# Aayush Rajesh

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## Research Interests

Information and Coding Theory, Communication Systems, Probability Theory, Signal Processing

## Education

**Indian Institute of Technology Bombay** — Mumbai, India
*Bachelor of Technology (with Honours) in Electrical Engineering* — 2020 - 2024
*Minor in Computer Science and Engineering*
*CPI: 9.90/10*

## Scholastic Achievements

- Recipient of **Institute Academic Prize** for excellence in academic year *(2021, 2023)*
- Achieved **AP grade** for outstanding performance in Machine Learning and Biology courses *(2021, 2023)*
- Awarded **Urvish Medh Memorial Prize** and **Aditya Choubey Memorial Prize** for top performance *(2021)*
- Secured **All India Rank 78** in **JEE Advanced** out of 150 thousand candidates *(2020)*
- Achieved **All India Rank 115** in **JEE Main** out of 1 million candidates *(2020)*
- Awarded the **KVPY Fellowship** with an **All India Rank 677** by Govt. of India *(2020)*
- Among the top **331** students selected for **Indian National Astronomy Olympiad** *(2019)*

## Publications

- M. Gastpar and **A. Rajesh**, "The Persuasion Bottleneck," *2024 IEEE International Symposium on Information Theory (ISIT)*, Athens, Greece, 2024, pp. 2472-2477, doi: 10.1109/ISIT57864.2024.10619395
- H. K. P. Anilkumar, **A. Rajesh**, V. Narayanan, M. M. Prabhakaran and V. M. Prabhakaran, "Randomness Requirements for Three-Secret Sharing," *2023 IEEE International Symposium on Information Theory (ISIT)*, Taipei, Taiwan, 2023, pp. 252-257, doi: 10.1109/ISIT54713.2023.10206455

## Research Experience

**Byzantine-Resilient Gradient Coding** — *July 2023 - Present*
*Guides: Prof. Nikhil Karamchandani, Prof. Vinod Prabhakaran* — *Undergraduate Thesis*
Gradient coding is a coding-theoretic framework to distribute the computation of a large gradient to multiple workers, some of which may be faulty. We study exact gradient coding in an adversarial setting

- Working on developing **low-replication** gradient coding protocols under byzantine errors given access to a gradient oracle for general data allocation, and analyzing bounds on their communication and computation requirements
- Proposed a scheme requiring **fewer** the local computations than previously required under full communication
- Exploring the **trade-off** involved in required computation upon introducing communication constraints

**Information-Theoretic Persuasion** — *May 2023 - February 2024*
*Guide: Prof. Michael Gastpar* — *École Polytechnique Fédérale de Lausanne*
We are working on a project modeling persuasion using selective information revelation through the analysis of a rate-distortion setting on an indirect source observation

- Studying the actions of an agent attempting to persuade a worker to encode maximum information about the agent's objective by revealing **partial information** about the worker's objective
- Derived the optimal choice of linear **observation kernel** in the case of jointly Gaussian worker and agent objectives
- Working on quantifying the persuasion using **information inequalities** on the associated quantities and making remarks about the optimal choice of partial observation and encoding rate in the general case

**Correlated Multi-Secret Sharing** *May 2022 - February 2023*
*Guide: Prof. Vinod Prabhakaran* *Tata Institute of Fundamental Research, Mumbai*

- Worked on information-theoretic cryptography, specifically the analysis of 3-party **multi-secret sharing** schemes over all possible combinations of binary secrets
- Computed the optimal lower bound on **randomness complexity** of secret sharing in these scenarios and searched for secret sharing schemes with randomness requirements matching the calculated lower bounds
- Presented **combinatorial bounds** on randomness complexity in scenarios with loose information-theoretic bounds
- **Published** paper at International Symposium on Information Theory (ISIT) 2023

## Technical Projects

**Image Enhancement and Processing** *August 2023 - November 2023*
*Guide: Prof. Ajit Rajwade* *CS663: Digital Image Processing*

- Implemented computationally efficient **mean shift**-based and PCA-based filtering techniques for image-denoising
- Designed a PCA-based face recognition system achieving peak recognition rate of **94.53%** on ORL database and **60%** on Yale database taking into account Lambertian reflectance model
- Implemented a **detail transfer** and denoising pipeline for digital photography using flash/no-flash image pairs

**EEG Data Acquisition System** *January 2023 - April 2023*
*Guides: Prof. Siddharth Tallur, Prof. Laxmeesha Somappa* *EE344: Electronic Design Lab*

- Created schematic design for an EEG data acquisition system based on an extensive analysis of devices used for **bio-potential measurements** and their constraints
- Implemented a **modular design** capable of acquiring and displaying 4-channel EEG data for analysis
- Designed a **4-layer PCB** complete with 24-channel data acquisition analog front-end, daisy-chained ADCs, power supply regulators, and peripheral interfacing with the on-board microcontroller
- Among groups awarded **Best Project Award** for performance in project demonstration and presentation

