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Cooperative Output Regulation of Linear Multi-Agent Systems

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Abstract

In this technical note, we consider the cooperative output regulation of linear multi-agent systems. The overall system consists of two groups of subsystems. While the first group of subsystems can access the exogenous signal, the second cannot. As a result, the problem cannot be solved by the decentralized approach. By devising a distributed observer, we can solve the problem by a dynamic full information distributed control scheme. The problem can also be viewed as a generalization of some results of the leader-following consensus problem of multi-agent systems.

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Decentralized Robust Control Invariance for a Network of Storage Devices

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Abstract

Robust control of networked storage devices is considered. Each storage device is modeled as a single-state, discrete-time integrator with bounded control input, and subject to additive disturbance. The values of the disturbance are unknown but are assumed to belong to bounded sets. Nodes exchange stored resource through links of limited capacity. Characterization of the maximal robust control invariant (RCI) set is provided and decentralization of the robust feasibility problem is considered. A notion of decentralized RCI set is introduced and a parametrization of a family of decentralized RCI sets is proposed. It is shown that the set of parameters for which the decentralized RCI sets are non-empty is a polyhedral set. The result offers a possibility to use convex optimization for selection of bounds on the admissible flow through the network which ensure feasibility of the proposed decentralized design.

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Decentralized Control via Gröbner Bases and Variable Elimination

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Abstract

We consider the problem of optimal decentralized controller synthesis. There are several classes of such problems for which effective solution methods are known, including the quadratically invariant one. In this technical note, we use Gröbner bases and elimination theory to characterize all closed-loop maps achievable by forming a feedback loop with decentralized controllers. We show that this approach allows solution of a wide class of optimal decentralized control problems; it includes not only quadratically invariant problems under a technical condition but also some other problems which are not quadratically invariant.

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Networked Markov Decision Processes With Delays

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Abstract

We consider a networked control system, where each subsystem evolves as a Markov decision process with some extra inputs from other systems. Each subsystem is coupled to its neighbors via communication links over which the signals are delayed, but are otherwise transmitted noise-free. A centralized controller receives delayed state information from each subsystem. The control action applied to each subsystem takes effect after a certain delay rather than immediately. We give an explicit bound on the finite history of measurement and control that is required for the optimal control of such networked Markov decision processes. We also show that these bounds depend only on the underlying graph structure as well as the associated delays. Thus, the partially observed Markov decision process associated with a networked Markov decision process can be converted into an information state Markov decision process, whose state does not grow with time.

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Optimized Dynamic Policy for Receding Horizon Control of Linear Time-Varying Systems With Bounded Disturbances

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Abstract

This paper deals with the problem of reducing the online computational complexity of receding horizon control (RHC) algorithms for a class of linear systems with a polytopic system description and with bounded additive disturbances. We explore a class of admissible polytopic controller dynamics involving a disturbance feedforward term for a dynamic policy which ensures reduced conservativeness and also offers a way to significantly simplify the online computations by allowing the controller dynamics to be optimized offline. Moreover, for a deterministically time-varying system with additive disturbances, we explore the use of the proposed dynamic policy as the terminal control policy appended to a standard finite-horizon disturbance-based RHC policy. We also present results on the stability of the system under the RHC schemes based on the proposed policy, in the context of both the nominal and the (H_{infty} -based) minmax cost minimizations. Results of simulation studies that illustrate the effective performance and the computational efficiency of the proposed control schemes are included.

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Stability and Transient Performance of Discrete-Time Piecewise Affine Systems

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Abstract

This paper considers asymptotic stability and transient performance of discrete-time piecewise affine systems. We propose a procedure to construct a nested sequence of finite-state symbolic models, each of which abstracts the original piecewise affine system and leads to linear matrix inequalities for guaranteed stability and performance levels. This sequence is in the order of decreasing conservatism, and hence gives us the option to pay more computational cost and analyze a finer symbolic model within the sequence in return for less conservative results. Moreover, in the special case where this sequence is finite, an exact analysis of stability and performance is achieved via semidefinite programming.

