Shashank Ramesh

Mechanical Engineering
Integrated MTech in Robotics
Indian Institute of Technology Madras
Graduated in 2021, **CGPA: 9.49/10**

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Research Interests

Dynamics and Control of Robots

Publications

- **Journal** – Nagamanikandan G., **Shashank R.**, Asokan T., "Design of a Variable Stiffness Joint Module to Quickly Change the Stiffness and to Reduce the Power Consumption", in IEEE Access, vol. 8, pp. 138318-138330, 2020, doi: 10.1109/ACCESS.2020.3012031.
- **Patent (Filed)** – Nagamanikandan G., **Shashank R.**, Asokan T., "A Device for Adjusting Joint Stiffness", IDF No.1861

Research Experience

➢ **Project Assistant** | Stochastic Control Lab, RBCCPS[1], IISc[2] Bangalore — Aug'21 – Present

Guide: Prof. Shishir N. Y. Kolathaya

- Built a C++ package for hardware-in-loop training of a black-box position control system using genetic algorithm
- Programmed a C++ ROS[3] node for trajectory planning of quadruped robot foots to control its body pose while standing
- Devised legs made of plastic-silicone composite for a quadruped robot to absorb ground impacts during walking
- Determined the compatibility of actuators for a quadruped robot by studying its frequency and step response

➢ **Final Year Project Student** | Manipulator Robotics Group, Eng. Design Dept., IIT Madras — May'20 – Present

Guide: Prof. Sandipan Bandyopadhyay

- **Path Planning of Semi Regular Stewart Platform Manipulator**
  - Implemented a novel method for finding the largest SFS[5] in C++ involving finding up to 228 solutions precisely in a second
  - Built a C++ library for finding singularity-free parametric path with least length using the NSGA-II genetic algorithm
- **Computational Kinematics of a Hybrid 6-Axis Manipulator**
  - Established a novel procedure for solving its IK[4] involving 5 elimination steps resulting in a 40-degree univariate polynomial
  - Identified singularities of the manipulator by analysing the conditions for the proposed elimination sequence to break down
  - Handled symbolic expressions of disk sizes up to 1TB in Mathematica using specialised methods for algebraic operations
- **Workspace and Singularity Analysis of a 5R Parallel Manipulator**
  - Formulated an analytical method for finding the maximal safe working zone in the workspace of the manipulator
  - Performed kinematic design for maximising its safe working zone and derived the optimal link lengths in the closed-form
  - Characterized the singularity manifold of the manipulator based on the nature of its double points for different link lengths
- **Higher-Order Singularity Analysis of Parallel Manipulators**
  - Corelated the degree of shakiness at a singularity to the nature of FK[6] solutions by analysing its higher-order constraints
  - Compared various methods in the literature for finding the principal screws and identified the method relevant to the study

➢ **Research Assistant** | Robotics Lab, Eng. Design Dept., IIT Madras — Oct'18 – July'20

Guide: Prof. Asokan Thondiyath

- Performed system identification on the GraspMan multi-modal robot using the grey-box modelling technique in MATLAB
- Implemented an optimal controller on the 2-DOF[7] GraspMan brachiator robot for trajectory planning with minimum power consumption, using the OptimTraj library in MATLAB
- Designed a novel cam based variable stiffness mechanism (VSM) that consumes zero power for maintaining a stiffness value
- Conducted a literature survey on variable stiffness actuators and researched on their mechanism and control algorithms used
- Synthesized a cam profile for maintaining the VSM in static equilibrium by orienting the friction cones at the contact points

Technical Experience

➢ **Team Lead** | Anveshak, Center for Innovation (CFI), IIT Madras — Aug'17 – June'19

Guide: Prof. Asokan Thondiyath. The team works on building Field Robots and Space Rovers

- Supervised the implementation of a path planning algorithm for a 3R articulated robotic arm using python in ROS framework
- Conducted twelve boot camp sessions on robotics covering concepts on robot kinematics, dynamics, and control

[1] Robert Bosch Centre for Cyber-Physical Systems [2] Indian Institute of Science [3] Robot Operating System [4] Inverse Kinematics [5] Singularity Free Sphere

