Systematic Design of Stabilizing Model Predictive Controllers for Nonholonomic Systems

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Nonholonomic systems, which are characterized by the nonholonomic constraints on their velocities, are ubiquitous in applications such as transportation and robotics, yet their control remains challenging. In order to achieve asymptotic stability of a desired equilibrium, model predictive control (MPC) schemes without stabilizing terminal conditions have recently been proposed for nonholonomic kinematic systems, see the previous works [2, 6]. Here, stability was gained through the use of mixed-exponent stage costs, since conventional quadratic stage costs generally do not provide asymptotic stability of the MPC closed loop [5]. However, this approach still required lengthy system-specific calculations.

This work presents the recent development of a systematic design for MPC stage costs tailored to nonholonomic systems [4], where only a single calculation of parameters and coordinates is required. These are specific to the geometry of the nonholonomic system and can be used to form a controllable approximation of the system, as is described in [3]. Further, it is proven in [4] that, using a time-continuous MPC controller with these stage costs, the stability of the MPC closed loop is guaranteed through the homogeneity properties of the aforementioned approximation, using the results of [1].

Moreover, the proposed design methodology is extended beyond purely kinematic models to a wider class of systems with non-negligible dynamics, for which stability is shown in [4]. Then, the systematic design procedure is demonstrated, using the example of an articulated vehicle from [4]. The simulated setpoint stabilization is shown for the proposed stage costs, and compared to the use of conventional stage costs with quadratic exponents.

Literatur

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