Panav Arpit Raaj

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Education

- **Indian Institute of Technology (IIT) Patna** — Patna, India
  B.Tech in Electrical and Electronics Engineering — *2021 – 2025*
- **Clarence High School** — Bangalore, India
  Indian School Certificate (ISC) ***Percentage: 95.5%*** — *2019 – 2020*

Accomplishments

- **2023 Gold Medalist** in the Inter IIT Tech 12.0
- **2020** Karnataka Rank **8th** in NSTSE
- **2024** Founded and led IIT Patna's Rover Team in IRoC -U 2024
- **2023, 2024** Captain of IIT Patna's Robocon team, achieving the highest score among IIT teams in the National Finals at ABU Robocon 2024 and Vice-Captain in 2023, ranking 4th nationally (Stage 1) in Asia's oldest robotics competition

Experience

- **Robotics Software** — Bangalore
  10xConstruction.ai — *July 2025 – Present*
  - Developed a **customized fourth motion model** in **MPPI** Controller for swerve drives, acted upon steering angle and speed limits for faster navigation in constrained spaces.
  - Added **ambiguity detection**, region of interest to auto-initialization of robot pose with genetic algorithm optimization and Local Refinement.
  - Engineered a robust **multi-modal sensor fusion pipeline (EKF)** enabled high-frequency fusion with 3D ICP, ensuring stable localization.
  - Developed **Lichtblick**, a custom visualization stack (TypeScript/ROS2) that reduced peak compute usage by **78%** (120% to 26%) compared to Foxglove, integrating customized features such as pose recovery, MoveIt2 Support within Browser/Android Apps.
  - Implemented **real-time collision monitor**, Improvement over Nav2 with <100ms latency integrating Behavior Trees, Collision Recovery, primary navigation sensors, using efficient **composable nodes**. **Nav2 local planner (MPPI)** parameters for narrow passage navigation and path planning reliability.

- **Mobile Robotics Intern** — Noida
  Addverb Technologies — *May 2024 – August 2024*
  - Developed and tested **localization and mapping algorithms** for **Autonomous Mobile Robots (AMR)** using **2D LIDAR**, **Intel RealSense**, and monocular cameras, optimizing performance in dynamic industrial environments.
  - Implemented and integrated advanced **feature detection algorithms** using **FLIRT** and **FALKO**, improving LiDAR feature extraction and registration for robust SLAM.
  - Developed and tested **graph optimization techniques** to enhance localization accuracy, leveraging the **IRIS LaMa** framework for computational efficiency and scalability.

Projects

- **GNN-based Combinatorial Optimization for Robotic Manipulation** — Manuscript in preparation
  PyTorch Geometric, GATv2, Imitation Learning, Path Planning — *[September 2024 - December 2024]*
  - Formulated the **NP-Hard** Pick-and-Place sequencing problem as a graph classification task, utilizing **Graph Attention Networks (GATv2)** to encode complex object-bin spatial relationships.
  - Engineered a **Supervised Learning pipeline** trained on expert demonstrations from an **Integer Linear Programming (ILP)** solver, employing **Curriculum Learning** to scale generalization from 5 to 200+ objects.
  - Surpassed standard **Greedy heuristics** (Nearest Neighbor) by minimizing total end-effector travel distance, achieving **near-optimal performance (<2% gap to Integer Linear Programming for 40 Objects)** and upto 200 Objects where ILP failed to give a solution, while keeping inference time within 400 **milliseconds**.

- **Flipkart Grid Robotics 6.0** **Completed**
  Computer Vision, Mistral LLM, YoloV11, PyTorch, Robotics, IoT *September - October 2024*
  - Utilized **Mistral LLM, GPT-2, Gemini** and **PyTorch** models for product text extraction, optimizing image processing features.
  - Trained **YoloV11** and **YoloV9** models with **OpenCV** to assess the freshness indices of consumables.
  - Utilized **U-Net** and **CNN** for segmentation and OCR respectively.

- **B. Tech Project: Autonomous Robot Navigation and SLAM** **Completed**
  ROS 2 Humble, Nav2, Gazebo, URDF, Sensor Fusion, micro-ROS *May 2024 – August 2024*
  - Architected a custom differential drive AMR from scratch, creating a parametric **URDF/Xacro** robot description with accurate inertia matrices and collision geometries for **Gazebo** simulation **and hardware**.
  - Developed a hardware interface using **micro-ROS** on ESP32 to bridge motor drivers and quadrature encoders with **ros2_control**, achieving real-time velocity control loops, Implemented **Sensor Fusion (EKF)**.

- **RigBetel Labs Inter IIT Tech Meet 13.0** No Prep Problem Statement
  Rigbetel Labs *December 2023*
  - Tasked with implementing **multi-robot mapping and localization** using robots of **TurtleBot3 specification** running **ROS 2 Humble**, in a simulated environment.

- **ABU Robocon 2023,2024** Source Code
  Captain - Team Robocon IIT Patna *Dec 22 - May 23*
  - Led a team of 60+ students to the **National Finals of ABU Robocon**, representing one of only two IITs to qualify in Asias largest robotics event, achieving high rankings in the competition.
  - Formed a team of 35 students to design and develop a **lunar rover prototype** from scratch for the **ISRO Robotics Challenge 2024**, including mechanical, electronics, and software subsystems.
  - Integrated closed loop drive, distributed computing and
  - Designed **PCBs for motor control, sensor integration, and power management**, streamlining the electronics systems for Robocon 2024 and ensuring compatibility with all subsystems.
  - Programmed and debugged **microcontrollers and SBCs** including Cube Orange, Raspberry Pi, Arduino, ESP32, and ESP32-CAM for various tasks like image processing, sensor interfacing, and communication.
  - Developed robust algorithms for **multi-bot coordination and path planning**, leveraging **ROS** for communication and real-time control in collaborative robot scenarios.

- **Server for Collecting, Processing, and Visualizing Sensor Data from Mobile Phones** GitHub
  June 2024 Present
  - Built a flexible server supporting both **Node.js and Python backends** for real-time mobile sensor data collection and processing.
  - Implemented **WebSocket and REST API endpoints** to support reliable integration with mobile apps and external systems.
  - Enabled **data logging and analytics** to monitor, analyze, and debug high-frequency sensor data streams.
  - Developed a **3D dashboard visualization** to deliver intuitive, real-time insight into incoming sensor readings.
  - Integrated **SSL/TLS support** to ensure secure, encrypted client-server communication for sensor data transport.
  - Designed for **ROS (Robot Operating System) integration**, supporting ROS Humble and enabling interoperability with robotics perception stacks.

Technical Skills

Languages: C/C++, Python, Bash
Robotics: ROS 2 (Humble), Nav2 Stack, SLAM, Localization (AMCL), Path Planning, Sensor Fusion, Custom Motion models
Simulation & Visualization: Gazebo, RViz2, Foxglove (foxglove_bridge), NVIDIA Isaac Sim
Computer Vision: OpenCV, Image Segmentation (U-Net), Object Detection & Tracking (YOLO v9/v11, DeepSort), Feature Detection, OCR
Systems & Embedded: Linux, Git, Docker, Microcontrollers, SBCs (Raspberry Pi, Cube Orange, ESP32), PCB Design (KiCAD), IoT **Software Engineering**: Git, Docker, CI/CD (GitHub Actions, GitLab CI), Linux (Ubuntu), Unit Testing (GTest, PyTest)
Tools & Workflow: Agile/Scrum, Asana, Confluence, CMake, Colcon