Saksham Rathi

Curriculum Vitae

Department of Computer Science,
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Education

2022 - 2026 **Indian Institute of Technology Bombay** *Bachelor's of Technology*
Pursuing majors in Computer Science and Engineering (**CSE**) along with **honors** and **minor** in Machine Intelligence and Data Science (**CMInDS**) (CPI - **9.69**/10)

2020 - 2022 **Disha Delphi Public School, Kota** *Senior Secondary Education*
Secured **99.0%** in CBSE Class **12th** Board Examination

2008-2020 **Delhi Public School, Kota** *Primary and Secondary Education*
Secured **98.6%** in CBSE Class **10th** Board Examination

Internships and Research Experience

Current **Commodities Software Engineering Internship**
Citadel, London
(a) Built a robust **listener** and parser for **trade** messages, boosting accuracy via async **LLM** integration
(b) Developed a **real-time** health monitor to validate **live market data** across several markets
(c) Extended trade upload tool with **trade** and **risk date** support for accurate tracking and downstream use

2024 **Applied Scientist Internship**
Amazon, Bangalore
(a) Worked on Amazon's Large Language Model **Olympus** and improved its instruction following ability
(b) Implemented **Classifier-free Guidance** method to enhance focus on key parts of user queries and system prompts, optimizing the balance between conditional and unconditional probabilities using a hyper-parameter
(c) Evaluated the performance of Olympus and some open source models on various single and multi-turn datasets

2024-25 **Structured LLM Optimization**
Indian Institute of Technology Bombay. Guide: Prof. Mythili Vutukuru
(a) **Fine-tuning** LLMs via **QLoRA** for multi-query programs, sharing a system prompt and control flow
(b) Reusing **KV cache** across generation calls using **RadixAttention** and **cache-aware** scheduling
(c) Maintaining **radix tree** with **LRU** eviction to optimize **multi-level** KV cache reuse at runtime

2024-25 **Compressive Lognormal Regression**
Indian Institute of Technology Bombay. Guide: Prof. Ajit Rajwade
(a) Enhanced viral load estimation in pooled **RT-PCR** via **Bayesian** inference and compressed sensing
(b) Developed a superior Orthogonal Matching Pursuit (**OMP**) variant using combinatorial group testing
(c) Optimized **sparse** recovery using **block gradient descent**, LASSO, NNLS, and proximal algorithms

Academic Achievements

2022 Secured **All India Rank 18** in **Joint Entrance Examination Advanced** among 250,000 selected students
2023 Awarded the **Institute Academic Prize** for being among the **top 20** out of 1400 students in first year
2023, 25 Achieved **10** Semester Performance Index **(SPI)** by scoring a perfect grade in two of the Spring Semesters
2020 Awarded the **NTSE Scholarship** after a two-tier merit-based procedure by NCERT, Government of India
2021, 22 Recipient of the **Kishore Vaigyanik Protsahan Yojana**, a coveted fellowship by the Department of Science and Technology, Government of India by securing **All India Ranks 24** and **33** in the SX and the SA streams
2022, 25 Granted the distinguished **AP** (Advanced Performer) grade, given to the highest **1%** among **1400+** students, twice: in Calculus as well as in Advanced Machine Learning
2022 Secured **All India Rank 321** in **JEE-Main** with **99.97** percentile among **1 million+** students

Olympiads and Competitions

2022 Among the **top 26** students to clear the Indian National Astronomy Olympiad (INAO) and selected to attend the **Orientation-Cum-Selection Camp** for **International Astronomy Olympiad** (IOAA)
2024, 25 Was among the **top 50** at Limestone Data Challenge conducted by **Tower Research Capital**, India in collaboration with the Finance Club, IIT Bombay amongst 200+ participating candidates across all academic years
2020 Selected among the **top 40** students to clear the Indian National Junior Science Olympiad (INJSO) and selected to attend the **Orientation-Cum-Selection Camp** for **International Junior Science Olympiad** (IJSO)

2022 Among the top 300 students selected for the **Indian National Physics Olympiad** conducted by HBCSE
2018 Selected among the top 300 students for the **Indian National Mathematics Olympiad**, HBCSE

