IEEE CONTROL SYSTEMS SOCIETY TECHNICAL COMMITTEE ON DISCRETE EVENT SYSTEMS

Newsletter..... March 2017

Editor: Hai Lin
Chair, IEEE CSS Technical Committee on DES
Associate Professor
Distributed Cooperative Systems Research (DISCOVER) Lab
Department of Electrical Engineering
University of Notre Dame
Notre Dame, IN 46556,
USA

Phone: (+1) 574-631-3177
Fax: (+1) 574-631-4393
e-mail: hlin1@nd.edu
Website: http://www3.nd.edu/~hlin1/

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Welcome to the newsletter of the IEEE Control Systems Technical Committee on Discrete Event Systems!

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Activities

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2.1 Sponsored Activities

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2017 American Control Conference
Seattle, United States, May 24 - May 26, 2017
http://acc2017.a2c2.org/

2017 Conference on Control Technology and Applications
Kohala Coast, United States, Aug 27 - Aug 30, 2017
http://ccta2017.ieeecss.org/

2017 Conference on Decision and Control
Melbourne, Australia, Dec 12 - Dec 15, 2017
http://cdc2017.ieeecss.org/

2.2 Technically Co-Sponsored activities

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The 36th Chinese Control Conference
Dalian, China, Jul 26 - Jul 28, 2017
http://ccc2017.dlut.edu.cn/

2016 IEEE Conference on Norbert Wiener in the 21st Century: Thinking Machines in the Physical World
Melbourne, Australia, Jul 13 - Jul 15, 2016

http://21stcenturywiener.org/

2017 Indian Control Conference
Guwahati, India, Jan 4 - Jan 6, 2017
http://icc.org.in/

6th International Conference on Systems and Control (ICSC 2017)
Batna, Algeria, May 7 - May 9, 2017
http://lias.labo.univ-poitiers.fr/icsc/icsc2017/

The 6th International Symposium on Advanced Control of Industrial Processes (AdCONIP 2017)
Taipei, Taiwan, May 28 - May 31, 2017
http://www.adconip2017.org/

2017 International Conference on Unmanned Aircraft Systems (ICUAS'17)
Miami, United States, Jun 13 - Jun 16, 2017
http://www.uasconferences.com/

IEEE CASE 2017, the 13th IEEE International Conference on Automation Science and Engineering
Xi'an, China, August 20-23, 2017
http://www.case2017.org

Selections of Journal Publications

Contributed by: Xiang Yin (xiangyin@umich.edu)

SELECTIONS OF THE IEEE TRANSACTIONS ON AUTOMATIC CONTROL
VOLUME: 62 ISSUE: 3
March 2017

(1) Approximation of Markov Processes by Lower Dimensional Processes via Total Variation Metrics

Author: Ioannis Tzortzis, Charalambos D. Charalambous, Themistoklis Charalambous, Christoforos N. Hadjicostis, and Mikael Johansson

Abstract

The aim of this paper is to approximate a Finite-State Markov (FSM) process by another process defined on a lower dimensional state space, called the approximating process, with respect to a total variation distance fidelity criterion. The approximation problem is formulated as an optimization problem using two different approaches. The first approach is based on approximating the transition probability matrix of the FSM process by a lower-dimensional transition probability matrix, resulting in an approximating process which is a Finite-State Hidden Markov (FSHM) process. The second approach is based on approximating the invariant probability vector of the original FSM process by another invariant probability vector defined on a lower-dimensional state space. Going a step further, a method is proposed based on optimizing a Kullback-Leibler divergence to approximate the FSHM processes by FSM processes. The solutions of these optimization problems are described by optimal partition functions which aggregate the states of the FSM process via a corresponding water-filling solution, resulting in lower-dimensional approximating processes which are FSHM or FSM processes. Throughout the paper, the theoretical results are justified by illustrative examples that demonstrate our proposed methodology.

