Reza Hamrah, PhD

Mechanical and Aerospace Eng.
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A graduate of a PhD degree in Mechanical and Aerospace Engineering with more than 5 years of experience in research and development with a focus on controls, robotics and autonomous vehicles. Expert in developing algorithms for trajectory generation, nonlinear tracking control, guidance and navigation, nonlinear state estimation, as well as designing and developing advanced hardware systems for autonomous unmanned systems.

SKILLS

Nonlinear and Geometric Control | Optimal Control and Estimation | Trajectory Generation
Robotics & Mechatronics | Matlab/Simulink/S-Function, C/C++, Python | SolidWorks, ANSYS Mechanical,
Maple/Mathematica | PX4/ArduPilot, QgroundControl, Mission Planner, Betaflight | MS Office, LaTeX, Linux

- Strong background and deep understanding of Control Theories e.g. PID control, optimal control (LQR, LQG), model-predictive control (MPC), adaptive control, geometric nonlinear control etc.
- More than 4 years of experience in developing and implementing nonlinear geometric control, optimal control and path planning (trajectory generation) optimization algorithms in both simulation and real hardware in the loop.
- Deep understanding of state estimation techniques: state observers, Kalman filter, nonlinear state estimation.
- Experience in areas related to sensing, localization, and navigation, robot control system (position, velocity, force control), and SLAM.
- More than 10 years of experience with MATLAB and Simulink.
- Knowledge and experience in Robot Operating System (ROS), MAVROS, Gazebo, RViz for integration of software with sensors, actuators, and all hardware components.
- Experience in component and system integration, testing and verification on system and vehicle level.
- Familiarity with available machine learning toolkits (e.g., Tensorflow, Keras).
- Strong experience with sensors/sensor fusion: Accels, Gyros, GPS, Vision, Lidar, Radar, Sonar, Motion capture cameras (MoCap), etc.
- Hands-on experience with open-source flight hardware and software (e.g. Pixhawk, PX4, ArduPilot)
- Proficiency with CAD design and 3D modeling in Solidworks.

WORK EXPERIENCE

Research Assistant | **AUSLab** | **Syracuse Center of Excellence & Syracuse University** | **Syracuse, NY** 2016 - present

- Designed a discrete-time stable pose tracking control scheme with asymptotic stability for underactuated robotic systems.
- Developed a finite-time stable tracking control scheme in discrete-time for underactuated robotic systems.
- Designed a finite-time stable attitude and angular velocity bias estimation for rigid bodies with unknown dynamics.
- Developed a finite-time stable observer for relative attitude estimation of a rigid body using onboard sensors on an unmanned vehicle.
- Embedded software implementation of developed geometric tracking control schemes on quadrotor UAV platforms.
- Designed a trajectory generation scheme on SE(3) as an optimal Linear Quadratic Regulator (LQR) problem in the exponential coordinates with applications to a class of underactuated vehicles.
- Designed a trajectory generation and tracking control scheme on SE(3) for an underactuated vehicle with pointing direction constraints.
- Developed an optimal trajectory generation scheme on SE(3) as a discrete-time LQR problem in order to pass through multiple waypoints.

Robotics Research Intern | **Akrobotix LLC** | **Syracuse Tech Garden** | **Syracuse, NY** June 2017 - present

- Generated geometric control algorithms for tracking control, state estimation and trajectory generation for autonomous UAVs using Level 2 S-Functions in Simulink, and programming in MATLAB, and C/C++.
- Implemented the developed control algorithms on different platforms of autonomous UAVs with onboard computers such as Raspberry Pi, DragonBoard, Pixhawk, Nvidia Jetson TX1, and TX2, along with LIDAR and optical flow sensors, and analyzed the performance of the developed control schemes.
- Designed an experimental platform particularly for optimal trajectory generation and tracking applications in GPS-denied environments in the presence of VICON Motion Capture pose data stream to ROS.
- Developed ROS nodes written in Python for UAVs with onboard Nvidia TX2 and Raspberry Pi computers to perform various flight missions indoor with MoCap feedback.
- Implemented the developed algorithms in software, unit level and system level testing using both simulation and real systems in the loop.
- Developed appropriate user interfaces, test procedures, requirements documentation and verification as needed.

