# IEEE Control Systems Society
# Technical Committee on Discrete Event Systems

**Newsletter** **January 2020**

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Welcome to the 2020 January issue of the newsletter, also available online at
http://discrete-event-systems.ieeecss.org/tc-discrete/newsletters

## Editorial

You are welcome to submit new items to the newsletter (topics including schools, workshops, sessions, conferences, journals, books, software, positions). Also please encourage relevant colleagues and students to subscribe to this newsletter.

- To **submit a new item**, please use the following website:
  https://www.control.eng.osaka-cu.ac.jp/miscellaneous/css-tc-des/submission
  or email to kai.cai@eng.osaka-cu.ac.jp.
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## Contents

# 1 Selections of Journal Publications

Contributed by: Xiang Yin (yinxiang@sjtu.edu.cn)

## 1.1. IEEE Transactions on Automatic Control

Volume: 65, Issue: 1, January 2020

- **An Approach to Improve Permissiveness of Supervisors for GMECs in Time Petri Net Systems**
  **Authors:** Liang Li ; Francesco Basile ; Zhiwu Li
  **Abstract:** This paper deals with the enforcement of generalized mutual exclusion constraints (GMECs) on time Petri nets (TPNs) with uncontrollable transitions by restricting the firing intervals of controllable transitions. Existing approaches do not exploit the timing information and consequently the system permissiveness is limited. The key idea behind the proposed approach is the online computation of a graph representing a reduced portion of the state space of a TPN system, and precisely the states that can be reached from the current one by firing only uncontrollable transitions. Such a graph is called partial modified state class graph (PMSCG) and is derived from another graph recently presented in the literature. Based on the PMSCG, a procedure to compute a supervisory control law enforcing a GMEC on a TPN system in a maximally permissive way is presented.

- **Supervisor Localization of Timed Discrete-Event Systems Under Partial Observation**
  **Authors:** Renyuan Zhang ; Kai Cai
  **Abstract:** We study supervisor localization for timed discrete-event systems under partial observation in the Brandin-Wonham framework. First, we employ timed relative observability to synthesize a partial-observation monolithic supervisor; the control actions of this supervisor include not only disabling action of prohibitible events (as that of controllable events in the untimed case) but also "clock-preempting" action of forcible events. Accordingly, we decompose the supervisor into a set of partial-observation local controllers one for each prohibitible event, as well as a set of partial-observation local preemptors one for each forcible event. We prove that these local controllers and preemptors collectively achieve the same controlled behavior as the partial-observation monolithic supervisor does. The above-mentioned results are illustrated by a timed workcell example.

- **Critical Observability for Automata and Petri Nets**
  **Authors:** Tomas Masopust
  **Abstract:** Critical observability is a property of cyber-physical systems to detect whether the current state belongs to a set of critical states. In safety-critical applications, critical states model operations that may be unsafe or of a particular interest. De Santis et al. introduced critical observability for linear switching systems, and Pola et al. adapted it for discrete-event systems, focusing on algorithmic complexity. We study the computational complexity of deciding critical observability for systems modeled as (networks of) finite-state automata and Petri nets. We show that deciding critical observability is: 1) NL-complete for finite automata, i.e., it is efficiently verifiable on parallel computers; 2) PSPACE-complete for networks of finite automata, i.e., it is very unlikely solvable in polynomial time; and 3) undecidable for labeled Petri nets, but becoming decidable if the set of critical states (markings) is finite or cofinite, in which case the problem is as hard as the nonreachability problem for Petri nets.

- **Structural Controller for Logical Expression of Linear Constraints on Petri Nets**
  **Authors:** Jiliang Luo ; Weimin Wu ; Mengchu Zhou ; Hui Shao ; Kenzo Nonami ; Hongye Su
  **Abstract:** Based on the P-type composition of Petri nets (PNs) defined in this paper, a framework for a structural control of discrete event systems (DESs) is constructed such that a closed-loop PN is obtained by composing a plant PN and a controller. As for a disjunction or conjunctive normal form (CNF) of linear constraints, a new approach is proposed to design a structural controller in this framework. First, a switching-net is defined for a disjunction of constraints, and an extended plant is obtained through the P-type composition of a plant PN and switching-net. Second, the disjunction of bounded constraints is transformed into a conjunction of switching-constraints on the extended plant. Third, a controller is synthesized by designing monitors for conjunctive switching-constraints

according to a supervision-based-on-place-invariant method. Fourth, in a similar manner, a controller is also designed for a CNF of bounded constraints. The resulting controller is maximally permissive if each disjunction of constraints meets the jump-free condition, and its size grows polynomially with the number of constraints. Another advantage is that the closed-loop system is still a PN for many real DES since a CNF can describe not only convex but also nonconvex state regions.

