Madhav Joshi

Curriculum Vitae

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Research Interest

My research interests include optimization, robotics, control and planning. I am particularly interested in developing optimization and control algorithms for improving the performance and efficiency of engineering systems.

Education

2019–2024 **Indian Institute of Technology Bombay, Mumbai, India**

- Major: **Mechanical Engineering** (B.Tech. + M.Tech. in CAD & Automation)
  GPA: **9.25/10 (Department Rank: 2 out of 41)**
- Minor: **Systems and Controls Engineering**
- **Institute Academic Award** for being among top 2 performing students in department

2017–2019 **MP Deo Dharmapeth Science College, Nagpur, India**

- Higher Secondary Certificate, Maharashtra State Board of Secondary and Higher Education
- Subject: Science and Electrical Maintenance (**College Topper**, Score: **94.9%**)

Internships and Research

May'22 – Jul'22 **Modelling and Control of Compliant Mechanisms | Research Internship**
Guide: Dr. Abhijeet Joshi | Siemens Technology India

- Examined open source **SOFA framework** targeting real time for interfacing mesh, solvers, collision models and material properties to simulate a soft robot
- Implemented a research paper on soft robot system modeling using Koopman operator and MPC control on compliant springs with strings coupled with brushed DC motors
- Utilized Raspberry Pi 4B as a controller to interface various hardware components such as camera, Arduinos, and a PWM driver (PCA9685) using the I2C communication protocol
- Installed ROS on Raspbian OS and developed a ROS package that can be scaled to accommodate more complex robots with controller accuracy of **±3 mm**

Jan'21 – Jul'21 **Topology Optimization | iSURP - In Semester UG Research Program**
Guide: Prof Amuthan A Ramabathiran | Aerospace Department, IIT Bombay

- Analyzed **density based** Topology Optimization in context of linear elasticity and applied it to a heat sink design optimization problem using open source **FEniCS** project in Python
- Implemented various numerical methods such as gradient descent, forward/backward Euler, FDM, and FEM in Python to solve constrained optimization problems
- Derived primal and adjoint equations using variational calculus to compute objective function derivative for constrained optimization problem in Poisson membrane scenario

Dec'20 – Jan'21 **Microwave Metal Heating - 3D Modelling**
Guide: Prof Shruti Bhatt | Mechanical Engineering Dept | Nirma University, Gujrat, India

- Modelled **transient electromagnetic heating** of AA6061 specimen using COMSOL 3.5a
- Verified the efficiency of microwave metal casting process by calculating the time to reach the melting point, and comparing it with experimental data to conclude with **95%+ accuracy**

Research Publications

S. C. Bhatt, N. D. Ghetiya & **Madhav Joshi** (2022) Multiphysics simulation and validation of microwave melting characteristics of AA6061 by finite element analysis, *Advances in Materials and Processing Technologies*, 8:sup3, 1557-1568, DOI: 10.1080/2374068X.2021.1948708

Projects

Jan'23 – Feb'23 **JLR Robot Charging Challenge | Inter IIT Tech Meet 11.0**

*Bagged the 1^{st} **runner up** out of a total of 10+ teams from various IIT's across India*

- The problem statement prescibed us to devise a system that can automatically detect the charging port of the vehicle and plug the socket into the charging port
- Designed a 6 DoF robotic arm using Solidworks for maximum range of motion without self collision and simulated it on MATLAB and Simscape in a team of 13
- Computed system trajectory to move the end effector using analytical inverse kinematics and respecting constraints like self-collisions, joint limits, and velocity limitations
- Performed torque and energy calculations to respect the torque limits on joint motors and compare energy consumed for traversing different trajectories of the robotic arm

Feb'22 – May'22 **H-Bot 3D Printer**

Course: Design of Mechatronic Systems | Guide: Prof. Prasanna Gandhi, IIT Bombay

- Constructed an H-Bot 3D printer mechanism using TIVA C microcontroller, stepper motors, timing pulleys, aluminum extrusions, and LSM13 linear encoder
- Implemented a subroutine using PWM signals to drive two stepper motors simultaneously, QEI to read linear encoder values, and take the station to the desired input position

Feb'22 – May'22 **Temperature Control of Fluid Column**

Course: Advanced Feedback Theory | Guide: Prof. P.S.V. Nataraj, SysCon, IIT Bombay

- Conducted bump test on an integrating system and collected the data from National Instruments DAQ card using MATLAB interface for modelling purposes
- Tuned and tested a PI controller based on Ziegler Nichols tuning rules, and integrated a feed forward block to enhance the disturbance rejection for the system

Feb'22 – May'22 **Vision Transformer on Small Data-set**

Course: Machine Learning for Remote Sensing | Guide: Prof. Biplab Banerjee, IIT Bombay

- Demonstrated proficiency in implementing state-of-the-art (SOTA) ViT and SL-ViT models for image classification on CIFAR-10 and CIFAR-100 to increase locality inductive bias
- Enhanced locality inductive bias through the use of Shifted Patch Tokenization and Locality Self Attention techniques, resulting in more spatial information and locally focused attention
- Achieved top-5 accuracy of 99.13% for CIFAR-10 and 82.92% for CIFAR-100 dataset

