Nikhil Sobanbabu

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Research Interests

Passionate in the fields of **Controls, Dynamics, and Reinforcement Learning**, particularly in the context of **legged locomotion** and **space robotics.**

Education

- **Indian Institute of Technology Madras** Aug 2020 - May 2024
  *Bachelor of Technology in Electrical Engineering (Honors) Department Rank-**6/155*** **CGPA: 9.37/10**

Publications

RSS 2024 (to be submitted) — **OGMP: Oracle Guided Multimodal Policies for Agile and Versatile Robot Control**
Lokesh Rajan, **Nikhil Sobanbabu**, Quan Nguyen (Framework and Videos)

Technical Skills

Courses: Reinforcement Learning | Linear Dynamical Systems | Non-linear System Analysis | Intro to Motion Planning Linear Algebra | Synthesis of Control Systems.
Programming Languages: C, C++, Python, MATLAB
Tools & Frameworks: Git, Mujoco, Isaac Gym, Robot Operating System(ROS), Eagle, Latex, Pytorch, Tensorflow.
Key Competencies : Controls, Deep Reinforcement Learning, Optimisation, Diagnosis and Debugging of Electronics.

Research Experience

- **Dynamic Robotics and Control Laboratory USC** *(Prof. Quan Nguyen)* (*May'23- Present*)
  - Secured a highly competitive spot as one of the top **15** out of over **400** applicants for the **IUSSTF-Viterbi Summer Research** Internship Program.
  - Developed a task-driven planner for an RL policy to solve high-level locomotive tasks by selecting behaviours encoded as latent modes, using **Monte-Carlo** Roll-outs in a **Receding-Horizon** approach. This solved the tasks while ensuring **robust recovery** from disturbances.
  - Developed a novel **Preview Controller** for a **centroidal model** of a **biped**, enabling the generation of dynamically feasible reference trajectories. This controller played a crucial role in supporting a **Multi-Modal Reinforcement Learning (RL) policy**, operating in a closed-loop manner, to achieve **parkour-inspired** motions.
- **Control Engineering Laboratory - IIT Madras** *(Prof. Bharath Bhikkaji)* (*Oct'23-Present*)
  - Working on a Multi-Agent RL framework to solve 3D **pursuit-evasion-target** scenarios.
  - Developing analytical solutions to a simple **reach-avoid model** to guide the RL policy in high-level tasks.
- **Research Intern - Robert Bosch Centre for Cyber-Physical Systems** (*Jan'23-Apr'23*)
  - Worked with **Dr. Shishir Kothalya and Mr. Amith Somanath** on the Implementation of **vision-based algorithms** for localization for the quadruped robot in association with **ARTPARK.**
  - Applied **PCA**-based plane detection to **Intel RealSense RGB** images, focusing on regions of interest identified through open-source stair detectors utilizing CNNs.
  - Successfully correlated these ROIs with corresponding regions in a 3D point cloud of the staircase and subsequently integrated them with **LiDAR** point cloud data.
- **Team Anveshak - Mars Rover Team of IIT Madras** (*May'21- Present*)
  - Created a **Frontier-Based** algorithm leveraging 3D point cloud data from the terrain to construct an extended traversability map. Employed the **A*** algorithm on this map to calculate the rover's optimal obstacle-avoiding path, contributing to the **International Rover Design Challenge 2021**.
  - Developing RL-based obstacle avoidance policy for the rover to transverse an uneven Martian terrain using a custom-implemented PPO framework.
  - Engineered an energy-efficient power distribution and monitoring framework, reducing rover energy consumption to 86%. Enabled remote monitoring of electrical parameters from a distant base station, enhancing rover performance.

