Rachit Shrivastava

PhD Candidate, University of Minnesota - Twin Cities

📞 (612) 458-8042 | ✉ shriv058@umn.edu | 🏠 people.ece.umn.edu/ shriv058/ | ⌂ rachitsh1 | in www.linkedin.com/in/rachitsh1 |

Opto-mechanical and FPGA based Control & Estimation; Automated Imaging & Sensing; Probabilistic Modeling; Machine Learning, Reinforcement Learning & Model Predictive Control; Protein Expression & Probing using Single Molecule & DNA Techniques

Education

University of Minnesota │ *Twin Cities, MN*   *Sep 2016-Present*

PhD in Electrical Engineering and Masters in Mathematics │ GPA: 3.77/4.0 (Major GPA: 4.0/4.0)

Indian Institute of Technology, Bombay │ *Mumbai, India*   *Sep 2008-Aug 2013*

Bachelors and Masters of Technology in Energy Engineering │ GPA: 7.98/10

Skills

Software	MATLAB, Python, NI LabView, C++, Nikon Elements, Fiji (ImageJ), Origin, Tableau, PowerBI, GIT, AWS, Adobe Illustrator
Libraries	CASADI, Tensorflow, Keras, Pytorch, Matplotlib, Seaborn, OpenAI gym
Instrumentation	Optical Tweezers, Atomic Force Microscope, Flow Cytometers, TIRF Microscopy, NI cRIO FPGA, Laser based control systems
Simulation	Electromagnetic Simulations, Markov Chain and Monte Carlo Simulations
Biochemistry	Protein expression, purification and measurement, *in-vitro* motor protein motility, FRET Assays, DNA Origami
Coursework	Advance Control Theory, Optimization, Probabilistic and Stochastic Modeling, Machine Learning, Reinforcement Learning

Achievements and Awards

Fellowships and Awards

- Recipient of Doctoral Dissertation Fellowship (2021-22); Kaveh Fellowship, ECE Block Grant Fellowship, Bernard Paul Graduate Fellowship (2016-17)
- Recipient of Student Research Achievement Award at Biophysical Society Meeting, San Francisco, 2022 (Flagship meeting of biophysicists)
- Outstanding Teaching Award by Center for Educational Innovation, University of Minnesota (Robust Multivariable Controls Course, Spring 2020)
- Recipient of Fellowship for Undergraduate Studies at IIT Bombay from 2008-13 by Govt. of Madhya Pradesh, India
- Elected guest blogger for 2020 Biophysical Society Annual Meeting, San Diego and published 3 scientific blogs covering the conference
- Study on Myosin VI characterisation featured as the cover article for Nov. 2019 special issue of journal ACS Biochemistry

Experience

R&D Systems Engineer Intern │ **Becton Dickinson (BD) Biosciences** │ *San Jose, CA*   *Jun 2019 - Aug 2019*

- Developed automated data-driven fault detection and localisation algorithms using novel LED-based methods for flagship BD Flow Cytometers
- Automatically classified between optics vs fluidics failure using LED method to achieve 10x faster system start-up (patent submitted)
- Automated the experimental workflow using powershell resulting in 20x reduction in manual data collection time during flow cytometry experiments

R&D Engineer │ **Power Grid Corporation of India Ltd.** │ *Gurgaon, India*   *Aug 2013 - Aug 2016*

- Designed and commissioned world's first 1200 kV Electricity transmission substation at Bina, India under Govt. of India initiative
- Coordinated innovative upgrade of all switchgear equipment from existing 800 kV to 1200 kV level, collaborating with 35 equipment manufacturers
- Supervised a multinational team for commissioning the substation strengthening the backbone of Indian electricity transmission system
- Achieved 6x power carrying capacity compared to 400 kV system enabling electricity delivery to under-developed remote locations in India
- The multi-million dollar paradigm changing project got recognition in several international conferences and got featured in various national dailies

Visiting Researcher │ **Aarhus University** │ *Aarhus, Denmark*   *Jun 2011 - Aug 2011*

- Modeled continental scale wind energy system for Europe and predicted wind power generation with more than 95% accuracy

Research Projects

Development of Hybrid Optical Tweezer-TIRF Opto-Mechanical system for interrogation of Motor Proteins

- Conceptualized, designed and built a hybrid Optical Tweezer and Total Internal Reflection Fluorescence Microscope for simultaneous piconewton level force probing and nanometer scale visualization of motor proteins
- Integrated infrared laser, Acousto-optic Deflector (actuator), Quadrant-photo diode (sensor), NI-cRIO FPGA (Data Acquisition), and CCD Cameras to achieve a feedback control based forcespectroscopy and visualization system
- State-of-the-art instrument has a bandwidth of 100 kHz, femtonewton scale force resolution and single nanometer scale spatial resolution

Orientating Optically Trapped Non-Spherical Micro-Particles using Iterative Learning Control

- Simulated an optically trapped cylindrical particle using T-matrix method to automatically learn control strategy to manipulate particle orientation
- Used model-free iterative learning control algorithm and high frame-rate vision based feedback to orient 5x smaller particle than previous methods
- Novel control algorithm was presented at American Control Conference, 2022 and is due for publication in conference proceedings

Robust Feedback Control based Force Clamp using Atomic Force Microscope

- Designed a force clamp using H_2/H_∞ optimal control for force spectroscopy with piezo driven actuators and laser and QPD as sensor
- Implemented force clamp control algorithm in LabView using NI-cRIO FPGA and DAQ system
- Demonstrated Proof of Concept for protein pulling experiments at 10x higher bandwidth as compared to classical controllers
- Research presented in International Scanning Probe Microscopy 2018 conference

