

## 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

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### 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

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### 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

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- 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

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- 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

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**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

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- 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

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**Programming:** C++, C, Python, Perl, Java, R, Bash, Awk, Numpy, Scipy, Matplotlib, SQL, Pandas

**Software:** L<sup>A</sup>T<sub>E</sub>X, Git, MATLAB, PyMOL, BLAST, LAMMPS, ImageJ, Doxygen, Beamer

## KEY COURSEWORK

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**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

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- 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