Param Rathour

Fifth Year Electrical Undergraduate, IIT Bombay
paramrathour@iitb.ac.in paramrathour.github.io paramrathour

Education

Indian Institute of Technology Bombay, Mumbai *(Jul 2019 - Present)*
Dual Degree (B.Tech + M.Tech) in Electrical Engineering (Specialization: Control and Computing) *(CPI: 9.03/10)*
Completed a Minor in Computer Science & Engineering *(Minor CPI: 8.25/10)*
Sant Tukaram National Model School, Latur *(Jul 2017 - Apr 2019)*
Intermediate (Central Board of Secondary Education) *(Percentage: 96.6%)*
Podar International School, Latur *(Jul 2015 - Apr 2017)*
Matriculation (Central Board of Secondary Education) *(CGPA: 10/10)*

Scholastic Achievements

- Achieved a perfect **10 SPI** during the 8^{th} and 9^{th} semester at IIT Bombay with 36 and 48 credits respectively *(2023)*
- Awarded an **AP** grade for exceptional performance in the Advanced Computer Architecture course at IIT Bombay *(2023)*
- Secured **All India Rank 926** in Joint Entrance Examination (**JEE**) **Advanced** among 161 thousand candidates *(2019)*
- Secured **99.9%** percentile in Joint Entrance Examination (**JEE**) **Main** among 1.1 million candidates *(2019)*
- Scored **418** marks out of 450 in Birla Institute of Science and Technology Admission Test (**BITSAT**) *(2019)*
- Secured **99.92%** percentile in **MHT-CET** among 270 thousand candidates conducted by the Maharashtra Govt. *(2019)*

Scholarships and Recognitions

- Recipient of the National Talent Search (**NTS**) Scholarship received by the top 1000 students in the country *(2017)*
- Awarded Academic Excellence Scholarship (**AES**) by SOF given to a **single student** per class in each state *(2017)*
- Recipient of the Maharashtra Talent Search (**MTS**) Scholarship with **State Rank 11, 10,** and **16** *(2015, 2016, 2017)*

Work Experience

NVIDIA | GPU Subsystem

Guide: Raghuram L
ASIC Intern | Modeling the **NVLink** pipe ID in the GPU performance simulator *(May 2022 - Jul 2022)*

- Explored **PerfSim** building blocks, knobs, debugging, and architectural & performance testing of models in C++
- Worked on enhancing the NVLink interconnect performance model to incorporate multiple pipes per High-Speed Hub
- Integrated a 1-D arbiter class template to the NVLink performance model while thoroughly maintaining its functionality

IIT Bombay Racing | Electrical Subsystem

Faculty Advisor: Prof. Amber Shrivastava
A cross-functional team of 70+ students which designs, fabricates and assembles an Electric Race Car for Formula Student UK
First Indian team to win the Engineering Design event in the history of FSUK (4^{th} overall out of 73 international teams)
Junior Design Engineer | LV Safety Subsystem *(Sep 2020 - May 2021)*

- Simulated the LV Safety board on **LTSpice** and verified the working of RTDS, brake light, and error blocks of the subsystem
- Explored Electromagnetic Interference (**EMI**) reduction techniques to be incorporated into PCB designs of the subsystem
- **Mentored** 3 trainees in understanding the subsystem through the FS rulebook, circuit design tasks, and LTspice simulations

Trainee | Electrical Subsystem *(Jan 2020 - Aug 2020))*

- Investigated the Electronic Control Unit (**ECU**) subsystem, working with RPM and position sensors and realised the working of the steering, acceleration pedal and brake sensors of the car with **Arduino IDE** (Integrated Development Environment)
- Acquired knowledge of Controller Area Network (**CAN**) protocol & Data Acquisition (**DAQ**) system and their implementation, programmed code for wireless communication using **LPC1768 Mbed** microcontroller and **XBee** module

Research Projects

Data-Driven Control using Informativity in Presence of Adversarial Attacks *(Jul 2023 - Present)*

Guide: Prof. Debasattam Pal *(Dual Degree Project, IIT Bombay)*

- Explored the **Behavioral Approach** in control to develop suitable mathematical framework for analysing dynamical systems
- Investigated into inferring the dissipativity properties of linear systems from measured data using the **Informativity** framework
- Developing a threat model for an **adversarial attacker** and working on verifying system properties using corrupted data