Full-text available at: http://ieeexplore.ieee.org/document/7487050/

(2) Basis Marking Representation of Petri Net Reachability Spaces and Its Application to the Reachability Problem

Author: Ziyue Ma, Yin Tong, Zhiwu Li, Alessandro Giua

Abstract

In this paper, a compact representation of the reachability graph of a Petri net is proposed. The transition set of a Petri net is partitioned into the subsets of explicit and implicit transitions in such a way that the subnet induced by implicit transitions does not contain directed cycles. The firing of implicit transitions can be abstracted so that the reachability set of the net can be completely characterized by a subset of reachable markings called basis makings. We show that to determine a max-cardinality- TI basis partition is an NP-hard problem, but a max-set- TI basis partition can be determined in polynomial time. The generalized

version of the marking reachability problem in a Petri net can be solved by a practically efficient algorithm based on the basis reachability graph. Finally, this approach is further extended to unbounded nets.

Full-text available at: http://ieeexplore.ieee.org/document/7480433/

(3) Fundamental Limits of Remote Estimation of Autoregressive Markov Processes Under Communication Constraints

Author: Jhelum Chakravorty, Aditya Mahajan

Abstract

The fundamental limits of remote estimation of autoregressive Markov processes under communication constraints are presented. The remote estimation system consists of a sensor and an estimator. The sensor observes a discrete-time autoregressive Markov process driven by a symmetric and unimodal innovations process. At each time, the sensor either transmits the current state of the Markov process or does not transmit at all. The estimator estimates the Markov process based on the transmitted observations. In such a system, there is a trade-off between communication cost and estimation accuracy. Two fundamental limits of this trade-off are characterized for infinite horizon discounted cost and average cost setups. First, when each transmission is costly, we characterize the minimum achievable cost of communication plus estimation error. Second, when there is a constraint on the average number of transmissions, we characterize the minimum achievable estimation error. Transmission and estimation strategies that achieve these fundamental limits are also identified.

Full-text available at: http://ieeexplore.ieee.org/document/7491287/

(4) Temporal Logics for Learning and Detection of Anomalous Behavior

Author: Zhaodan Kong, Austin Jones, Calin Belta

Abstract

The increased complexity of modern systems necessitates automated anomaly detection methods to detect possible anomalous behavior determined by malfunctions or external attacks. We present formal methods for inferring (via supervised learning) and detecting (via unsupervised learning) anomalous behavior. Our procedures use data to construct a signal temporal logic (STL) formula that describes normal system behavior. This logic can be used to formulate properties

such as “If the train brakes within 500 m of the platform at a speed of 50 km/hr, then it will stop in at least 30 s and at most 50 s.” Our procedure infers not only the physical parameters involved in the formula (e.g., 500 m in the example above) but also its logical structure. STL gives a more human-readable representation of behavior than classifiers represented as surfaces in high-dimensional feature spaces. The learned formula enables us to perform early detection by using monitoring techniques and anomaly mitigation by using formal synthesis techniques. We demonstrate the power of our methods with examples of naval surveillance and a train braking system.

Full-text available at: http://ieeexplore.ieee.org/document/7500142/

(5) Petri-Net Controller Synthesis for Partially Controllable and Observable Discrete Event Systems

Author: JiLiang Luo, MengChu Zhou

Abstract

To enforce linear constraints on Petri nets that are partially controllable and observable, this work proposes an approach based on constraint transformation. First, a state-space equation of a Petri net control system based on event feedback is obtained by expressing a control action as a matrix, and the optimal control policy is designed. However, this policy needs to solve a nonlinear program on line. Second, pre-transition-gain-transformation is proposed to equivalently transform a constraint into a disjunction of new ones for an uncontrollable transition, and, similarly, post-transition-gain-transformation to transform a constraint into a disjunction of new ones for an unobservable transition. An algorithm is then given to transform a constraint into a disjunction of admissible ones, and, consequently, an efficient policy, which may not be optimal, can be designed. Third, in order to guarantee that the policy be both efficient and optimal, a dynamic linear constraint is introduced. Further, observing-transformation is proposed to simplify a dynamic constraint for an unobservable transition, and an algorithm is given to equivalently transform a class of linear constraints into admissible dynamic ones. As a result, an optimal controller requiring little online computation can be designed accordingly for some class of Petri nets. Finally, a maze system is used to illustrate the theoretical results.

