

Rachana Agrawal
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RESEARCH INTERESTS

Space Exploration, Astrodynamics, Space systems design and development, EDL analysis, Optimization, Mission planning, Trajectory design

EDUCATION

PhD candidate, School of Aeronautics and Astronautics *August 2017 - Ongoing*

Purdue University, West Lafayette, IN

Major: Astrodynamics and space systems

Minor: Systems Engineering

Master of Technology and Bachelor of Technology, Aerospace Engineering *July 2017*

Indian Institute of Technology Bombay, India

Minor: Systems and Controls Engineering

RESEARCH EXPERIENCE

Purdue University, West Lafayette, IN

Human Mars Mission Logistics Nodes *Ongoing*

Supervisor: Prof. Sarag J. Saikia

- Concept design of Mars Orbital Logistics Node with Aggregation Refueling Refurbishing capabilities
- Designing mission that involves a permanent logistics node
- Trade studies orbital nodes of interest around Mars for a Human mission and its impact
- Studying the Arrival and landing problem and launch from Mars to a departure trajectory

Ocean Worlds (Europa and Enceladus) Surface Mobility Systems *Ongoing*

Supervisor: Prof. Sarag J. Saikia

- Studying the scientifically interesting landing sites on Europa and Enceladus
- Close study of the surface features to establish requirements on the mobility system

Human Mars Mission Water Demand Scenarios and Projection for Long-Term Exploration *Aug – Dec'17*

Supervisor: Prof. Sarag J. Saikia

- Studying the current Mars architectures to assess the design factors affecting water demand
- Establishing relation between evolving mission variables and water requirement

Indian Institute of Technology Bombay, India

Control of spacecraft in periodic orbits around the triangular libration points in CR3BP *May'16-June'17*

Supervisor: Prof. Ravi N. Banavar, Systems and Controls Engineering

- Did an extensive literature survey on the natural dynamics around the libration points in the CR3BP
- Studied the third order periodic orbit around the triangular libration point and its invariant manifolds
- These were exploited to design controller for station-keeping of spacecraft

Circular orbit spacecraft control at the L4 point using Lyapunov functions *July'15-May'16*

Supervisor: Prof. Ravi N. Banavar, Systems and Controls Engineering

- Designed a controller using lyapunov function for stabilizing a spacecraft in a circular orbit around the triangular libration point in CR3BP
- The asymptotic stability of the orbit was proved using LaSalle's invariance principle
- The work was presented in ECC 2016

TECHNICAL PROJECTS

Single Tire Testing facility for Ocean Worlds (Europa and Enceladus) Rover

Ongoing

Mechanisms and Electrical systems

- Developing a tire testing facility to test performance of tires of various dimensions and surface simulants
- Designing Slip and Camber mechanism for the tire test rig

Pratham, IIT Bombay Student Satellite Project

April'13–May'17

Core-team member

- Successful completion of Flight model leading to launch by ISRO on 26th September 2016 on PSLV-C35
- Participated in pre-launch activities at SHAR to place satellite on launch vehicle
- Successfully completed all environmental testing and reviews at ISAC Bangalore

Head, TT&C subsystem

- Designed and automated ground station to fulfil the payload requirements of Pratham and to receive signals from amateur satellites
- Conducted ground station workshop and helped 15 Indian Universities to establish ground stations, as a part of the Social Goal of the project, a pro bono outreach effort to facilitate knowledge sharing
- Established wireless link between two CC1101 transceivers as a test for developing the communication hardware and software of the satellite
- Integrated the Communication system with OBC and Power system on-board the satellite

Mentor, Advitiy, Second student satellite

- Mentored the new team as part of knowledge transfer activity for the continuation of the project

Mars Rover Team, Mars Society India

August'12–May'15

Head, Robotic-Arm subsystem

- Developed the control algorithm for a 6 degree of freedom (DOF) robotic arm to perform activities held in Arkaroola, Australia to test functionality of the rover in Mars analogues environment
- Implemented inverse kinematics algorithm on RPi for 3 DOF control of arm
- Designed the electrical and controls system of 6 DOF arm to complete the tasks to be performed at the University Rover Challenge 2015, MDRS, Utah

WORK EXPERIENCE

Planetary Science Summer Seminar, Jet Propulsion Laboratory, NASA

Mentors: Charles Budney, Karl Mitchell, JPL

- Selected among hundreds of applicants to be part of a team of 18 students and professionals for a 12-week training in science mission design culminating in a one-week session at JPL
- Designed a science mission to an interstellar object
- Actively participated in a one-week program at JPL involving exercise with A team and Team X
- Performed cost estimation for the mission as the Cost Chair along with Team X mentors
- Presented the mission cost to a panel of JPL scientists and engineers

