization; decomposition algorithms; energy systems

## Professional Appointments

### Postdoctoral Appointee (2021 – Present)

Mathematics and Computer Science Division, Argonne National Laboratory.

Supervisor: Mihai Anitescu.

### Research Assistant (2016 – 2021)

Department of Chemical and Biological Engineering, University of Wisconsin-Madison.

Supervisor: Victor M. Zavala.

### Research Intern (2020)

Advanced Network Science Initiative, Los Alamos National Laboratory.

Supervisor: Carleton Coffrin and Kaarthik Sundar.

### Research Intern (2018)

Mathematics and Computer Science Division, Argonne National Laboratory.

Supervisor: Mihai Anitescu.

### Research Intern (2016)

Energy Process Engineering Laboratory, Seoul National University.

Supervisor: Jong Min Lee.

## Publications

### Thesis

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

## Journal Publications

- [J12] **S. Shin**, Y. Lin, G. Qu, A. Wierman, and M. Anitescu. Near-optimal distributed linear-quadratic regulator for networked systems. [arXiv:2204.05551](#). Under Review.
- [J11] F. Pacaud, **S. Shin**, M. Schanen, D. A. Maldonado, and M. Anitescu. Condensed interior-point methods: porting reduced-space approaches on GPU hardware. [arXiv:2203.11875](#). Under Review.
- [J10] 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](#).
- [J9] D. L. Cole, **S. Shin**, and V. Zavala. A julia framework for graph-structured nonlinear optimization. *Industrial & Engineering Chemistry Research*, 2022, [arXiv:2204.05264](#). Accepted.
- [J8] 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](#). Accepted. \*Equal contribution.
- [J7] J. Jalving, **S. Shin**, and V. M. Zavala. A graph-based modeling abstraction for optimization: Concepts and implementation in Plasmojl. *Mathematical Programming Computation*, 2022, [arXiv:2006.05378](#). Accepted.
- [J6] **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.
- [J5] **S. Shin** and V. M. Zavala. Diffusing-horizon model predictive control. *IEEE Transactions on Automatic Control*, 2022, [arXiv:2002.08556](#). doi:10.1109/TAC.2021.3137100.
- [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

- [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 infrastructures. 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/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.

## Honors and Awards

**IFAC NMPC Young Author Award** (2021).

**IFAC ADCHEM Young Author Award** (2021).

**AICHe CAST Directors’ Student Presentation Award** (2020).

**Grainger Wisconsin Distinguished Graduate Fellowship** (2020 – 2021).

**Travel Awards** (CDC 2020; Wisconsin Student Research Grants Competition 2019; MLSE 2019)

**Kwanjeong Scholarship** (2016 – 2020).

**Korea Presidential Science Scholarship** (2010 – 2016).

## Presentations

### Invited Talks

- [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

- [P14] **S. Shin**. MadNLP.jl: A mad nonlinear programming solver. JuliaCon2021.
- [P13] **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.
- [P12] **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.
- [P11] **S. Shin**, M. Anitescu, and V. M. Zavala. Overlapping schwarz decomposition for constrained quadratic programs. 58th IEEE Conference on Decision and control (Virtual), 2020.
- [P10] **S. Shin**, V. M. Zavala, and M. Anitescu. Unifying theorems for subspace identification and dynamic mode decomposition. AIChE Annual Meeting (Virtual), 2020.
- [P9] **S. Shin** and V. M. Zavala. Diffusing-horizon model predictive control. AIChE Annual Meeting (Virtual), 2020.
- [P8] **S. Shin**, M. Anitescu, and V. M. Zavala. Overlapping domain decomposition schemes for solving graph-structured optimization problems. AIChE Annual Meeting (Virtual), 2020.
- [P7] **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.
- [P6] **S. Shin**, V. M. Zavala, and M. Anitescu. Overlapping domain decomposition schemes for solving graph-structured optimization problems. AIChE Annual Meeting, Orlando, FL, 2019.
- [P5] **S. Shin** and V. M. Zavala. Low-rank system identification from high-dimensional data. Computing in Engineering Forum, Madison, WI, 2019.
- [P4] **S. Shin**, A. D. Smith, S. J. Qin, and V. M. Zavala. Optimization algorithms for dynamic latent variable problems. MLSE, Atlanta, GA, 2019.
- [P3] **S. Shin** and V. M. Zavala. Stability-preserving economic optimization of microgrids. AIChE Annual Meeting, Pittsburgh, PA, 2018.
- [P2] **S. Shin** and V. M. Zavala. Multi-grid (hierarchical) control of power networks. AIChE Annual Meeting, Minneapolis, MN, 2017.
- [P1] **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

- [S1] **MadNLP.jl** (Main developer): a solver for nonlinear programming.  
<https://github.com/MadNLP/MadNLP.jl>
- [S2] **MadDiff.jl** (Main developer): an automatic differentiation and algebraic modeling tool.  
<https://github.com/sshin23/MadDiff.jl>
- [S3] **BlockNLPMODELS.jl** (Contributor): a data structure for block nonlinear programming models.  
<https://github.com/exanauts/BlockNLPMODELS.jl>
- [S4] **BlockNLPAgorithms.jl** (Contributor): a decomposition solver for block BlockNLPMODELS.  
<https://github.com/exanauts/BlockNLPAgorithms.jl>
- [S5] **Plasmo.jl** (Contributor): a graph-based algebraic modeling framework.  
<https://github.com/plasmo-dev/Plasmo.jl>
- [S6] **SBML2Julia** (Contributor): a tool to for estimating parameters of models in SBML format.  
<https://github.com/paulflang/SBML2Julia>

## Teaching Experience

**Teaching Assistant**, Statistics for Chemical Engineers, UW-Madison (Spring 2019)

**Teaching Assistant**, Process Dynamics and Control, UW-Madison (Fall 2018, Fall 2017)

**Tutor**, Process Control and Design, Seoul National University (Fall 2015)

**Tutor**, Process Fluid Mechanics, Seoul National University (Spring 2015)

**Tutor**, Basic Chemistry, Seoul National University (Spring 2015)

## Mentoring Experience

Undergraduate: Sang-il Kwon (UW-Madison, Fall 2017)

Graduate Interns: Rishabh Gupta (University of Minnesota, Spring 2022); David Cole (UW-Madison, Summer 2022).

## Professional Services

### Academic Services

Co-Chair and Reviewer, AIChE Annual Meeting CAST Division (10B co-chair/reviewer; 10E reviewer; 2022); Judge for Research Presentation Sessions, Argonne Postdoctoral Research and Career Symposium (2022).

### Peer Review

AIChE Journal; Automatica; Computers & Chemical Engineering; IEEE Control Systems Letters; IEEE Transactions on Control Systems Technology; IEEE Transactions on Automatic Control; IFAC Conference on Nonlinear Model Predictive Control; IFAC International Symposium on Advanced Control of Chemical Processes; Industrial & Engineering Chemistry Research; Journal of Optimization Theory and Applications; SIAM Journal on Optimization

### Outreach

SCIENCountErs (volunteered to help build a pipeline of STEM students from underrepresented groups; Fall 2018).

## Skills

Language: English and Korean

Programming: Julia; MATLAB; Python; C/C++;  $\text{\LaTeX}$ ; git; MPI; linux; shell scripting

## References

Provided upon request.

*Last updated: August 3, 2022*