Computational Commutative Algebra and Geometry *(Jul 2022 - Nov 2022)*

Guide: Prof. Debasattam Pal *(Supervised Research Exposition, IIT Bombay)*

- Investigated into the theory and computation of **Gröbner Bases** for Ideals in a polynomial ring $k[x_1, \ldots, x_n]$ over a field F
- Explored the algebraic and geometric applications of Gröbner Bases in solving Ideals, Varieties and Nullstellensatz problems
- Implemented fast solvers for system of linear & polynomial equations and Sudoku in **SageMath** using Elimination Theory

Pushdown Timed Automata: Theory and Practice *(May 2022 - Dec 2022)*

Guide: Prof. Akshay S. *(Research and Development, IIT Bombay)*

- Conceptualized modelling problems for Pushdown Timed Automata (PDTA) from Embedded Systems and WCET Benchmarks
- Conducted intensive review of various tools for the simulation and **reachability analysis** of Pushdown Automata & PDTA
- Developed methodology to extract Pushdown Systems of **Boolean** and **Remopla** programs using **Moped** Model Checker

Coded Computing for Straggler Mitigation, Security and Privacy *(Sep 2021 - Nov 2021)*

Guide: Prof. Nikhil Karamchandani *(EE605 | Error Correcting Codes)*

- Investigated polynomial coding and Lagrange Coded Computing (LCC) techniques to mitigate fundamental bottlenecks in **Large-Scale Distributed Computing** for computing matrix multiplications and evaluating arbitrary multivariate polynomials
- Explored applications of LCC in secure & private **Multi-Party Computing** (MPC) and **privacy-preserving** machine learning

Data-Driven Dynamical Systems *(Jan 2023 - May 2023)*

Guide: Prof. Vivek Borkar *(EE736 | Stochastic Optimization)*

- Reviewed the paradigms of Koopman Theory, Dynamic Mode Decomposition (**DMD**) and Extended DMD with control
- Examined the ideas for discovering governing equations from data by Sparse Identification of Nonlinear Dynamics (**SINDy**)
- Investigated Compressed Sensing and **Sparse Regression** techniques for solving the intermediate stages of SINDy

Scenario Approach to Robust Optimization *(May 2021 - Jul 2021)*

Guide: Prof. Debasish Chatterjee *(Summer Undergraduate Research Program, IIT Bombay)*

- Worked on improving scenario approach to robust optimization problems in the **moderate to high dimensional** regime
- Studied **concentration of measure** phenomenon for the analysis of randomized algorithms and the scenario approach
- Analysed various randomized algorithms like **MCMC, Propp-Wilson, simulated annealing** using Finite Markov Chains

Paper Reviews *(IIT Bombay)*

- Overview of Millimeter Wave Communications for 5^{th}-Generation Wireless Networks *(EE301 | Electromagnetic Waves)*
- Challenges for quantum-assisted machine learning in near-term quantum computers *(EE350 | Technical Communication)*

Key Projects

Intelligent and Learning Agents *(Jul 2021 - Nov 2021)*

Guide: Prof. Shivaram Kalyanakrishnan *(CS747 | Foundations of Intelligent and Learning Agents)*

- Implemented and compared ε-greedy, **UCB**, KL-UCB and Thompson Sampling for a stochastic multi-armed bandit framework
- Performed **MDP Planning** using Value Iteration, Howard's Policy Iteration and Linear Programming with **PuLP** in Python
- Propelled up a weak car placed at the bottom of a sinusoidal valley using **Sarsa** with **Tile Coding** in the **OpenAI** Gym

Efficient Cache Replacement Policy using Reinforcement Learning *(Sep 2023 - Nov 2023)*

Guide: Prof. Biswabandan Panda *(CS683 | Advanced Computer Architecture)*

- Implemented Reinforcement Learned Replacement (RLR), an eviction policy based on age, hit and type priority of cache-lines
- Designed Micro-Armed Bandit-based (MAB) replacement, utilising **temporal homogeneity** in the action space of policies
- Evaluated both policies in **ChampSim** using 49 memory intensive traces from **SPEC** 2017 benchmarks and achieved an overall IPC speedup over LRU of **5%** for RLR and **1.2%** for MAB with LRU, SHiP, SRRIP, DRRIP in its action space