Key Projects

Spring 2025 **Analyzing Selfish Mining and Eclipse Attack in a P2P Cryptocurrency Network**
Guide: Prof. Vinay Ribeiro | Course Project: Blockchains, Cryptocurrencies and Smart Contracts
Developed a **P2P blockchain** network simulator with **100+** nodes to demonstrate how coordinated attackers can manipulate block propagation through combined Selfish Mining and Eclipse Attack strategies
Conducted comprehensive analysis showing attack effectiveness at various adversary thresholds **(5%-100%)**, revealing that malicious control of >50% network nodes results in complete blockchain takeover
Designed and implemented a **trust-based** countermeasure system that reduced malicious block acceptance by 95%, effectively neutralizing attacks even with 40% malicious nodes present

Autumn 2023 **Socket-Based Trading Engine with Arbitrage Detection**
Guide: Prof. Ashutosh Gupta | Course Project: Data Structures and Algorithms
Devised trading strategies utilizing **sockets** and **threads** to enhance market responsiveness and execution efficiency
Developed a **dynamic market** platform that intelligently matches traders based on optimal prices, enhancing overall market performance and has robust measures to identify and prevent **arbitrage** opportunities
Implemented **median trading** and **statistical arbitrage**, to exploit market anomalies and drive consistent returns

Spring 2025 **Approximate Nearest Neighbour Search via Group Testing**
Guide: Prof. Ajit Rajwade | Course Project: Advanced Image Processing
Implemented a novel **FLINNG** algorithm combining Locality Sensitive Hashing with distance-sensitive Bloom filters to optimize nearest neighbor search operations
Designed and evaluated a **parameterized search index** achieving $O(N^{(1/2+\gamma)})$ query time complexity, demonstrating significant performance improvements over traditional approaches
Conducted comprehensive performance analysis across multiple metrics (**precision, recall, F1 score**) to validate theoretical guarantees and practical efficiency of the proposed method

Summer 2023 **Modeling Economic Systems with Reinforcement Learning**
Web and Coding Club | Seasons of Code
Formulated and implemented various economic problems as **Markov Decision Processes** in the Gym framework
Employed a combination of **Bandit** algorithms and **Reinforcement Learning** algorithms, known for their adaptability and learning capabilities, to address complex matching markets, auction dynamics, and allocation problems
Modeled **stock exchange** as a **double auction**, which incorporated market sentiment and the individual objectives of users and conducted simulations involving a diverse group of over **100** participants to assess the model's efficacy

Spring 2025 **Automated Index Creation in a Database**
Guide: Prof. Sudarshan | Course Project: Database and Information Systems
Developed an automatic indexing system for PostgreSQL that dynamically creates and removes indices based on query patterns, reducing execution time by **40%** in tests
Implemented adaptive indexing policies using weighted **attribute frequencies** and PostgreSQL's query planner to optimize database performance without manual DBA intervention
Created a real-time query monitoring interface with custom data structures that tracks attribute access patterns and applies cost-aware filtering through the **hypopg** extension

Autumn 2023 **Working with Low Level Systems**
Guide: Prof. Biswabandan Panda | Course Project: Digital Logic and Computer Architecture
Utilized the **champsim** simulator to implement and analyze **stream** and **IP stride prefetchers**, while evaluating the effectiveness of **LRU**, **FIFO**, **LFU** and **BIP** replacement policies based on IPC and accuracy metrics
Designed a **VHDL** circuit which encodes **musical chords**, achieving conversion of 8-bit binary notes into chords
Implemented **Heap Sort**, **Merge Sort** and Binary Search algorithms in the **MIPS** and **x86** Assembly Language

Spring 2025 **C Compiler Development**
Guide: Prof. Uday Khedker | Course Project: Implementation of Programming Languages
Built a complete **C compiler** in C++ using **Lex** and **Yacc**, creating lexical analyzer, parser, **context-free grammar** and **abstract syntax** trees for simplified C language
Implemented full compilation pipeline from source to assembly, developing all compiler phases including **intermediate code** generation and **assembly code** generation through six progressive steps
Added comprehensive **error detection** and validation across all compilation phases to identify and reject invalid C programs during compilation

Summer 2024 **Mathematics of Derivative Pricing**
Maths and Physics Club | Summer of Science
Achieved proficiency in **mathematical models** used in derivative pricing through comprehensive coursework
Acquired knowledge about Derivatives such as **Futures** and **Options**, with a focus on trading strategies
Gained in-depth understanding of **Black-Scholes model**, **Binomial model**, and **Greeks** for risk management

