Shivendra Singh Verma

Indian Institute of Technology Madras (India)

+91-79743-61752 • na20b062@smail.iitm.ac.in • https://shiven-verma.github.io

Education

Program	Institution/Board	%/CGPA	Year
B.Tech. (Naval Arch. & Ocean Engg.)	Indian Institute of Technology Madras	**7.82/10**	2020-Present

Achievement and Awards

- Among 150 students (Out of 12000+) to receive Samsung Star Scholarship **INR 150K** per year.
- Ranked within the top **1 percentile** of students who cleared the JEE Advanced 2020 conducted by IIT Kharagpur.

Relevant Courses & Skills

- **Online Courses**: *Control Systems Engineering, Robotics and Control, Machine Learning*
- **Programming Languages**: *Python, C, C++, MATLAB, MySQL*
- **Softwares and Tools**: *Reinforcement Learning, Robotics Operating System, Gazebo, Altium, STM32Cube IDE*
- **Libraries**: *PyTorch, CasADi, OpenCV, SciPy, NumPy, Matplotlib, Pandas, sqlite, scikit-learn*

Research Projects

• MODEL PREDICTIVE CONTROL OF KVLCC2 L3 MODEL SHIP **June 2023 - Present**
(*Guide: **Dr. Abhilash Somayajula**, Ocean Engineering, IIT Madras*) *IIT Madras*

- Simulated **Turning Circle** and **Kempf Overshoot** maneuvering on nonlinear **MMG** modeled dynamics ship model
- Implemented **Serret-Frenet frame** guidance law with heading control to generate a reference trajectory for path following.
- Deployed a **Support Vector Machine**(SVM) model to predict nonlinear Nomoto Parameters using Kempf overshoot.
- Created a **Non-linear Model Predictive Controller**(NMPC) using non-linear nomoto model with a bias for path following and obstacle avoidance using **IPOPT** optimizer.
- Implemented **ESP32 UWB** technology for the establishment of indoor positioning and **Real-Time Locating System** (RTLS) in GPS denied environment for localisation of ship models in wave basin.
- Developed a **turtlesim** based simulation for demonstration of collision avoidance for Btech Project review.
- Conducted path following simulation tests with different predicting and simulation model, achieving **87%** reduction for **cross track** error and **96%** for **along track** error.

• MULTI-AGENT GAME THEORETIC FRAMEWORK DEVELOPMENT **Dec 2022 - March 2023**
(*Guide: **Dr. Bharath Bhikkaji**, Electrical Engineering, IIT Madras*) *IIT Madras*

- Contributed in development of **multi-agent game theoretic framework for safety of critical infrastructure** in python.
- Implemented a **Receding Horizon** Based based multi-agent **LQR** controller on **TAD** game theoretical framework.
- Developed a turtlesim based **custom simulation** for early stage testing of the agents in ROS.
- Tested the **capture and evasion criteria** for different sets of initial conditions for **co-operating** and **individual agents**, with results showing cooperating agents performing better than individual agents in more than **60%** of the cases.
- Initiated the further development of the framework for **multiple attacker** scenarios.

• AUTONOMOUS NAVIGATION OF ROVER **Jan 2023 - March 2023**
(*Guide: **Dr. T. Asokan**, Engineering Design, IIT Madras*) *IIT Madras*

- Leveraged point cloud data from a **stereo camera** for obstacle detection and cost map creation using **Navigation Stack**.
- Simulated real world scenarios in **Gazebo** and tuned the Navigation Stack Parameters using **RViz** in ROS.
- Deployed **Extended Kalman Filter** to fuse the sensor data from **Depth Sensing camera, IMU and GPS** for localisation.
- Tested the robot on rough sandy terrain with differential drive dynamics, resulting maximum drift of **0.5 meter** for two waypoints **20 meters** apart, achieving **97.5%** accuracy.

• EMBEDDED SYSTEMS DESIGN AND PROGRAMMING **July 2021 - March 2022**
(*Guide: **Dr. T. Asokan**, Engineering Design, IIT Madras*) *IIT Madras*

- Engineered and implemented an Embedded System for a six-wheeled rover, utilizing a range of micro-controllers including **Arduino, STM32, ESP-32**, and microprocessors like **RP2040** to develop a **custom motor driver board**.
- Established intra-board communication between different ICs using protocols like **I2C and SPI** to make system modular.
- Implemented **CAN protocol** on STM32 for inter-board communications to control motor drivers actively on manipulator **upto 2m** distance with encoder feedback and control commands sent through same channel.
- Integrated single board computers and micro-controllers over **serial communication** for collection of sensor data.

• ELECTRIC CIRCUIT DESIGN FOR CONTROL OF ROVER AND MANIPULATOR **July 2021 - March 2022**
(*Guide: **Dr. T. Asokan**, Engineering Design, IIT Madras*) *IIT Madras*

- Developed circuit board for **traversal system** of the 6 wheel rover and manipulator control for 5DOF arm, with feedback based debugging.