Visual Learning and Recognition of 3-D Objects from Appearance *(Oct 2023 - Nov 2023)*

Guide: Prof. Ajit Rajwade *(CS663 | Fundamentals of Digital Image Processing)*

- Implemented a high-performance training and testing pipeline for object detection and pose estimation using **Python**
- Utilised Principal Component Analysis **(PCA)** and cubic interpolation to construct parametric manifolds for each object
- Conducted a comprehensive study across objects with varying complexities to determine **optimal** hyperparameter values
- Achieved an object recognition accuracy of **99.172%** and a mean pose error of **6.872**° by using the **COIL-100** dataset

Distributed Deep Learning *(Mar 2020 - Jul 2020)*

Institute Technical Summer Project (ITSP) *(Institute Technical Council, IIT Bombay)*

- Developed a Hierarchically-Distributed Deep CNN learning model for training **super-high-resolution datasets** via spatial segmentation of each sample and observed an increase in **training speed** and a decrease in **memory utilisation** per node
- Compared the performance of state-of-the-art VGG16, ResNet, and AlexNet when used as the underlying Neural Networks
- Verified the approach by using **Retinal OCT** and **CINIC-10** datasets on Kaggle attaining more than **70%** accuracy for each

Autonomous Robotic Systems and Control *(Jan 2023 - May 2023)*

Guide: Prof. Debasattam Pal *(EE615 | Control and Computing Lab)*

- Realised **path planning** and **obstacle avoidance** of autonomous mobile robots in **MATLAB** using Vector Field Histogram
- Executed **sensor fusion** using complementary and **Kalman filter** to estimate the orientation of inertial measurement units
- Implemented stabilisation of Rotary Inverted Pendulum using Swing-Up Control and **Linear-Quadratic Regulator** Control

Dining Philosophers: A Synchronisation Problem *(Jan 2022 - May 2022)*

Guide: Prof. Mythili Vutukuru *(CS347 | Operating Systems)*

- Modelled the threads by creating custom semaphores using condition variables and mutex abstractions of **pthreads** API
- Devised and implemented two solutions by using **semaphores** and **condition variables** each and proved their correctness

Cryptanalysis of Pseudorandom Generators *(Jan 2023 - May 2023)*

Guide: Prof. Virendra Sule *(EE793 | Cryptology)*

- Analysed Linear Complexity (LC) profiles of the bit multi-sequences with **3-SAT**, Quadratic Residue and Exponential Map
- Implemented reduced-**Moustique**, a self-synchronising stream cipher, achieving **almost perfect LC** profiles in **SageMath**

Tennis Scoreboard Simulator *(Jan 2021 - May 2021)*

Guide: Prof. V Raj Babu *(EE337 | Microprocessors Laboratory)*

- Simulated a **robust** tennis scoreboard using **Embedded C** in the **best-of-three tiebreak** set format on the Pt-51 board
- Displayed usage directions and the current score, Game, Set, Match Point for each player using an LCD HD44780U module
- Employed **UART** Module and **RealTerm** software for interfacing between a keyboard and **Atmel AT89C51** micro-controller

Temperature Controller Using Heating Element and PWM Control *(Jan 2022 - May 2022)*

Guide: Prof. Kushal R. Tuckley *(EE344 | Electronic Design Lab)*

- Utilised Simscape physical modelling to design, simulate and test a low-cost, easy-to-maintain and reliable food oven with the ability to maintain any temperature within the range of **90-260°C** with **1-2%** accuracy and achieve it within **2 minutes**
- Ideated a control mechanism accounting for the temperature differences, oscillations, and overheating of the furnace
- Selected suitable components for the driver circuitry, temperature sensing and interfacing by estimating thermal parameters

Two-Way Fetch Superscalar Processor *(Jan 2022 - May 2022)*

Guide: Prof. Virendra Singh *(EE739 | Processor Design)*

- Designed a **six-stage** 16-bit superscalar processor capable of handling **19** arithmetic, logical, and branching instructions
- Employed two-way instruction fetch, decode, dispatch, execute and write-back stages with **branch prediction** techniques
- Designed a **16-bit signed ALU** implementing addition using **Kogge-Stone** fast adder and verified it using Intel Quartus

