Ajinkya Pawar

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"Innovation begins where convention ends."

RESEARCH INTERESTS

Autonomous Systems, Aerial Robotics, Learning-Based Control, Motion Planning, Computer Vision, Deep Learning

EDUCATION

Indian Institute of Technology Bombay [2022 - 2026]

Bachelor of Technology in Metallurgical Engineering & Materials Science Cumulative GPA: **8.28 / 10**

- Pursuing a Minor in Artificial Intelligence and Data Science from Centre for Machine Intelligence and Data Science

PUBLICATIONS

- Coauthored "IIT Bombay Racing Driverless: **Autonomous Driving** Stack for Formula Student AI," focusing on perception, SLAM, path planning and controls development of an autonomous racecar (link)

RESEARCH EXPERIENCE

Clutter Removal using Transformer-based Push Prediction [April '25 - July '25]

Robotics Research Intern | Guide: Prof. Jingjin Yu, ARC Lab, Computer Science, Rutgers-New Brunswick (Demo)

- Preparing two manuscripts for submission to **IEEE Robotics and Automation Letters (RA-L)**: one on **Transformer-based Push Prediction** and the other on **Reinforcement Learning Push Policy** for clutter removal & manipulation
- Replaced the MLP-based push interaction prediction architecture with a **Transformer model**, improving accuracy by over **40%** and enabling robust generalization to diverse cluttered scenes with **variable object configurations**
- Developed a **baseline spiral push policy** to enable efficient obstacle clearance and target retrieval, rigorously validated through extensive simulations in **Isaac Gym** and real-world experiments for performance benchmarking
- Performed extensive **hyperparameter tuning** and ablation studies to evaluate architecture design choices
- Explored **reinforcement learning** approaches for decluttering through end-to-end simulation-trained push policies
- Gained hands-on experience with **6-DoF UR5e** robot, deepening understanding of learning-based control methods

Contact Force Control of Quadcopter-Mounted Aerial Manipulators [Jan '25 - Present]

Undergraduate Thesis | Guide: Prof. Vivek Sangwan, INDUS Lab, Mechanical Engineering, IIT Bombay

- Development and control of an autonomous quadcopter with an under-actuated linked manipulator using ArduPilot
- Achieved < **2%** steady-state error and < **5s** settling time using precise **PID** tuning for hover and helical trajectories
- Optimized controller gains via MATLAB / Gazebo simulations for outer-loop control with **10x** faster attitude inner-loop
- Implemented **3D path planning** for drones using **splines**, optimizing trajectory generation in complex environments
- Utilized **VICON** camera motion capture system for high-accuracy indoor localization, crucial for autonomous flight
- Redesigned quadcopter chassis using **lightweight carbon-fiber** composites, decreasing the total weight by **10%** and removing vibration-induced noise, which directly enhanced flight stability and **improved sensor data accuracy**
- Implementing end-effector **contact force control** for unmanned applications in disaster management, debris removal, door / window opening in fire or emergency situations and painting / window cleaning in high rise buildings

Numerical Solver for the Kronig-Penney Model in 2D and 3D [Jan '25- May '25]

Semester Research Project | Guide: Prof. Triratna Muneshwar, Materials Science, IIT Bombay

- Developed an efficient **numerical solver** for the 1D Kronig–Penney model to compute electronic band structures
- Extended and optimized the formulation to 2D and 3D using **finite-difference discretization** & eigenvalue methods
- Implemented detailed simulations in **Python/MATLAB** for band gap visualization and parameter sensitivity analysis
- Validated results with analytical models, demonstrating strong **computational and quantitative modeling** skills

ACHIEVEMENTS

- Represented the **1st and only Indian contingent** at Formula Student AI '24, United Kingdom for autonomous racing
- Secured All India Rank 3019 in JEE Advanced (150k candidates) & Rank 5130 in JEE Mains (1 Million+ candidates)
- Achieved **20+ AAs/ABs** (top 15%) across **43 courses**, including **Machine Learning**, **AI & Data Science**