- Implemented various control schemes such as finite-time stable tracking control, asymptotically stable tracking control and geometric PD/PID-type control schemes, and trajectory generation on embedded microcontroller/computer platforms.
- Built UAV platforms from scratch with various flight controllers and micro-controllers like Omnibus and Naze 32 flight controllers, ESP8266 Development Board, Arduino boards, and Pixhawk.
- Involved in development of algorithms for a ground robot platform assisting with detection of sidewalk, street borders, and all moving and stationary objects for blind or visually impaired, and disabled people using Machine Learning techniques. This project also included a real-time mapping of environments involving state estimation, SLAM, nonlinear optimization, and 3D/visual geometry.
- Involved in development of an Autonomous Navigation Unit; The scopes of this product development include multi-channel Lidar-based SLAM & LOAM, visual servoing, sensor fusion, visual feature segmentation, classification, path planning, and feedback control.
- Involved in design, building, printing, and manufacturing an Airborne Multi-spectral Payload, and worked with other engineers to improve the design for manufacturing while controlling cost and weight.

Research Assistant | **Space Dynamics and Control Lab.** | **Shahid Beheshti University** | **Tehran, Iran** 2009 - 2014

- Developed and proposed a scheme to determine the maximum collision probability among space objects (space debris).
- Developed an algorithm for precise position determination of space objects using their propagation model.
- Modeled and simulated attitude dynamics and control for gravity gradient stabilized and spin-stabilized satellites, and optimal control of satellite despinning.

EDUCATION

PhD | Mechanical & Aerospace Engineering | Syracuse University | Syracuse, NY 2016 - 2020
Master of Science | Aerospace Engineering | Shahid Beheshti University | Tehran, Iran 2009 - 2012
Bachelor of Science | Aerospace Engineering | MUT University of Technology | Isfahan, Iran 2004 - 2008

TEACHING AND MENTORSHIP EXPERIENCE

Teaching Assistant | **Department of Mechanical and Aerospace Engineering** | **Syracuse University** 2017 - 2019

- Advanced Nonlinear Control | PhD-level course | Taught three sessions
- Methods of Analysis in Mechanical Engineering | Graduate course | Teaching Assistant
- Control Systems for MAE | Undergraduate course | Teaching Assistant

Mentor | **Akrobotix LLC & AUSLab.** | **Syracuse, NY** 2017 - present

- Mentored graduate and undergraduate students and new interns on robotics hands-on skills, experimental technique, hardware & software tasks, and research work.

SELECTED AWARDS

- **Research Excellence Doctoral Funding (REDF) Fellowship** | **Syracuse University** March 2019
- **Best Thesis Award** | **Iranian Aerospace Society** 2014
  For the best M.Sc. thesis selected among the top M.Sc. theses in the academic year 2012/13.
- **Best Paper Award** | **Iranian Aerospace Society** 2012
  For the best paper selected among the 290 accepted papers for oral presentation.

SELECTED PUBLICATIONS

- R. Hamrah and A. K. Sanyal, . "Finite-time stable tracking control for an un-deractuated system in SE(3) in discrete time". In: *International Journal of Control*,pp. 1–16.DOI:10.1080/00207179.2020.1841299.
- R. Hamrah, A. K. Sanyal, and S. P. Viswanathan, "Discrete finite-time stable attitude tracking control of unmanned vehicles on SO(3)," in *2020 American Control Conference (ACC)*, Denver, CO, USA, July 1-3, 2020.
- R. Hamrah, R. Warier, and A. K. Sanyal, "Finite-time stable estimator for attitude motion in the presence of bias in angular velocity measurements," Submitted in *Automatica*, 2019 (under review).
- R. Hamrah, A. K. Sanyal, and S. P. Viswanathan, "Discrete finite-time stable position tracking control of unmanned vehicles," in *58th IEEE Conference on Decision and Control (CDC)*, Nice, France, December 11-13, 2019.
- N. Wang, R. Hamrah, and A. Sanyal, "A finite-time stable observer for relative attitude estimation," in *58th IEEE Conference on Decision and Control (CDC)*, Nice, France, December 11-13, 2019.
- M. H. Dhullipalla, R. Hamrah, R. R. Warier, and A. K. Sanyal, "Trajectory generation on SE(3) for an underactuated vehicle with pointing direction constraints," in *2019 American Control Conference (ACC)*, July 2019, pp. 1930–1935.
- A. K. Sanyal, R. R. Warier, and R. Hamrah, "Finite time stable attitude and angular velocity bias estimation for rigid bodies with unknown dynamics," in *18th European Control Conference (ECC)*, June 2019, pp. 4047–4052.
- R. Hamrah, R. R. Warier, and A. K. Sanyal, "Discrete-time stable tracking control of underactuated rigid body systems on SE(3)," in *57th IEEE Conference on Decision and Control*, CDC 2018, Miami, FL, USA, December 17-19, 2018, pp. 2932–2937.
- M. H. Dhullipalla, R. Hamrah, and A. K. Sanyal, "Trajectory generation on SE(3) with applications to a class of underactuated vehicles," in *56th IEEE Conference on Decision and Control (CDC)*, Dec 2017, pp. 2557–2562.
- More publications are available on *Google Scholar Citations profile*.