Remote Control Plane *(Sep 2019 - Oct 2019)*

RC Plane Competition *(Aeromodelling Club, IIT Bombay)*

- Designed and constructed a remote-controlled trainer plane with a proper estimation of wing, body and tail dimensions
- Integrated **BLDC rotors, RF receivers** and **Servo Motors** to achieve controlled flight and maneuverability

Remote Control Obstacle Manoeuvring Bot *(Aug 2019 - Sep 2019)*

XLR8 Competition *(Electronics and Robotics Club, IIT Bombay)*

- Steered the bluetooth-controlled bot along an obstacle-ridden path using AT-tiny 2313 microcontroller, L293D motor driver

Miscellaneous Projects

DC Power Supply – Realised a regulated voltage supply of 5V, 12V and –12V using **IC 7805**, **Zener Diodes** on **PCB** *(EE113)*
Music Synthesizer – Designed an FSM to play 7 Indian music notes in a particular order with **Behavioral Style VHDL** *(EE214)*
Keyboard Scanning – Implemented **Key Debouncing** using Finite State Machine (FSM) in 8051 and MIPS Assembly *(EE309)*
Course TimeTabling – Developed an Integer Linear Program (ILP) with **Pulp** for rooms and slots allocation of courses *(CS218)*
Automatic LED Lamp – Used **Schmitt Trigger** circuit and **LDR** in conjunction with a relay interfaced with an LED *(EE113)*
Digital Counter for Object Counting – Interfaced LED-IR detector pair to 7490, 7447A and a 7-segment display *(EE113)*

Bootcamps and Workshops

Tinkering Bootcamp *(Summer 2020)*

Learner's Space (LS) *(Tinkerers' Laboratory, IIT Bombay)*

Self Irrigation System

- Developed using **Arduino IDE** to toggle between ON and OFF state according to readings from **DHT1** humidity sensor
- Provided **manual control** and **monitoring** through **Google Assistant** by projecting real-time data to **Blynk** servers

Intruder Detection Alarm

- Developed an intruder detection system using a Passive Infrared **(PIR)** sensor which uses a buzzer module for alarm

Corona Cases Tracker

- **Automated** daily fetching of count of corona cases in India from the official website using **ESP32** and **ThingHTTP**

Harry Potter's Invisibility Cloak

- Simulated live **removal of foreground** of range of colours from a webcam using **OpenCV** to create a transparency effect

Data Analytics Bootcamp *(Summer 2020)*

Learner's Space (LS) *(Analytics Club, IIT Bombay)*

- Utilised **Pandas** and **seaborn** for loading, cleaning, manipulating, analysing, visualising datasets and model development
- Investigated **scikit-learn** for machine learning algorithms and statistical techniques to make and evaluate predictions
- Explored the statistical techniques in Data Wrangling, Exploratory Data Analysis, Model Development and Model Evaluation

Quantum Computing *(Summer 2020)*

10-day Workshop *(Maths and Physics Club, IIT Bombay)*

- Designed quantum circuits and implemented teleporation of information & entangled pairs using qubits in **Qiskit** by IBM
- Developed Hands-on experience with designing quantum circuits and implementing diverse operations using quantum gates
- Implemented **Deutsch-Jozsa**, Grover's algorithm, Quantum Fourier Transform and **BB84** Protocol for secure communication

Scientific Computation and Mathematical Modelling in Python *(Summer 2020)*

Learner's Space (LS) *(Maths and Physics Club, IIT Bombay)*

- Simulated mathematical models for heat transfer, predator-prey, epidemiology and economy using SciPy's **odeint** solver
- Animated cellular automaton such as **Game of Life** and **Langton's Ant** using **FuncAnimation** provided by Matplotlib

Positions of Responsibility

Teaching Assistant | IIT Bombay

Computer Programming and Utilisation | CS101 *(Autumn 2020, Autumn 2021, Spring 2022, Autumn 2022)*