TECHNICAL HIGHLIGHT - AUTONOMOUS RACING

Chief Autonomous Systems Officer & Deputy Team Leader | IITB Racing [Mar '23 - Present]

Formula Student Racing Team | Guide: Prof. Archak Mittal, Civil Engineering, IIT Bombay *(Research Paper)*

Leading the **Level 4 autonomous vehicle** division in a team of **100+** students representing **India** as the **1st** and **only** Indian self-driving EV racecar contingent among **80+** teams at IMechE Formula Student AI, United Kingdom

Impact and Accolades

- Responsible for **India's 1st autonomous EV racecar** integrated with vision, SLAM, path planning and controls
- Secured **4th place** among 25 teams in the Formula Student AI '25 competition, a 7-place jump from previous year
- Won the **3rd prize in Real World Artificial Intelligence** for global AV sector analysis at Formula Student AI '23
- Stood **Top 5** in Simulation Development and Business Plan Presentation at Formula Student AI '24 (DDT)
- Achieved **Overall Winner** (Formula Bharat '24), Ather Energy **System Intelligence** award (Formula Bharat '22)
- Won a cash prize from **Jaguar Land Rover** for pioneering self-driving research & development in electric race-cars

Robotics and Controls

- Designed and implemented a **Nonlinear Model Predictive Controller (NMPC)** using a **dynamic bicycle model** to minimize lap time, achieving a **15% performance gain** through optimal path following and velocity management
- Built high-fidelity **CARLA–Unreal Engine** simulation environment for testing and validation of the autonomous stack
- Developed a **path planning framework** combining **Delaunay Triangulation** for visibility graph generation with **RRT*** for trajectory planning, enabling **real-time adaptability** to dynamic tracks with minimal path deviation
- Reduced cross-track error by **16%** by tuning non-linear **pure pursuit controller** and validating across 60+ scenarios
- Built a **ROS-integrated stack** on **Linux** with sensor fusion (LiDAR, Camera, IMU) for robust state estimation
- Built a **1/6th scale driverless racecar prototype** integrating an **STM32** microcontroller with **CAN communication**

Computer Vision

- Achieved **22% higher** accuracy by developing a novel depth estimation deep neural network for monocular-vision
- Reduced object detection and classification latency from **100ms to 7ms** with a C++ **TensorRT** engine for **YOLOv5**
- Implemented LiDAR based perception with ground removal, DBSCAN clustering and Camera-LiDAR transformation

PROFESSIONAL EXPERIENCE

Freelance Teacher [Jan '23 - Apr '25]

Instructed diverse students (ages 15-17), including international students, in Physics and Chemistry for various exams

- Tutored **400+** students in Masterclass, a coaching class based in Mumbai, preparing for examinations like **JEE/NEET**
- Designed & delivered **comprehensive lesson plans**, catering to various learning styles and academic backgrounds
- Adapted teaching methods for **international students**, facilitating effective cross-cultural communication
- Employed **innovative techniques**, **interactive demos**, and real-world applications to simplify the complex subjects

KEY PROJECTS

StarTrack : Arduino-based Star Tracker [Feb '25 - Apr '25]

Robotics Course Project | Guide: Prof. Abhishek Gupta, Mechanical Engineering, IIT Bombay *(Prototype)*

- Led a team of six to develop a **dual-axis** robotic star tracker for automated celestial alignment and sidereal tracking
- Built 2-axis equatorial mount using **Arduino, RTC**, and stepper motors with **gyro-based** feedback for stable pointing
- Designed a compact **actuation system** with **3D-printed** gears and firmware for **real-time tracking** and correction
- Implemented automated calibration routines, improving **tracking precision** under environmental disturbances

Segmentation-based Bokeh [Aug '24 - Nov '24]