Spring 2025 **Building Decentralized Exchange**
Guide: Prof. Vinay Ribeiro | Course Project: Blockchains, Cryptocurrencies and Smart Contracts
Engineered a complete Automated Market Maker (AMM) **DEX** system using **Solidity**, implementing the constant product meechanism with ERC-20 token support, liquidity pool management, and LP token minting/burning mechanisms
Developed an **arbitrage** detection smart contract that automatically identifies profitable trading opportunities between DEXes, factoring in swap fees and minimum profit thresholds
Analyzed key metrics like Total Value Locked (**TVL**), **reserve ratios**, **slippage** impact, and trading volumes while documenting security measures against front-running attacks

Spring 2024 **Systems Programming**
Guide: Prof. Mythili Vutukuru | Course Project: Operating Systems
Implemented **producer-consumer** thread pools, **reader-writer** locks and custom **semaphores** using pthreads API
Built a comprehensive **Unix shell** from scratch supporting foreground/background execution, **signal** handling, process groups, **serial/parallel** command execution, and built-in commands
Extended **xv6** operating system with custom system calls, implemented memory-mapped I/O with **demand paging**, and developed **copy-on-write fork** mechanism with reference counting

Other Projects

Autumn 2024 **Image Compression**
Guide: Prof. Ajit Rajwade | Course Project: Digital Image Processing
Implemented multiple image compression algorithms including **JPEG-inspired DCT** with quantization, run-length encoding, and advanced **PCA** techniques
Implemented and enhanced **Edge-Based** Image Compression with **Homogeneous Diffusion**, reducing artifacts in uniform intensity regions through artificial segmentation
Conducted performance analysis across diverse image datasets, evaluating **RRMSE vs BPP** metrics to quantify compression efficiency while preserving visual quality

Spring 2024 **Game of Trust**
LimeStone Data Challenge | Tower Research Capital
Reverse-engineered player strategies from noisy game data by developing mathematical models to characterize decision-making patterns in a **multi-round Prisoner's Dilemma variant**, successfully identifying distinct algorithmic strategies despite **10% miscommunication** rates
Built machine learning models to **predict player moves** and classify strategic behaviors, using historical game data to forecast opponent actions across multiple rounds
Created simulation framework to **test strategy performance** and rankings, evaluating how different **noise levels** affect optimal gameplay and developing winning **counter-strategies**

Autumn 2024 **Audio Network Communication**
Guide: Prof. Vinay Ribeiro | Course Project: Computer Networks
Utilized **frequency based** bit transmission with robust error correction through **CRC** algorithm capable of detecting and correcting upto **2-bit** errors
Implemented a modified **CSMA-CA** protocol with **RTS/CTS** mechanism for collision avoidance and included specialized handling for **broadcast** messages
Built a **multi-threaded** architecture with one thread managing message buffering and another handling the communication protocol, complete with exponential backoff strategy for collision management and clock synchronization via NTP

Spring 2025 **LLM Decoding Techniques Implementation and Analysis**
Guide: Prof. Sunita Sarawagi | Course Project: Advanced Machine Learning
Implemented multiple **LLM sampling** strategies (greedy, **temperature scaling**, top-k, **nucleus**) on **Llama-2** for Hindi-English translation, achieving **BLEU** score of **0.31** on IN22-Gen dataset
Developed word-constrained decoding using **Trie** structures to leverage oracle word lists, improving BLEU score from 0.31 to **0.51** and outperforming all baseline methods
Implemented **Medusa speculative decoding** with **multi-head beam search** optimization, analyzing **RTF** vs. quality trade-offs across various beam widths and head configurations

Spring 2025 **Denoising Diffusion Probabilistic Models**
Guide: Prof. Sunita Sarawagi | Course Project: Advanced Machine Learning
Built and evaluated **unconditional** and **conditional DDPMs** across multiple datasets, studying effects of diffusion steps and **noise schedules** (linear, cosine, sigmoid) using **NLL** and **EMD**
Implemented **Classifier-Free Guidance** (CFG), analyzing guidance scale impact on sample quality using both trained classifiers and DDPM-based classifiers
Integrated **Soft Value-Based Decoding** (SVDD) for **reward-guided** sampling from unconditional models using classifier-derived rewards

Spring 2024 **Saliency-Guided GMM Image Segmentation**
Guide: Prof. Suyash Awate | Course Project: Medical Image Computing
Implemented **Gaussian Mixture Model** (GMM) with **Saliency Map** for accurate image segmentation
Achieved better accuracy and reduced computational cost over Markov Random Field and mean template based GMM

