Education

- MS, Aeronautics and Astronautics , University of Washington
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Teaching

- AA 528 Spacecraft Dynamics and Control (2015W)

Research Interests

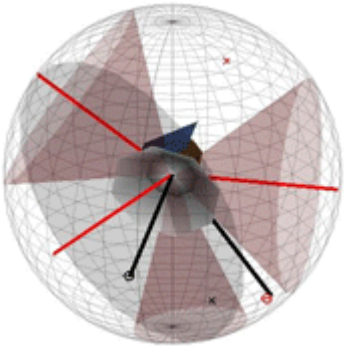
- Spacecraft Attitude Control
- Hybrid Model Predictive Control
- Convex Optimization
- Network Dynamic Systems
- Nonlinear Dynamics and Controls
- Unit Dual Quaternion parameterization

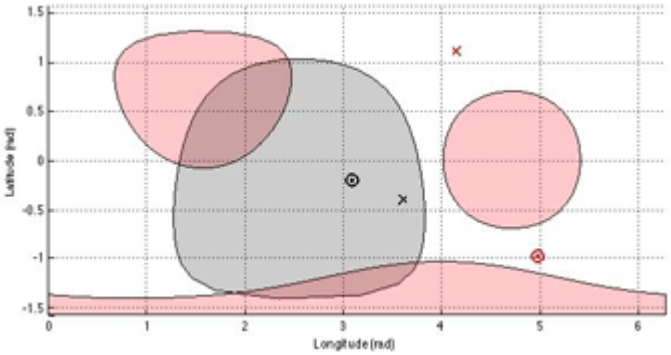
UW CubeSAT project

- UW CubeSat ADCS devlopement
- Europa CubeSat Design

See here for more researches on space systems

Spacecraft Large Angle Reorientation Under Multiple Attitude-Constrained Zones



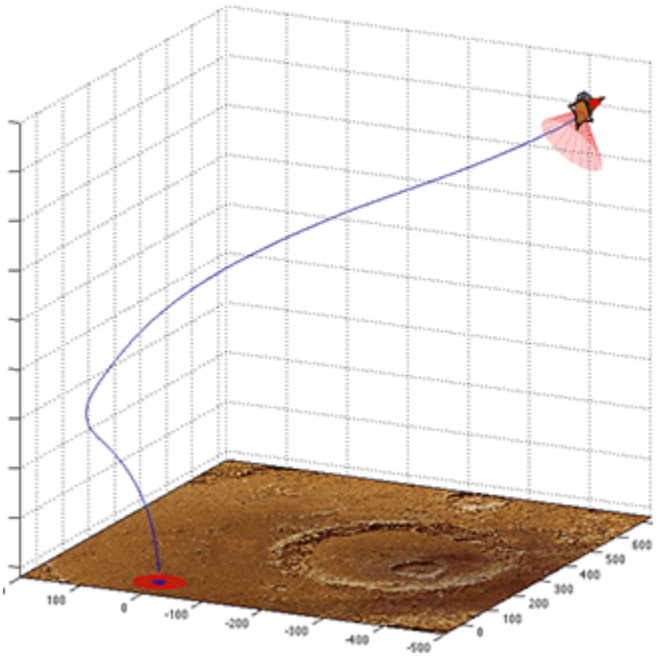


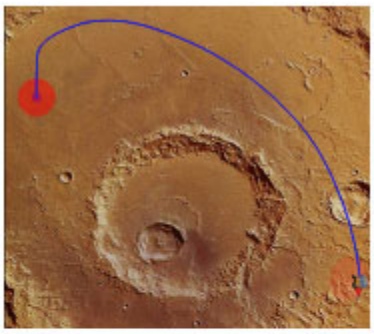
This problem considers an autonomous maneuver planning algorithm for three-axis attitude reorientation in the presence of multiple types of attitude-constrained zones. This is inspired by the finding that the subgroup of the unit quaternions corresponding to attitude-constrained zones can be represented by a ***convex set.*** Along with this, two types of attitude-constrained zones are defined, namely, the **attitude-forbidden** and **mandatory zones.** The successful formulation of a ***strictly convex logarithmic barrier potential*** enables the synthesis of an almost globally stabilizing feedback control law using unit quaternions.

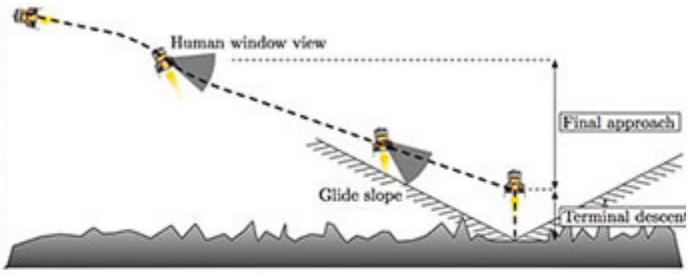
Two types of feedback controllers were examined: **model-independent** and **model-dependent** control laws. We have also simulated time/fuel optimal maneuvering using a pseudo-spectral method.

