Ridhi Puppala

IIT Madras, Chennai 600036, India ridhipuppala.github.io

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 5^{th} semester): 8.84/10

Sri Chaitanya Junior College, Raman Bhavan, Vijayawada *2015*
Class XII (Board of Intermediate Education Andhra Pradesh) | 97.7%

Dr. KKR's Gowtham International School, Vijayawada *2013*
Class X (Central Board of Secondary Education) | 10/10

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]

PROFESSIONAL AND RESEARCH EXPERIENCE

Distributed control and visibility maintenance in multi-robot systems *ongoing*
Dynamics & Control Lab, IIT Madras *Master's Thesis*

- Designing a **distributed multi-robot framework** incorporating **collision avoidance (CA), coordinated control** and **connectivity maintenance** under limitations of motion, sensing and communication
- Conducted literature study on wide range of topics like distributed coordination control, coverage planning, dynamic consensus, formation control, rendezvous and constraint based safety and resilience for multi-robot systems
- Developed MATLAB-ODE and ROS-Gazebo multi-robot simulation packages for validation of algorithms
- Proposed and validated a novel **network based rendezvous algorithm** that hierarchically tracks the network's minimum spanning tree to assigns control velocities to mobile agents while ensuring connectivity maintenance
- Conceptualizing a **LiDAR enabled multi-robot collision avoidance algorithm** that uses concepts of geometry, graph & set theory and simultaneously conducting validation through simulations in ROS-Gazebo & MATLAB

***Concepts & Skills**: Multi-robot motion planning, Distributed Control, Graph theory, Nonlinear Control*

Reactive planning for global navigation using minimal sensing and computation *May'19-July'19*
The Autonomous Robots and Multi-robot Systems Lab, IIT Bombay *Intern*

- Formulated **global online navigation framework** that just utilizes coarse **bearing** and **2D LiDAR** measurements
- Designed a novel sensor based trigger to switch between homing (source-seeking) & collision avoidance modes
- Derived controller for following dynamic target agents/robots using **geometry, robot kinematics, nonlinear control**; theoretically proved **stability & robustness** for overall switched system while ensuring practical feasibility
- Developed a scalable & modular multi-robot simulation package on ROS-Gazebo platform
- Successfully validated controller using Gazebo (ROS) simulations and experiments in VICON motion capture setup
- Manuscript containing our research is under preparation for submission to top robotics conferences like ICRA, IROS

***Concepts & Skills**: Non-linear Control, Stability & Robustness, Kinodynamic Planning, Perception, ROS*

Design optimization and its performance investigations of glider - RoBuoy *Aug'18–May'19*
Robotics Lab, IIT Madras *Research Assistant*

- 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 multi-objective optimization
- Proposed mode switching algorithm using pitch feedback to achieve smooth & energy-efficient trajectories; and correlated experimental trajectory data with dynamical simulation results
- Journal article containing our design optimization study and its effect on performance is under preparation

***Concepts & Skills**: Design Optimization, System Modelling, Embedded programming, Experimentation*

Modelling of hybrid aerial-underwater robot - *Acutus* *Jan'18–Dec'18*
Robotics Lab, IIT Madras *Research Assistant*

- 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
- *Co-authored two conferences publications and presented at the proceedings of **ICINCO 2019** in Prague, Czechia*
  ***Concepts & Skills**: Dynamical Modelling, Simulations, Experimentation, CAD, CFD, Prototyping*

Design & development of in-house Junker test setup and Load washer *May'18–Jul'18*
Bajaj Auto Ltd. (Pune R&D) *Intern*

- 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 & Skills**: Design for Manufacturing, Multi body simulation (MBS), Finite Element Analysis (FEA)*

