HIMANI SINHMAR

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EDUCATION

Ph.D. *Aerospace Engineering, Cornell University with Prof. Hadas Kress-Gazit*   ('19 - Expected '24)
Specialization in Dynamics, Controls and Robotics, Minor in Computer Science

Bachelor and Master of Technology *Indian Institute of Technology Bombay*   ('14 - '19)
Specialization in System and Controls, Major in Aerospace Engineering, Minor in Physics

RESEARCH FOCUS AND SKILLS

My research focuses on developing verifiable-safe motion planners and controllers for robotic systems with resource-efficient hardware to address real-world challenges. I utilize insights from diverse disciplines such as control theory, collective intelligence, formal methods, sensor networks, and optimization. I have implemented various motion planners on physical platforms such as mobile manipulator Stretch Robot, UAV Crazyflie 2.1, mobile robot iRobot Create.

Research Interests: Motion Planning, Control for Autonomy, Autonomous Mobile Robots, Manipulation
Programming Languages: C++, Python, MATLAB, C#
Tools: Unity Game engine, Robot Operating System (ROS), ANSYS, SolidWorks

PEER-REVIEWED PUBLICATIONS

6. **Himani Sinhmar**, Hadas Kress-Gazit, *Decentralized Control of Minimalistic Robotic Swarms For Guaranteed Encapsulation Behavior*, [Paper] International Conference on Intelligent Robots and Systems (IROS 2022)

5. **Himani Sinhmar**, Hadas Kress-Gazit, *Guaranteed Encapsulation of Targets with Unknown Motion by a Minimalist Robotic Swarm*, [Paper] Accepted in Transactions on Robotics, (T-RO 2023)

4. **Himani Sinhmar**, Marcus Greiff, Stefano Di Cairano *Practical and Safe Navigation Function Based Motion Planning of UAVs*, under review in International Conference on Robotics and Automation, (ICRA 2024)

3. **Himani Sinhmar**, Srikant Sukumar, *Distributed model independent algorithm for spacecraft synchronization under relative measurement bias* [Paper], Proceedings of the 2019 CEAS EuroGNC conference. Milan, Italy. Apr'19. CEAS-GNC-2019-060

2. **Himani Sinhmar**, Vinod Kumar, *Relative Autonomous Navigation Without Communication Between Spacecraft Using Line of Sight Measurements* [Paper] IEEE/CSAA Guidance, Navigation and Control Conference, Aug'18

1. Pallavi Sinha, Srikant Sukumar, **Himani Sinhmar**, *Consensus of networked double integrator systems under sensor bias*, [Paper] International Journal of Adaptive Control and Signal Processing, Nov'22

PROFESSIONAL AND RESEARCH EXPERIENCE

Practical and Safe Motion Planning of UAVs   (Summer'23)
Research Intern with Dr. Marcus Greiff, Mitsubishi Electric Research Labs (MERL)

- Developed a reference governor-based motion planning framework by introducing a refined practical version of artificial potential functions for non-convex free spaces

- Demonstrated certifiable-safe real-time operation of a Crazyflie UAV, in an environment cluttered with polyhedral obstacles and significant input disturbances

Learning for Task Allocation and Motion Planning (Spring'23)

Project with Prof. Sanjiban Choudhury, Cornell University

- Developed automated task allocation and task execution using **imitation learning** to optimize resource utilization and cost minimization for a heterogeneous multi-robot team

- Demonstrated the effectiveness of **DAgger and Q-learning policies** in maximizing the collection of objects in maze scenarios with static obstacles and diverse agent capabilities

- Created a dynamic learning environment by generating 10,000 random complex maze instances

Motion Planning, Localization, and Mapping for iRobot Create [github] (Spring'20)

Project with Prof. Hadas Kress-Gazit, Cornell University

- Implemented **SLAM** and motion planning algorithms, including **sampling-based methods**, roadmaps, and potential functions, alongside **EKF and particle filters** for state estimation, to enable goal navigation and collision avoidance on the iRobot Create platform using LiDAR and RGB-D data

IMU Alignment of a Store Dropped from Aircraft (Summer'18)

Research Internship with Dr. Aditya Paranjape, Imperial College London

- Engineered an in-flight Inertial Measurement Unit (IMU) transfer-alignment algorithm to facilitate accurate position and attitude estimation for dropped payloads across all flight phases

