

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	7.89/10	2020-24

Research Projects

- **MODEL BASED REINFORCEMENT LEARNING FOR SAFETY CRITICAL SYSTEMS** Sep 2024 - Present
(Project Associate, Mechanical Engineering) IIT Madras
 - Working to implement safety filter using Control Barrier Functions(CBF) for obstacle avoiding autonomous cars.
- **OBSERVER-BASED DELAY TOLERANT NETWORKED SYSTEMS** June 2024 - Sep 2024
(Guide: Dr. Anuj Tiwari, Mechanical Engineering, IIT Madras) IIT Madras
 - Deployed a **Communication Disturbance Observer(CDOB)** to mitigate the effects of delay on stability of a system.
 - Devised similar CDOB with **Delay Self Reinforcement(DSR)** approach for **multi agent systems** ensuring network stability while maintaining cohesion during transition of consensus in a pure sensing environment.
 - Created SimulinkTM model for simulations and achieved **97% cohesive** transitions and stability up to **1 seconds**.
 - Developed six mini ground robots, DIRoBots from scratch and performed **system identification** to be used on observers.
 - Conducting experimental work with **AprilTag** markers and overhead **RealSense** camera for state feedback.
- **MODEL PREDICTIVE CONTROL OF KVLCC2 L3 MODEL SHIP** June 2023 - May 2024
(Guide: Dr. Abhilash Somayajula, Ocean Engineering, IIT Madras) IIT Madras
 - 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.
 - Devised **varying cost function** for terminal states and **dynamic control horizon** to improve obstacle avoidance.
 - Developed a **pygame simulation** of the vehicle following the path and avoiding obstacles using ROS, with simple Nomoto model being prediction model and complex **MMG model** being the operating model.
 - Conducted path following simulation tests with different predicting and simulation model, achieving **87%** reduction for **cross track** error and **96%** for **along track** error.
 - 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 for experiments.

Projects

- **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.
- **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 six wheel rover and manipulator control for 5DOF arm.
 - 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 for the **soil collection mechanism** and **in-situ analysis** of soil samples.
- **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 localization.
 - Tested the robot on rough sandy terrain with differential drive dynamics, resulting maximum drift of **0.5 meters** 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.
- **BEAMFORMING AND TRAJECTORY TRACKING FOR SWARM DRONES** Apr 2022 - Jan 2023
IIT Madras
(Guide: **Dr. Bharath Bhikkaji**, Electrical Engineering, 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
IIT Madras
(Course Instructor: **Dr. Satadal Ghosh**, Aerospace Engineering, 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
IIT Madras
(Course Instructor: **Dr. Suresh R**, Ocean Engineering, 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 **second 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
IIT Madras
(Course Instructor: **Dr. Abhilash Somayajula**, Ocean Engineering, 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.

Relevant Courses & Skills

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

Positions of Responsibility

- **TEAM HEAD - TEAM ANVESHAK** Jan 2023 - Jan 2024
 - 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**.