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Synchronization of Coupled Oscillators is a Game

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Abstract

The purpose of this paper is to understand phase transition in noncooperative dynamic games with a large number of agents. Applications are found in neuroscience, biology, and economics, as well as traditional engineering applications. The focus of analysis is a variation of the large population linear quadratic Gaussian (LQG) model of Huang 2007, comprised here of a controlled N-dimensional stochastic differential equation model, coupled only through a cost function. The states are interpreted as phase angles for a collection of heterogeneous oscillators, and in this way the model may be regarded as an extension of the classical coupled oscillator model of Kuramoto. A deterministic PDE model is proposed, which is shown to approximate the stochastic system as the population size approaches infinity. Key to the analysis of the PDE model is the existence of a particular Nash equilibrium in which the agents 'opt out' of the game, setting their controls to zero, resulting in the 'incoherence' equilibrium. Methods from dynamical systems theory are used in a bifurcation analysis, based on a linearization of the partial differential equation (PDE) model about the incoherence equilibrium. A critical value of the control cost parameter is identified: above this value, the oscillators are incoherent; and below this value (when control is sufficiently cheap) the oscillators synchronize. These conclusions are illustrated with results from numerical experiments.

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A pure vision-based topological SLAM system

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Abstract

In this paper, we present a feasible solution to the problem of autonomous navigation in initially unknown environments using a pure vision-based approach. The mobile robot performs range sensing with a unique omnidirectional stereovision system, estimates its motion using visual odometry and detects loop closures via a place recognition system as it performs topological map building and localization concurrently. Owing to the importance of performing loop closing regularly, the mobile robot is equipped with an active loop closure detection and validation system that assists it to return to target loop closing locations, validates ambiguous loop closures and provides it with the ability to overturn the decision of an incorrectly committed loop closure. A refined incremental probabilistic framework for an appearance-based place recognition system is fully described and the final system is validated in multiple experiments conducted in indoor, semi-outdoor and outdoor environments. Lastly, the performance of the probabilistic framework is compared with the rank-based framework with additional experiments conducted in the semi-autonomous mode, where the mobile robot, provided with *a priori* information in the form of a topological map that is built in a separate occasion in an offline manner, is required to reach its target destination.

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CAT-SLAM: probabilistic localisation and mapping using a continuous appearance-based trajectory

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Abstract

This paper describes a new system, dubbed Continuous Appearance-based Trajectory Simultaneous Localisation and Mapping (CAT-SLAM), which augments sequential appearance-based place recognition with local metric pose filtering to improve the frequency and reliability of appearance-based loop closure. As in other approaches to appearance-based mapping, loop closure is performed without calculating global feature geometry or performing 3D map construction. Loop-closure filtering uses a probabilistic distribution of possible loop closures along the robot's previous trajectory, which is represented by a linked list of previously visited locations linked by odometric information. Sequential appearance-based place recognition and local metric pose filtering are evaluated simultaneously using a Rao–Blackwellised particle filter, which weights particles based on appearance matching over sequential frames and the similarity of robot motion along the trajectory. The particle filter explicitly models both the likelihood of revisiting previous locations and exploring new locations. A modified resampling scheme counters particle deprivation and allows loop-closure updates to be performed in constant time for a given environment. We compare the performance of CAT-SLAM with FAB-MAP (a state-of-the-art appearance-only SLAM algorithm) using multiple real-world datasets, demonstrating an increase in the number of correct loop closures detected by CAT-SLAM.

+one: Computational Optimization and Applications

Nov. 2011, Springer Netherlands, Issn: 0926-6003, 1-16

The nearest point problem in a polyhedral set and its extensions

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Abstract

In this paper we investigate the relationship between the nearest point problem in a polyhedral cone and the nearest point problem in a polyhedral set, and use this relationship to devise an effective method for solving the latter using an existing algorithm for the former. We then show that this approach can be employed to minimize any strictly convex quadratic function over a polyhedral set. Through a computational experiment we evaluate the effectiveness of this approach and show that for a collection of randomly generated instances this approach is more effective than other existing methods for solving these problems.

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A computational analysis of lower bounds for big bucket production planning problems

Kerem Akartunalı and Andrew J. Miller

Abstract

In this paper, we analyze a variety of approaches to obtain lower bounds for multi-level production planning problems with big bucket capacities, i.e., problems in which multiple items compete for the same resources. We give an extensive survey of both known and new methods, and also establish relationships between some of these methods that, to our knowledge, have not been presented before. As will be highlighted, understanding the substructures of difficult problems provide crucial insights on why these problems are hard to solve, and this is addressed by a thorough analysis in the paper. We conclude with computational results on a variety of widely used test sets, and a discussion of future research.