Image Processing Course Project | Guide: Prof. Abir De, Computer Science & Engineering, IIT Bombay (Report)

- Implemented real-time **semantic segmentation** with **DeepLabV3** to accurately isolate human face in video streams
- Applied **Gaussian blur** and **alpha matting** for natural **bokeh effect** for improving the image quality and transitions
- Evaluated the model accuracy using **IoU, Pixel Accuracy** and **F1 Score metrics**, achieving up to **96% precision**
- Integrated **TensorRT for GPU optimization**, thus reducing the latency and **enhancing real-time segmentation**

Architectural Design Optimization [Jan '24 - Apr '24]

Data Science Project | Guide: Prof. Vinay Kulkarni, CMInDS, IIT Bombay *(Report)*

- Applied advanced clustering and image **data mining** techniques to optimize architectural design processes
- Conducted **data analysis** & **feature engineering** on 1183 building layout images using complex **OpenCV** functions
- Employed **K-Means & CNN** clustering to identify design families & classified layout complexity into **three** categories
- Developed a robust system with **95% accuracy** to **predict the relevant design families** based on three parameters

Ping Pong Juggling Robot [Aug '23 - Nov '23]

Robotics Course Project | Guide: Prof. Tanushree Chaudhary, Materials Science, IIT Bombay

- Designed and developed an Automatic Ping Pong Juggling robot by leading a team of four members
- Engineered and programmed a Ping Pong Juggling Robot using **Arduino UNO**, using advanced **C++** scripts
- Implemented a sophisticated **PID controller** to achieve precise control of the robot's movements during ball juggling
- Integrated a **microphone sensor** to precisely locate the ping pong ball in real time within the robot's system

POSITION OF RESPONSIBILITY

Marketing Coordinator [May '23 - Nov '23]

The Entrepreneurship Cell, IIT Bombay

- Approached **5000+** marketing executives from more than **100** companies to secure essential sponsorships for **Eureka!**, **Asia's largest** student-run business model competition, boasting an impressive 15,000+ registrations yearly
- Ideated and executed **10+** innovative publicity campaigns to significantly increase registrations for **Eureka!** by **25%**
- Served as the **first point of contact** for sponsorship negotiation and partnership development with many companies

Web Coordinator [May '23 - Nov '23]

The Entrepreneurship Cell, IIT Bombay

- Created a web portal for conduction of **Eureka!** among **15k** participants using **Django** and **Angular Framework**
- Utilized **Angular** features like **components, routing, and services** to create a highly responsive web application

SKILLS

- **Programming Languages** : Python, C, C++, Java, JSON, HTML, LaTeX, JavaScript, Excel, 8085 Assembly
- **Packages/Libraries** : PyTorch, Pandas, TensorRT, Keras, Numpy, OpenCV, PyGame, SciPy, Casadi
- **Frameworks** : ROS, GitHub, CUDA, mavros, Pixhawk, Django, Angular
- **Languages** : English, Hindi, Marathi, Sanskrit

RELEVANT COURSES

Robotics	Robotics, Makerspace, Microprocessors & Automatic Controls
ML & Computer Vision	Introduction to Machine Learning, Machine Learning - Principles & Techniques, Principles of Satellite Image Processing, Computer Graphics, AI and Data Science, Programming for Data Science, Computer Programming and Utilization
Mathematics	Numerical Methods, Linear Algebra, Calculus

EXTRA-CURRICULAR ACTIVITIES

- Mentored and Tutored **Physics and Chemistry** to various **NGO** kids for their different examinations under **NSS**
- Mentored **20+** students from **class XII** who qualified **JEE Advanced** examination by helping them with their issues
- Received **Scientist of The Year** Award in school for extracting DNA of Banana and observing it under microscope
- Received **2nd** Prize in inter-school Science Exhibition for successfully manufacturing an enzyme from wet garbage

* Text in bright blue contains embedded links for proofs