Full-text available at: http://ieeexplore.ieee.org/document/7502164/

(6) Characterization of Admissible Marking Sets in Petri Nets With Conflicts and Synchronizations

Author: Ziyue Ma, Zhiwu Li, Alessandro Giua

Abstract

In this paper we study the problem of constraint transformation for Petri nets with uncontrollable transitions and containing both conflicts and synchronizations. We show that given an arbitrary net and a set of legal markings, the admissible marking set cannot always be represented by a finite number of disjunctions of GMECs. Moreover, we characterize the GMEC inflation phenomenon, that is, the case in which the representation of the admissible marking set may be too complex to be efficiently implemented in a closed-loop net. To rule out the possibility of GMEC inflation we consider a subclass of constraints called singular GMECs with an acyclic backward-conflict-free uncontrollable subnet. By these assumptions we propose an algorithm to transform a given singular GMEC into a controllable OR-GMEC which precisely characterizes its admissible marking set.

Full-text available at: http://ieeexplore.ieee.org/document/7501468/

(7) Anytime Capacity of a Class of Markov Channels

Author: Polo Minero, Massimo Franceschetti

Abstract

Several new expressions for the anytime capacity of Sahai and Mitter are presented for a time-varying rate-limited channel with noiseless output feedback. These follow from a novel parametric characterization obtained in the case of Markov time-varying rate channels, and include an explicit formula for the r-bit Markov erasure channel, as well as formulas for memoryless rate processes including Binomial, Poisson, and Geometric distributions. Beside the memoryless erasure channel and the additive white Gaussian noise channel with input power constraint, these are the only cases where the anytime capacity has been computed. At the basis of these results is the study of the threshold function for m-th moment stabilization of a scalar linear system controlled over a Markov time-varying digital feedback channel that depends on m and on the channel's parameters. This threshold is shown to be a continuous and strictly decreasing function of m and to have as extreme values the Shannon capacity and the zero-error capacity as m tends to zero and infinity, respectively. Its operational interpretation is that of achievable communication rate, subject to a reliability constraint.

Full-text available at: http://ieeexplore.ieee.org/document/7500143/

(8) Diagnosability Analysis of Labeled Time Petri Net Systems

Author: Francesco Basile, Maria Paola Cabasino, Carla Seatzu

Abstract

In this paper, we focus on two notions of diagnosability for labeled Time Petri net (PN) systems: K-diagnosability implies that any fault occurrence can be detected after at most K observations, while τ-diagnosability implies that any fault occurrence can be detected after at most τ time units. A procedure to analyze such properties is provided. The proposed approach uses the Modified State Class Graph, a graph the authors recently introduced for the marking estimation of labeled Time PN systems, which provides an exhaustive description of the system behavior. A preliminary diagnosabilty analysis of the underlying logic system based on classical approaches taken from the literature is required. Then, the solution of some linear programming problems should be performed to take into account the timing constraints associated with transitions.

Full-text available at: http://ieeexplore.ieee.org/document/7506325/

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SELECTIONS OF AUTOMATICA
VOLUME: 77
March 2017

(1) Computation of minimal diagnosis bases of Discrete-Event Systems using verifiers

Author: Leonardo P.M. Santoro, Marcos V. Moreira, João C. Basilio

Abstract

This paper addresses the model-free nonlinear optimal control problem based on data by introducing the reinforcement learning (RL) technique. It is known that the nonlinear optimal control problem relies on the solution of the Hamilton–Jacobi–Bellman (HJB) equation, which is a nonlinear partial differential equation that is generally impossible to be solved analytically. Even worse, most practical systems are too complicated to establish an accurate mathematical model. To

overcome these difficulties, we propose a data-based approximate policy iteration (API) method by using real system data rather than a system model. Firstly, a model-free policy iteration algorithm is derived and its convergence is proved. The implementation of the algorithm is based on the actor–critic structure, where actor and critic neural networks (NNs) are employed to approximate the control policy and cost function, respectively. To update the weights of actor and critic NNs, a least-square approach is developed based on the method of weighted residuals. The data-based API is an off-policy RL method, where the "exploration" is improved by arbitrarily sampling data on the state and input domain. Finally, we test the data-based API control design method on a simple nonlinear system, and further apply it to a rotational/translational actuator system. The simulation results demonstrate the effectiveness of the proposed method.

