Bharat Singhal

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Education

Washington University in St. Louis, Missouri **April 2025**
Ph.D. Candidate in Systems Science and Mathematics *GPA: **3.96/4.00***
M.S. in Systems Science and Mathematics

Indian Institute of Technology Kharagpur, India (IIT-Kharagpur) **June 2017**
M.Tech. in Control System Engineering *GPA: **8.85/10.00***
B.Tech. (Honors) in Electrical Engineering

Research Experience

Graduate Research Assistant | *Washington University in St. Louis* **September 2020 - Present**
9 Research articles published, 4 under review

- Researched reduced-order representations for high-dimensional (often infinite-dimensional) systems employing probabilistic moment-based techniques, resulting in 90% faster computational time for predicting system behavior.
- Developed relational inference methods for interacting systems using spectral approximation and variable selection techniques, achieving superior classification performance than graph and convolutional neural networks.
- Collaborated to develop data-driven control algorithms for controlling large-scale networks with unknown dynamic models, utilizing collected measurements and iterative optimization. The proposed algorithms require 30% less data than traditional reinforcement learning methods such as Deep Q-Network and Proximal Policy Optimization.
- Created graph classification algorithms using optimal transport and spectral graph theory, improving accuracy while reducing the computational time of existing methods up to 10%.

Master's Research | *IIT Kharagpur* **July 2016 - June 2017**
Master's Thesis: Modeling and Control of an Anti-lock Braking System in Hybrid Electric Vehicles

- Constructed a complete four-wheel vehicle model for its longitudinal motion with an option to change road conditions.
- Applied sliding mode control algorithms to prevent wheel lockout and minimize stopping distance in the event of a sudden brake, achieving 50% improvement in stopping distance compared to traditional rule-based control.
- Designed a controller to maximize regenerative energy while maintaining stopping distance for hybrid vehicles.

Work Experience

Taiwan Semiconductor Manufacturing Company (TSMC) | *Engineer* **September 2017 - September 2020**

- Worked on Integrating different SOC designs like ASIC on ASIC (AOA), system on integrated chip (SOIC), and wafer on wafer (WOW) to implement 3D-IC RC tech files for 7nm and 12nm nodes.
- Developed a comprehensive Gate resistance model to reduce silicon to simulation gap when multiple vias land on gate-poly by analyzing multiple resistance network combinations for 5nm finfet.
- Modelled various RC features like Cfi tables to compensate for gate-to-drain and gate-to-source capacitance, damage-based dielectric constant, and marker layers by anatomizing silicon data for 5nm and 7nm nodes.

Publications

Submitted Papers

- **Bharat Singhal**, and Jr-Shin Li. "Feedback Control of Heterogeneous Nonlinear Oscillator Ensembles with Uncertain Parameters." Systems & Control Letters (under revision).
- **Bharat Singhal**, Jorge Luis Ocampo-Espindola, K.L. Nikhil, Erik Herzog, István Z. Kiss, and Jr-Shin Li. "Uncertainty Quantification of Network Inference with Data Sufficiency." IEEE Transactions on Network Science and Engineering.
- **Bharat Singhal**, and Jr-Shin Li. "Data-Driven Synchronization of Oscillator Networks: A Robust Approach Using Fourier Analysis." Nonlinear Dynamics.
- **Bharat Singhal**, István Z. Kiss, and Jr-Shin Li. "Control of Oscillator Networks with Mean-Field Measurement: A Hybrid Open/Closed-Loop Approach." IEEE Transactions on Control Systems Technology.

Accepted Papers

- **Bharat Singhal**, István Z. Kiss, and Jr-Shin Li. "Optimal phase-selective entrainment of heterogeneous oscillator ensembles." SIAM Journal on Applied Dynamical Systems 22, no. 3 (2023): 2180-2205.
- **Bharat Singhal**, Shicheng Li, and Jr-Shin Li. "Identification of network interactions from time series data: An iterative approach." Chaos: An Interdisciplinary Journal of Nonlinear Science 34, no. 5 (2024).

