# Parth **Pujari**

## Interests

Algorithms, Machine Learning, Computer Architecture, Discrete Structures, Group Theory, Music

## Education

**Indian Institute of Technology, Bombay** - *India* (2021-2025)
Bachelor of Technology - Computer Science & Engineering    **CPI: *9.0/10* (equivalent to *4.5/5* GPA)**
**Minor** in Machine Intelligence and Data Science

## Publications (Ongoing)

Amit Sethi and Parth Pujari, **"The Modification of the A* algorithm with Reeds Shepp curves"**: link

## Achievements and Honors

**JEE (Advanced)** - Joint Entrance Examination for admission into Indian Institutes of Technology. (2021)
Secured a nationwide rank of **537** out of more than **100,000** students.

Attained a percentile of 99.75 in the **JEE Main** examination out of 0.9 million candidates. (2021)

Awarded **Branch Change** to Computer Science and Engg. (17 in 1400) for academic excellence. (2022)

Stood in the top **1 percentile** in the **BITSAT** examination out of over **300,000** students (2021)

## Projects

### AI and Data Science

**Autonomous Vehicle : SeDriCa** - under **Innovation Cell, IIT Bombay** | GitHub (2022)
- Working in the **Motion planning** and **Computer Vision** subsystem under the Self Driving Car team, UMIC
- Formulated a pipeline to develop a path planning algorithm improving upon **Hybrid $A^*$**.
- Wrote and implemented models on **road segmentation** and **object detection** using OpenCV & TensorFlow
- Researched on **Model Predictive Control** systems and other Optimization Models on kinematic vehicles
- Implemented Dynamic Window Planning models to simulate real time collision avoidance.

**Stable Diffusion** - *Ongoing Project - Seasons of Code, WnCC |* (2023-present)
- Researching **NLP models**, text encoders, **GANs**, Variational autoencoders and Attention models
- Implementing Resnet model in Pytorch from scratch and applying the resnet50 model to classify Pokemons
- Working on high resolution image synthesis models using latent **diffusion models** in **PyTorch** link
- Implementing the paper on **Denoising Diffusion Probabilistic models** link

**Reinforcement Learning** - *Ongoing Project - Seasons of Code, WnCC |* GitHub (2023-present)
- Studying Deep Reinforcement Learning (referencing Grokking Deep Reinforcement Learning)
- Researching on **Monte Carlo** methods to program RL models to play games like Tic Tac Toe and Snake
- Researching on **Temporal Difference Learning**, **Q-Learning** and Eligibility Traces
- Studying tabular methods and **Deep Q Network** models to play **Atari** games in the Open AI gymnasium
- Studying approximate solution methods and coding up an RL based Chess Engine

**Deep Learning Biology Models** - *iSURP-Prof. Venkatesh K.V. |* GitHub (2022)
- Utilised meta data and developed classification models for hypertension detection in adolescents
- Utilised multilayer perceptrons, LASSO regression and random forest classification models for the same
- Researched on CNNs, NLP and video feature encoding techniques on autism screening using video analysis
- Achieved accuracy of 86% on hypertension detection and autism screening on adolescents

**Generating Representative Images via PCA** - *Data Analysis*, **IIT Bombay** | GitHub (2022)
- Used MATLAB to implement a program that used a dataset of images of various fruits and using **Principal Component Analysis** (PCA), sampled random images to generate new, representative images of fruits.
- Analysed handwritten digit images from the **MNIST** Database and optimally reduced their dimensionality.

## Algorithm Design

**Hybrid A\* algorithm** - under **Innovation Cell, IIT Bombay** | GitHub                    (2023)
● Formulated a novel pipeline to develop a path planning algorithm based on **Reeds Shepp and Dubin's curves** in C++ using Pontryagin's Minimum Principle and implemented it on the **Robot Operating System**
● Modified the A\* path finding algorithm, modifying its heuristic and using a tree structure to create self branching paths
● Used self branching paths to allow it to operate on continuous space and provide **holonomic** pathways in unstructured environments and improving its time complexity
● Implemented **C∞**, **clothoid spiral** based smoothening and **numerical optimisation** on the generated paths to make them feasible for vehicles with minimum turning radii and constraints on angular accelerations

**Railway Planner** - course Project | *Data Structures*, **IIT Bombay**                    (2022)
● Developed a large Railway Planner in C++ using algorithms such as Merge Sort, KMP and Quicksort.
● Utilised Data Structures such as AVL Trees, Hash tables, Tries and Priority queues to handle large data.
● Utilized modified **Dijkstras**, **spanning tree**, **Bellman Ford**, **Kosaraju's**, **Ford Fulkerson's** and other algorithms to plan efficient journies based on user preference
● Included features like adding journeys, reviews, search engine features like auto completion and ratings.

## Computer Architecture

**Branch Predictors in Graph Analytics** - | *Computer Arch.* **IIT Bombay** | GitHub                    (present)
● Implementing the **Tagged Geometric Length Predictor** (TAGE) and the **L-TAGE** branch predictor on the **ChampSim** simulator based on a paper by INRIA : link
● Comparing its results with the hashed perceptron branch predictors on standard graph algorithm traces like connected components, single source shortest path problems, page rank, BFS, etc.
● Improving bad speculation, specific cases of branch mispredictions, instructions per cycle, etc. using optimizations in the TAGE predictor.