- Encouraged the team towards innovating novel mechanisms by allocating more funds to the research and development sector
- Engineered a flexible gripper finger by cascading two four-bar linkages designed for form enclosing the grasped object
- Designed an embedded controller PCB[8] in Autodesk Eagle with daisy chaining and customized motor speed control capability
- Guided the electronics group towards designing circuitry for signal isolation from power devices and battery monitoring system

➢ **Mechatronics Engineer** | Internship at F. T. Motors, Sina Mobility — May'19 – June'19

The company works on building self-balancing two-wheeled vehicles

- Formulated the forward dynamics of a control moment gyroscope using the Lagrangian method in Wolfram Mathematica
- Implemented LQR[9] control on a single axis control moment gyroscope for the stabilization of a two-wheeled vehicle
- Designed an embedded controller based on ATMega328 microcontroller for the digital control of orientation and motion of a two-wheeled vehicle

➢ **Digitization of Gear Design** | Design of Machine Elements — July'18 – Nov'18

Guide: Prof. Ratna Kumar Annabattula

- Developed a GUI[10] using python Tkinter library for automating the design of helical gears based on AGMA standards
- Automated the generation of gear production drawings using PDF library in python with the dimensions of the gear as inputs
- Designed a 5-speed automatic transmission gearbox with two helical planetary gear sets using the gear design GUI

➢ **iBoT Club Coordinator** | CFI, IIT Madras — Aug'17 – May'18

- Guided over 10 teams towards building floor-sweeping robots in the Cleaning Bots Session organized by CFI
- Conducted sessions on embedded system covering concepts on motor drivers, Arduino controller and control algorithms

Projects

➢ **Adaptive Positioning Collaborative Robot (CoBots)** | A.I. in Manufacturing — Jan'19 – May'19

Guide: Prof. G. L. Samuel

- Devised a visual servoing algorithm based on HSV[11] object detection and centre of intensity for position tracking of objects
- Enhanced the safety of CoBots by including human detection using Convolutional Neural Network with YOLO[12] architecture

➢ **Walking Beam Indexer Mechanism** | Kinematics and Dynamics of Machinery — July'17 – Nov'17

Guide: Prof. P. Chandramouli

- Synthesized a walking beam mechanism for the desired motion curve and indexing rate using the graphical approach
- Optimized the link lengths of the mechanism for a near straight-line motion of the beam by studying its coupler curves

Relevant Course Work

- Non-smooth analysis in control
- Modern Control Theory
- Multi-Body Dynamics
- Process Optimization
- Design, Analysis and Control of Manipulators
- Principles of guidance for autonomous vehicles
- Mechanics of Human Movement
- Artificial Intelligence in Manufacturing
- Nonlinear Control System
- Real Analysis
- CNC and Adaptive Control
- Probability and Statistics

Skills

- **Mathematical Tools**: MATLAB, Simulink, Wolfram Mathematica
- **Programming Languages**: C/C++, Python, ROS, STM32Cube IDE, Atmel Studio 7.0, Arduino IDE
- **CAD Tools**: Solidworks, AutoCAD, Autodesk Fusion 360, Autodesk Eagle
- **Software Tools:** LaTeX, Inkscape, Microsoft Office, Unity 3D, Davinci Resolve
- **Other Skills:** Product Design, Prototyping, Project Management, Teaching

Achievements

- Anveshak placed 1st in the Indian Rover Challenge and 12th in University Rover Challenge 2019 organized by Mars Society
- Appointed as an intern at the University of Manitoba – Winnipeg, Canada, for working on the project "Intelligent Anti-Vibration Control of Industrial Manufacturing Robots" under Mitacs Globalink Research Program 2020 (Cancelled due to COVID-19).
- Conducted a workshop on 3D modelling in Autodesk Fusion 360 organized by Mechanica 2019, IIT Madras
- Awarded technical excellence in Carbon Zero Challenge organised by IIT Madras and U.S. Consulate for innovating smart streetlights that dim when not in use thereby saving significant energy
- Cleaning bots session set the Asia and India Book of Records for building 45 bots sweeping 750 sq. ft of area

[6] Forward Kinematics [7] Degree of Freedom [8] Printed Circuit Board [9] Linear Quadratic Regulator [10] Graphical User Interface
[11] Hue Saturation Value [12] You look only once