- Minh Vu*, **Bharat Singhal***, Shen Zeng, and Jr-Shin Li. "Data-Driven Control of Oscillator Networks with Population-Level Measurement." Chaos: An Interdisciplinary Journal of Nonlinear Science 34, no. 3 (2024) (*: equal contribution).
- Jorge Luis Ocampo-Espindola*, **Bharat Singhal***, Jr-Shin Li, and István Z. Kiss. "Optimal phase-selective entrainment of electrochemical oscillators with different phase response curves." Chaos: An Interdisciplinary Journal of Nonlinear Science 34, no. 7 (2024) (*: equal contribution).
- Walter Bomela, **Bharat Singhal**, and Jr-Shin Li. "Engineering Spatiotemporal Patterns: Information Encoding, Processing, and Controllability in Oscillator Ensembles." Biomedical Physics & Engineering Express, vol. 9, no. 4, p. 045033, 2023.
- Walter Bomela, Michael Sebek, Raphael Nagao, **Bharat Singhal**, István Z. Kiss, and Jr-Shin Li. "Finding influential nodes in networks using pinning control: Centrality measures confirmed with electrochemical oscillators." Chaos: An Interdisciplinary Journal of Nonlinear Science 33, no. 9 (2023).
- **Bharat Singhal**, Minh Vu, Shen Zeng, and Jr-Shin Li. "An Iterative Approach to Optimal Control Design for Oscillator Networks." In 2023 American Control Conference (ACC), pp. 3466-3471. IEEE, 2023.
- **Bharat Singhal**, Minh Vu, Shen Zeng, and Jr-Shin Li. "A Data-efficient Framework for Inference of Nonlinear Oscillator Networks." IFAC-PapersOnLine 56, no. 2 (2023): 10089-10094.
- Minh Vu, **Bharat Singhal**, Jr-Shin Li, and Shen Zeng. "Data-driven moment-based control of linear ensemble systems." In 2024 American Control Conference (ACC), pp. 5004-5009. IEEE, 2024.

Conference Talks & Poster Presentations

SIAM Conference on Applications of Dynamical Systems, 2023

Organized by Society for Industrial and Applied Mathematics, Portland, United States

- Talk: Optimal Phase-Selective Entrainment of Heterogeneous Oscillator Populations.

American Control Conference, 2023

Organized by American Automatic Control Council, San Diego, United States

- Talk: An Iterative Approach to Optimal Control Design for Oscillator Networks.

22nd World Congress of the International Federation of Automatic Control, 2023

Organized by International Federation of Automatic Control, Yokohama, Japan

- Talk: A Data-efficient Framework for Inference of Nonlinear Oscillator Networks.

Making Connections in Computational Neuroscience (MCCN)

Center for Theoretical and Computational Neuroscience, WashU

- Poster: A novel 2-step network inference method for inferring functional connectivity in the suprachiasmatic nucleus.

Teaching Experience

Optimization | *Department of Electrical & Systems Engineering, WashU* **Fall 2021 & 2022**

- Taught optimization algorithms, such as Gradient Descent, Newton's method, and Conjugate Gradient method, to a class of 70 undergraduate students.

Control & Instrumentation Laboratory | *Department of Electrical Engineering, IIT Kharagpur* **Fall 2016**

- Guided 35 undergraduate students through laboratory experiments and helped them to understand the theoretical ideas behind the experiment.

Embedded Systems Laboratory | *Department of Electrical Engineering, IIT Kharagpur* **Spring 2016**

- Taught assembly language programming for AVR ATmega32 microcontroller to 40 students.

Technical Skills

Skills: Statistical Inference, Machine Learning, Deep Learning, Data-Driven Control, Time series Analysis
Languages: Python, R, MATLAB, C, C++
Technologies/Frameworks: Tensorflow, PyTorch, Matplotlib, Keras, pandas, scikit-learn, NumPy

Professional activities and services

Professional societies: Institute of Electrical and Electronics Engineers (Student member)
Reviewer services: Scientific Reports, IEEE Transactions on Cybernetics, IEEE Transactions on Neural Networks and Learning Systems, IEEE Transactions on Network Science and Engineering, American Control Conference

Awards & Achievements

- Ranked 1130 in the Joint Entrance Examination (JEE) 2012, top 0.2% out of 500,000 participants.
- Awarded excellent grade for outstanding performance in the Advanced Very Large Scale Integration (VLSI) Design summer course at IIT Kharagpur.
- Ranked 2nd among Dual Degree students in the Department of Electrical Engineering, IIT Kharagpur.