- Designed a circuit board for easily switching between **analog cameras** using 8-channel multiplexer **74HC4051D** IC.
- Developed a **Battery Monitoring System(BMS)** to monitor voltage and determine SOC, for the rover using an array of **UA714 operational amplifier** for 6S LiPo batteries.
- Developed and validated a specialized circuit board for both the **soil collection mechanism** and **in-situ analysis** of soil samples.

• **BEAMFORMING AND TRAJECTORY TRACKING FOR SWARM DRONES** **Apr 2022 - Jan 2023**
(*Guide: **Dr. Bharath Bhikkaji**, Electrical Engineering, IIT Madras*) *IIT Madras*

- Hardware implementation of the publication "**Simultaneous beamforming and trajectory tracking in a multi-agent formation**" by Dr. Bharath Bhikkaji, to confirm simulation data.
- Worked on implementation of the **trajectory tracking algorithm** with a swarm of **bitcraze quadrotors**.
- Achieved accuracy of **94%** in trajectory tracking in complex trajectories like **infinity shape** and **helix shape**.
- Possessed hands-on experience working with **OptiTrack motion capture** systems, being used for state feedback to Python API.

Course Projects

• **HOMING GUIDANCE LAW FOR COOPERATIVE ACTION** **Aug 2023 - Nov 2023**
(*Course Instructor: **Dr. Satadal Ghosh**, Aerospace Engineering, IIT Madras*) *IIT Madras*

- Implemented a newly formulated homing guidance law for **cooperative guidance** of two agents for simultaneous attack.
- Analysed the comparison of Individual Proportional Navigation and **Cooperative Proportional Navigation**(CPN), with results showing better attack strategy than individual homing agents for **95%** of the cases.
- Simulated the variations of the guidance law using **True Proportional Navigation** to prove optimal case occurring for proportional constant **3**.

• **EXTENDED KALMAN FILTER FOR STATE ESTIMATION** **Aug 2023 - Nov 2023**
(*Course Instructor: **Dr. Suresh R**, Ocean Engineering, IIT Madras*) *IIT Madras*

- Simulated **PM spectrum** from wave transfer function for inducing high frequency response as noise to measured data.
- Implemented **Discrete-Time Kalman Filter** to estimate ship states by fusing sensor data from **IMU and Accelerometer**.
- Modeled **2nd order low pass filter** for filtering high frequency **yaw response** from measured data.
- Evaluated the effectiveness of heading angle control utilizing the Nomoto model, derived from estimated states obtained through **filtered data** as feedback. Achieved precise path tracking with a maximum stabilization time of **30** seconds

• **MODELING AND SIMULATION OF MANEUVERING TESTS ON KCS SHIP** **Jan 2023 - Apr 2023**
(*Course Instructor: **Dr. Abhilash Somayajula** , Ocean Engineering, IIT Madras*) *IIT Madras*

- Conducted simulation-based analysis on the kinematics and dynamics of a KCS ship, evaluating its stability indicating parameters, derived from hydrodynamic coefficients, by introducing disturbances.
- Simulated **Davidson and Schiff model** on KCS ship and compared the **Controllability** with Nomoto model using PD controller, with **D-S model resulting in better accuracy**.
- Performed **PMM, Turning Circle, Bech Spiral** and **Pure Yaw tests** using KCS ship dynamics.

Positions of Responsibility

• **TEAM HEAD - TEAM ANVESHAK** **Jan 2023 - Present**

- Overseeing both technical and managerial facets of **Team Anveshak**, a 40-member student Mars rover team from IIT Madras, representing the institution in diverse international events.
- Successfully directed a team of 30 people for submission of **Systems Acceptance Report**(SAR) for University Rover Challenge(URC) and got selected among **37** teams out of **120+** teams worldwide, one of the only five teams from India.
- Headed a team to secure sponsorship from **ANSYS**, successfully acquiring the **professional version** of their product.
- Facilitated the signing of a **Memorandum of Understanding** (MoU) with an agricultural startup located in Hyderabad to collaborate on the development of a rover tailored for **crop harvesting**.
- Secured a sponsorship of **INR 80K** in credits for PCB manufacturing from **PCB Power India**.
- Co-developer of the team website showcasing the team's **achievements, projects, and activities**.

Co-Curricular and Extracurricular Activities

• **ANATOLIAN ROVER CHALLENGE 2022** **July 2022**

- Placed overall **6th Internationally** in first ever edition of Anatolian Rover Challenge 2022 out of 30+ team submissions.
- Achieved a position in the **TOP-3** for an **autonomous task** set in simulating a moon field at **ITU Istanbul, Turkey**.

• **STUDENT MENTORSHIP AT AVANTI FELLOWS** **Dec 2021 - May 2022**

- Provided mentorship and guidance to two talented grade XII students from JNV Puducherry for JEE Mains and Advanced preparation.
- One of them got selected for Computer Science **NIT Sikkim** and other for Mechanical Engineering at **PEC, Puducherry**.

• **STUDENT WORKSHOP** **Jan 2022**

- Conducted an online workshop on **Circuit Simulation and PCB Designing** during official technical festival of IIT Madras Shaastra, attended by **30+** students.