Autumn 2024 **Network Routing Protocol Implementation**
Guide: Prof. Vinay Ribeiro | Course Project: Computer Networks
Built a custom **routing protocol** in C++ that finds shortest paths between network nodes, achieving convergence **under 1ms** for networks up to **50 nodes** through optimized table sharing and **split-horizon** techniques
Implemented packet forwarding system with automatic handling of node failures, **TTL-based loop prevention**, **validity counters** for route expiration, and broadcast mechanisms for network discovery

Spring 2025 **Probabilistic Graphical Models and Message Passing Implementation**
Guide: Prof. Sunita Sarawagi | Course Project: Advanced Machine Learning
Implemented **junction tree** algorithms for probabilistic inference including graph **triangulation** via minimum degree heuristic and maximal clique extraction using **Bron-Kerbosch** algorithm
Developed **sum-product** and **max-product** message passing algorithms to compute exact marginal probabilities and MAP assignments on complex probabilistic networks
Optimized **top-K** assignment retrieval with pruning strategies to reduce computational complexity while maintaining accuracy on multi-variable graphical models

Summer 2023 **Option Pricing Models**
Finance Club | Finsearch
Engaged in **Stock Markets** and **Options Trading**, with a focus on understanding diverse Option Strategies
Implemented the **Black-Scholes** model, the **Binomial** model, and **Monte Carlo** simulations using Python libraries
Evaluated the precision and **performance** of the Black-Scholes Model by applying it to **real-world** data sourced from the National Stock Exchange (**NSE**) markets and achieved a high accuracy by optimizations

Spring 2025 **Gambler's Triumph**
LimeStone Data Challenge | Tower Research Capital
Developed predictive models for autoregressive card sequences using **time series forecasting** techniques, achieving optimal strategy formulation across **5** different **casino tables** with varying statistical distributions
Reverse-engineered hidden data patterns to decode the relationship between backend system values and **card outcomes**, achieving **100% accuracy** in predicting card values from data streams
Built coordinated **multi-table strategy** to simultaneously optimize gameplay across **three correlated tables**, leveraging cross-table information to maximize winnings through strategic timing

Spring 2025 **Simulation of a P2P Cryptocurrency Network**
Guide: Prof. Vinay Ribeiro | Course Project: Blockchains, Cryptocurrencies and Smart Contracts
Implemented a simulator modelling transaction generation, message propagation with realistic network latencies and Proof-of-Work (PoW) mining using exponential distributions
Analyzed blockchain tree evolution to assess the impact of node speed and CPU power on mining success and fork resolution

Summer 2023 **Exploring Reinforcement Learning**
Maths and Physics Club | Summer of Science
Completed an extensive **reading project** on Reinforcement Learning (main reference: **Sutton & Barto**)
Investigated Dynamic Programming, Monte Carlo Methods, n-step bootstrapping, **Temporal Difference** learning and **on-policy** methods with their applications and **implemented** all the algorithms in Python

Spring 2023 **Python Web Crawler**
Guide: Prof. Kameswari Chebrolu | Course Project: Software Systems Lab
Designed a sophisticated Web Crawler equipped with the ability to **recursively extract** all the hyperlinks of a

webpage and generating a comprehensive **graph** showcasing various link types, with user-defined recursion levels
Harnessed the power of **Python libraries** to visualize this wealth of data, resulting in an interpretable representation

Winter 2022 **Alien Invasion Game**
Self Project
Developed a **customized** version of Alien Invasion Game with **pygame** aiming for an engaging gameplay experience
Added layers of excitement and depth to the gaming experience by allowing the players to shoot advancing extraterrestrial invaders, encountering three **unique types**, each with individually tailored point rewards
Enhanced gameplay by introducing escalating difficulty **levels**, with each new level increasing game speed and point rewards for aliens and implemented a **high-score** tracking system that saved and retrieved player high scores

Positions of Responsibility

2025 **Teaching Assistant** | Discrete Structures, IIT Bombay
Instructor: Prof. Akshay S

2025-26 **ISMP Mentor** | Student Mentor Program

2025 **Teaching Assistant** | Operating Systems, IIT Bombay
Instructor: Prof. Mythili Vutukuru
Collaborated with the professor in creating labs, exams and autograders

2024-25 **DAMP Mentor** | Department Academic Mentorship Programme, IIT Bombay CSE
Selected via a rigorous procedure of SoP, Peer Reviews, and Interviews to be part of a team of 37 out of 90 applicants
Guiding sophomores on academic and extra-curricular decisions and helping them navigate their curriculum

