Haricharan Balasundaram

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EDUCATION

Indian Institute of Technology, Madras **CGPA: 9.57/10.00, Department Rank 1**

B. Tech. (Hons.) in Engineering Physics + M. Tech. in Electrical Engineering; Minor in Computer Science *Nov 2021 - Present*

PUBLICATIONS

Accepted:

1. *Estimating Error in Natural Distribution Estimation*
   H. Balasundaram, A. Thangaraj. *Annual Allerton Conference on Communication, Control, and Computing 2025.*
2. *Stability Notions for Hospital Residents with Sizes*
   H. Balasundaram, Krishnashree J. B., G. Limaye, M. Nasre. *Foundations of Software Technology and Theoretical CS 2025.*

Ongoing:

1. *Learning to Transmit Over Unknown Erasure Channels with Empirical Erasure Rate Feedback*
   H. Balasundaram, K. Jagannathan.
2. *Generalized Capacity Planning for the Hospital-Residents Problem*
   H. Balasundaram, G. Limaye, M. Nasre, and A. Raja. *Submitted to Elsevier Theoretical Computer Science.*

AWARDS AND ACHIEVEMENTS

- Presented research at **Allerton Conference** held at UIUC in the *Informational Characterization* session [Slides].
- Sole undergraduate recipient of *Teaching Assistant Recognition Award (TARA)* 2025 in the EE Dept for serving as Head TA.
- Recipient of *Ms. Latha and Sampath Srinath* prize for *Highest CGPA* in semesters 3 and 4 in the Engineering Physics program.
- Achieved an *JEE Advanced* All India Rank of *1153* and *JEE Mains* All India Rank of *2565* out of over 1 million candidates.
- *Candidate Master* on Codeforces Competitive Programming; Global Rank #59 in Round #886 among 25,000 participants.

RESEARCH EXPERIENCE

Estimating Error in Natural Distribution Estimation [Master's Thesis]
Guide: Prof. Andrew Thangaraj, Department of Electrical Engineering, IIT Madras *Feb 2025 - Present*

- Studied **distribution estimation** of an unknown discrete distribution over a large alphabet, where *natural estimators* incur large error.
- Introduced a novel *error statistic* that captures the unavoidable estimation error at frequency l and proposed a *non-linear estimator* for this.
- Proved low bias and consistency for the estimator and validated the approach using simulations on synthetic and natural language datasets.

Constrained Online Convex Optimization with Adversarial Constraints
Guide: Prof. Rahul Vaze, School of Technology and Computer Science, Tata Institute of Fundamental Research *May 2025 - Present*

- Working on **Constrained Online Convex Optimization (COCO)**– simultaneous minimization of regret and cumulative constraint violation.
- Improved analysis for the existing algorithm, thus breaking the long-standing $O(\sqrt{T})$–cumulative constraint violation bound in 2D.
- Proved that *Nested Convex Body Chasing with Convex Cost* is solvable under some assumptions and is hard otherwise.

Learning to Transmit over Unknown Erasure Channels [Bachelor's Thesis]
Guide: Prof. Krishna Jagannathan, Department of Electrical Engineering, IIT Madras *Dec 2023 - May 2025*

- Developed algorithms for *transmission over erasure channels* with unknown erasure rates, using limited empirical erasure feedback.
- Analyzed two strategies: *Estimate-then-Transmit* (1 query, $O(T^{2/3})$ regret) and *Windowing* (logarithmic queries, $O(\sqrt{T})$ regret).
- Established theoretical regret guarantees and validated performance through simulations, showing applicability to low-feedback systems.

Approximation Algorithms for Hospital-Resident Matchings
Guide: Prof. Meghana Nasre, Department of Computer Science and Engineering, IIT Madras *Oct 2023 - Nov 2024*

- Developed *approximation algorithms* and *inapproximability results* for quota augmentation in the **Hospital–Residents** setting.
- Analyzed *the Hospital–Residents with Sizes (HRS) problem*, studying occupancy-stability and designing efficient approximation algorithms.

Many-to-oneness of Lattice Filters
Guide: Prof. C. S. Ramalingam, Department of Electrical Engineering, IIT Madras *Sep 2023 - Nov 2023*

- Utilized MATLAB to carry out brute-force calculations to determine the *oddness or evenness* of lattice coefficients.
- Explored conditions on one-oneness, one-manyness and many-oneness of the mapping from lattice coefficients to transfer functions.

Control Systems for Rehabilitation
Guide: Prof. Sourav Rakshit, Gait and Motion Analysis (GAMA) Lab, Machine Design Section, IIT Madras *Sep 2022 - Jan 2023*

- Applied *LQR*, *iLQR*, and *SAC* control systems for trajectory tracking in **gait training** of paralyzed patients, achieving 75% accuracy.
- Created Python package and contributed to *open-source repository* for implementing LQR to achieve multi-motor position control.

