Shabnam Sahay

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RESEARCH INTERESTS

Computational Biology, Mathematical Modelling, Biological Networks, Cell Cycle, Heterogeneity

EDUCATION

Indian Institute of Technology Bombay   *2019-23*
Bachelor of Technology (Honors) in Computer Science and Engineering | CGPA: 9.22/10
Minor in Biosciences and Bioengineering | CGPA: 9.80/10

PREPRINT(S)

- **S. Sahay**, S. Adhikari, S. Hormoz, S. Chakrabarti. "An improved rhythmicity analysis method using Gaussian Processes detects cell-density dependent circadian oscillations in stem cells." In: *bioRxiv (2023)*. doi: 10.1101/2023.03.21.533651. *Under review in Bioinformatics*.

RESEARCH EXPERIENCE

Probabilistic Edge Tuning of Boolean Networks to Influence Cell Fate   *Ongoing*
Guide: Prof. Ganesh Viswanathan, Biomolecular Engineering Lab, IIT Bombay
- Modelling stochastic cancer signalling networks in a boolean framework with random asynchronous updates
- Manipulating steady state properties (corresponding to distribution of cell fates) via probabilistic edge tuning
- Verifying experimental edge-tuning outcomes and identifying biological entities key to influencing phenotype

Agent-Based Modelling of Cellular Proliferation and Movement Dynamics   *Ongoing*
Guide: Prof. Sandip Kar, Theoretical Systems Biology Lab, IIT Bombay
- Modelling heterogeneous single cells as hexagonal lattice agents having contact-based migration propensities
- Analysing corresponding experimental time-lapse microscopy data to extract information for model validation
- Performing statistical analyses to correlate cell cycle phase with cell velocity under varying culture conditions

Estimating the Dynamics of Large Boolean Networks 📄   *2022*
B. Tech Thesis | Guide: Prof. Ganesh Viswanathan, IIT Bombay
- Constructed partial state-transition graphs with minimal permutations recapitulating true network dynamics
- Derived minimal state spaces capable of reproducing true network flow and attractor absorption probabilities
- Utilised influence maximisation to identify minimal node sets driving the network towards specified attractors
- Evaluated derived approximations and mean-field estimates of network dynamics with suitable error metrics

Effects of Chronic Hypo-Osmotic Stress (CHS) on Suspension Cells 📄   *2022*
MUST Programme | Guides: Dr. Bin Shen Wong & Prof. Rong Li, MBI, NUS
- Compared the effects of CHS on cell cycle and growth in suspension (Nalm6) cells and adherent (RPE) cells
- Characterised variations in population growth and viability through cell counting and time-lapse microscopy
- Performed western blotting independently with positive controls to quantify upregulation in p53 expression
- Identified significant increase in cell cycle arrest of RPE cells relative to Nalm6 cells under CHS via FACS

Detecting Oscillations in Biological Data with Gaussian Processes   *2021–22*
Guide: Prof. Shaon Chakrabarti, Simons Centre, National Centre for Biological Sciences
- Developed an R package combining GP regression with Bayesian model selection to detect noisy oscillations
- Identified and adapted gaussian process kernels best-suited for capturing non-stationary oscillatory patterns
- Evaluated performance against existing methods on experimental data and exhaustive simulated datasets

Evolutionary Dynamics of the Novel Coronavirus   *2021*
Summer Undergraduate Research Program | Guide: Prof. Supreet Saini, IIT Bombay
- Constructed a pipeline in Perl to retrieve, process and analyze genomes of 400,000+ SARS-CoV-2 sequences
- Utilised codon usage bias to visualize translation profiles & temporal variation of dN/dS for each gene
- Implemented the Needleman-Wunsch algorithm to extract and analyze information of indel mutations
- Traced mutation lineages in the S gene and generated ancestral trees for identification of epistatic linkages

INTERNSHIPS

Dissipative Particle Dynamics in Jax-MD 2023
PI: Dr. Anton Goloborodko, Institute of Molecular Biotechnology, Vienna Biocenter
- Implemented and integrated DPD into the existing public codebase with optimised Jax-vectorised operations
- Incorporated the novel ABOBA integration scheme and performed validation testing on a variety of systems

