Krishna Narasimhan **Agaram**

Fourth year Computer Science undergraduate, IIT Bombay

kagaram@cse.iitb.ac.in | mathismusic | personal website

Education

Indian Institute of Technology Bombay — 2021 - 2025 (expected)
B.Tech. with Honors in Computer Science and Engineering — (GPA: 9.87/10)

Research Interests

Learning theory, proof systems, reinforcement learning, formal verification for deep learning models, quantum information

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 - Jul. 2023)

- Proposed a RL-based method for **zero-shot** high-fidelity **state preparation**, a problem of much importance to quantum error correction and quantum machine learning, that learns short circuits for preparing arbitrary target states
- Wrote a **home-made** library of deep RL algorithms from **DQN** to **PPO** and **TD3** to evaluate the framework
- Achieved perfect fidelity and **60% shorter** circuits compared to baselines, even with a state space with 10^{20}+ states
- Theoretically estimated generalization of the model to unseen states, achieving at least **4000x** generalization
- Publication under review at **ICLR 2025**

Lower bounds on testing 3-colorability

RnD II, CS Honors, IIT Bombay
Guide: Prof. Akash Kumar, Dept. of Computer Science, IIT Bombay — (Jan. 2024 - Apr. 2024)

- Established a **linear** lower-bound for 1-sided testing of 3-colorability on $(1/3-\alpha)$-far vs 3-colorable **expander** graphs
- Studied **Yao's minimax** principle and various **lower-bound techniques** in an attempt to prove a 2-sided lower bound for 3-colorability of colorable vs α-far graphs

Key Projects

Compiler for a subset of C

Course Project: Compilers Lab
Guide: Prof. Uday Khedker — (Jan. 2024 - Apr. 2024)

- Wrote a **compiler** for a subset of C with parsing, syntactic-semantic analysis and code generation phases; handles expressions, control structures, loops, **nested scoping** and shadowing, **functions** and **arrays** of any dimension
- Proposed extensions to the code for type inference, pre-processing, **pointers** and support for structures & **methods**
- Implemented a top-down **program generator** for the language to serve as **testbed** for compiler speed & correctness
- Beat the reference implementation in speed by more than **4x**, compiling **10,000** lines of code in under **1.5** seconds

Video Style Transfer

Course Project: Machine Learning
Guide: Prof. Preethi Jyothi — (Aug. 2023 - Nov. 2023)

- Implemented a convolution-based **style transfer** algorithm for **videos** following Gatys et al and Ruder et al
- Enforced temporal coherence of output videos using **optical flow**, preserving style of moving objects across frames
- Tuned parameters affecting **occlusion detection**, reconstruction and style losses with **wandb** to improve quality

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**

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 **scratch** implementations in IBM Qiskit following a study of Linear Algebra, Quantum Mechanics and Circuits
- Built a SAT solver with optimal gate complexity $\mathcal{O}(2^{n/2})$ using **Grover**'s Algorithm for unstructured search
- 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, with **PennyLane**

Other Projects

Miscellanous Development Projects

Self Projects

INSPIRED BY VARIOUS COURSES (Apr. 2022 - Dec. 2023)

- **AutoLib**: Wrote a library to work with finite **automata**, supporting unions, joins, DFA **minimization**, transformations from ε-NFAs to DFAs; also supports context-free grammars and the **CYK** algorithm for language membership
- **LinAlg**: Built a C++ linear algebra library supporting vector operations, matrix row operations, reduction to **echelon** form, Gram Schmidt & **QR** decompositions, determinant and **inverse** methods, and a **system-of-equations** solver
- **Minute-learn**: Authored a small python library **implementing** portions of the **scikit-learn** & **PyTorch API**s; includes API support for regression, clustering, decision trees, PCA, computational graph backprop & neural networks

Railway Management System

Course Project: Data Structures Lab

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

- Architected a tiny "Google Maps" for a railway network in C++, allowing clients to find **all journeys** between two stations (filtered by layovers/waiting time, et cetera) and train reviews, with **autocompletion** and suggestions
- Implemented data structures such as lists, hash tables, **self-balancing trees**, heaps, tries and graphs from scratch

Replacement Policies for Graph Algorithms

Course Project: Computer Architecture

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

- Analysed various LLC **replacement policies** for graph algorithm workloads and compared the LLC miss rate with that of the optimal Belady policy, using the ChampSim simulator and a scratch cache and Belady implementation

