Shankar Kulumani

CONTACT INFORMATION

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RESEARCH INTERESTS

Dynamics and Control of Aerospace Systems Application of geometric mechanics and control to systems evolving on nonlinear manifolds.

EDUCATION

George Washington University, Washington, DC — Aug 2014-present
PhD, Mechanical and Aerospace Engineering

Area of Study: Geometric Mechanics and Control of Aerospace Systems
Advisor: Taeyoung Lee

Purdue University, West Lafayette, IN — Jan 2011-Dec 2013
M.S., Aeronautical and Astronautical Engineering

Area of Study: Astrodynamics, Analytical Mechanics

United States Air Force Academy, Colorado Springs, CO — Jun 2005-May 2009
B.S., Astronautical Engineering

QUALIFICATIONS AND SKILLS

Proficient with MATLAB, UNIX shell scripting, DVCS (Git), TEX (LATEX, BIBTEX)
Experience with the JPL produced SPICE package, Satellite Toolkit (STK), Python, and C++
Proficient with AutoCAD, SolidWorks
Experience with Vicon/PhaseSpace motion capture systems

PROFESSIONAL EXPERIENCE

George Washington University, Washington DC
Graduate Research/Teaching Assistant — Aug 2014-present

- Graduate teaching assistant for Engineering Drawing and Computer graphics course. Responsible for teaching the fundamentals of sound engineering design and use of technical design software. Developed assignments and examinations to test students ability in applying principles in technical drawing.
- Performing research in the Flight Dynamics and Control laboratory with applications in geometric mechanics and control. Developing methods of continuous low thrust orbital transfers by leveraging the nonlinear manifolds of the three body problem.
- Applying computational geometric mechanics to develop algorithms which preserve the geometric properties of mechanical systems to obtain accurate numerical results and long term stability.
- Designing constrained geometric control for the coupled translation and rotational dynamics of spacecraft. This allows for globally defined control systems that track a desired trajectory while simultaneously avoiding obstacles or path constraints.

Space Scholar, AFRL Scholar Program — Jun 2015-Jul 2015

- Investigated combined translational and rotational control techniques for spacecraft rendezvous and proximity operations in the presence of constraints. Developed a geometric nonlinear controller which allows for global attitude tracking.
- The control system is developed directly on the nonlinear manifold and defined globally without the need of local parameterizations. Attitude constraints are incorporated directly on the nonlinear manifold through the use of barrier functions and allow for excellent convergence properties in the presence of constraints.

United States Air Force, Captain
Threat Systems Engineer, Missile and Space Intelligence Center
Defense Intelligence Agency (MSIC/DIA) — Sep 2014-present

- Responsible for the development of computational tools for the analysis of rocket and missile systems. Developed software to accurately model the aerodynamic forces and effects on rocket systems through all phases of flight. Accurate modeling of the aerodynamics allows for improved simulation accuracy and performance predictions.
- Developed software to accurately interface operational sensor systems. Implemented an extensive MATLAB/ Python library to simulate and analyze missile systems and sensors.

Lead Test Engineer, Guidance, Navigation, & Control Group
Air Force Research Laboratory (AFRL/RVSVC) Aug 2011-Sep 2014

