Bharat Singhal

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Research Interests

- My research interests lie primarily in the area of control theory, optimization, network science, and nonlinear dynamics. Specifically, I apply tools from control theory and optimization to understand complex networks of nonlinear units and effectively regulate their collective behavior.

Education

Ph.D. in Systems Science and Mathematics   *Exp. May'25*

WASHINGTON UNIVERSITY IN ST. LOUIS, MISSOURI

- GPA 3.98/4.0, Advisor: Jr-Shin Li

M.Tech. in Control System Engineering   *July'16-June'17*

INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR, INDIA **(IIT-KHARAGPUR)**

- GPA 8.85/10, Advisor: Siddhartha Mukhopadhyay

B.Tech. (Honours) in Electrical Engineering   *July'12-June'16*

INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR, INDIA **(IIT-KHARAGPUR)**

- GPA 8.85/10

Publications

Accepted:

- **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" (Accepted for IFAC World Congress 2023).
- **Bharat Singhal**, István Z. Kiss, and Jr-Shin Li, "Optimal phase-selective entrainment of heterogeneous oscillator ensembles" (Accepted at SIAM Journal on Applied Dynamical Systems).
- 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.

In-Submission:

- Minh Vu*, **Bharat Singhal***, Shen Zeng, and Jr-Shin Li, "Data-Driven Control of Neuronal Networks with Population-Level Measurement" (Under review at Nature Communications Physics; *: equal contribution)

Research Experience

Graduate Research Assistant   *Sep. 2020 - Present*

APPLIED MATHEMATICS LAB, WASHINGTON UNIVERSITY IN ST. LOUIS

- Understanding how neuron connectivity influences the behavior of populations as a whole, as well as how to harness the connectivity structure for effective regulation, which is essential to neuroscience and circadian biology.
- Developing data-driven protocols to decode the connectivity structure of complex networks and predict the collective dynamics.
- Designing fast entrainment protocols for the heterogeneous nonlinear oscillators.

Professional Experience

Taiwan Semiconductor Manufacturing Company (TSMC)   *Oct. 2017-Sep. 2020*

ENGINEER (RC INTERCONNECT MODELING FOR SUB 10NM CMOS TECHNOLOGY NODES)   *Hsinchu, Taiwan*

- 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.
- Provided 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.
- Modeling of 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.

Altisource Business Solutions   *May 2015-July 2015*

Intern, Business Analyst   *Bangalore, India*

- Designed and implemented the front end for Vresolve, Altisource's web-based mortgage collection platform which resulted in increased efficiency of company's mortgage collection.

Research Projects

Modeling and Control of an Anti-lock Braking System in Hybrid Electric Vehicles   *July 2016 - May 2017*

Master's thesis, Department of Electrical Engineering, IIT Kharagpur

- Developed a complete four-wheel vehicle model for its longitudinal motion and implemented a sliding mode controller to prevent wheel lock-out and minimize stopping distance.
- Designed a controller to maximize the amount of regenerative energy, in case of braking, while maintaining stopping distance for hybrid vehicles.

Speed Control of E-bikes Based on User-Customized Assistance Level   *July 2015 - April 2016*

Bachelor's project, Department of Electrical Engineering, IIT Kharagpur

- Built a Simulink model of a three-phase star-connected BLDC motor using state space and implemented a PI controller to regulate the speed oof motor as per assistance level
- Simulated dynamics of a bicycle from the force on pedals, through the transmission system, to wheels in Simulink.

Online Monitoring System for Overhead Equipment Traction Parameter Measurement   *May 2014 - June 2014*

Summer Research Project, Department of Electrical Engineering, IIT Kharagpur

- Implemented image segmentation and blob detection algorithm using real-time image processing software (Sapera APF) for non-contact measurement of dynamic conditions of overhead equipment synchronized with position obtained via GPS.

Teaching Experience

Control and Instrumentation Laboratory   *Fall 2016*

Department of Electrical Engineering, IIT Kharagpur

- Guided 35, 3rd-year undergraduate, students through laboratory experiments and helped them to understand the theory behind the experiment.

Embedded Systems Laboratory   *Spring 2016*

Department of Electrical Engineering, IIT Kharagpur

- Taught assembly language programming for AVR ATmega32 microcontroller and helped 40 students to implement keyboard, LCD, and ADC interface.

Optimization   *Fall 2021 & 2022*

Department of Electrical & Systems Engineering, Washington University

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

Technical Skills

Languages, C, C++, R, Python, Matlab

Libraries, NumPy, pandas, Matplotlib, Tensorflow, Keras, scikit-learn,

EDA Tools, StarRC, Calibre, Hspice, Cadence Virtuoso