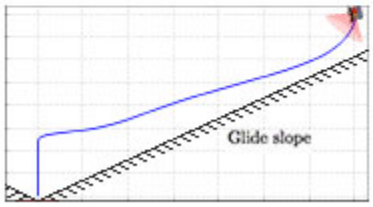
Related pulications: [5], [6], [12]

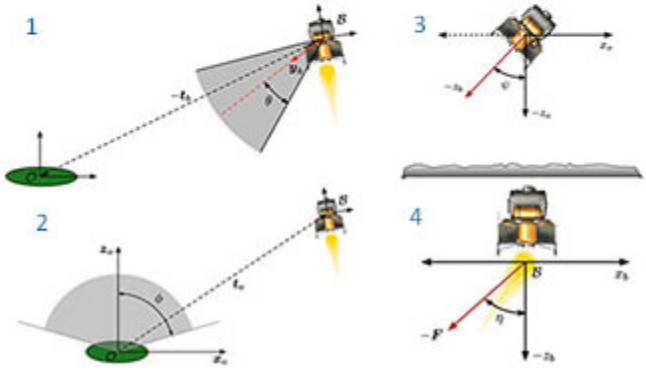
Constrained Powered-Descent Guidance Control











This problem considers a convex programming approach, based on model predictive control, for the numerical solution to a Mars powered-descent guidance problem in the presence of motion constraints. Specifically for the case of a Mars lander spacecraft, we consider the following constraints:

- Line of sight constraint (window view constraint)
- Glide slope constraint
- General attitude constraint
- Thrust vector angle constraint

It is challenging to design an autonomous control algorithm for such a problem, due to the fact that coupled rotational and translational motions affect the required constraints. In our approach, utilizing a unit dual quaternion parameterization, the general motion dynamics for a rigid body are first represented

using unit dual quaternions. Subsequently, an almost globally stable feedback control law, based on nonlinear control techniques, is developed for simultaneous rotational and translational motion control.

We then develop a novel convex-representable subset of unit dual quaternions that correspond to translational and rotational states, satisfying predefined constraints with respect to a moving body frame.

Finally, we construct an LTV model predictive control problem, using a convex quadratically constrained quadratic program (QCQP) to serve as the real time powered-descent guidance algorithm for a Mars lander. The resulting guidance algorithm has shown potential to be implemented onboard a spacecraft for real-time applications.

Related publications: [4], [7], [13]

See here for more research works on Space Systems

Publications

1. **Unsik Lee** and Mehran Mesbahi, "Dual Quaternion based Spacecraft Rendezvous with Rotational and Translational Field of View Constraints," AIAA/AAS Astrodynamics Specialist Conference (AIAA SPACE 2014), San Diego, California, 2014.
2. Yue Zu, **Unsik Lee**, Ran Dai, "Distributed Motion Estimation of Space Objects Using Dual Quaternions," AIAA/AAS Astrodynamics Specialist Conference, San Diego, California (AIAA SPACE 2014), 2014.
3. **Unsik Lee**, David Besson, and Mehran Mesbahi, "Fast Inertia Property Estimation via Convex Optimization for the Asteroid Redirect Mission," 53th IEEE Conference on Decision and Control, 2014.
4. **Unsik Lee** and Mehran Mesbahi, "Optimal Powered Descent Guidance with 6-DoF Line of Sight Constraints via Unit Dual Quaternions ," AIAA Guidance, Navigation, and Control, 2015
5. **Unsik Lee** and Mehran Mesbahi, "Optimal Spacecraft Reorientation under complex attitude constrained zones", AAS/AIAA Astrodynamics Specialist Conference, 2013.
6. **Unsik Lee** and Mehran Mesbahi, "Feedback Control for Spacecraft Reorientation under attitude constraints via Convex Potentials", IEEE Transactions on Aerospace and Electronic Systems, 2014.
7. **Unsik Lee** and Mehran Mesbahi, "Dual quaternions, Rigid Body Mechanics, and Powered-Descent Guidance", 51th IEEE Conference on Decision and Control, 2012.
8. Ran Dai, **Unsik Lee**, Saghar Hosseini and Mehran Mesbahi, "Optimal Sun Path Planning for Solar-Powered UAVs based on Unit Quaternions", 51th IEEE Conference on Decision and Control, 2013.
9. **Unsik Lee** and Mehran Mesbahi, "Spacecraft Attitude Synchronization in presence of Constrained zones" In Proc. of the IEEE American Control Conference, 2012
10. **Unsik Lee** and Mehran Mesbahi, "Constrained Consensus via Log Barrier function", 50th IEEE Conference on Decision and Control and European Control Conference, 2011.
11. Ran Dai, **Unsik Lee** and Mehran Mesbahi, "Distributed Orbit Determination via Estimation Consensus", AAS/AIAA Flight Mechanics Conference, 2011.
12. **Unsik Lee** and Mehran Mesbahi, "Spacecraft Reorientation in Presence of Attitude Constraints via Logarithmic Barrier Potentials", In Proc. of the IEEE American Control Conference, 2011.
13. **Unsik Lee** and Mehran Mesbahi, "Constrained Autonomous Precision Landing via Dual Quaternions and Model Predictive Control," *Journal of Guidance, Control, and Dynamics, 2016*

Current Research & Publications in preparation

- Yue Zu, **Unsik Lee**, and Ran Dai, "Distributed Estimation for Spatial Rigid Motion Based on Dual Quaternions," Aerospace Science & Technology, *submitted.*
- **Unsik Lee** and Mehran Mesbahi, “On the Gemoetrically Constrained Attitude Synchronization” in preparation for IEEE Transaction on Automatic Control.
- **Unsik Lee** and Mehran Mesbahi, “Line-of-Sight Constrained Autonomous Rendezvous using Dual Quaternions and Model Predictive Control ” in preparation for Journal of Guidance, Control, and Dynamics.
- **Unsik Lee**, "Design of ADCS for HuskySAT-1"
- **Unsik Lee**, Kristi Morgansen, and Mehran Mesbahi, "Development of Efficient Trade Study Toolbox for Solar Electric Propulsion in Earth Orbit"