Prachit Gupta

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EDUCATION

Indian Institute of Technology Bombay   Mumbai, India
B.Tech. in Mechanical Engineering; GPA: 3.67/4.0   *Nov 2021 – May 2025 (Expected)*
Minor Degree in Systems and Controls   *July 2022 – May 2025 (Expected)*

The Shishukunj International School   Indore, India
Intermediate; GPA: 99.2/100   *July 2021*

The Shishukunj International School   Indore, India
Matriculation; GPA: 96.5/100   *June 2019*

RESEARCH INTEREST

Safety-critical Control, Robotics, Control theory, Optimal control, Multi-agent control, Game theory, Distributive optimization, Learning-based control, Reinforcement Learning, Unmanned Aerial Systems, Quadrupeds, Mobile robotics

AWARDS & ACHIEVEMENTS

- Awarded **fellowship** by **Canadian** Government to pursue research at Queens University, Kingston   *('21)*
- Qualified as a **KVPY** Fellow and finished among **top 3 %** of applicants from a pool of **97000+** candidates   *('21)*
- Secured All India Rank **917** out of **150,000+** candidates in the **JEE Advanced** Exam   *('21)*
- Secured All India Rank **388** in **Joint Entrance Exam Mains** among over **1.4 million** applicants   *('21)*

RESEARCH EXPERIENCE

Advanced Safety and Control Systems for Autonomous Vehicles ⭕   IIT Bombay, India
Dept. of Systems and Control Engineering | Advisor: Prof. Arpita Sinha   *July 2023 – March 2023*

- Developed a **safety verification system** for autonomous cars using **forward reachability**, ensuring collision-free navigation and generating optimized emergency trajectories using **convex optimization** in **CVXPY**
- Computed **avoid sets** for AVs, realized as the viscosity solution of the **Hamilton-Jacobi PDE** for safe **robot-human interactions**, using the **helperOc** package for **dynamic programming** and optimal controls.
- Integrated reachability-based safety guarantees into a **Model Predictive Controller** for overtaking maneuvers of autonomous vehicles, modeled as a **zero-sum differential game** between the ego and a human lead vehicle.

Safewalk Robotics ⭕   Queen's University, Canada
Dept. of Electrical and Computer Engineering | Advisor: Prof. Matthew Pan   *May 24- July 24*

- Developed **ROS** controllers for detection based dynamic object following on **Quadruped Unitree GO1**.
- Crafted **human-following** algorithms based on skeletal detection in **ROS2** for **Turtlebot4** using RGBD cameras
- Implemented **SLAM** and **Follow the Gap** based object avoidance using ROS2 and **NAV2** for indoor navigation.
- Designed a hybrid **SL-based RL policy** framework for person-following robots in outdoor environments, robust to occlusions, and detection inaccuracies by training **deep neural networks** on a custom expanded dataset.

Multi-Agent Control with Safety Guarantees ⭕   IIT Bombay, India
Dept. of Systems and Control Engineering | Advisor: Prof. Mayank Barnwal   *Aug '24 - Present*

- Developed decentralized neural networks in **PyTorch** to ensure **safe multi-agent** control across varying scales.
- Jointly trained control policies and **barrier functions**, enhancing safety and scalability in complex environments.
- Leveraged **Large Language Models** (LLMs) to intuitively and effectively optimize **Reinforcement Learning** (RL) reward functions for **Deep -Q-Network** agents in an Intelligent driving scenario in a **human-centric** way.

Communication and Control of Autonomous Drones   IIT Bombay, India
Dept. of Aerospace Engineering | Advisor: Prof. Dhwanil shukla   *Feb '22 - Dec' 22*

- **Senior Avionics Engineer** responsible for conducting state-of-the-art research to achieve full aerial autonomy.
- Employed wind data for **barometric compensation**, ensuring stable altitude and preventing sudden drops.
- Customized the **Ardupilot's** autopilot codebase to develop a custom mode enabling immediate motor shutdown.
- Developed **Minimum Snap** trajectories with optimized time segments using **constrained quadratic programming**

PROJECTS

Unmanned Aerial System Competition (UAS) 2023, UK 📄   Feb '23 - Jun '22
- Achieved outstanding results, winning 3 awards: **Best Design**; **Scrutineering Award** for meeting supportability goals; **Advancement Award** for highest score among newcomers at Buckminster, UK
- Designed a **7 kg drone** for relief operations, capable of lifting 150,000 of payload & a flight of **20+ min**.
- Leveraged **Lua Scripting**, **Pymavlink**, and **RPI GPIO** interfaces for safe and reliable payload drop actuation
- Simulated the complete mission in **Gazebo** environment using **ROS** with **ArduPilot** as the flight control stack.
- Tested additional **safety features** like datalink loss, GC Fail Safe, and geo-fencing of autopilot for high-speed

International Aerial Robotics Competition (IARC), Norway ▶   Aug '22 - Oct '22
- Recognized by the organizers with **Special Mention** for the concept of a system of mother and daughter drone.
- Manufactured and assembled a **15kg** payload drone, Audrey, sized 2m x 2m with **Xavier NX** onboard computer
- Engineered the entire circuitry and developed C code for an autonomous replacement and gripper assembly
- Designed and successfully fabricated a **custom PCB** board using **EAGLE** software to ensure compact circuitry

Estimation on Lie Groups 🔗   Jan '24 - Apr '24
- Derived spacecraft attitude estimators and observers using **Wahba**, **Quest**, **Triad** and **Kalman filter** algorithm.
- Authored a review paper on a Model Predictive Tracking Control for Invariant Systems on Matrix **Lie Groups**, utilizing **stable embedding** into Euclidean spaces combining manifold-based motion description with **MPC constraint handling**.

