

Ridhi Puppala

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RESEARCH INTERESTS

Multi-agent coordination, localization & distributed control, Reactive navigation & planning for autonomous robots, Nonlinear analysis, Robot design & modelling, Hybrid systems, Field & Service robots (aerial, underwater & ground)

EDUCATION

Indian Institute of Technology Madras (IIT Madras)

2020 (ongoing)

B.Tech. in Mechanical Engineering and M.Tech. in Robotics (Minor - Control Systems)

CGPA: 8.31/10 | Advanced GPA (from 5th semester): 8.84/10

PUBLICATIONS

- **Puppala, R.**, Sivadasan, N., Vyas, A., Molawade, A., Ranganathan, T. and Thondiyath, A. (2019). "*Design, Estimation of Model Parameters, and Dynamical Study of a Hybrid Aerial-underwater Robot: Acutus*". In Proceedings of the 16th International Conference on Informatics in Control, Automation and Robotics (ICINCO) [SCITEPRESS]
- Abhijeet Vyas, Akshay Molawade, Nikhil Sivadasan, **Ridhi Puppala**, Thiyagarajan Ranganathan and Asokan Thondiyath. "*Modelling and Dynamic Analysis of a Novel Hybrid Aerial-Underwater Robot - Acutus*". In Proceedings of OCEANS 2019 MTS/IEEE Marseilles, France [IEEE]
- Arun G.K., **Ridhi Puppala** and Leena Vachhani. "*Reactive controller for globally convergent navigation in cluttered environments using local information and coarse bearing-only measurements*" (Under preparation)
- Thiyagarajan Ranganathan, **Ridhi Puppala** and Asokan Thondiyath. "*Design Optimization and Performance Investigations of a Novel Underwater Glider: RoBuoy*" (Journal article under preparation)

RESEARCH EXPERIENCE

Distributed coordination and control for Multi robot systems

ongoing

Guide: Dr. Arun Mahindrakar | Dynamics & Control Lab, IIT Madras

Master's Thesis

- Designing a **unified framework** for collision avoidance, coordination control and connectivity maintenance in multi-robot systems; with limitations in communication and available sensor (local) information
 - Conducted literature study on **Graph & set theoretic methods; Gradient & Optimization based controllers**, Collision avoidance, Distributed coordination and control in multi-robot formations
- Concepts:** Graph and Set-theoretic methods, Lyapunov based stability analysis, Gradient and Optimization methods

Reactive controller for global navigation using minimal sensor information

May'19-July'19

Guide: Dr. Leena Vachhani | ARMS Lab, IIT Bombay

Research Internship

- Formulated planar global reactive navigation controller that just utilizes coarse bearing-only and 2D LIDAR measurements by fusing homing & boundary following operational modes through novel exit condition
 - Derived controller for static or dynamic targets using **geometry, robot kinematics, sliding mode control**; proved **finite time stabilization** for individual modes & overall switched system, ensuring practical feasibility
 - Successfully validated controller using Gazebo (ROS) simulations and experiments in VICON motion capture setup
- Concepts:** Non-linear control, Mathematical Proofs for stability, Robot Simulations, Experimental evaluation, ROS

Performance investigations and optimization of glider - RoBuoy

Jan'18-Apr'19

Guide: Prof. Asokan Thondiyath | Robotics Lab, IIT Madras

Undergraduate Research

- Modelled **nonlinear dynamics** of underactuated shape-changing glider based on **Newton-Euler formulation**
 - Optimized gliding-depth-to-range ratio w.r.to fixed wing location & area through MATLAB dynamical simulations
 - Proposed sequential switching algorithm using pitch feedback to achieve smooth & energy-efficient trajectories; and correlated experimental trajectory data with dynamical simulation results
- Concepts:** Mathematical modelling, Numerical simulations, Embedded programming, Design optimization

Modelling of hybrid aerial-underwater robot - Acutus

Aug'17-Dec'18

Guide: Prof. Asokan Thondiyath | Robotics Lab, IIT Madras

Undergraduate Research

- Developed aerial-underwater vehicle that switches between quadcopter & fish morphology with **minimal actuation**
 - Estimated inertial, added mass & damping parameters using computational system identification techniques and observed **hydrodynamic drag reduction** by about 50% compared to existing hybrid systems
 - Constructed mathematical model for **dynamical analysis**; developed prototype to practically validate concept
- Presented paper at the proceedings of ICINCO 2019 in Prague, Czechia**
- Concepts:** Dynamical Modelling & Simulation, CAD, Prototyping, Computational Fluid Dynamics (CFD)

