Scanning the Issue*

Plug-and-Play Fault Fault Detection and Isolation for Large-Scale Nonlinear Systems With Stochastic Uncertainties

F. Boem, S. Riverso, G. Ferrari-Trecate, and T. Parisini

This paper proposes a novel scalable model-based fault detection and isolation approach for the monitoring of nonlinear large-scale systems, consisting of a network of interconnected subsystems and affected by stochastic uncertainties. The proposed architecture is distributed and designed to automatically manage the potential plug-in of novel subsystems and unplug of existing ones. Convergence results for the distributed estimation scheme are provided. A novel fault isolation method, based on a generalized observer scheme and providing guaranteed error probabilities of the fault exclusion task, is also proposed. Detectability and isolability conditions are provided.

Integrated Relative Localization and Leader–Follower Formation Control

Z. Han, K. Guo, L. Xie, and Z. Lin

This paper focuses on the integration of relative localization and formation control over leader–follower networks. First, a consensus-like relative localization scheme for each agent to estimate the real-time relative positions of its neighbors is designed. Second, an integrated relative localization and leader–follower formation control is developed by combining the proposed relative localization scheme and a complex Laplacian-based formation control scheme.The integrated scheme is generalized to achieve moving similar formation control.

A Convex Optimization Approach to Discrete Optimal Control

V. Valls and D. J. Leith

In this paper, a framework that brings the celebrated maxweight features (discrete control actions and myopic scheduling decisions) to the field of convex optimization is presented. The proposed approach consists in formulating the Lagrange dual problem and equipping the subgradient method with a perturbation scheme that can be regarded as using stochastic and ε-subgradients. The effectiveness of the proposed approach is demonstrated by means of an example that considers discrete scheduling decisions with constraints in the context of wireless networks.

Distributed Balancing of Commodity Networks Under Flow Interval Constraints

C. N. Hadjicostis and A. D. Dominguez-Garcia

This paper deals with networks described by digraphs the edges of which admit a flow (or weight) within a finite interval with nonnegative end points. This paper proposes and analyses a distributed algorithm for obtaining admissible and balanced flows, i.e., flows that are within the given intervals at each edge and are balanced (the total in-flow equals the total out-flow) at each node. The proposed iterative algorithm assumes bidirectional communication and allows the nodes to asymptotically reach admissible and balanced flows if the necessary and sufficient circulation conditions are met.

Transformation of Optimal Centralized Controllers into Near-Globally Optimal Static Distributed Controllers

S. Fattahi, G. Fazelnia, J. Lavaei, and M. Arcak

This paper studies the optimal static distributed control problem for linear discrete-time systems in both deterministic and stochastic settings. The main goal is to design stabilizing static controllers the performance of which are close to that of the optimal centralized controller. The paper first derives a condition that guarantees existence of a distributed controller that generates input/state trajectories close to their counterparts in the closed-loop system with centralized optimal controller. This condition is then reformulated as an optimization problem which admits a closed-form solution that can be efficiently computed for large-scale systems.

A Systematic Process for Evaluating Structured Perfect Bayesian Equilibria in Dynamic Games With Asymmetric Information

D. Vasal, A. Sinha, and A. Anastasopoulos

N selfish player games, with private type player information and publicly observed actions, are considered. Conditional on current actions, player types are assumed to evolve as independent Markov processes. A subset of strategies, which are both sequentially rational and consistent with the beliefs that generate them, but depend only on a common public belief and the current private player type, is considered. They characterize so-called structured Bayesian perfect equilibria. A forward-backward algorithm to compute the strategies, when they exist, is developed, while sufficient conditions for their existence are established. Applications to public good examples are considered and signalling phenomena are displayed.

Open-Loop Stackelberg Strategy for the Linear Quadratic Mean-Field Stochastic Differential Game

Y. Lin and W. Zhang

A new class of bilevel games, mean field stochastic linear quadratic Stackelberg, is considered on a finite control horizon. A sufficient condition for the existence and uniqueness of an open-loop Stackelberg equilibrium is developed. Under a convexity condition, the sufficient condition is equivalent to the solvability of a set of generalized Riccati differential equations, and the open-loop Stackelberg equilibrium is then expressible as a feedback on an adequately defined state space. Examples illustrate the usefulness of the results.

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A Local Separation Principle via Dynamic Approximate Feedback and Observer Linearization for a Class of Nonlinear Systems

M. Sassano and A. Astolfi

This paper develops output feedback control laws for (local) asymptotic stabilization of an equilibrium point or for asymptotic tracking of reference signals in nonlinear systems. The approach combines a dynamic extension-based approximate feedback linearization procedure, applicable to nonlinear systems that may be linearly uncontrollable or that may not possess a well-defined relative degree, and a related observer design procedure that allows to arbitrarily assign the poles of the local behavior of the error dynamics independently from its zeros, differently from the classic high-gain observer design. The resulting design procedure and accompanying analysis constitute a (local) nonlinear separation principle.

Throughput Optimal Decentralized Scheduling of Multihop Networks With End-to-End Deadline Constraints: Unreliable Links

R. Singh and P. R. Kumar

We consider the multihop networks serving multiple flows in which packets have hard deadlines. We address the design of packet scheduling, transmit power control and routing policies that maximize any specified weighted average of the timely throughputs of the multiple flows. We determine a tractable linear program the solution of which yields an optimal routing, scheduling and power control policy, when nodes have average-power constraints. The optimal policy is fully decentralized, with decisions regarding any packet's transmission scheduling, transmit power level, and routing, based solely on the age and location of that packet.