Linear Cryptanalysis of the DES Cipher

Course Project: Cryptography and Network Security

GUIDE: PROF. MANOJ PRABHAKARAN (Mar. 2023 - Apr. 2023)

- Explored linear cryptanalysis of DES, following Matsui 1994; wrote tests to verify the **S-box weakness** in DES and presented a **key recovery** attack for reduced-round DES using graph shortest paths & single-round weaknesses

Reading Projects

Probabilistic Proof Systems

(May. 2024 - Jun. 2024)

- Studied the complexity-theoretic foundations of **probabilistic proof systems** from *Proofs, Arguments, and Zero-Knowledge* by Justin Thaler, covering interactive proofs, succinct arguments (SNARGs), PCPs and IOPs

Fast Algorithms for PageRank

(Jul. 2023 - Nov. 2023)

- Explored **fast algorithms** for single-node PageRank and presented a **simple theory** (report in the link above) for PageRank vectors that brings out similarities between some algorithms, also **implemented** this very fast algorithm

Group Theory and Counting

(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

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 (Jan. 2023 - Present)

Responsible for conducting weekly/bi-weekly **problem solving sessions** for a batch of **40**+ students

- **MA110** - Linear Algebra and Differential Equations (Spring 2024)
- **MA106** - Linear Algebra (Spring 2023)

Responsible (in part) for setting **assignments**, **labs**, preparing exams and **grading** for a batch of 200 students

- **CS215** - Data Analysis and Interpretation (Fall 2024)
- **CS213** - Data Structures and Algorithms (Fall 2023)

Department Academic Mentor (Jun. 2023 - Jun. 2024)

- Guided six sophomores of the department in navigating coursework, research, internships and other opportunities as well as personal development during their second undergraduate year

Technical Mentorships

- **Summer of Science**. Mentored **six** students in a self-study of probability and statistics (May. 2024 - Jul. 2024)
- **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)

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

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

Scholastic Achievements

- Department **rank 2** in a class of 194 students in the Computer Science department (2024)
- Selected to attend the **Cornell-Maryland-Max Planck Pre-doctoral Research School** (CMMRS) (2024)
- Placed **8th** (twice) in the East Division at the Simon Marais Mathematics Competition (**SMMC**) (2022, 2023)
- Among the **top 35** students selected for the **International Mathematics Olympiad Training Camp** (2020, 2021)
- Secured All India Rank **40** & 122 in **JEE Advanced** and JEE Main among 140K+ & 1M+ aspirants respectively (2021)
- Among the **top 47** eligible for the International Olympiad on **Astronomy and Astrophysics** Selection Camp (2020)
- Secured Global Rank **1** in the Southeast Asian Mathematical Olympiad (**SEAMO**) 2020 (2020)
- Conferred with the **AP** (Advanced Performer) grade for exceptional performance in **Compilers** Lab, **Logic** in CS, **Discrete** Math, **Data** Analysis, **Quantum** Physics, Physical **Chemistry** and **Differential** Equations (2021-2024)

Scholarships and Recognition

- Awarded the **Institute Academic Prize** awarded to the **top 3** out of 194 students in the department (2024)
- Received the **Institute Academic Prize** given to the **top 20** out of 1300+ students for stellar academic record (2022)
- Conferred with the *Kishore Vaigyanik Protsahan Yojana* (**KVPY**) scholarship with All India Rank **23** (2020)
- Granted the *National Talent Search Examination* (**NTSE**) scholarship, ranked **2nd** in Stage 1 (2019)

Selected Coursework

Computer Science	Logic & Automata, Approximation Algorithms, Learning Theory, Quantum Information, Formal Methods in ML*, Computer Networks, Operating Systems, Embedded Control*
Mathematics	Real Analysis*, Abstract Algebra*, Discrete Math, Spectral Graph Theory, Numerical Analysis

**To be completed by Nov. 2024*

Technical Skills

Languages/Tools	C/C++, Python, Bash, LaTeX, x86 Assembly, Rust, JavaScript, Git, PostgreSQL, Wireshark
Libraries	NumPy, Pandas, Matplotlib, PyTorch, TensorFlow, scikit-learn, stable-baselines, OpenAI Gym, IBM Qiskit, PennyLane, stim, Manim

Miscellaneous

- Worked with **Vizuara** in developing short animated videos to **motivate concepts** in school-level Mathematics for use in schools, using the Python animation 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, Topology & Automated theorem proving with Lean (Jul. 2020, 2021)
- Passed the Trinity College London **Piano** Grade 6 examination (Sep. 2018)