Predictive Model for Optical Link Failures 2022
Software Engineering Internship | Hyperscale Networking Team, Microsoft IDC India
- Built a predictive maintenance model for link flaps, integrating device metrics and link configuration data
- Designed custom features to enable forecasting and evaluated multiple classifiers for maximal f1-scores
- Deployed the optimised model as a web-service for real-time flap prediction, achieving $\geq 70\%$ accuracy
- Received an offer to join the team full-time after graduation based on exemplary internship performance

Multiphysics Modelling of DNA Nanorobots 🎧 2022
Engineering Internship Program | Guides: Dr. Mark Baldry & Prof. Marcela Bilek, University of Sydney
- Built, tested, and refined a deformable mesh model in C++ to simulate the rolling-adhesion of leukocytes
- Utilised a variable mesh to enable design of DNA origami nanorobots that can act as synthetic leukocytes

Coarse-Grained Model for Protein-Protein Docking 2021
Max Planck MtL-URO Program | Guide: Prof. Martin Zacharias, Technical University of Munich
- Implemented a reduced amino acid representation for faster protein docking and refined selection of minima
- Optimised LJ potential parameters and pseudo-atom radii via energy minimization on benchmark complexes
- Refined attraction-repulsion parameters by performing comparison of native complexes with artificial decoys

TECHNICAL PROJECTS

Generating 3D Chromatin Configurations | *Guide: Prof. Ranjith Padinhateeri, IIT Bombay* 2022
- Constructed 3D SBS polymer ensembles modelling chromatin loci corresponding to experimental Hi-C input
- Implemented Simulated Annealing Monte Carlo optimization to identify the model best describing the input
- Analysed temporal variation of simulated polymer descriptors including radius of gyration to evaluate accuracy

Simulating Sympatric Speciation | *Guide: Prof. Supreet Saini, IIT Bombay* 2021
- Modelled beak-size variation over time of a bird population having bimodal beak-size vs. fitness distribution
- Incorporated trade-off between attracting mates and maximising survival in males, and choosiness in females

Orientation Selectivity of Visual Neurons | *Online Quantitative Biology Workshop Project* 🎧 2020
- Extracted fluorescence traces from image stacks of visual neurons responding to a rotating light grating
- Constructed individual orientation tuning curves with a baseline fluorescence to demarcate ON/OFF periods
- Evaluated orientation selectivity indices and visualized the location-OSI relationship with a population map

Analysis of Mode Switching in Carnatic Music | *HS 4114: Music Analysis through Computing* 2023
- Built a pitch-class distribution (PCD) generation routine for Carnatic music clips with a known base tonic
- Enabled purely computational identification of new *raagas* (modes) being switched into after the initial *raaga*
- Automated identification of time point(s) when a transition occurs between *raagas* during mode switching
- Utilised the PCD generation routine to qualitatively differentiate between speaking and singing audio clips

Compiler for a C-Like Language | *CS316: Implementation of Programming Languages Lab* 2022
- Built a compiler in C++ to generate Abstract Syntax Tree (AST) and Register Transfer Language (RTL)
- Integrated support for arithmetic and relational expressions, control flow statements, and function usage
- Implemented the scanner in lex, parser in yacc and constructed a modular representation for AST and RTL

Anti Tic-Tac-Toe | *CS747: Fundamentals of Intelligent and Learning Agents* 2021
- Encoded Tic-Tac-Toe with reversed winning conditions into a Markov Decision Process for each player
- Derived a player's optimal MDP policy utilising Howard's Policy Iteration, given a fixed opponent policy

Mastermind Player | *CS228: Logic for Computer Science* 2021
- Encoded moves of the mastermind game into a SAT problem and solved using conflict driven clause learning
- Implemented solver in Python using z3py, making it robust to the 'codemaker' lying upto 50% of the time