Feb'22 – May'22 **Two Degrees of Freedom Robotic Arm**

Course: Robotics | Guide: Prof. Abhishek Gupta | Mechanical Engineering, IIT Bombay

- Designed and constructed a 2 DoF Robotic Arm with a plane movement capability, based on a CAD model created in Solidworks that comprised of PLA links and servo motors at joints
- Implemented hardware and software integration by developing a red spot detection algorithm and integrating the system with an Arduino for closed loop feedback control
- 3D printed all the components required for assembling while ensuring accuracy and precision
- Successfully achieved accurate joint parameters, and current and desired positions of the end-effector, resulting in the precise movement of the robot arm to coordinates pointed by a red spot detected by a phone camera around the robot

Jul'21 – May'22 **Stride | Student Technical Team**

Focuses on building a quadruped which can walk autonomously on all terrain | IIT Bombay

- Developed the Newton-Euler method in MATLAB for calculating the reaction forces and torques needed to achieve desired angular velocities and accelerations in any configuration
- Reviewed the MIT Cheetah 3 papers, robot design, including examining its implementation of MPC with QP formulation in ROS and simulating the robot in Gazebo and RViz
- Conducted extensive research on trajectory generation techniques using Bezier curves and the localization and mapping of quadruped robots in diverse environments.

Mar'22 – Apr'22 **Optimization of Swiggy Instamart Hub Locations**

Course: IEOR | Guide: Prof. Avinash Bharadwaj | Mechanical Engineering, IIT Bombay

- Formulated Swiggy Instamart's revenue system as an **integer programming problem** by considering investment costs, operating costs and profits from all probable hub locations
- Optimized net profit for both limited and infinite capacity hub scenarios using CPLEX solver in **AMPL**. Ensured model robustness by conducting uncertainty and risk analysis

May'21 **Laser Surface Hardening (LSH)**

Course: Manufacturing Processes | Guide: Prof Ramesh K Singh, Mechanical Department, IITB

- Simulated LSH process via **FEM** using open-source **FEniCS** project with a **team of 5**
- Reviewed 5+ research papers and numerically solved **transient heat equation** to calculate temperature field and found the **laser velocity** for required **hardened depth** and vice versa

Key Courses and Technical Skills

Key Courses	Joint Biomechanics*, IEOR, Mechatronics, Robotics, Vibro-Acoustics, Machine Learning, Linear and Non Linear systems, Signals and Feedback systems
Labs	Microprocessors and Automatic Controls, Mechanical Measurements, Manufacturing Processes, Mechanical Workshop, Computer Programming
Coding	C, C++, Python (Numpy, Pandas, Tensorflow, FEniCS), MATLAB, LaTeX, Linux
Hardware	Arduino, ESP32, TIVA-C, Raspberry Pi 4B, Stepper and DC motor, I2C communication
Softwares	SolidWorks, AutoCad, Adams, ROS, LABView, MS-Office, G-Suite, COMSOL, SOFA

**To be completed by Apr'23*

Position of Responsibility

Jan'23 – Apr'23 **Undergraduate Teaching Assistant | IIT Bombay**

Kinematics and Dynamics of Machines (ME316)

- Assumed responsibility for guiding a cohort of **195 students** through the course by conducting tutorial sessions, grading exams, and maintaining performance records

Sept'21 – Sept'22 **Water Polo Team Captain | Aquatics | IIT Bombay Sports**

*Captained a **13-member** water polo team representing our institute in Inter IIT Aquatics meet*

- Implemented a revamped training process and restructured the team following a 2-year COVID-19 pandemic hiatus, leading to IIT Bombay's **first semifinal** appearance in 6 years
- Recruited players, evaluated individual strengths, organized team practices and matches, and facilitated constructive discussions to enhance team performance

Feb'20 – Mar'21 **Events Convener | Institute Sports Council | IIT Bombay**

***36-member** team responsible for execution of sports events for **10K+** students and faculties*

- Managed IIT Bombay's Aavhan sports fest attracting sports enthusiasts from **150+** colleges across India and **Blackcats Championship** a virtual fitness event for **200+** inter IIT players
- Coordinated India's first **Virtual Run** with **1.2K+ runners** nationwide, promoting physical activity during pandemic and raising INR 15K for NGO-Goonj's **COVID relief** campaign
- Organized **India's largest** 1-Day Online Chess tournament attracting 550+ players (15 GMs) with prizes worth Rs70K, and conducted **Virtual Cup** for hostels through fantasy leagues

Extra Curricular

2022 Selected **among 16 buddies** out of 115 applicants for Student Buddy Program which helps foreign exchange students breeze through their stay at our institute

2019-22 Earned podium finishes in both Inter IIT and Inter Hostel General Championship, including **Gold**, **Silver**, and **Bronze** medals, as well as two 4th place finishes

2019 Fabricated a Bluetooth controlled four-wheel bot and a Remote Controlled plane

2014-2017 Proficient in **Tabla**, have cleared three exams with distinction organized by ABGMVM

2015-2017 Served as member of the Nagpur City **Road Safety Patrol** for three consecutive years

2015-16 Secured district-level podium finishes, earned selection for 2 consecutive years to compete for my school at the **State Level** and CBSE-organized **Zonal** Swimming competitions

Last update: March 13, 2023