A generalized Markov Chain Based Computational Framework For Multi-Motor Intracellular Cargo Transport

- Designed a fast and accurate tool cargo transport by multiple motor proteins inside eukaryotic cells in a close-to-reality environment
- Developed markov chain based algorithm which is several order of magnitudes faster than Monte-Carlo algorithms
- Due to its efficiency, software can execute on regular desktop PCs as opposed to Monte-Carlo algorithms which require supercomputers
- Developed as a open-source toolbox in python, it is highly adaptable and accessible for the usecase of biophysicists at mass
- Due to its speed and wide applicability, this work received Student Research Achievement Award at Biophysical Society Meeting, 2022, San Francisco

Agent based game automation using deep reinforcement learning

- Automated Flappy Bird game with an objective to train the bird (agent) to navigate the environment full of obstacles without collision
- Created game engine using OpenAI Gym and PyGame and maximized expected rewards using the deep Q-Learning algorithm with experience replay
- Trained agent to learn the optimal policy and survive the game indefinitely, achieving the gold standard in game automation

Development of Indigenous Wind Power Forecasting Tool

- Designed a fast and accurate tool for forecasting wind velocity and power forecasting using data acquired from wind farms load dispatch centres
- Used Auto-Regressive Moving Average model to predict wind velocities at varied time scales for making wind farm operational decisions
- Used Akaike and Bayesian Information Criterion for evaluation of potential models to obtained Mean Average Percentage Error of less than 1%

Characterizing motor protein Myosin VI mechanisms using FRET, DNA Origami, and Optical Tweezers

- Developed a highly innovative protocol to study mechano-biological properties of Myosin VI, a motor protein involved in intracellular transportation
- Used DNA origami constructs to control the exact number of Myosin VI molecules attached to the beads establishing one-of-its-kind biochemical assay
- Protocol increases the efficiency of experimental output 10 folds compared to dilution based protocols and obviates the need of conducting large number of single molecule experiments required for Poisson statistics
- Proposed mechanism for linkage stiffness enabled tuning of motor protein functions; research featured as a cover article of Biochemistry Journal
- Extended the experimental protocol to characterize mechanochemical coupling between adapter protein GIPC and motor protein myosin VI

Publications, Presentations, Talks

Journal Publications

- **Rachit Shrivastava**, Arnab Sen, Sivaraj Sivaramakrishnan, and Murti Salapaka. "A generalized Markov chains based framework for multi-motor intracellular cargo transport." (Under preparation for submission in Nature Computational Sciences)
- Ashim Rai, **Rachit Shrivastava**, Duha Vang, Michael Ritt, Fredrik Sadler, Shreyas Bhaban, Murti Salapaka, and Sivaraj Sivaramakrishnan. "Multimodal regulation of myosin VI ensemble transport by cargo adaptor protein GIPC." Journal of Biological Chemistry, 2022. | Link
- **Rachit Shrivastava**, Ashim Rai, Murti Salapaka, and Sivaraj Sivaramakrishnan. "Stiffness of cargo–motor linkage tunes myosin VI motility and response to load." Biochemistry, 2019. | *Featured as Journal cover article* | Link
- Sankesa Bhoyar, Suyash Dusad, **Rachit Shrivastava**, Sidharth Mishra, Nishank Gupta, and Anand B. Rao. "Understanding the impact of lifestyle on individual carbon-footprint." Procedia-Social and Behavioral Sciences, 2014. | Link

Peer reviewed Conference Proceedings

- Connor Edlund, **Rachit Shrivastava**, and Murti V. Salapaka. "Out-of-Plane Rotation of a Micro-Cylinder using Optical Tweezers with Iterative Learning Control." In 2022 Annual American Control Conference (ACC), 2022.
- Sivaraman Rajaganapathy, James Melbourne, Tanuj Aggarwal, **Rachit Shrivastava**, and Murti V. Salapaka. "Learning and estimation of single molecule behavior." In 2018 Annual American Control Conference (ACC), 2018. | Link

Platform Talks and Presentations

- **Rachit Shrivastava**, Ashim Rai, Murti Salapaka, and Sivaraj Sivaramakrishnan. "Effect of Cargo-Motor Dissociation on transport properties of molecular motor ensemble: A Semi-Analytical Approach." In APS March Meeting Abstracts, 2021.
- **Rachit Shrivastava**, Ashim Rai, Murti Salapaka, and Sivaraj Sivaramakrishnan. "Investigating the Effect of Cargo-Motor Linkage Stiffness on Cellular Functions of Myosin VI." Bulletin of the American Physical Society, 2020.
- **Rachit Shrivastava**, Shreyas Bhaban, James Melbourne, Sivaraman Rajaganapathy, and Murti Salapaka. "A Semi-Analytical Model to Investigate Cargo Transport by Bi-Directional Molecular Motor Ensemble." In APS March Meeting Abstracts, 2019.

Poster

- **Rachit Shrivastava**, Sivaraj Sivaramakrishnan, and Murti V. Salapaka. "Cargo-motor interaction kinetics regulate myosin VI based transport." Biophysical Journal, 2022.
- **Rachit Shrivastava**, Shreyas Bhaban, Sivaraman Rajaganapathy, Mingang Li, Thomas S. Hays, and Murti V. Salapaka. "Transport Properties of Molecular Motor Ensemble with Bi-Directional Motors: A Computational Approach." In American Society of Cell Biology Abstracts, 2018.