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

- **Recent.** Analytic, Extremal, Probabilistic Combinatorics and Graph Theory; Spectral Graph Theory
- **Other.** Theory of Quantum Computing, Reinforcement Learning, Formal Verification, Cryptography

Research Experience

On Quantum State Preparation using Deep RL *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 trading fidelity for a smaller circuit depth, for use in various NISQ-era applications such as classical data encoders for Quantum Machine Learning applications
- Discovered a **provably-optimal** reward function for the environment to guide the agent towards the target state
- Tested **home-made** implementations of deep RL algorithms from **DQN** to **PPO** and **TD3** to solve the environment
- Designed and implemented a **novel pipeline** that couples randomized training with a circuit optimizer to build a RL agent for a fixed number of qubits that can be **pre-trained once** to then efficiently prepare **any** target state

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 at the **Simon Marais** Mathematics Competition (2022)
- Conferred with the **AP** (Advanced Performer) grade for exceptional performance in
  - CS228 (Logic in Computer Science), awarded to 2 out of 196 students (Spring 2023)
  - CS207 (Discrete Structures), awarded to 3 out of 195 students (Fall 2022)
  - CS215 (Data Analysis and Interpretation), awarded to 3 out of 197 students (Fall 2022)
  - MA108 (Differential Equations), awarded to 7 out of 1372 students (Spring 2022)
  - PH107 (Quantum Physics & Application), awarded to 12 out of 1364 students (Fall 2021)
  - CH107 (Physical Chemistry), awarded to 21 out of 1387 students (Fall 2021)
- Secured **All India Rank 40** in JEE Advanced among 140,000 aspirants (2021)
- Secured **All India Rank 122** in JEE Main among more than 1,000,000 aspirants (2021)
- Among the **top 35** selected for the Indian **International Mathematics Olympiad** training camp (2020, 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)
- Stood **1st** in India at the **Technothlon 2019 Mains** conducted by IIT Guwahati (2019)

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)

Key Projects

FastChat

Course Project: Software Systems Lab

GUIDE: PROF. KAVI ARYA (Oct. 2022 - Dec. 2022)

- Built chat service with a **distributed** server-client architecture, **end-to-end** encryption and dedicated **load-balancer**
- Users can choose to chat **privately** or in a **group**, and apart from text, one can also send arbitrarily large **files**
- Encoded messages using standard **message protocol** and a message buffer ensures messages are not lost
- Used the python **socket** library to build the network, **PostgreSQL** for databasing and Sphinx for documentation

Railway Management System

Course Project: Data Structures Lab

GUIDE: PROF. SUPRATIK CHAKRABORTY (Aug 2022 - Nov. 2022)

- Implemented a railway journey planning system in C++ allowing clients to find all journeys between stations and curated (by keywords or rating) journey reviews, all with the ease of **autocompletion** of station names
- Data structures implemented for use include lists, hash tables, **self-balancing** trees, heaps, **tries** and graphs
- Modified the breadth-first search algorithm to find **all** routes between two stations and return a **timetable of journeys** while also allowing for **filtering** based on waiting time between trains and layovers in between

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**
- Implemented a **Quanvolutional Neural Network** in PennyLane using a quantum-classical hybrid model for MNIST

Reading Projects

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

Other Projects

Replacement Policies for Graph Algorithms

Course Project: Computer Architecture

GUIDE: PROF. BISWABANDAN PANDA (Mar. 2023 - Apr. 2023)

- Tinkered with various LLC **replacement policies** for graph algorithm workloads and compared the numbers to those of the theoretically optimal **Belady** policy, using the ChampSim microarchitecture simulator

Linear Algebra Library

Self Project

Inspired by MA106, Linear Algebra (Apr. 2022 - Jul. 2022)

- C++ library for linear algebra supporting row operations, reduction to reduced row **echelon** form, **Gram Schmidt** & QR decompositions, a **system-of-equations** solver (and for square matrices, **determinant** and **inverse** as well)

Service

Department Academic Mentor

(Jun. 2023 - Present)

- Guiding six sophomores of the department in navigating **coursework**, research and other opportunities as well as personal development during their second academic year

Teaching Assistantships

- **MA106 (Linear Algebra)**: Conducted **weekly** live tutorials and a help-session for **40+** freshmen (Spring 2023)
- **CS213 (Data Structures)**: Holding bi-weekly problem-solving sessions for 25+ sophomores and helping with creating autograded programming labs and exam grading (Fall 2023)

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

Technical Mentorships

- **Summer of Science**: Guided **four** students in a self-study of modern cryptography (May. 2023 - Jul. 2023)
- **Season of Code**: Co-mentored **eight** students studying the basics of Quantum Computing culminating in a review of a Quantum Cryptography or Quantum Machine Learning algorithm. (May. 2023 - Jul. 2023)

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, Cryptography, Quantum Information and Computation, Extremal Graph Theory*.
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*

Technical Skills

Languages	C, C++, Python, Bash, LaTeX, x86 Assembly, Haskell, MATLAB, Java.
Development	HTML5, CSS, Git, JavaScript, SQLite3, PostgreSQL, Sphinx, Wireshark.
Libraries	IBM Qiskit, PennyLane, Manim, NumPy, Pandas, PyTorch, TensorFlow, Matplotlib

Extracurriculars

- Completed the Trinity College London **Piano** Grade 6 examination (2018)
- Delivered four **lectures** on **Projective Geometry**, Barycentric Coordinates, Generating Functions & **Symbolic Combinatorics** to high-school students as part of the staff at the **Online Math Club** (Nov. 2021 - Dec. 2022)
- 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)
- Actively participated in the **Monsoon Math Camp** taught by students from top colleges like **MIT**, **Berkeley** and **IISc**; studied topics such as Knot theory, Analytical Number Theory & Automated theorem proving (Jul. 2020, 2021)