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 *Nov 2021 - Present*
Minor in Computer Science

ACCEPTED PUBLICATIONS

1. **Estimating Error in Natural Distribution Estimation**
   H. Balasundaram, A. Thangaraj; *Annual Allerton Conference on Communication, Control, and Computing 2025*

SUBMITTED PUBLICATIONS

1. **Learning to Transmit Over Unknown Erasure Channels with Empirical Erasure Rate Feedback** [ARXIV]
   H. Balasundaram, K. Jagannathan;
2. **Generalized Capacity Planning for the Hospital-Residents Problem** [ARXIV]
   H. Balasundaram, G. Limaye, M. Nasre, and A. Raja; *Elsevier Theoretical Computer Science*
3. **Stability Notions for Hospital Residents with Sizes** [ARXIV]
   H. Balasundaram, Krishnashree J. B., G. Limaye, M. Nasre; *FSTTCS 2025*

AWARDS AND ACHIEVEMENTS

- Recipient of *Ms. Latha and Sampath Srinath* prize for **Highest CGPA** in semesters 3 and 4 in the Engineering Physics program.
- Sole undergraduate recipient of **Teaching Assistant Recognition Award (TARA)** 2025 in the EE Dept for serving as **Head TA**.
- Achieved an **JEE Advanced** All India Rank of **1153** and **JEE Mains** All India Rank of **2565** out of over 1 million candidates.
- Won a **Bronze Medal** in the **Inter-IIT Tech Meet Quant Competition** (Dec 2023) for developing alpha models using stock market data.
- Attained **Candidate Master** title on **Codeforces** Competitive Programming, securing Global Rank #59 in Round #886 among 25,000 participants.

RESEARCH EXPERIENCE

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*

- Addressed the problem of **constrained online convex optimization (COCO)**— simultaneous minimization of regret and constraint violation
- **Improved analysis** for the existing gradient descent method, thus breaking the long-standing $O(\sqrt{T})$–cumulative constraint violation bound
- Provided lower bound of $O(T^{\beta})$–regret and $O(T^{1-\beta})$–cumulative constraint violation, thus confirming optimality of pre-existing algorithms

UNIFORMITY TESTING OF THE MISSING MASS

Guide: Prof. Andrew Thangaraj, Department of Electrical Engineering, IIT Madras *Feb 2025 - Present*

- Studied **distribution estimation** of an unknown discrete distribution over large a 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**

LEARNING TO TRANSMIT OVER UNKNOWN ERASURE CHANNELS [B. TECH. PROJECT]

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
- Proposed and 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 IoT systems

APPROXIMATION ALGORITHMS FOR HOSPITAL-RESIDENT MATCHINGS

Guide: Prof. Meghana Nasre, Department of Computer Science, IIT Madras *Oct 2023 - Nov 2024*

- Developed **approximation algorithms** and **inapproximability results** for *capacity* and *quota augmentation* in the **Hospital–Residents** setting
- Analyzed **the Hospital–Residents problem with Sizes (HRS)**, 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 and many-oneness** of the mapping from *lattice coefficients to transfer functions*

CONTROL SYSTEMS FOR REHABILITATION [REPOSITORY] [PYTHON PACKAGE]

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), oversaw 400+ students and coordinating with 6 faculty members– **TA award**
- **TA** for Multirate Digital Signal Processing, Probability Foundations– formulated assignments and conducted tutorial sessions
- **Shaastra 2023:** conducted workshop on Cryptography and **Shaastra 2024:** conducted workshop on Quantitative Finance
- Conducted information session on **Fundamentals of Mathematics and Programming** to incoming freshers in 2023

RELEVANT COURSEWORK

Electrical Engineering:

Information Theory, Estimation Theory, Detection Theory, Convex Optimization, Multirate Digital Signal Processing, Advanced Topics in Communications (5G), Radio-Frequency and Optical Communication, Communication Networks, Linear Algebra for Engineers, Probability and Statistics, Mathematical Physics, Quantum Computing

Minor in CS: Approximation Algorithms, Parameterized Algorithms, Advanced Graph Algorithms, Linear Programming

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
- Applied **LLMs** to automate vendor **email classification** and data extraction, reducing manual effort and streamlining workflows

SELECTED COURSE PROJECTS

EE5111: ESTIMATION THEORY [SLIDES]
Prof. Sheetal Kalyani, EE Department, IITM *May 2025*

- *Source Enumeration using Linear Shrinkage Coefficients*— addressed limitations of existing source enumeration methods in **low SNR** regimes
- Introduced a *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 wireless communications

EE5143: INFORMATION THEORY [SLIDES]
Prof. Andrew Thangaraj, EE Department, IITM *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, CS Department, 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, EE Department, 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, CS department, 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 for **Open House**
- **Supervised a cohort of 76 members**, including 4 project leads, 15 coordinators, and 57 deputy coordinators during 2023–24

EXTRA-CURRICULAR ACTIVITIES

- Strategist in **Programming** and **Cybersecurity** clubs
- Member of **Quiz Club**, winner of Shaastra Science and Technology Quiz
- Selected for **ICPC Regionals** at Amritapuri
- **Press Correspondent** for *The Fifth Estate,* IITM's newsletter
- Presented Mathematics Club achievements at the **G20 Global Summit**, held at IIT Madras to international delegates