**Autoencoders for Denoising and Colorization** *January 2023 - April 2023*
*Guide: Prof. Amit Sethi* *EE769: Introduction to Machine Learning*

- Studied **CNN-based autoencoder** architectures for the application of correcting errors in digital images
- Designed a denoising autoencoder trained on **MNIST dataset** capable of reconstructing test images corrupted by Gaussian noise and burst erasures by compressing into a coded format
- Explored colorization capabilities and limitations of autoencoders on **CIFAR-10** and **Intel** image datasets

**Learning in Constrained MDPs** *January 2023 - April 2023*
*Guide: Prof. Vivek Borkar* *EE736: Introduction to Stochastic Optimization*

- Conducted a literature review on the development of optimal learning algorithms in a constrained MDP setting
- Presented an analysis of the performance of a **sub-linear** regret algorithm with cost constraints

**Reinforcement Learning** *August 2022 - November 2022*
*Guide: Prof. Shivaram Kalyanakrishnan* *CS747: Foundations of Intelligent and Learning Agents*

- Implemented **regret minimizing** algorithms such as UCB, KL-UCB, and Thompson Sampling in various multi-armed bandit instances and compared their performance with theoretical expectations
- Modelled a situation within the game of cricket as an MDP, and used various methods like **policy iteration** and evaluation to solve for an optimal policy
- Developed an autonomous obstacle-avoidance algorithm based on action-value **function approximation** methods

**Introduction to Polar Codes** *August 2022 - November 2022*
*Guide: Prof. Nikhil Karamchandani* *EE605: Error Correcting Codes*

- Conducted a literature review on polar codes, building on the knowledge of classical error control coding
- Gave a presentation covering **channel polarization**, and the use of polar codes as a modern coding technique

**CISC and RISC Processor Design** *January 2022 - May 2022*
*Guide: Prof. Virendra Singh* *EE309: Microprocessors*

- Developed an on-paper design of a microcoded CISC Processor using Hardware Flowchart Method
- Designed and implemented a 16-bit multicycle RISC Processor in VHDL with a **Turing-complete** instruction set architecture of 17 instructions
- Extended the design to a 6-stage **pipelined** architecture and tested both on an Altera MAX V CPLD
- Optimized performance of pipeline by introducing **hazard mitigation** techniques such as data forwarding

## Key Positions Held

**Teaching Assistant**
Served as an undergraduate teaching assistant for a batch of **40+** students, with the responsibility of conducting weekly problem-solving sessions, academically mentoring students, and preparing and correcting examination solutions over the duration of the following courses:

| Year | Course | Instructor |
|---|---|---|
| Autumn 2023 | EE605: Error Correcting Codes | Prof. Nikhil Karamchandani |
| Spring 2022 | MA106: Linear Algebra | Prof. S. Sivaramakrishnan |
| Autumn 2021 | MA109: Calculus-I | Prof. Sourav Pal |

**Department Academic Mentor** *June 2022 - May 2023*
*Department of Electrical Engineering, IIT Bombay*

- Selected from among **100+ applicants** on the basis of interviews and extensive peer reviews
- Tasked with mentoring **8** sophomores in the department in managing their academic workload and extracurriculars
- Involved in the development of a new department mentor program **website** for student support resources

## Technical Skills

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|---|---|
| **Languages** | C++, Python, VHDL, Assembly, SQL |
| **Software** | Eagle, GNU Radio, Quartus, Keil $\mu$Vision, MATLAB, Ngspice, LaTeX |

## Relevant Coursework

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|---|---|
| **Communication Theory and Systems** | Information and Coding Theory, Error Correcting Codes, Communication Networks, An Introduction to Number Theory and Cryptography, Cryptocurrency and Blockchain Technologies, Digital Image Processing, Signal Processing |
| **Probability and Statistics** | Advanced Probability and Random Processes, Estimation and Identification, Advanced Concentration Inequalities, Introduction to Stochastic Optimization, Foundations of Intelligent and Learning Agents, Markov Chains and Queueing Systems |
| **Computer Science** | Discrete Structures, Design and Analysis of Algorithms, Data Structures and Algorithms, Logic for Computer Science, Computer Programming and Utilization |
| **Mathematics** | Calculus, Linear Algebra, Differential Equations, Complex Analysis |
| **Miscellaneous** | Optimization, Introduction to Machine Learning, Control Systems, Electromagnetic Waves |

## Extracurriculars

- Completed one year of **Chess** training under **National Sports Organisation, IIT Bombay** *(2020-21)*
- Stood **first** in **Bazinga Physics** organized by Math and Physics Club, IIT Bombay *(2021)*
- Achieved **second place** in **Astromania** organized by Krittika - The Astronomy Club, IIT Bombay *(2021)*