Krishna Narasimhan **Agaram**

Third year undergraduate, Computer Science, IIT Bombay

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Education

Indian Institute of Technology Bombay 2021 - 2025 (expected)
B.Tech. with Honors in Computer Science and Engineering (GPA: 9.80/10)

Research Interests

- **Experienced.** Algorithms and Combinatorics, Reinforcement Learning, Cryptography, Theory of Computation
- **Interested.** Theoretical Machine Learning, Networked and Operating Systems, Algorithmic Game Theory

Research Experience

Low Gate-Complexity Quantum State Preparation *Summer Internship, Aalto University, Finland*
Guide: Prof. Vikas Garg, Dept. of Computer Science, Aalto University (May 2023 - Present)

- Set up a RL framework for high-fidelity quantum **state preparation**; a problem of great interest for today's NISQ hardware, especially for hybrid algorithms that use some form of amplitude encoding of classical information
- Tested **home-made** implementations of deep RL algorithms from **DQN** to **PPO** and **TD3** to solve the environment
- Developed a agent that is able to successfully prepare **arbitrary** states (of up to **four** qubits) reaching **99%+** fidelity to the target using a **small number** of Clifford + T gates; currently working on scaling and improving the fidelity
- The training is one-shot (for a fixed number of qubits); once trained, the agent can prepare any state on the fly

Scholastic Achievements

- Department rank **7** in a class of 194 students in the Computer Science department (2023)
- Placed **1st** (India) and **8th** (East Division) in the pairs category, **Simon Marais Mathematics Competition** (2022)
- Among the **top 35** students selected for the **International Mathematics Olympiad Camp** (**IMOTC**) (2020, 2021)
- Secured **All India Rank 40** in JEE Advanced among more than 140,000 aspirants (2021)
- Secured **Global Rank 1** in the **Southeast Asian Mathematical Olympiad 2020** (2020)
- Among the **top 47** eligible for the **International Olympiad on Astronomy and Astrophysics** OCSC (2020)
- Conferred with the **AP** (Advanced Performer) grade for exceptional performance in Logic in Computer Science, Discrete Structures, Data Analysis, Quantum Physics, Physical Chemistry and Differential Equations (2021-2023)

Scholarships and Recognition

- Received **Institute Academic Prize** given to the top 20 out of 1300+ students for stellar academic record (2022)
- Awarded the *Kishore Vaigyanik Protsahan Yojana* **KVPY** scholarship for **All India Rank 23** (2020)
- Awarded the *National Talent Search Examination* **NTSE** scholarship, ranked **2nd** in Stage 1 (2019)

Projects

An Introduction to Quantum Computation and QML *Web and Coding Club, IIT Bombay*
Seasons of Code, 2022 (Apr. 2022 - Jul. 2022)

- Analysed **quantum algorithms** such as Quantum Teleportation, Phase Estimation, **Shor's Algorithm** and Search with home-made implementations in IBM Qiskit following a study of Linear Algebra and Quantum Circuits
- Built a SAT solver with time complexity $\mathcal{O}(2^{n/2})$ using **Grover's Algorithm** for unstructured search
- Examined and implemented a paper on finding the ground-state **molecular geometry** of simple molecules using the **Jordan-Wigner** transform for encodings and a **variational quantum circuit** for the optimization, in **PennyLane**

Probabilistic Method (Sep. 2023 - Present)

- Studying the fundamentals of the **probabilistic method** in combinatorics with emphasis on extremal graph theory from *The Probabilistic Method* by Alon & Spencer

Group Theory (Jun. 2023-Jul. 2023)

- Learned group theory with emphasis on combinatorial application, covering topics from the isomorphism & **Sylow theorems** to Burnside's lemma and the **Pólya enumeration theorem**, from *Abstract Algebra* by Dummit & Foote

Linear Cryptanalysis (Mar. 2023-Apr. 2023)

- Explored introductory Linear Cryptanalysis of the DES cipher following the paper by Matsui (1994), running tests to verify and exploit the **S-box weakness**; also gave a presentation on the same that can be found here

Analytic Combinatorics (Nov. 2022 - Dec. 2022)

- Examined **symbolic specifications** for various combinatorial structures & applied them to **enumeration** problems and finding **asymptotic** properties of random structures, from *Analytic Combinatorics* by Flajolet & Sedgewick

Complex Analysis (Oct. 2021 - Nov. 2021)

- Studied the Cauchy-Riemman equations, **Cauchy Integral theorem** and formula, Fundamental Theorem of Algebra, Laurent Series and **Residues** from *A first course in Undergraduate Complex Analysis* by Richard Spindler

Service

Teaching Assistantships

- **MA106 - Linear Algebra** (Spring 2023)
- **CS213 - Data Structures and Algorithms** (Fall 2023)

  Responsible for conducting weekly tutorial sessions for a batch of students throughout the semester, clearing conceptual doubts, preparing exams and grading answer scripts

Combinatorics-in-a-nutshell

Guide: Prof. Rekha Santhanam, IIT Bombay (Jul. 2023 - Present)

- Writing a **book** in the spirit of an adventure novel meant to serve as a primer for **enumerative combinatorics** for students in early high school; covers permutations, inclusion-exclusion, the twelve-fold way, generating functions

Staff, Online Math Club (Nov. 2021 - Dec. 2022)

- Delivered **lectures** covering introductory Symbolic Combinatorics, Barycentric Coordinates, Generating Functions and Projective Geometry to interested high-school students

Relevant Coursework

Computer Science	**Theory**	Discrete Structures, Data Structures & Algorithms, Analysis of Algorithms, Logic for Computer Science, Automata Theory*, Spectral Graph Theory*
	Systems	Software Systems Lab, Computer Architecture, Computer Networks, Operating Systems*, Programming Languages and Compilers**, Databases**
	Other	Computer Programming and Utilization, Paradigms in Programming, Data Analysis and Interpretation, Artificial Intelligence and Machine Learning*
Mathematics		Calculus, Linear Algebra, Differential Equations, Mathematical Structures for control, Modern Cryptography, Quantum Information, Extremal Graph Theory*, Numerical Analysis**
Others		Engineering Drawing, Quantum Physics, Basics of Electricity and Magnetism, Introduction to Electronics, Physical Chemistry, Organic and Inorganic Chemistry, Biology

**To be completed by November 2023 **To be completed by April 2024*

Miscellaneous

- Worked with **Vizuara** in developing short animated videos to **motivate concepts** in school-level Mathematics for use in **schools**, using the Python library **Manim** (Oct. 2022 - Dec. 2022)
- Selected to the **Monsoon Math Camp** organized by students from MIT, Berkeley, IISc etc; studied topics such as Knot theory, Analytical Number Theory & Automated theorem proving with Lean (Jul. 2020, 2021)