UAV Control 📄   Apr '23 - May '23
- Implemented and tuned **Control-Lyapunov** function-based Non-linear **Backstepping coupled Sliding Mode Controller** for better tracking and robust performance against disturbances and changing parameters
- Achieved stable tracking even with an additional **45%** uncertainty in rotary inertia and disturbances.
- Modelled lateral and longitudinal autopilots for a model of **Fixed-wing** aircraft in **Matlab** using **Simulink**.

Inverted Pendulum   Sep '24 - Nov '24
- Developed a framework to swing up and balance an inverted pendulum using **energy-based nonlinear** control.
- Designed a **state-feedback** control system to balance the pendulum at its vertical upward position using **LQR**.
- Implemented **LQR-based** swing-up strategy for **cart-pole** system, achieving stabilization from downward to upward position in **4 seconds**.

Soft Robotic Gripper 🔗   Sep '24 - Nov '24
- Developed a **soft robotic** compliant two-finger gripper mechanism for high **adaptability** and gentle gripping.
- Implemented a mechanism for adaptive handling of food items using **topological** and **shape optimization**.
- Designed a **3-DOF robotic arm** using servo motors and a solenoid actuator to demonstrate gripper's efficacy.

Taxi Route Optimization   Jan '24 - Apr '24
- Achieved **90%** cab-to-customer allocation of multi-depot problem by optimizing dispatch strategies.
- Enhanced the dispatch algorithm using a profit function that balanced number of cabs and customer waiting times
- Modelled the capacitated open **vehicle routing** with Pulp, using **MTZ constraints**, and **OpenStreetMap** for visualisation.

Bubble Trouble 🔗   Dec '24
- Developed a single-player bubble shooter game in **C++** with **event-handling**, headers, structures, **classes**, and Standard Template Libraries features such as vectors, arrays, and XEvent, utilizing SimpleCPP packages.
- Enhanced gaming experience with **interactive features** like scoring, timer, health bar and dynamically varying bubble sizes.

Pharma Bot   Aug '22 - Nov '22
- Cleared stage 1 of eyantra robotics competition (eYRC), ranked in **top 10** in Task 2 among **3000+** teams.
- Designed algorithm for lane detection, guidance, and QR code encryption using **OpenCV, Pyzbar** & Python
- Deployed algorithm for autonomous medicine delivery robot and showcasing results in **CoppeliaSim** virtual environment

Object Detection and Tracking using YOLO   Jan '23
- Achieved a **10%** performance improvement in object detection model via image augmentation and preprocessing
- Trained **YOLOv4** on the COCO dataset to achieve **98% accuracy** in person, vehicle, and object detection

Autonomous Maze Solver   Mar '22 - Jun '22
- Ideated and Developed **CAD** assembly of a **wall climbing bot** with a rocker-bogie like mechanism and a servo gripper to autonomously navigate, locate, and pick colored balls in a given arena using **Solidworks**.
- Crafted python scripts for implementing **bug0, bug1** and obstacle avoidance algorithms using **ROS** and Gazebo.

Mentorship and Teaching Experience

Technical Advisor Team Aerove 🌐   April 2023 − Present
UMIC aims to facilitate technical start-ups and foster an atmosphere of innovation.
Recruited and mentored new members in foundational robotics tools and algorithms
Led training sessions for 15 new recruits in ROS, OpenCV, and drone building.

Solve for society   Dec 2023 − Jan 2023
Led projects in Solve-For-Society by Amazon's Innovation Story Foundation.
Guided teams from underprivileged schools to create solutions for people with disabilities

Technical Skills

Programming: C/C++, Python, Arduino, Matlab, Lua, URDF, Xacro

Software Tools: ROS, ROS2, Git, MATLAB, Simulink, Solidworks, Eagle, Gazebo, Arduino, QGC, Mission Planner, CoppeliaSim, X-Plane, Rviz, Mavros, Ardupilot, PX4 LaTeX

Frameworks: Gymnasium, TIVA, Mavros, OpenCv, Scikit-learn, Numpy, Matplotlib, helperOc, CVXPY, CasADI

Relevant Coursework

Core: Engineering Mechanics, Solid Mechanics, Fluid Mechanics, Basic Thermodynamics Structural Materials, Mechanical Measurements, Manufacturing Processes, *Heat Transfer

Systems and Controls: Guidance & Control of UAVs, Signals and Feedback Systems, Linear and Nonlinear Systems, Microprocessors and Automation, *Random Processes in Learning and Control, Mathematical Structures for Control

Math and Computing: *Games and Information, Estimation on Lie Groups, Introduction to Numerical Analysis, Linear Algebra, Differential Equations, Introduction to Machine Learning, Operations Modeling

Hands-on Courses: Microprocessors and Automatic Control Lab, Mechanical Measurements, Kinematics and Dynamics of Machines, Manufacturing Processes Lab, *Design of Mechatronic Systems, *Machine Design

Online Certifications: Aerial Robotics (UPenn), Introduction to Internet of Things (UCI)

*(*To be completed by Dec '24)*

Extracurrical Activities

- Received 80+ hrs of training to complete an intermediate level one year training in NSO

- Represented IIT Bombay in a virtual PAN inter-IIT cycling event under men's category

- Delivered an elaborate presentation on the development of a smart attendance system, encompassing face recognition, missed alerts, and web support at Hardware Hackathon

- Mentored a team of 4 freshmen into building a RC controlled car for XLR8 flagship event

References

Prof. Mayank Baranwal
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