

# Sajid Bin Mahamud

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## Summary

Mathematics graduate with a strong foundation in analysis, algebra, and combinatorics. Extensive research experience combining linear algebraic methods with computation. Work in the interface of probabilistic modeling, dynamical systems, and combinatorics, with publication and conference presentations. Seeking to develop robust, adaptive, change-point filters for critical dynamical systems.

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## Education B.A. Mathematics, Reed College, Portland, OR 2021 - 2025

- **Honors:** Academic Commendation of Excellence.
  - **Selected Courses:** (Reed College) Linear Algebra, Abstract Algebra, Discrete Structures, Manifolds and Differential Geometry, Real Analysis, Probability, Complex Analysis, Algorithms and Data Structures, (Budapest Semester in Mathematics) Advanced Combinatorics, Discrete and Convex Geometry, Groups and Graph Limits.
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## Skills

- **Programming:** Python, C++, C, R, SageMath, MATLAB.
  - **Scientific Computing & Data:** NumPy, SciPy, pandas, PyTorch, PyFlux, Matplotlib, SQL, JAX.
  - **Systems & Engineering:** Git, Bash, Jupyter, RStudio, PX4, ArduPilot, HPC.
  - **Modeling Systems:** Fault detection, Variational inference, State space models.
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## Publication

- *Bin Mahamud, S. , et al. (2024). Coalescing sets preserving cospectrality of graphs arising from block similarity matrices. Electronic Journal of Linear Algebra (accepted, Nov 2024). [arXiv:2404.01561](https://arxiv.org/abs/2404.01561).*

## Selected Presentations

- *On coalescing results for the distance matrix*, Joint Math Meetings, Jan 5, 2024.
  - *Artificial intelligence and unit distance graphs*, Budapest Semesters in Mathematics, Research Presentation, Feb 22, 2024.
  - *Sylvester's four-point problem and Crofton's Formula*, Class Presentation - Probability, Reed College, Dec 16, 2024.
  - *The Closed Walk Matrix and relation to Graph Isomorphism*, Joint Math Meetings, Jan 9, 2025.
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## Research Experience

### Research Intern, Detecting GPS Spoofing in UAVs using Bayesian Inference, Galois, Inc., Portland, Oregon, 2025

- Developed a high-fidelity simulation and data-generation pipeline for adversarial GPS spoofing on UAVs using ArduPilot.
- Developed adversarial trajectory generation routines that control GPS position/velocity, GPS dilution-of-precision parameters, and frequency/velocity perturbations to simulate (known) real-world spoofing attacks.
- Constructed an HMM-based detector to differentiate between nominal and spoofed GPS signals with emission parameters learned via variational inference on multisensor data.
- Characterized failure modes of HMM-based detectors by analyzing the divergence of residual distributions between ground-truth and fused trajectories under spoofing attacks.

### Independent Project, Error Propagation and Regime Change Detection in Lorenz '63 system Self directed 2025

- Focused on understanding error propagation in atmospheric flow simulations and developing regime change detection schemes for Earth systems models.
- Implemented a 4th-order Runge-Kutta ODE solver using JAX, vectorizing operations for faster performance.
- Investigated the stability of attractors under stochastic forcing to distinguish model misspecification from intrinsic variability.
- Quantified forecast error growth in the system using ensemble methods, directly linking attractor geometry to short-term forecast capacity.

*Research Project, Closed Walk Matrix and The Isomorphism Problem Aalto University, Espoo, Finland, Summer 2024*

- Project supported by the Aalto University summer internship fund and supervised by Dr. Vanni Noferini.
- Investigated the graph invariant closed walk matrix (CWM), a matrix that encodes the length of all closed walks.
- Formally proved the Closed Walk Matrix (CWM) is not a complete graph invariant, disproving a hypothesis posed by Dr. Noferini.
- Offered an upper bound on the size of CWM equivalence classes and extended the result to cospectral classes.
- Deployed large-scale enumeration jobs on Aalto's HPC cluster to generate all counterexamples on 10, 11 vertices, enumerating and classifying up to 13005168 graphs.

*Research Project, Graph Coalescing For Distance Matrix Iowa State University, Summer 2023*

- Studied graph coalescing through the lens of spectral invariants and block-similarity transformations; implemented computational checks for cospectrality preservation.
- Derived sufficient algebraic conditions for coalescing operations to preserve (generalized) distance spectra and verified these conditions computationally.
- Generalized results to the distance-matrix family using simultaneous similarity arguments supported by computational experiments.
- Produced reproducible code and datasets for the associated preprint and presentations.

*Research Project, Constructing Dense Unit Distance Graphs (UDG), Budapest Semesters in Mathematics, Budapest Spring 2024*

- The project was done as part of coursework supervised by Dániel Varga and Pál Zsámboi.
- Designed beam-search heuristics to narrow down the combinatorial configuration space.
- Proved that tensor products preserve the UDG structure and improved the known upper bound on dense configurations by a constant factor for rigid UDGs.
- Implemented geometric search trees to test realizability constraints and prune low-density configurations.

*Honors Thesis, [A Spectral Characterization of the Closed Walk Matrix](#), Reed College, Spring 2025*

- Advised by Dr. Jamie Pommersheim, I formulated recurrences for combinatorial closed walks on simple graphs and implemented routines to test the novel recurrent relations using SageMath.
- Offered a novel characterization of the equivalence classes of strongly regular graphs through their closed-walk matrices.
- Investigated the upper bounds for gaps between eigenvalues of symmetric, integer matrices by studying bounds on the number of distinct characteristic polynomials of simple, undirected graphs.
- Established that  $f(n) = O(2^{\lfloor n^2 \rfloor})$ , where  $f(n)$  is the number of distinct characteristic polynomials of simple, undirected graphs on  $n$  vertices.
- Formulated the closed walk centrality measure and compared its effectiveness to degree and betweenness centrality in community detection problems

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## Teaching & Leadership

**Grader and Tutor Fall 2024:** Calculus I, Calculus II, Linear Algebra, Introduction to Computer Science.

**Teaching Assistant Fall 2022:** *Introduction to Probability and Statistics*: Assisted students in learning RStudio, held weekly office hours to support students outside class, and wrote answer modules.

**Higher Education 2021 – present:** Intern, Office of Admission and Financial Aid: Interviewed 60+ prospective applicants.

**Robotics 2018 - 2020:** Robotics Coach: Robotics and Programming Club, Mirzapur Cadet College.

**Awards and Fellowships:** *Summer Opportunity Fellowship-2023; Professor Thomas Wieting Mathematics and Physics Student Fellowship-2023*, Reed College; *Gold Award: Queens Commonwealth Essay Competition-2020; Gold Medalist: National Physics Olympiad-2018*, Bangladesh.

**Grants:** Career Advancement Grant, Opportunity Grant- 2023, Reed College, Undergraduate Travel Grant, 2023, NSF