Attitude Control of Quadrotor using MATLAB-ROS Framework implemented on Astec Hummingbird

Supervisor: Prof. Koushil Sreenath, Mechanical Engineering Department, Carnegie Mellon University

Summer 2015 Internship

- Studied the geometric controller for attitude and position control of a quadrotor
- Understood hardware setup for implementing the controller on Astec Hummingbird
- Designed a work-bench using MATLAB-ROS framework to test the controller

On-board computation system for Optical Telescope

Supervisor Prof. A R Rao, Department of Astronomy and Astrophysics, Tata Institute of Fundamental Research Summer 2014 Internship

- Developed algorithm to improve speed by processing while simultaneously reading image from CCD
- Studied star catalogues, data reduction algorithms, sorting and searching algorithms to optimize the on-board computing process time
- Completed a short course on X-ray detectors in astronomy which included basic physics, programming in C, Analysis methods, Introduction to X-ray detectors and basic astrophysics

PUBLICATIONS

Journal Manuscripts under preparation:

- **R Agrawal**, R Potter, S J Saikia, J Longuski, “Mars Orbital Logistics Platform for sustained human exploration”, To be submitted to Acta Astronautica, 2020
- K Moore, S Courville, S Ferguson, A Schoenfeld, K Llera, **R Agrawal**, P Buhler, D Brack, K Connour, E Czaplinski, M DeLuca, A Deutch, N Hammond, D Kuettel, A Marusiak, S Nerozzi, J Stuart, J Tarnas, A Thelen, J Castillo, W Smythe, D Landau, K Mitchell, C Budney, “Bridge to the stars: A mission concept to an interstellar object”, Submitted to Planetary and Space Science, 2020

Conference Papers and Presentations:

- **R Agrawal**, R Potter, S J Saikia, J Longuski, “Enabling sustainable human exploration of Mars via orbital logistics node”, AAS/AIAA Astrodynamics Specialist Conference, August 2019
- **R Agrawal**, B Aiken, M de Jong, A Pradeepkumar, J Longuski, SJ Saikia, “Surface mobility system with large deployable and conformal tires for Ocean Worlds exploration”, Poster Presentatio, 15th International Planetary Probe Workshop, June 2018
 - Awarded third position in best student poster category
 - Received IPPW Student Scholarship
- A Pradeepkumar, **R Agrawal**, Y Lu, B Aiken, M de Jong, SJ Saikia, “A Novel Mobility System for Exploration of Ocean Worlds”, Poster Presentation, Outer Planets Assessment Group Meeting, February 2018
- **R Agrawal** and R N Banavar, “Circular orbit spacecraft control at the L4 point using Lyapunov functions”, European Control Conference 15, 2016
- A Rajagopal, P Bende, **R Agrawal** et. al, “Design, modeling and control of a 6 degrees of freedom robotic arm with specific application in planetary exploration missions”, International Astronautical Conference 65, 2014
- A Yadav, **R Agrawal**, R Roopak, B Senwar, “Design of an automated system at the ground segment for data acquisition, processing and archiving for 'Pratham' IIT Bombay”, International Astronautical Conference 65, 2014

RELEVANT COURSE WORK

Purdue University, West Lafayette, IN

Optimal Landing of the First Stage of a Re-usable Rocket (AAE 508: Optimization in Aerospace Engineering)

- Designed the thrust control for minimizing fuel consumption while landing the first stage of Falcon 9 using the concepts of Optimal Control Theory

Indian Institute of Technology Bombay, India

Design of modular de-orbiting mechanism for satellites (AE 417: Aircraft Design Lab)

- Implemented a systematic design process to arrive at the conceptual design of a modular solar-sail as a de-orbiting mechanism for satellites

Parallel finite difference method for 1D wave equation (ME 766: High Performance Scientific Computing)

- Parallelized the code to solve 1D wave equation using various tools like OpenMp, MPI and CUDA

Controller implementation on embedded Linux platform (SC 700: Embedded Control Systems)

- Developed a wall following bot with proportional controller implemented on Embedded Linux. Implemented proportional controller on FPGA using Verilog

System modelling and controller design for omnidirectional robot (SC 301: Linear and Non-linear Systems)

- Developed the kinematics and dynamic model of a three wheeled omni-directional robot. Designed state-feedback based controller to make the robot follow a given trajectory

TECHNICAL SKILLS

- **Programming:** C/C++, Python, Embedded C, MPI, OpenMP
- **Packages:** MATLAB, Simulink, Eagle, SolidWorks
- **Embedded Platforms:** AVR, Raspberry Pi, FPG