TECHNICAL EXPERIENCE

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 25^{th} rank (amongst 95 international teams) in URC'18 at Utah, USA
- Designed clamps for wrist and shoulder joints of robotic manipulator, and casings for chassis and digger subsystem
- Developed **ROS packages** for joystick 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, sensors & microcontrollers with rover computer using custom designed PCBs
- Streamlined logistics, finance, management functions and led the efforts for corporate sponsorship & crowdfunding
- Mentored software, electronics & mechanical engineering teams to innovate in their design & prototyping processes
  ***Concepts & Skills**: Sensor fusion, SLAM, Perception, Planning, Deep Learning, Embedded Systems, Leadership*

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 systems and lack motion tracking mechanisms
- Modified & implemented CMU's **openpose** framework for vision-based real-time full human body 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 & Skills**: Depth estimation, Stereo Vision, Convolutional Neural Networks (CNN), Deep Learning*

Collaborative framework for aerial and ground robots for visual terrain exploration *Jul'18–Dec'18*
Semester project - RAFT Lab | Guide: Prof. Ranjith Mohan

- Implemented sequential sensor method based on **asynchronous Kalman filter** from literature for ground localization
- Deployed the local position and quaternion attitude estimator of PX4 firmware for aerial robot localization
- Scripted codes to generate dense point clouds from ZED camera for elevation mapping & traversability estimation
- Implemented cost map generator, Dijkstra's algorithm and purse pursuit controller for aerial & ground navigation
  ***Concepts & Skills**: EKF localization, Visual odometry, SLAM, Elevation mapping, Traversability estimation*

Neural networks (NN) based fastener sorting for industries *Jan'18–May'18*
Course: AI in Manufacturing | Guide: Prof. Samuel G.L.

- Achieved **91%** testing accuracy by training feed forward **NN classifier** on custom fastener data set generated from image augmentation of smartphone pictures of five classes of bolts, nuts and bearings
- Proposed dimensional measurement and **feature extraction** of classified part in constrained environment settings with direct applications to automobile manufacturing and recycling lines using classical image processing algorithms
- Co-scripted Python OOPS based reusable codes for every crucial component of the feed-forward neural networks
  ***Concepts & Skills**: Neural Networks, Object-oriented programming, Computer Vision, Image augmentation*

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 & Skills**: 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 & Skills**: 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** & **portable** 3D scanner with limited accuracy using **computer vision algorithms**
- 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 & Skills**: Computer Vision, Morphological transformations & Denoising algorithms, OpenCV (C++)*

COURSEWORK AND TECHNICAL SKILLS

Mechanics & Control of Serial Robots	Modern Control Theory	Linear Algebra
Guidance & Control of Marine Vehicles	Nonlinear Control	Differential Equations
Advanced Linear Control System	Instrumentation & Control	Probability & Statistics
Introduction to Field & Service Robotics	Introduction to Robotics	Robotics Lab
Optimization methods in Mech. design	Automation & AI in Mfg.	VR Engineering

Robotic System Development	:	Robot Operating System (ROS), Gazebo, OpenCV, PX4, Simulink
Programming & Mathematical	:	C, C++, Python, 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	:	LaTeX, Git, LabVIEW, Android Studio, Unity3D, Microsoft Office

EXTRACURRICULAR AND SOCIAL ACTIVITIES

Robotics Workshop Coordinator | Shaastra'16 (Tech Fest of IIT Madras) *2016*

- Conducted certified workshops, **teaching** robotics to **350+ students** from colleges across India
- Formulated problem statement for Vision based Object tracking workshop with custom robotic kits
- Administered the availability of the workshop as a free short online course on EdXengine

Publicity & Outreach Coordinator | Saarang (Cultural fest of IIT Madras) *2016*

- Boosted online engagement by **50%** & Saarang **footfall** by **10%** through India wide publicity events
- Developed **50+** Saarang student ambassador network from amongst various colleges in Hyderabad
- Organized Light Music event at zero expense through **sponsorship deals** with colleges & media studios

Volunteer | Lead India Movement *2010*

- Volunteered for Lead India 2020 mission started by Dr. A.P.J. Abdul Kalam to inspire young India
- **Taught** math & science; Donated books & stationery to **underprivileged** schools students
- Delivered lectures and workshops to school students on mental and social awareness