ACADEMIC ACHIEVEMENTS

- Achieved **All India Rank 10** among over 240,000 aspirants in the JEE Advanced — *2019*
- Attained the **Highest Mark in India** in A-Level Physics in March-June Cambridge Examinations — *2019*
- Secured **3rd Place in India** for Best Across 3 A-Levels in March-June Cambridge Examinations — *2019*
- Scored 120/120 in TOEFL iBT, and 170/170 (Quantitative) + 164/170 (Verbal) in GRE General — *2022*
- Awarded the AP grade for exceptional performance (**top 8** out of 295) in Environmental Studies — *2022*
- Achieved All India Rank 256 in the KVPY Fellowship Examination conducted by IISc Bangalore — *2018*

SCHOLARSHIPS

- Awarded the MUST Programme Fellowship by the National University of Singapore — *2022*
- Received the Engineering Vacation Research Scholarship from the University of Sydney — *2022*
- Offered the MtL-URO Fellowship by the Max Planck Institute for Medical Research — *2021*
- Awarded the prestigious Aditya Birla Scholarship (**top 16** engineering students across India) — *2019*
- Received the Desai-Sethi Family Scholarship for ranking **1st** among all females in JEE Advanced — *2019*

TEACHING AND MENTORING EXPERIENCE

Undergraduate Teaching Assistant | *IIT Bombay* — *2021-23*
- Mathematical Foundations of AI & ML (NCM-CEP) | Spring 2023 | Instructor: Prof. S. Kalyanakrishnan
- Computer Systems Bootcamp | Summer 2022 | Instructors: Prof. Mythili Vutukuru and Prof. Puru Kulkarni
- PH 107 - Quantum Physics and its Applications | Autumn 2021 | Instructor: Prof. Shankaranarayanan S.
- BB 101 - Biology | Spring 2021 | Instructors: Prof. Ambarish Kunwar and Prof. Neeta Kanekar

Designed and verified coding assignments, conducted tutorials and help sessions, and graded examinations

Department Academic Mentor | *Student Mentorship Program, IIT Bombay* — *2021-22*
- Selected out of 70+ applicants through a rigorous procedure based on interviews and strong peer reviews
- Aided 7 sophomores with curriculum-planning and balancing their academic and extracurricular endeavours

Computational Biology Mentor | *Summer of Science, Institute Technical Council, IIT Bombay* — *2023*
- Guided 2 sophomores new to computational biology by structuring a learning plan and curating resources
- Selected relevant journal articles to introduce current research in the field pertinent to their specific interests

WORKSHOPS AND CONFERENCES ATTENDED

- Theoretical Computer Science Winter School, IIT Delhi, India (one of 40 selected attendees) — *2022*
- Simons Symposium: Cellular Lineages & Development, Alleppey, India (presented a poster 🔗) — *2022*

TECHNICAL SKILLS

Programming: C++, C, Python, Perl, Java, R, Bash, Awk, Numpy, Scipy, Matplotlib, SQL, Pandas
Software: LaTeX, Git, MATLAB, PyMOL, BLAST, LAMMPS, ImageJ, Doxygen, Beamer

KEY COURSEWORK

Computer Science: Data Structures, Design & Analysis of Algorithms, Geometric Algorithms, Logic for Computer Science, Automata Theory, Implementation of Programming Languages, Data Analysis & Interpretation
Biology: Cell and Molecular Biology, Metabolism and Bioenergetics, Immunology, Biochemistry, Molecular Biophysics, Topics in Evolution, Bioinformatics, Quantitative Biology Workshop (MITx on edX)

EXTRACURRICULAR ACTIVITIES

- Awarded **1st Position** in Solo Classical and Folk Dance competition held for all freshmen at IITB — *2019*
- Trained for 9 years and completed **Arangetram** (graduation) in the classical dance Bharatanatyam — *2015*
- Choreographed & performed classical dance in IITB's Annual Insync Dance Show for 2000+ audience — *2023*
- Member of the IITB contingent securing **1st Position** in Scrabble at the **Inter-IIT** Cultural Meet — *2023*
- Represented IITB at the inaugural IITB Scrabble Open (internationally rated and WESPA certified) — *2022*
- Achieved **distinction** in Trinity Piano Grade 1, and completed a year-long violin course at IITB — *2019*