Ridhi Puppala

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EDUCATION

Indian Institute of Technology Madras (IIT Madras) *2020 (ongoing)*
B.Tech. in Mechanical Engineering and M.Tech. in Robotics (Minor - Control Systems)
CGPA: 8.3/10 | Advanced GPA (from 6^{th} semester): 8.75/10

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 coordination and control of multi-robot systems *ongoing*
Dynamics & Control Lab, IIT Madras *Master's Thesis*

- Designing a **distributed multi-robot framework** incorporating **collision avoidance (CA)** and **connectivity maintenance** under limitations of motion, sensing and communication applicable to **ground robots** or **UAVs**
- Conducted literature study on wide range of topics like distributed formation control, rendezvous, coverage planning, dynamic consensus, distributed localization and constraint-based safety frameworks for multi-robot systems
- Developed custom MATLAB-ODE and ROS-Gazebo multi-robot simulation packages for validation of algorithms
- Proposed a method to construct a proximity network graph for random spatial distribution of robots that is reduced to a minimum spanning tree (MST) using Prim's/Kruskal's algorithm (implemented by MATLAB & roscpp scripts)
- Proposed and validated a novel **network based rendezvous algorithm** that ensures connectivity maintenance
- Formulating a **LiDAR enabled multi-robot CA algorithm** by exploiting concepts like control barrier functions, convex optimization and quadratic programming which will be tested through MATLAB & ROS-Gazebo simulations

***Concepts/Skills**: Multi-robot motion planning, CA, Distributed Control, Graph theory, MATLAB, ROS-Gazebo*

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 **Object-Oriented Programming (OOP)** based **codebase** for **multi-robot Gazebo packages** containing C++ & Python nodes for individual robot initialization, control, perception & communication
- Successfully validated controller using **ROS simulation package** and **VICON motion capture** based experiments

***Concepts/Skills**: Kinodynamic Planning, LiDAR based CA, Nonlinear Control, ROS-Gazebo, OOP (C++/Python)*

Design optimization and its performance investigations of underwater 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 control algorithm using pitch feedback to achieve smooth & energy-efficient trajectories and correlated experimental trajectory data with dynamical simulation results

***Concepts/Skills**: Design Optimization, System Modelling, Embedded programming, Simulink, Hardware Testing*

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
- Implemented and experimentally tested the cascaded PI-PID controller for navigation of **aerial multi-rotor system**
- *Co-authored two conferences publications and presented at the proceedings of **ICINCO 2019** in Prague, Czechia*
  ***Concepts/Skills**: System Modelling, System Identification, Simulink, Hardware & Real-time Testing*

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 four fold and performed failure analysis on the digital twin
  ***Concepts/Skills**: Design for Manufacturing, CAD, Multi body simulation (MBS), Finite Element Analysis (FEA)*

Semi-autonomous Mars rover for University Rover Challenge (URC), Utah USA *Sept'16–May'19*
Team Anveshak | Centre for Innovation (CFI) *Head & Senior Software Engineer*

- **Headed 20+ member team** to secure 25^{th} rank (amongst 95 international teams) in URC'18 at Utah, USA
- Instituted a **software development life cycle** for our rover's ROS codebase as the Elec & Software Team lead
- Actively participated in design, implementation, testing, version control & documentation for Rover Software
- Developed **ROS packages** for joystick control of 6-wheel rover's differential drive, 4-wheel rover's steering drive, 3DOF serial manipulator's **Inverse Kinematic end-effector control** and gripper's RPY control based on live visual feedback from USB cameras relayed over long-distances through **antenna** based **communication channels**
- Interfaced onboard electronics, BMS, sensors & microcontrollers with rover computer using custom designed PCBs
- Implemented Deep Neural Networks for goal marker detection along with **IMU+GPS+LiDAR** based navigation
- Added customized goal navigation & CA scripts to **ROS Navigation Stack** for autonomous path planning
- Streamlined logistics, finance, management functions and led the efforts for corporate sponsorship & crowdfunding
  ***Concepts/Skills**: Robot Software Development, Hardware Testing, Localization, Mapping, Planning, Vision & DL*

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** CNN 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, Deep Neural Networks, Hardware Testing, TensorFlow, Unity3D*

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 Asynchronous Kalman filter from literature for **ground robot localization**; local position & quaternion attitude estimator of the PX4 firmware for **aerial robot localization**
- Implemented dense & sparse point cloud generation from ZED API for elevation mapping & traversability estimation
- Scripted codes for Cost map generator, Dijkstra's algorithm, Pure pursuit controller for cooperative navigation
- Modified scripts of EKF localization, mapping & planning of **PX4's Object-oriented codebase** for aerial robot
  ***Concepts/Skills**: UAV Localization, Navigation & Controls, Visual Odometry, SLAM, Path Planning, ROS*

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
  ***Concepts/Skills**: Machine Learning, Object-oriented programming, Image augmentation, OpenCV, TensorFlow*

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, MATLAB*

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 control - Design & Tuning, Hardware*

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 C++ OpenCV based** routines to adjust camera & thresholding parameters, perform background subtraction, extract line laser pixels & stitch them together to obtain scanned object's **3D point cloud**, render point cloud in OpenGL for visualization and perform geometric transformations for extracting real-world coordinates
- Performed **software integration** by utilizing **python bindings** based master script to sequentially call executable C++ objects and routines for **OpenGL** based **point cloud-visualization** & **Arduino serial communication**

***Concepts/Skills**: Computer Vision algorithms, OpenCV, OpenGL, Software-Hardware Development and Testing*

COURSEWORK AND TECHNICAL SKILLS

Introduction to Field & Service Robotics	Introduction to Robotics	Robotics Lab
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
Optimization methods in Mech. design	Programming in C++*	VR Engineering

Software	:	Robot Operating System (ROS), Gazebo, MATLAB, Simulink, OpenCV, PX4
Hardware	:	GPS, IMU, LiDAR, Camera, Arduino, STM, RPi, TX2, Odroid, Linux based SBCs
Programming	:	C, C++, Python, Data Structures & Algorithms, OOP (Windows & Linux)
CAD/CAE	:	Fusion 360, SolidWorks, AutoCAD, ANSYS, ADAMS MSC, Eagle (PCB)
Prototyping	:	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 subjects and donated books & stationery to underprivileged schools students
- Conducted workshops and delivered lectures to school students on mental and social awareness