Adaptive Actuator Failure Compensation for Possibly Nonminimum-Phase Systems Using Control Separation Based LQ Design

L. Wen, G. Tao, H. Yang, and B. Jiang

This paper proposes an adaptive failure compensation control scheme for discrete-time (possibly nonminimum phase) systems with unknown actuator failures such that some unknown system inputs are stuck at some unknown fixed or varying value at unknown time instants, and the actuator failures as system disturbances are not matched by other inputs. The failure compensation control problem is solved by using a new control separation design based on a new linear quadratic (LQ) control formulation. The adaptive control problem is solved using a stable adaptive law for parameter estimation.

Automatic Pan-Tilt Camera Control for Learning Dirichlet Process Gaussian Process (DPGP) Mixture Models of Multiple Moving Targets

H. Wei, P. Zhu, M. Liu, J. P. How, and S. Ferrari

Information value functions based on the Kullback–Leibler divergence have been shown to be the most effective for planning sensor measurements using greedy strategies. This paper shows that the problem of optimally controlling a sensor over a finite time horizon is NP-hard. The new lexicographic approach presented relies on new information value functions that are shown to be additive and can be optimized efficiently over time. This paper also derives a convex approximation of the sensor nonlinear field-of-view that allows for real-time sensor control, and is accompanied by performance guarantees. Extensive results on real pedestrian data show that the lexicographic control algorithm significantly improves modeling and prediction performance when compared to existing algorithms.

On the Local Input-Output Stability of Event-Triggered Control Systems

M. Ghodrat and H. J. Marquez

This paper deals with the design of triggering mechanisms such that the resulting sampled-data system preserves local L_2 disturbance attenuation property. The results apply to nonlinear systems with exogenous disturbances bounded by some Lipschitz-continuous function of the state. An exponentially decaying function of time allows extending the inter-event periods. An analytic estimate of the increase in intersampling periods, at least for an arbitrary period of time, is proposed. A discrete triggering condition to quantitatively find the improvement in inter-event times at least for an arbitrary number of triggering iterations is also presented.

A Convex Optimization Approach for Computing Correlated Choice Probabilities With Many Alternatives

S. Damla Ahipasaoglu, X. Li, and K. Natarajan

The Cross Moment model has been proposed as an alternative to the Multinomial Probit model to capture correlation in discrete choice models. This paper develops a representative agent model representation of the Cross Moment model. Strong convexity is established and a first-order gradient method to compute choice probabilities has been developed. This algorithm scales well with large number of alternatives, in comparison to semidefinite optimization methods. An added advantage is that it is easy to invert the choice probabilities to the mean utilities that is important for estimation purposes.

Consensus Protocol for Multi-Agent Systems With Undirected Topologies and Binary-Valued Communications

Y. Zhao, T. Wang, and W. Bi

This paper studies the consensus of multi-agent systems with binary-valued communication. We consider a multi-agent system with an undirected graph and binary-valued measurements of neighbors' states with stochastic noises. A two-time-scale protocol which alternates estimation and control is constructed. For the state estimation, we propose a convergent identification algorithm without truncation, for which the convergence rate is given. The whole system can be proved to achieve weak consensus and mean square consensus by using a stochastic Lyapunov analysis and the consensus speed is given.

Nonlinear Unknown Input Observability: Extension of the Observability Rank Condition

A. Martinelli

This paper provides the analytic condition to check state observability in the presence of unknown inputs. The considered systems are nonlinear in the state and linear in the inputs. The condition can be applied automatically, regardless of the complexity and type of nonlinearity. Similar to the observability rank condition, it is based on the computation of the observable codistribution, which is obtained by recursively computing the Lie derivatives of the outputs along the vector fields that characterize the dynamics. However, in correspondence of the unknown input, the corresponding vector field must be appropriately rescaled and the Lie derivatives must also be computed along new vector fields obtained by recursively computing Lie bracketing of the vector fields that define the dynamics.

Continuous Estimation Using Context-Dependent Discrete Measurements

R. Ivanov, N. Atanasov, M. Pajic, J. Weimer, G. J. Pappas, and I. Lee

The problem of continuous state estimation from discrete context-based measurements is investigated. A recursive context-aware filter is developed by approximating the posterior distribution with a Gaussian distribution. It is revealed that all eigenvalues of the filter's covariance matrix converge to zero after repeated updates if and only if a persistence of excitation condition holds for the context measurements. Finally, the results are demonstrated by estimating a patient's blood oxygen content during surgery using real-patient data.

Nonlinear Reference Tracking: An Economic Model Predictive Control Perspective

J. Köhler, M. A. Muller, and F. Allgöwer

This paper studies the system theoretic properties of a simple and intuitive reference tracking Model Predictive Control scheme for nonlinear discrete-time systems. Sufficient conditions for exponential reference tracking for reachable reference trajectories are proposed. Moreover, unreachable reference trajectories are considered and sufficient conditions to ensure practical stability of the unknown optimal reachable reference trajectory are proposed. The theoretical guarantees are based on the notion of incremental stabilizability, strict dissipativity, and results in (Economic) Model Predictive Control without terminal constraints.

Luenberger Observers for Non-Autonomous Nonlinear Systems

P. Bernard and V. Andrieu

It is shown how the (classical) Luenberger methodology can be used to design observers for nonautonomous nonlinear systems. Their implementation relies on the resolution of a PDE, the solutions of which transform the dynamics into linear asymptotically stable ones. Existence and injectivity (after a certain time) of such transformations are established under standard observability assumptions. Examples illustrate how the PDE can be solved and how the observability assumptions can be checked.