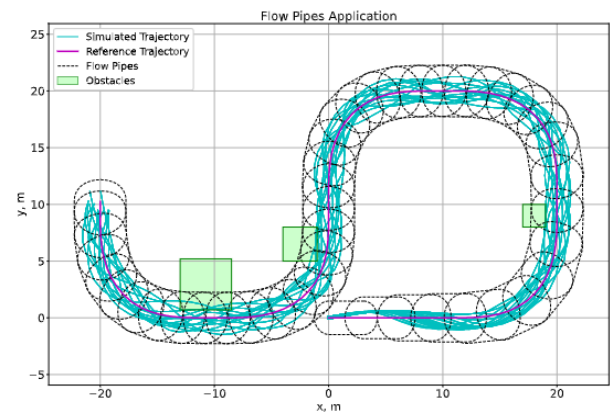
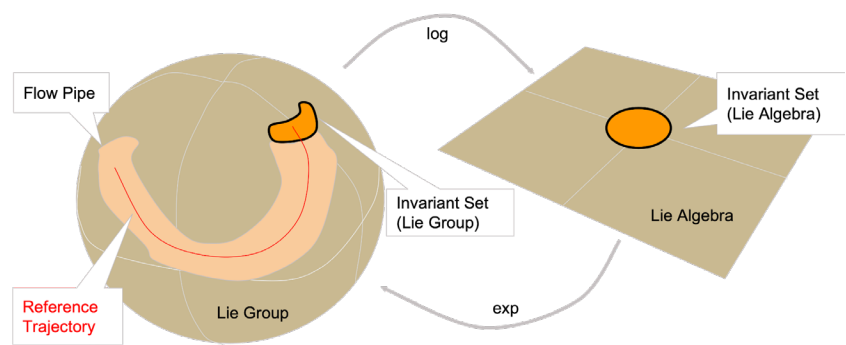


AAE 590: Lie Group Methods for Control and Estimation



This course presents the mathematical theory of Lie groups with a focus on applications to aerospace systems. Lie group theory provides a rigorous and efficient framework for studying the curved configuration spaces that arise in flight dynamics, robotics, and computer vision. Students will explore how traditional parameterizations—such as quaternions, Euler angles, and modified Rodrigues parameters—introduce singularities and redundancies that can be avoided through Lie-theoretic formulations. The course introduces the special orthogonal and Euclidean groups ($SO(2)/SO(3)$, $SE(2)/SE(3)$), the exponential and logarithmic maps, and the Ad/ad operators. Applications in estimation, control, and formal verification demonstrate the power of Lie group methods for real-world aerospace problems.

Course Details

- Credit Hours: 3
- Schedule: TBD
- Instructor: Dr. James Goppert

Course Objectives

- Leverage Lie groups for nonlinear control, estimation, and optimization of rigid bodies.
- Understand the properties of abstract groups and algebras.
- Understand the properties of Lie groups and Lie algebras, including the Ad/ad operators, wedge/vee operators, and the exponential map.

Homework Details

- Homework will require the use of Python, but instruction on usage will be provided for those unfamiliar.

Grading Rubric

Weight	Component	Comments
10%	Participation	Will be evaluated via Hotseat quizzes in class
40%	Homework	Drop Lowest (4 total)

50%	Final Report	Conference paper format (5-10 pages)
-----	--------------	--------------------------------------

Course Weekly Schedule

<i>Week</i>	<i>Lecture</i>	<i>Assignment</i>
W01	Lie Groups/ $SO(2)$	
W02	Lie Groups/ $SO(2)$	
W03	$SO(2)$ / Ad/ad, wedge/vee	
W04	$SO(2)$ / Exponential Map	HW01 Assigned (W01-W04)
W05	Mapping Diff. Eq.	
W06	$SE(2)$	
W07	$SE(2)$ applications	HW01 Due, HW02 Assigned (W05-W07)
W08	$SO(3)$	
W09	$SO(3)$ applications	HW02 Due, HW-03 Assigned (W08-W09)
W10	$SO(3)$ applications	
W11	$SE(3)$	
W12	$SE(3)$ applications	
W13	Reachability	HW03 Due, HW-04 Assigned (W10-W13)
W14	Dynamics within Lie Groups	Final Report Proposals Due
W15	Manipulators	HW04 Due, Final Report Proposal Feedback
W16	Other Topics	
W17	None	Final Report Due