- Implemented **sensor fusion and state estimation methodologies**, utilizing a fifteen-state Kalman filter for data integration and error estimation within the INS/GPS integration framework

- Constructed sensor models for both the IMU and auxiliary sensors of the payload, incorporating standard error models for accurate representation

- Developed a MATLAB-based simulator capable of generating consistent test data in the absence of IMU, GPS, or magnetometer unit

Autonomous Navigation for Spacecraft Rendezvous (Fall'17)

Research Co-op with Control Dynamics & Simulations Group, ISRO

- Developed an algorithm for autonomous spacecraft navigation, using Line of Sight measurements (LOS) to estimate relative position, attitude, and angular rates, offering a **robust alternative** to traditional gyro-based methods and mitigating errors caused by gyro data loss or communication delays

- Extended an algorithm designed for star tracker-based attitude determination, to estimate relative angular rates solely from LOS measurements between spacecraft using a visual navigation system, with an Extended Kalman Filter (EKF) and validated through numerical simulations

Task and Motion Planner for Robot Manipulation [github] (Spring'22)

Project with Prof. Tapomayukh Bhattacharjee, Cornell University

- Developed a reactive planner that automatically generates adaptable, physically feasible motion plans for diverse tasks given high-level task specifications and object affordances

- Implemented the planner on Stretch Robot for a series of reactive manipulation tasks

Decentralized Control for a Minimalistic Robotic Swarm (Spring'21 - present)

Project with Prof. Hadas Kress-Gazit, Cornell University

- Designed provably correct decentralized control algorithms ensuring complex desired swarm behavior for robots devoid of memory and localization abilities

Cooperative Control Under Bias in Measurements (Summer'18 - Summer'19)
Thesis with Prof. Srikant Sukumar, IIT Bombay, Received **Institute Undergraduate Research Award**

- Created an adaptive control law, utilizing collective initial excitation-based results and Lyapunov stability theory to achieve exponential consensus and accurate bias estimation for bipartite network graphs

Hardware Algorithm Co-Design for a Morphing Soft Robot (Fall'19 - Fall'21)
Advisor Prof. Hadas Kress-Gazit, Cornell University

- Created a physics-based simulator using C# scripts and Unity game engine for control synthesis of optimal gaits for a micrometer-sized sheet robots (MetaBots) that could form 3D surfaces from 2D actuation patterns, cycle among different shapes, and locomote

State Tracking and Fault Diagnosis in Nonlinear uncertain systems (Spring'18)
Project with Prof. Srikant Sukumar, IIT Bombay

- Developed a sensor bias estimator for state tracking in model reference adaptive control setting
- Implemented algorithms on a 4th order longitudinal dynamics model of an aircraft in a wings-level cruise

Pratham - IIT Bombay Student Satellite Team (Fall'14 - Summer'15)
Successfully launched on 26 th September 2016

- Assisted in modeling of the satellite body, panels and other onboard components in SolidWorks
- Performed structural and thermal simulations of the satellite in ANSYS
- Collaborated in the designing, modeling and characterization of Cross Yagi antennas
- Established communication link with the LEO satellites, receiving data using off-the-shelf equipments

ACHIEVEMENTS AND RESPONSIBILITIES

- Awarded the **Institute Undergraduate Research Award**
- **Session Chair** for: *Swarm Robotics* IROS 2022, *Navigation Technology* IEEE/CSAA GNC 2018
- **Reviewer** for *IEEE Transactions on Robotics* and *IEEE Transactions on Control of Network Systems*
- Lead a session on microscopic robots and differential geometry in EYH conference
- **Teaching Assistant**: Autonomous Mobile Robots, Spaceflight Mechanics, Dynamics and Control
- Graduate Resident Fellow at Willam T. Keeton House, Cornell University
- Chief Editor for department newsletter Lift-Off (2016-17)
- Presided an International conference on *Next Generation Skills Development and Challenges in Aeronautical and Aerospace Industry* organized by Aeronautical Society of India
- Recipient of INSPIRE scholarship for being in the top 1% in Senior Secondary Examination

KEY COURSES

Robotics	Autonomous Mobile Robots, Robot Manipulation, Learning for robot decision making Formal methods in robotics, Machine learning, Optimal control, Multivariable control, Adaptive control, Non-linear dynamics, Navigation and guidance
Mathematics	Calculus, Data analysis and interpretation, Differential equations, Linear algebra