Full-text available at:
http://www.sciencedirect.com/science/article/pii/S0005109814004373

(2) Optimal strategies for impulse control of piecewise deterministic Markov processes

Author: Benoîte de Saporta, François Dufour, Alizée Geeraert

Abstract

This paper deals with the general discounted impulse control problem of a piecewise deterministic Markov process. We investigate a new family of ϵ-optimal strategies. The construction of such strategies is explicit and only necessitates the previous knowledge of the cost of the no-impulse strategy. In particular, it does not require the resolution of auxiliary optimal stopping problem or the computation of the value function at each point of the state space. This approach is based on the iteration of a single-jump-or-intervention operator associated to the piecewise deterministic Markov process.

Full-text available at:
http://www.sciencedirect.com/science/article/pii/S0005109816304824

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SELECTIONS OF THE IEEE TRANSACTIONS ON SYSTEMS, MAN AND CYBERNETICS: SYSTEMS
VOLUME: 47 ISSUE: 3

March 2017

(1) A Decision Support System for Optimizing Operations at Intermodal Railroad Terminals

Author: Mariagrazia Dotoli, Nicola Epicoco, Marco Falagario, Carla Seatzu, Biagio Turchiano

Abstract

In this paper, we present a decision support tool to optimize two of the most critical activities in intermodal railroad container terminals, in an iterative and integrated framework devoted to the terminal profit improvement. First, the model allows optimizing the freight trains composition, maximizing the company profit, while respecting physical and economic constraints, and placing in the train head/tail containers prosecuting to subsequent destinations. Hence, based on the resulting train composition, the decision support system allows optimizing the containers allocation in the terminal storage yard, in order to maximize the filling level while respecting physical constraints. The model is successfully tested on a real case study, the inland railroad terminal of a leading Italian intermodal logistics company.

Full-text available at: http://ieeexplore.ieee.org/document/7370812/

(2) Scheduling of Single-Arm Cluster Tools for an Atomic Layer Deposition Process With Residency Time Constraints

Author: FaJun Yang, NaiQi Wu, Yan Qiao, MengChu Zhou, ZhiWu Li

Abstract

In semiconductor manufacturing, there are wafer fabrication processes with wafer revisiting. Some of them must meet wafer residency time constraints. Taking atomic layer deposition (ALD) as a typical wafer revisiting process, this paper studies the challenging scheduling problem of single-arm cluster tools for the ALD process with wafer residency time constraints. It is found that there are only several scheduling strategies that are applicable to this problem and one needs to apply each of them to decide whether a feasible schedule can be found or not. This work, for each applicable strategy, performs the schedulability analysis and derives the schedulability conditions for such tools for the first time. It proposes scheduling algorithms to obtain an optimal schedule efficiently if such conditions are met. It finally gives illustrative examples to show the application of the proposed concepts and approach.

Full-text available at: http://ieeexplore.ieee.org/document/7395391/

(3) Calculation of Siphons and Minimal Siphons in Petri Nets Based on Semi-Tensor Product of Matrices

Author: Xiaoguang Han, Zengqiang Chen, Zhongxin Liu, Qing Zhang

Abstract

In this paper, we address the problems of enumerating siphons and minimal siphons in ordinary Petri nets (PNs) by resorting to the semi-tensor product (STP) of matrices. First, a matrix equation, called the siphon equation (SE), is established by using STP. Second, an algorithm is proposed to calculate all siphons in ordinary PNs. An example is presented to illustrate the theoretical results and show that the proposed method is more effective than other existing methods in calculating all siphons of PNs. Third, an efficient recursion algorithm is also proposed, which can be applied to computing all minimal siphons for any ordinary PNs. Last, some results on the computational complexity of the proposed algorithms, in this paper, are provided, as well as experimental results.

Full-text available at: http://ieeexplore.ieee.org/document/7365471/

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