PROFESSIONAL AND TECHNICAL EXPERIENCE

Design & development of in-house Junker test setup and Load washer

May'18–Jul'18

Guide: Manoj Kumar Sharma | Bajaj Auto Ltd. (Pune R&D)

Industry Internship

- Designed custom Junker test rig incorporating flexibility in operating frequency, load or test specimen type
- Improved maximum operating frequency by **4 fold**; performed failure analysis by MBS & FEA on digital twin
- Developed **analytical** model for custom load washer & validated model with experimental strain vs load data

Concepts: Design for Manufacturing, Multi body simulation (MBS), Finite Element Analysis (FEA)

Semi-autonomous Mars rover for University Rover Challenge (URC)

Sept'16–Dec'18

Team Anveshak | Centre for Innovation (CFI)

Head & Senior Member

- Headed 20+ member team to secure 25th worldwide rank (amongst 95 teams) in URC'18 at Utah, USA
- Developed **ROS packages** for rover control; and implemented **autonomous waypoint navigation**
- Devised **inverse kinematics** based 3-DOF robot arm control and chassis drive & steering controller
- Interfaced onboard electronics, BMS and microcontrollers with rover computer using custom developed PCBs
- Streamlined logistics, finance, project and team management functions, corporate sponsorship, crowdfunding

Concepts: Sensor fusion, Perception & Planning algorithms, Chassis & arm control, ROS, Embedded systems

PROJECTS

Stereo vision based position tracking of smartphone Virtual Reality (VR) headset

Jul'18–Nov'18

Course: Virtual Reality Engineering | Guide: Prof. M. Manivannan

- Proposed standalone & cost-effective method of position tracking for Smartphone VR systems since they only possess accurate head orientation tracking and lack motion tracking
- Incorporated disparity calculations on **CNN** based human body tracking from two USB cameras for 3D shoulder pose estimation, which is then used to compute **3D real-time position** of smartphone VR headset

Concepts: Disparity calculations for stereo vision, Convolutional neural network (CNN), VR simulation

Model predictive controller (MPC) for non-linear FCC model

Jul'17–Nov'17

Course: Modern Control Theory | Guide: Prof. Raghunath Rengasamy

- Implemented EKF based **state estimation** on discretized non-linear model using MATLAB ODE Suite
- Programmed **MPC** and analyzed effects of changes in initial value, control & prediction horizon, EKF parameters

Concepts: Discrete State space models, EKF state estimation, Model Predictive Control design

Self orienting arm controlled with two BLDC propulsion units

Jan'17–May'17

Course: Measurement, Instrumentation and Control | Guide: Prof. Sathyan Subbiah

- Developed prototype of centrally pivoted arm whose orientation is controlled with BLDC propulsion units
- Designed and tuned a **PID** controller for **active orientation control** against disturbances & static loads

Concepts: Classical control methods, Linear systems theory, PID controller design and tuning

Portable and cost-effective 3D Scanner for hobbyists

Feb'16–Aug'16

Student led project | Electronics Club, CFI, IIT Madras

- Developed a **cost-effective** and **portable** 3D scanner with limited accuracy
- Conceptualized frugal scanning setup with elements like USB camera, laser & motorized rotating platform
- Scripted algorithm to extract laser pixels & stitch them into scanned object's **3D point cloud**

Concepts: Computer Vision, Morphological transformations & Denoising algorithms, OpenCV (C++)

COURSEWORK AND TECHNICAL SKILLS

Mechanics & Control of Serial Robots
Guidance & Control of Marine Vehicles
Advanced Linear Control System
Introduction to Field & Service Robotics
Optimization methods in Mech. design

Modern Control Theory
Nonlinear Control
Instrumentation & Control
Introduction to Robotics
Automation & AI in Mfg.

Linear Algebra
Differential Equations
Probability & Statistics
Robotics Lab
VR Engineering

Robotic System Development	:	ROS, Gazebo, OpenCV, Simulink, MATLAB ODE Suite, TensorFlow
Programming & Mathematical	:	C, C++, Python, C#, MATLAB, Mathematica (Windows & Linux)
Computer Aided Engineering	:	Fusion 360, SolidWorks, AutoCAD, ANSYS, Fluent, ADAMS MSC
Embedded Systems	:	Eagle (PCB), Arduino, Raspberry Pi, Ordroid, Linux based SBCs
Prototyping Techniques	:	3D printing, CNC, Laser cutting, Milling, Lathe, Water Jet, Soldering
Other Skills	:	L ^A T _E X, Git, LabVIEW, Android Studio, Unity3D, MeshLab