Projects and Competitions

- **Simultaneous beamforming and trajectory tracking in a multi-agent formation** (*May'22-Nov'22*)
  - Worked on **autonomous** control of multiple **crazyflie quadrotors** using **multi-optitrack** system and **ROS** packages with **Mellinger and PID** controllers self-implemented under the guidance of Dr.Bharath Bikkaji.
  - Created **ROS** meta packages for **safe landing** of the **quadrotors** in the event of loss of communication.
  - This project was credited as part of **Undergraduate Research Credits EE4901** and the Poster Presentation was done in front of the entire department.
- **Multi-agent Game theoretic framework for security of critical infrastructure**
  - Worked under **Dr. Bharath Bikkaji** and **Dr. Vishwananda Reddy** on ROS implementation of a **Receding Horizon** based multi-agent **LQR** controller on **TAD** game theoretical framework.
  - Developed a simulation stack based on Turtlesim which uses pose feedback of all the agents using a centralized ROS node and subsequent velocity control under this framework.
- **Team Anveshak** (*May'21- Present*)
  - Designed custom **PCBs** utilizing **MPC2515 CAN** controller to facilitate precise control of the actuators in the manipulator of the rover via **Nvidia's Jetson Xavier.**
  - Developed a software stack that leverages **bitmask encoding** to transmit **16 bit** information through the **8 bit** MPC2515 for manipulator control.
  - Played a pivotal role in the team's outstanding performance, securing a **global 6th** place at the **Anatolian Rover Challenge in Turkey, 2022.**
- **EYRC - KrishiBot** (*Oct'22- Mar'23*)
  - Placed **4th** nationally out of **372** teams in the **Krishibot(Autonomous Fruit Harvester)** theme in the **E-Yantra Robotics Competiton** conducted by Indian Institute of Technology,Bombay.
  - Implemented **Wall following** Algorithm through laser scan feedback and a **PID controller** for autonomous navigation of the robot around the warehouse setup.
  - Integrated colour and centroid detection techniques to identify bell peppers within images captured by an Intel RealSense depth camera and executed a pick-and-place workflow using **ROS MoveIt**.
- **LDR Based Optical Tachometer** (*Oct'19-Jan'20*)
  - Created an **LDR** based **Optical tachometer** to determine the RPM of a motor within a range of 100RPM as an investigative project in class 12.
  - Learnt the characteristics of a **BC547 transistor** and used a **CD4026 IC** to display the rpm in a 7-segment common cathode display.

Course Projects

Non-Linear System Analysis	• Developed a controller for **Swing-up and Stabilisation** of a linear Inverted Pendulum. • Implemented swing up using **Energy control** by designing a suitable **Lyapunov function** and stabilisation after swing up using **Pole placement** technique. • Analysed the stability of **sliding mode control** for stabilization in this system.
Intro to Motion Planning	• Implemented Sampling-based motion planning algorithms **RRT* and Bi-Directional RRT** for the **KUKA Mobile Manipulator**. • Integrated these algorithms with an **A* and Traveling salesman**-based Navigation algorithm for the most optimal pick and place task of scattered objects in a Gazebo Environment.
PLC & SCADA (MOOC)	• Implemented timers and counters in **IEC-61131-3 PLC** ladder logic and Interfaced **Scada/HMI** system for remote control of industrial process units.
Applied Programming Lab	• Built a **Spice simulator** to solve both AC and DC circuits given a netlist file,using MNA matrix method. • Computed **DFT** using **FFT**,autocorrelation of Zadoff-Chu Sequence, utilized the Hamming Window to increase the accuracy in estimation of Fourier coefficients by 30%

Scholastic Achievements

- Secured **All India Rank 286** in **JEE Advanced 2020** ranking in top **0.2** percentile out of **1.2 million** students in all over India.
- **NTSE**[1] **Scholar 2018** being **State Topper** in **Stage 1** out of **50,000+**students in the state of **Tamil Nadu.**
- **KVPY**[2] **Fellow SX 2020** and secured an **All India rank** of **243**.
- Cleared **NSEA 2019** and was among **331** students among 15,000+ students to appear for **INAO**[3] **2020**
- Cleared **NSEP 2019** and was among **458** students among 50,000+ students to appear for **INPhO**[4] **2020**

Extracurriculars and Mentoring Experience

- **Teaching Assistant** for the course **EE3004 Control Engineering** under **Prof. Bharath Bikkaji.**
- Elevated to the role of **Team Lead** for **Team Anveshak**, serving from July 2022 to July 2023.
- Coordinated **Tech and Innovation Fair** with **500**+participants which aims to convert a Project to a **Minimum Viable Product** in **Shaastra**, the Annual Tech Festival of IIT Madras.
- Conducted Workshop with a Hands-on Session for 30+ students on **ROS** and **Gazebo.**
- Member of the **Dance Contingent** of IIT Madras and conducted Workshops for the General Student Body.

[1] National Talent Search Examination [2] Kishore Vaigyanik Protsahan Yojana [3] IndianNationalAstronomyOlympiad [4] Indian National Physics Olympiad