Tejal Ashwini Barnwal

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Education

Indian Institute of Technology Bombay *(Jul '19 - Aug '23)*
Major: Mechanical Engineering *Mumbai, India*

Experience

Vision-Based Force Measuring Paw for Legged Robots *(May '22 - Ongoing)*
Advisors: Prof. Kostas Alexis, Mihir Dharmadhikari, Jørgen Olsen | Autonomous Robots Lab *NTNU*

- Prototyped paw with **Nicla-Vision** to assess 3D contact-force upto **200N** applied to compliant foot in real-time
- Executed algorithms like PCA, blob detection & **optical flow** at the edge using **Micropython** & **OpenMV**
- Performed **camera calibration** & deployed **TensorFlow Lite** based regression model for force estimation
- Estimated paw orientation by **fusing** accelerometer and gyroscope data from LSM6DSOX IMU module

Precision Agriculture with Quadrotors *(May '21 - Nov '21)*
Advisors: Prof. Hemendra Arya and Prof. Arpita Sinha *Systems and Controls Department, IIT Bombay*

- Performed autonomous **raster scan** on custom crop-field Gazebo world using **PX4 SITL** and **MAVROS**
- Implemented **sliding mode control**(**20Hz**) on MATLAB/Simulink & studied PX4 developer's documentation
- Created custom URDFs, material textures, sensor plugins and crop-field-like simulation scenarios on Gazebo

Competitions

The Robotic Charging Challenge | 11th InterIIT Tech Meet *(Feb '23)*
Worked in a team of 8 to design a robotic arm capable of autonomously charging an electric vehicle

- **Ranked 2nd** across 23 IITs | Devised a 6-DOF robotic arm performing plug detection and move towards it
- Implemented joint space **trajectory planning** considering velocity limits using a trapezoidal velocity profile

Vision Based Obstacle Avoidance Drone | 9th InterIIT Tech Meet *(Mar '21)*
Worked in a team of 8 to autonomously explore static cluttered environments & land on target after detection

- **Ranked 6th** across 23 IITs and devised navigation pipeline with three layers of intelligence algorithms
- Developed **scan & survey pipeline** to negotiate dead ends inside ROS/Gazebo using **ArduPilot SITL**

Intelligent Picking Robot | Flipkart Grid 2.0-Robotics Challenge *(Jun '20 - Aug '20)*
Worked in a team of 5 on an autonomous robotic arm capable of picking and transporting items in a warehouse

- Among the **top 2%** teams qualified for Level 3 out of 6000+ teams registered for Level 1 from all over India
- Designed a **4-DOF robotic manipulator** & visualized pick and place on RViz using **MoveIt** framework

International Micro-mouse Challenge | Techfest, IIT Bombay *(Dec '20)*
Simulated an autonomous bot using ROS & Gazebo to solve an unknown maze in the shortest time possible

- Bagged **1st position** and implemented **omni-wheel** drive and PD controller to reduce steering latency
- Designed an **breadth-first search** based planning algorithm while incrementally building a maze representation

The Hilti SLAM Challenge | IROS'21 Workshop *(Sept '21)*
Estimated poses and motion trajectories on sequences from the given dataset recorded with handheld device

- Comprehended visual inertial odometry and applied **ORB-SLAM3** on monocular camera and IMU sensor feed
- Calibrated for **Kannala-brandt camera model** using datasheet & IMU noise parameters using imu utils

Open Source Contributions

- **OpenMV**: provides an Arduino like experience for simple machine vision tasks on camera-based modules
  - Added support for **TensorFlow-lite regression** models along with its python bindings (link1, link2)
- **Gazeboism**: Tools and libraries for robotics applications. Home of the Gazebo simulator.
  - Helped review Garden tutorials during the **Gazebo Garden Party 2022** and got a Gazebo Hoodie (link)
  - Adding support simulation and rendering of **BAYER format** images (link)

Key Technical Projects

SeDriCa | Unmesh Mashruwala Innovation Cell, IIT Bombay *(May '21 - Ongoing)*

Participating in Auto-Nav and design track of Annual Intelligent Ground Vehicle Challenge(IGVC)' 23

- Working in **30+ member** team aiming to build **level 4 self-driving car** capable of transversing on city roads
- **Led Decision-Making** subsystem & developed pipelines for traffic signs, intersection handling & lane changing
- Conceptualized system-level behavioural architectures using **Finite State Machines** and **Behaviour Trees**
- Added vehicle sensor plugins and task-specific environments to IGVC self-drive simulation stack on **Gazebo**