**Data Prefetching & Cache Replacement Policies** - | *Computer Arch.* **IIT Bombay** | GitHub                    (2023)
● Implemented simulations in C++ of a **best offset data prefetcher** at the L2 cache level on the simulation software **ChampSim** based on the research paper by IRISA, INRIA and HIPEAC : link
● Tested the prefetcher on various program traces including the ones tested in the research paper (with similar results) and obtained significant improvement in prefetched miss rates and instuctions per cycle rates
● Simulated cache coherence and bus interconnection mechanisms like the **MSI** protocol
● Implemented cache replacement policies such as the least recently used, least frequently used, first in first out and random eviction and compared them analytically on various traces

**Assembly Programming** - | *Computer Arch.* **IIT Bombay** | GitHub                    (2023)
● Wrote assembly level (**MIPS-32** and **X86**) programs on algorithms such as *inplace iterative mergesort*, matrix multiplication and the extended Euclids algorithm
● Optimized the code by finding hotspot functions, bad speculation, cache bounds, etc. on **Intel VTune**
● Reverse engineered binaries and obtained data on branch predictors, random number generators, etc.

## Networks and Game Development

**FastChat** - *Software Systems*, **IIT Bombay** | GitHub                    (2022)
● Built a network of TCP/IP clients interacting through servers as mediators using **Python socket** libraries.
● Obtained high throughput using load balancing servers while ensuring low latency of individual messages.
● Ensured end to end encryption using **RSA and AES** encryption libraries and PostgreSQL server databases

**CodeWars-v3** - *WnCC*, **IIT Bombay** | GitHub                    (2023)
● Developed the backend of a multiplayer strategy game in C++ that runs on automated scripts
● Utilised the **C++ Boost** libraries for socket communication and SFML libraries for graphic integration
● Developed optimized multithreaded asynchronous servers to reduce latency

## Positions of Responsibility

### Insitute Web and Coding Club Convener (2022-2023)

- Worked in a team of 10 to organise 40+ events catering to the programming interests of 10K+ students
- Coded and hosted the hackathon - **CodeWars-v3** which received a participation of over 1000 students
- Conducted events on Google's Summer of Code to promote Open Source Softwares
- Organised and mentored workshops on Git and Github and created open source repositories under Hacktober Fest, moderating 30+ repositories

## Teaching and Mentoring

**Teaching Assistant** - | *Computer Architecture and Lab* | **Prof. Biswabandan Panda** (Autumn 2023)

- Teaching assistant for second year computer science students responsible for designing laboratory assignments, autograders and mentoring students in assembly, **VHDL** and **ChampSim**

**Computer Architecture** - | *Summer of Science* **IIT Bombay** (2023)

- Mentoring a select group of students on **Computer Architecture**, specifically CPU design
- Covering topics from michroarchitecture of a single cycle CPU to pipelined architecture, control and data hazards, branch prediction, cache hierarchy and prefetching
- Further including cache coherence, superscalar and O3 processors, multithreading, speculative execution and DRAM organization

**Videogame Physics Engine** - | *Summer of Code* **IIT Bombay** | GitHub (2023)

- Mentoring a select group of 8 students along with 3 co-mentors in a 3 month long project in game physics engine development and graphics implementation using **OpenGL**
- The project involves implementing broadphase **collision detection** and **collision resolution** algorithms
- Creating a game involving **randomized** world generation based **proximity graphs** and game laws
- Further integrating the game with **OpenGL** and the broadphase system, calculating convex hulls, developing wrappers for graphic libraries and merging the game with a larger project on game development

**Web Development** - | *Web and Coding Club* **IIT Bombay** | GitHub (2022)

- Prepared and moderated a course with over 500 mentees for the Institute's Technical Summer School's Learner's Space programme on An Introduction to Web Development using **React JS and Next JS**
- Inlcuded an in depth view of HTML, CSS, JavaScript, Bootstrap, Tailwind, React JS, React components, pure components and the use of **vite** to create apps, building towards a project on a storage inventory portal
- Researched on and covered **React States**, lifecycles, hooks, the **Recoil JS library**, the use of **Next JS**

## Relevant Courses

**CS** - Design and Analysis of Algorithms, Digital Logic Design and Architecture, Formal Methods and Logic for CS, Discrete Structures, Software Systems, Computer Networks, Operating Systems, Compilers
**Maths** - Linear Algebra, Optimization Models, Calculus, Differential Equations
**Physics** - Quantum Physics, Fundamentals of Electromagnetism, Quantum Chemistry

## Skills

**Programming** C, C++, Java, Python, Bash, MATLAB, MySQL, PostgreSQL, AWK, Sed
**Development** HTML, CSS, JavaScript, JQuery, Bootstrap, Angular, Django
**Data Science** PyTorch, Pandas, NumPy, Scikit-learn, Scipy, Matplotlib, TensorFlow
**Tools** Git, Robot Operating System (ROS), LaTeX, SolidWorks, AutoCAD, Doxygen, Sphinx

## Others

**International Rank 1** in Sangeet Visharad for proficiency in singing out of over **100,000** candidates (2019)
Mentoring selected experienced pianists in the **Advanced Music Learning Program 2023** (2023)
Worked as a professional classical musician at the **All India Radio for 4 years** (2016-2019)
Played basketball at the inter-school level from grades 8 to 10 for St. Mary's School, Pune