Graduate Student Research Seminar

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Linear Transfer Operators for Off-road Navigation: A Convex Approach

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3:00 pm (EST) – 132 Fluor Daniel Building

Abstract

Navigation problems is a field that is extensively studied in the robotics community. Amongst these, the off-road navigation problem has gained momentum in recent years. Starting from an initial set and trying to reach the desired location while navigating through an obstacle-riddled environment is often solved using a gradient controller with the primitive of said gradient having a potential with a minimum in the target set. However, such gradient-based controllers are challenging to design for the unstructured environment because of the nonconvex nature of the design problem. Moreover, the problem is further exaggerated with the lack of appropriate reduced-order models suitable for control design.

We propose a novel approach based on linear transfer operator theory involving Perron-Frobenius (P-F) and Koopman operators for the optimal navigation in unstructured terrain. One of the main contributions of this work is to provide a convex formulation to the optimal navigation problem in an unstructured terrain. The traversability measure of the terrain, which captures the terrain parameters such as elevation map, terrain roughness, slope, and terrain texture, is taken as the cost function for the optimal navigation problem. The convex formulation of the optimal navigation problem is made possible by lifting the problem in the dual space of density using the P-F operator. The finite-dimensional approximation of the linear operator is obtained using time-series simulation data without the explicit knowledge of system dynamics. Hence, our proposed approach is suitable in a setting where explicit knowledge of vehicle dynamics is not available or models are too complicated for control design.

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