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GAUSSIAN-PROCESS-BASED MODEL PREDICTIVE CONTROL FOR CONSTRAINED VEHICLE GUIDANCE

Abstract

In the field of aerospace vehicle guidance, attention is consistently drawn to solutions that are effective in constrained circumstances. A variety of limitations including terrains, control saturations, and terminal impacts are crucial for guidance in real implementations. This paper investigates the guidance design of a class of nonlinear systems subject to state and input constraints.

In this paper, a model predictive control (MPC) framework with shrinking prediction and control horizons is presented that, at each time step, minimizes the most accurate prediction of a complete cost for a discrete system. Such a new framework is developed to solve an optimization problem with path and terminal constraints on the state and input. Furthermore, a Gaussian process (GP) regression is combined with the proposed MPC framework to against unknown disturbances and modeling uncertainties. The GP regression is a powerful technique for onboard estimation or prediction. The main advantage of the GP regression is that it not only provides the estimated mean of disturbances or uncertainties, but also offers a variance. Such a variance can be integrated into the MPC framework to enhance the accuracy and robustness of the guidance system.

To illustrate the effectiveness of our proposed method, two simulation studies are carried out. The first study addresses the terminal time and angle constrained vehicle guidance in a flat-Earth inertial Cartesian reference frame. The second study investigates a landing trajectory generation problem of an aerodynamically controlled vehicle. The simulation results demonstrate the advantages and enhancements of the proposed method compared with the existing ones. The control efforts of the new method can compete with that of the open-loop optimal solutions, while its feedback performance make it more suitable for dealing with disturbances and uncertainties.