Seasons of Code | Web & Coding Club (WnCC), IIT Bombay *(Apr '21 - Jul'21)*

- **Facial Expression Recognition**
  - Constructed a **deep convolution neural network** to recognize facial expressions from 7 categories
  - Trained FER dataset from Kaggle in **Keras** to achieve **74%** training accuracy and **66%** test accuracy
- **Instance Segmentation - Self Driving Cars**
  - Performed transfer learning on **Mask RCNN** for vehicle detection and integrated it with **CARLA** sim
  - Tailored the model for specifically **8 categories** and fine-tuned it to reduce the average loss by **50%**

Institute Mess Digitization Project | Institute Technical Council, IIT Bombay *(Dec '20 - Apr '21)*

Digitized institute mess to replace mess cards with student ID Cards reducing the workload of mess workers

- Developed an in-house product prototype to be deployed in all the institute messes used by **10k+ students**
- Conceptualized a **Master/Slave** architecture (R-Pi/ ESP32) and integrated it with RC522 **RFID** reader
- Employed **MQTT** protocol to establish wireless communication between Raspberry Pi and multiple ESP32s

Adaptive Control of Autonomous Vehicle | Course Project *(Nov '21)*

Advisor: Prof. Srikant Sukumar *Systems and Control Department, IIT Bombay*

- Implemented **dynamic 2D bicycle** model to capture vehicle motion in normal driving conditions
- Designed an **adaptive back-stepping** controller and carried out simulations using MATLAB/ Simulink

Key Courses Undertaken

Mechanical	Solid Mechanics, Kinematics and Dynamics of Machines, Engineering Drawing, Industrial Engg. & Operations Research, Structural Materials, Machine Design
Electrical & Controls	Introduction to Electronic Circuits, Mathematical Structures for Control, Signal and Feedback Systems, Linear and Non-Linear systems, Non-Linear Control Theory*, Microprocessors and Automatic Control, Embedded Control & Robotics*
Computer Science & Mathematics	Calculus, Linear Algebra, Computer Programming, Numerical Analysis, Introduction to ML, Image Processing, Probability & Stochastic Models, Motion Planning*, Design Optimization*

**to be completed in Spring 2023*

Technical Proficiency

Languages	Python, C++, MATLAB, Micro-python, Markdown, LaTeX
Softwares & Tools	Docker, Git, SolidWorks, Abaqus, Simulink, EAGLE, Gazebo, AutoCAD, Ansys
Frameworks & Libraries	ROS 1 & ROS2, OpenMV, Tensorflow, Keras, OpenCV, Pandas, Scikit-learn
Electronics	Raspberry Pi, Arduino UNO & Mega, Node MCU, ESP32, Nicla Vision

Positions of Responsibility

Convener | Electronic and Robotics Club (ERC), Institute Technical Council *(May '20 - Apr '21)*

Part of a 15+ member team that conceptualises and organises events for tech enthusiasts in the Institute

- Conducted club orientation and a 2-day **Arduino Basics Workshop**, attended by **100+ freshmen**
- Contributed articles on Occupancy Grid Mapping, Kalman Filter and ROS to the **'ERC Wiki repository'**
- Organised **'ER101'**- a 7 week series of sessions on design and development of a robotics manipulator
- **Delivered a talk** on Kinematics & Dynamics of a 2-DOF manipulator with MATLAB demonstrations

Extracurriculars

- **Cultural**
  - Volunteered in **Kaladarshan** (annual photography and fine arts exhibition of IITB) for ideating theme, creating art installations, road painting and contributed five sketches to be put up in exhibition
  - Received training for **6 years** in **painting**, and secured distinction by Bangiya Sangeet Parishad, Calcutta
  - Awarded distinction in **Kathak** by Akhil Bharatiya Gandharva Mahavidyalaya Mandal, Mumbai
- **Volunteering**
  - Guided two **teams of 4 freshmen** for a project based on Robotics and Image Processing in ITSP
  - Volunteered in organizing a summer course for **Practical Python Programming** with **1000+ enrollments**
  - **Delivered session** on Serial Communication Protocols in embedded systems in a summer course registered by **200+ students** with TinkerCAD simulations and framed practice assignments for better understanding