Stability and Robustness Analysis for Curve Tracking Control using Input-to-State Stability

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Abstract
We study an important class of feedback controllers that arise in curve tracking problems for robotics. Previous experimental results suggested the robust performance of the control laws under perturbations. Here we use input-to-state stability to prove predictable tolerance and safety bounds that ensure robust performance under perturbations and time delays. Our proofs are based on an invariant polygon argument and a new strict Lyapunov function design.

Verification of Infinite-Step Opacity and Complexity Considerations

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Abstract
We describe and analyze the complexity of verifying the notion of infinite-step opacity in systems that are modeled as non-deterministic finite automata with partial observation on their transitions. Specifically, a system is infinite-step opaque if the entrance of the system state, at any particular instant, to a set of secret states remains opaque (uncertain), for the length of the system operation, to an intruder who observes system activity through some projection map. Infinite-step opacity can be used to characterize the security requirements in many applications, including encryption using pseudo-random generators, coverage properties in sensor networks, and anonymity requirements in protocols for web transactions. We show that infinite-step opacity can be verified via the construction of a set of appropriate initial state estimators and provide illustrative examples. We also establish that the verification of infinite-step opacity is a PSPACE-hard problem.
Optimal Supervisory Control of Probabilistic Discrete Event Systems

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Abstract
Probabilistic discrete event systems (PDES) are modeled as generators of probabilistic languages and the supervisors employed are a probabilistic generalization of deterministic supervisors used in standard supervisory control theory. In the case when there exists no probabilistic supervisor such that the behavior of a plant under control exactly matches the probabilistic language given as the requirements specification, we want to find a probabilistic control such that the behavior of the plant under control is “as close as possible” to the desired behavior. First, as a measure of this proximity, a pseudometric on states of generators is defined. Two algorithms for the calculation of the distance between states in this pseudometric are described. Then, an algorithm to synthesize a probabilistic supervisor that minimizes the distance between generators representing the achievable and required behavior of the plant is presented.

International Journal of Robotics Research


Towards a discretely actuated steerable cannula for diagnostic and therapeutic procedures

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Abstract
We have designed, developed, and evaluated the performance of a multi-degree-of-freedom discretely actuated steerable cannula with shape-memory alloy (SMA) actuators. This will enable us to deliver diagnostic as well as therapeutic devices to the target location through the hollow inner core of the cannula. We propose to use SMAs to generate bending forces due to its small size and high power density. We annealed the SMA wires through a customized training process in an arc shape and mounted them at discrete locations on the outer surface of the cannula to enable joint motion. A pulse-width modulation (PWM)-based control scheme was implemented to control all SMA actuators simultaneously to enable multiple joint motion using a single power supply. The proposed controller was validated through an experiment inside gelatin to mimic the motion of the cannula inside a medium which requires a significant amount of force to move the joints of the cannula. Trajectory planning using a suitable metric and trajectory execution were successfully implemented. To demonstrate the delivery of a diagnostic tool through our cannula, we demonstrate that we can pass an optical coherence tomography probe through the cannula and perform in situ microscale imaging.
Trajectory generation and control for precise aggressive maneuvers with quadrotors

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Abstract
We study the problem of designing dynamically feasible trajectories and controllers that drive a quadrotor to a desired state in state space. We focus on the development of a family of trajectories defined as a sequence of segments, each with a controller parameterized by a goal state or region in state space. Each controller is developed from the dynamic model of the robot and then iteratively refined through successive experimental trials in an automated fashion to account for errors in the dynamic model and noise in the actuators and sensors. We show that this approach permits the development of trajectories and controllers enabling such aggressive maneuvers as flying through narrow, vertical gaps and perching on inverted surfaces with high precision and repeatability.

Global convergence conditions in maximum likelihood estimation

Yiqun Zou; William P. Heath

Abstract
Maximum likelihood estimation has been widely applied in system identification because of consistency, its asymptotic efficiency and sufficiency. However, gradient-based optimisation of the likelihood function might end up in local convergence. In this article we derive various new non-local-minimum conditions in both open and closed-loop system when the noise distribution is a Gaussian process. Here we consider different model structures, in particular ARARMAX, BJ and OE models.
Parameter-optimal iterative learning control using polynomial representations of the inverse plant

David H. Owens; Bing Chu; Mutita Songjun

Abstract
Based on the observation that iterative learning control (ILC) can be based on the inverse plant but that the approach can be degraded by modelling errors, particularly at high frequencies, this article investigates the construction and properties of a multi-parameter parameter-optimal ILC algorithm that uses an approximate polynomial representation of the inverse with natural high-frequency attenuation. In its simplest form, the algorithm replicates the original work of Owens and Feng but, more generally, it is capable of producing significant improvements to the observed convergence rate. As the number of parameters increases, convergence rates approach that of the ideal plant inverse algorithm. Introducing compensation into the algorithm provides a formal link to previously published gradient and norm-optimal ILC algorithms and indicates that the polynomial approach can be regarded as approximations to those control laws. Simulation examples verify the theoretical performance predictions.