- Directed a 6 member team in developing orbit determination software and designing an observation campaign for the ANGELS flight experiment. An Unscented Kalman Filter (UKF) was developed to verify and validate the performance of a GPS receiver in geostationary orbit. Additionally, a ground based collection strategy, incorporating AFSSN sensors, was developed and tested on operational satellites. The AFRL ANGELS vehicle launched in 2014 to advance autonomous rendezvous and proximity operation control algorithms. The UKF and ground based observation campaign was critical for accurate navigation and allowed for more aggressive maneuvers.
- Designed custom astrodynamics force model for the ANGLES flight experiment. Incorporated the effects of solar radiation pressure, attitude control actuators and sensors, Earth gravitational models, and thruster uncertainties to predict the expected performance of the spacecraft. Analysis predicted a coupling between rotational and translational motion during angular momentum desaturation burns. A orientation profile was developed which minimized the accumulation of undesired angular momentum and allowed for extended quiescent periods in support of orbit determination activities.
- Led $5M lab development program to develop an in situ attitude dynamics and control simulator. Responsible for procurement, design, and integration of the largest spherical air-bearing platform in the world. Developed software to interface with inertial measurement units, motion capture systems, and control hardware to allow for hardware in the loop system testing. The facility is currently being used to validate future flight attitude control actuators and algorithms.
- Developed a method for space based geolocation via time difference of arrival signals. Implemented geometric techniques to develop a closed form analytical solution to locate a noncooperative electromagnetic signal based on the time of arrival to a formation of satellites.
- Led the development of a satellite relative motion simulator using embedded ground based robotic systems. Designed the software to allow for accurate scaling and simulation of spacecraft motion. Directly implemented a motion capture system on embedded hardware to allow for accurate positioning and control.

Deputy Space Vehicles Lead, Responsive Space Squadron
Space Development and Test Directorate (SDTD/SDDR) May 2009-Aug 2011

- Responsible for development, integration, test, & launch of ORS-1 (Operationally Responsive Space) satellite ORS-1 was the first operational satellite developed under the ORS office and supports US Central Command Battlespace Awareness. An accelerated development cycle allowed for the integration and launch in under 2 years.
- Extensive experience with technical management of diverse contractor/government teams leading to successful ORS-1 launch and orbit operation. Managed a team of 5 to ensure the correct integration and testing of the space vehicle. Ensured mission requirements were being met during the integration period.
- Resolved a $600K satellite flight sensor failure. Directly managed the repair analysis team to prevent launch delays and ensure the system capability. Monitored the hardware repair process and verified they were completed correctly.
- Firsthand experience monitoring 100+ days of integration and testing of ORS-1. Sole space vehicles lead during launch site operations at Wallops Island, VA. Ensured correct

procedures and standards leading to on-time launch on 29 June 2011
- Assessed and served as on-site government inspector of 200+ satellite test plans. Verified technical analysis and testing procedures or all flight hardware of ORS-1. Test plans were critical in ensuring correct performance of both ground and space hardware and critical to mission success.

PUBLICATIONS

- Shankar Kulumani and Taeyoung Lee. Systematic design of optimal low-thrust transfers for the three-body problem. In *Proceedings of the AAS/AIAA Astrodynamics Specialist Conference, Vail, Colorado*, number 757, August 2015
- Shankar Kulumani. Space based TDOA Geo-Location. In *Proceedings of the Space Control Conference, MIT/Lincoln Laboratories*, May 2013

PROFESSIONAL MEMBERSHIPS

American Astronautical Society (AAS), Member	2015-present
American Institute of Aeronautics and Astronautics (AIAA), Member	2012-present
Sigma Gamma Tau, Member	2008-present

AWARDS

George Washington University
- Most Innovative/Creative Project Award, 5th Annual Student Competition Society of Satellite Professionals International (SSPI)
  Systematic design of optimal low-thrust orbital transfers in the three-body problem 2015
- Graduate Research Fellowship, George Washington University 2014

Responsive Space Squadron
- Rotary National Award for Space Achievement Foundation Stellar Award nomination for successful ORS-1 mission accomplishments 2011
- ORS-1 named by C4ISR Journal as one of the top 25 most important intelligence, surveillance and reconnaissance concepts of the year 2011

United States Air Force Academy
- Commandant/Dean pin for high military/academic performance 2005-2009
- Top Academic Performer - Astrodynamics 321 2007

SECURITY CLEARANCE

Cleared for Top Secret information and granted access to sensitive compartmented information based on a single scope background investigation completed on 21 June 2010.
Please contact SSO AF Reserve Command for additional clearance information.