2024 **Teaching Assistant** | Data Analysis and Interpretation, IIT Bombay
Instructor: Prof. Sunita Sarawagi
Instructed sophomore students, offering guidance and support both during tutorials and doubt solving sessions
Collaborated with the professor in creating weekly quizzes, exams, assignments, practice problems, tutorial notes and grading

2024 **Teaching Assistant** | Software Systems Lab, IIT Bombay
Instructor: Prof. Kameswari Chebrolu
Instructed a cohort of 50 freshman students, offering guidance and support both during tutorial and lab hours
Collaborated with the professor in creating labs, exams, autograders, quizzes, practice problems and tutorial notes

2024 **Mentor** | Seasons of Code, IIT Bombay
Web and Coding Club
Instructed a group of 25 students for Competitive Programming and provided them the appropriate resources and problems for Dynamic Programming, Sorting, Greedy, Graphs, Trees, Range and String Algorithms

2023 **Teaching Assistant** | Calculus, IIT Bombay
Instructor: Prof. Ravi Raghunathan
Guided and instructed a group of 40 freshmen students enrolled in a semester-long calculus course
Actively collaborated with the professors to ensure the seamless and effective execution of the course

2023 **Mentor** | Winter in Data Science, IIT Bombay
Analytics Club
Provided mentorship to a team of 10 students for a **data analysis** project involving **Python** and **MATLAB**, guiding them in presenting results on a personal website through HTML, JavaScript, and CSS integration

Coursework

Computer Science Data Structures and Algorithms[§], Design and Analysis of Algorithms, Digital Logic Design and Computer Architecture[§], Computer Networks[§], Programming Paradigms[§], Implementation of Programming Languages[§], Database and Information Systems[§], Logic and theory for Computation, Operating Systems[§], Software Systems Lab[§], Computer Programming and Utilization[§], Computing and Science[§], Applied Algorithms, Game Theory and Algorithmic Mechanism Design, Blockchains, Cryptocurrencies and Smart Contracts, Network Security, Advanced Computer Architecture, Object Oriented Programming

Matematics Discrete Structures, Calculus, Linear Algebra, Differential Equations, Mathematical Structures for Control

Data Science Data Analysis and Interpretation, Optimization, Medical Image Computing, Artificial Intelligence and Machine Learning[§], Digital Image Processing, Advanced Image Processing, Advanced Machine Learning

Others Organic and Inorganic Chemistry[§], Physical Chemistry[§], Classical and Quantum Physics, Makerspace, Management, Philosophy, Biology, Economics, Design Thinking for Innovation, Development of Mathematics in India, Physiology, Environmental Studies, Entrepreneurship, Indian Culture and Tradition

[§] *along with a lab component*

Technical Skills

Programming Languages C++, Python, HTML, CSS, Git, JavaScript, VHDL, MIPS, Sed, Awk, Shell, Bash

Software Tools LaTeX, Qiskit, GitHub, Autodesk Fusion 360, Arduino, Pygame

Data Science Matplotlib, MATLAB, NumPy, Keras, TensorFlow, PyTorch, SciPy, Pandas

Verbal Debate, Group Discussion

Extracurriculars

2024 Received the **Excellence** in **CSE Teaching Assistantship** Award for the Software Systems Lab course

2025 Awarded special recognition for outstanding dedication and contribution to the **DAMP** program

2023 Engineered a manually controlled **robot**, imbued with the ability to navigate through a diverse array of obstacles while participating in the prestigious **XLR8** Competition, the Robotics Club of IIT Bombay

2019 Secured **third rank** in Rajmata Gayatri Devi National Inter-School **Verbattle Debate** Competition

2024 Actively involved in Competitive Programming contests on **Codeforces** (**Expert**)

2025 Acknowledged for my contributions as a **Department Academic Mentor** in the CSE department

2019 Appointed as the **Prime Minister** during a **Model United Nations** session, which serves as a platform aimed at fostering political discourse and encouraging the exchange of thoughtful ideas of international affairs

2023 Completed a one-year course in **Weightlifting** under National Sports Organization, IIT Bombay

2019 Secured **First Rank** in **Science Quiz** organised by Defence Laboratory, Jodhpur on National Science Day

2019 Secured **First Rank** in **Science Quiz** organised by Career Point World School on National Science Day