- Academically guided **50** students and cleared their doubts through weekly doubt sessions, labs and personal interaction
- Prepared and evaluated examinations & lab problems and conducted Hindi help sessions for students facing language barriers
- Brainstormed **60+ practice problems** for CS101, shared via a personal **webpage** with tips and resources to boost interest

Multivariable Control | EE640 *(Autumn 2023)*

- Academically guided **40+** students, clearing their doubts through tutorials and assisting the instructor in course evaluation

Mentor | Summer of Science *(Summer 2021, Summer 2022, Summer 2023)*

Topics: Linear Algebra, Data Structures and Algorithms, Cryptography, Reinforcement Learning *(Maths and Physics Club, IIT Bombay)*

- Mentored **six students** in exploring the subject and guided them through interesting resources of their respective topic
- Checked their progress regularly, personally cleared their doubts, reviewed and evaluated their reports and presentations

Editor | Department Newsletter Team *(2020)*

Background Hum: Team of 20 enthusiastic students *(Electrical Engineering Student Association, IIT Bombay)*

- Ideated and worked on an overview of **exciting labs** in the department to increase their awareness in the student community
- Prepared **content recommendations** of scientific and engineering marvels to inspire curiosity among the readers

Technical Skills

Languages	C, C++, Python, Julia, MATLAB, Scilab, LaTeX, HTML, CSS, SQL, Embedded C, VHDL, MIPS, 8086
Frameworks	Git, Docker, SageMath, Qiskit, NumPy, SciPy, pandas, scikit-learn, OpenCV, TensorFlow, Keras, Jekyll
Software	Simulink, EAGLE, SPICE, Intel Quartus, Keil μVision, GNURadio, Adobe Illustrator, SOLIDWORKS

Key Courses Undertaken

Electrical	Advanced Computer Architechture, Digital Systems, Signal Processing, Information Theory and Coding
Control Systems	Nonlinear Dynamical Systems, Multivariable Control, Optimal Control, Behavioral Theory of Systems
Computer Science	Data Structures and Algorithms, Design of Algorithms, Operating Systems, Computer Networks, Digital Image Processing, Intelligent and Learning Agents, Formal Methods in Machine Learning
Mathematics	Calculus, Complex Analysis, Differential Equations, Linear Agebra, Large Sparse Matrix Computations, Logic for Computer Science, Discrete Structures, Number Theory, Topics in Cryptology, Game Theory and Mechanism Design, Probability and Random Processes, Stochastic Optimisation

Extracurriculars

Technical	• Qualified Round 1 of **Mathathon** conducted by Maths and Physics (MnP) Club, IIT Bombay *(2021)* • Completed Summer of Science in **Nonlinear Dynamics** and **Game Theory** by MnP Club *(2020, 2021)*
Volunteering	• Conducted an institute-wide **Computer Programming** session (TSC) attended by 100+ students for discussing doubts and previous year papers, organized by the Student Support Services *(2022)* • Contributed to Career Counselling Campaign and A Session on Climate Change for **12,000+** indigent students conducted by **Abhyuday** in association with **NCC** across **80+** schools in Mumbai *(2019)* • **Mentored** students appearing for JEE during **COVID-19** crisis as a part of **CovEd Education** *(2020)*
Sports	• Secured 2nd runner-up in the **Inter-IIT Scrabble** League representing the IIT Bombay contigent *(2020)* • Part of the **Inter-Department E-Sports** Fest winning squad representing the **Smashkarts** team *(2022)* • Awarded the title of **Best Smashkarts Player** by Electrical Engineering Students Association *(2022)* • Represented IIT Bombay in **Inter-College Cricket** Competition organised by NCC, IIT Bombay *(2019)*
NCC	• Completed a year-long **training program** as **NCC Cadet** under 2 MER NCC at IIT Bombay *(2019)* • Attended a ten-day-long **Annual Training Camp** (ATC) organised by NCC, IIT Bombay *(2019)* • Part of **Republic Day Parade** Contingent held on 26th January 2020 at IIT Bombay Gymkhana *(2020)*
Culturals	• Participated in **Group Act Competition**, Cultural GC organised by NCC IIT Bombay *(2019)* • Studied **Beginner Music Theory** as a part of Summer School of Cult conducted by ICC *(2020)*