TEACHING EXPERIENCE

- **Head Teaching Assistant (TA)** for Signals and Systems (EE1101), coordinated 400+ students and 6 faculty members– **TA award**.
- **TA** for Multirate Digital Signal Processing, Probability Foundations– formulated assignments and conducted tutorial sessions.
- Conducted workshop on Cryptography in *Shaastra 2023* and conducted workshop on Probability, Statistics and Finance in *Shaastra 2024*.
- Conducted information session on *Fundamentals of Mathematics and Programming* to incoming freshers in 2023.

RELEVANT COURSEWORK

EE:	Information Theory	Estimation Theory	Detection Theory	Convex Optimization
	Multirate DSP	RF and Optical Communication	Communication Networks	Linear Algebra
	Probability and Statistics	Mathematical Physics	Advanced Topics in Communications (5G)	
Minor in CS:	Approximation Algorithms	Parameterized Algorithms	Advanced Graph Algorithms	Linear Programming

SELECTED COURSE PROJECTS

EE5111: Estimation Theory [Slides]
Prof. Sheetal Kalyani, Department of Electrical Engineering, IIT Madras *May 2025*

- *'Source Enumeration using Linear Shrinkage Coefficients'*– addressed limitations of existing methods in *low SNR* regimes.
- Introduced a novel *running average–based filter* on the shrinkage coefficients to enhance detection accuracy.
- Achieved better results than traditional methods for *source enumeration* under colored noise, with applications to cellular communications.

EE5143: Information Theory [Slides]
Prof. Andrew Thangaraj, Department of Electrical Engineering, IIT Madras *Feb 2024*

- Presented **Lempel-Ziv compression algorithms (LZ77 and LZ78)**, focusing on information-theoretic analysis and optimality.
- Compared advantages of LZ compression over Huffman-coding, explained practical applications such as `gzip` and `GIF` formats.

CS6130: Advanced Graph Algorithms [Slides]
Prof. Meghana Nasre, Department of Computer Science and Engineering, IIT Madras *Apr 2024*

- Presented '*Vital Edges for* (s,t)*–min-cut*': classification into tight and loose vital edges and a general Maxflow-Mincut theorem.
- Explained utilization of data structure (ancestor tree) to compute all tight edges and bounded the number of loose edges.

EE5121: Convex Optimization [Poster]
Prof. Uday Khankhoje, Department of Electrical Engineering, IIT Madras *Nov 2023*

- Poster presentation on the paper '*Subsampled Hessian Newton methods for solving supervised learning problems*'.
- Achieved *12% improvement* on overqualified constraint datasets by integrating approximate Hessian direction with the gradient.

CS6841: Approximation Algorithms [Slides]
Prof. Meghana Nasre, Department of Computer Science and Engineering, IIT Madras *Nov 2023*

- Presented an approximation algorithm for the '*Connected Dominating Set problem using only local information*' in graphs.
- Proved that the algorithm achieved a H_n–approximation factor, matching the theoretical lower bound on approximation.

POSITIONS OF RESPONSIBILITY

Head and Founder
Mathematics Club, Centre for Innovation, IITM *Nov 2022 - Mar 2024*

- Co-founded and headed the *Mathematics Club* at IIT Madras, building a community with a reach of 1000+ students.
- *Conducted sessions* on number theory, probability, and linear algebra and headed projects on probability and group theory.
- Supervised a cohort of 76 members, including 4 project leads, 15 coordinators, and 57 deputy coordinators during 2023–24.

PROFESSIONAL EXPERIENCE

Software Developer Intern at D. E. Shaw India
Using LLMs to Automate Processing Vendor Emails *May 2024 - Jul 2024*

- Built Python pipelines to process and validate large-scale financial data, improving speed and accuracy of business operations.
- Leveraged LLMs to automate vendor *email classification* and data extraction, reducing manual effort and streamlining workflows.

EXTRA-CURRICULAR ACTIVITIES

- Presented Mathematics Club achievements at the *G20 Global Summit* held at IIT Madras to national and international delegates.
- *Bronze Medal* in the Inter-IIT Tech Meet Quant Competition (Dec 2023).
- Heading the *Communications* problem at Inter-IIT Tech Meet '25.
- Member of the Quiz Club IITM, winner of Shaastra SciTech Quiz '25.
- *Strategist* in the Programming and Cybersecurity clubs.
- Selected for ICPC Regionals at Amritapuri.
- Correspondent for *The Fifth Estate*, IITM's newsletter.