- **Markov Chains With Maximum Return Time Entropy for Robotic Surveillance**
  **Authors:** Xiaoming Duan ; Mishel George ; Francesco Bullo
  **Abstract:** Motivated by robotic surveillance applications, this paper studies the novel problem of maximizing the return time entropy of a Markov chain, subject to a graph topology with travel times and stationary distribution. The return time entropy is the weighted average, over all graph nodes, of the entropy of the first return times of the Markov chain; this objective function is a function series that does not admit, in general, a closed form. This paper features theoretical and computational contributions. First, we obtain a discrete-time delayed linear system for the return time probability distribution and establish its convergence properties. We show that the objective function is continuous over a compact set and therefore admits a global maximum. We then establish upper and lower bounds between the return time entropy and the well-known entropy rate of the Markov chain. To compute the optimal Markov chain numerically, we establish the asymptotic equality between entropy, conditional entropy, and truncated entropy, and propose an iteration to compute the gradient of the truncated entropy. Finally, we apply these results to the robotic surveillance problem. Our numerical results show that for a model of rational intruder over prototypical graph topologies and test cases, the maximum return time entropy Markov chain outperforms several pre-existing Markov chains.
- **A Universal Empirical Dynamic Programming Algorithm for Continuous State MDPs**
  **Authors:** William B. Haskell ; Rahul Jain ; Hiteshi Sharma ; Pengqian Yu
  **Abstract:** We propose universal randomized function approximation-based empirical value learning (EVL) algorithms for Markov decision processes. The "empirical" nature comes from each iteration being done empirically from samples available from simulations of the next state. This makes the Bellman operator a random operator. A parametric and a nonparametric method for function approximation using a parametric function space and a reproducing kernel Hilbert space respectively are then combined with EVL. Both function spaces have the universal function approximation property. Basis functions are picked randomly. Convergence analysis is performed using a random operator framework with techniques from the theory of stochastic dominance. Finite time sample complexity bounds are derived for both universal approximate dynamic programming algorithms. Numerical experiments support the versatility and computational tractability of this approach.
- **Asymptotic Optimality of Finite Model Approximations for Partially Observed Markov Decision Processes With Discounted Cost**
  **Authors:** Naci Saldi ; Serdar Yuksel ; Tamas Linder
  **Abstract:** We consider finite model approximations of discrete-time partially observed Markov decision processes (POMDPs) under the discounted cost criterion. After converting the original partially observed stochastic control problem to a fully observed one on the belief space, the finite models are obtained through the uniform quantization of the state and action spaces of the belief space Markov decision process (MDP). Under mild assumptions on the components of the original model, it is established that the policies obtained from these finite models are nearly optimal for the belief space MDP, and so, for the original partially observed problem. The assumptions essentially require that the belief space MDP satisfies a mild weak continuity condition. We provide an example and introduce explicit approximation procedures for the quantization of the set of probability measures on the state space of POMDP (i.e., belief space).
- **Reduced-Order Observer Design for Boolean Control Networks**
  **Authors:** Zhihua Zhang ; Thomas Leifeld ; Ping Zhang
  **Abstract:** In this paper, we propose an approach to design reduced-order state observer for Boolean control networks by applying the semi-tensor product. At first, an approach is given to find reducible

state variables. After that, we introduce an approach for reduced-order observer design based on the reducible state variables. Then, it is shown that similar to the Luenberger-like observer, the state estimate provided by the reduced-order observer also converges to real state at time not later than the minimal reconstructibility index. Additionally, the reduced-order observer requires lower computational effort, which facilitates an online implementation.

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### 1.2. Automatica

Volume: 111 January 2020

- **Constrained discounted Markov decision processes with Borel state spaces**
  **Authors:** Eugene A.Feinberg ; Anna Jaskiewicz ; Andrzej S.Nowak
  **Abstract:** We study discrete-time discounted constrained Markov decision processes (CMDPs) with Borel state and action spaces. These CMDPs satisfy either weak (W) continuity conditions, that is, the transition probability is weakly continuous and the reward function is upper semicontinuous in state-action pairs, or setwise (S) continuity conditions, that is, the transition probability is setwise continuous and the reward function is upper semicontinuous in actions. Our main goal is to study models with unbounded reward functions, which are often encountered in applications, e.g., in consumption/investment problems. We provide some general assumptions under which the optimization problems in CMDPs are solvable in the class of randomized stationary policies and in the class of chattering policies introduced in this paper. If the initial distribution and transition probabilities are atomless, then using a general "purification result" of Feinberg and Piunovskiy we show the existence of a deterministic (stationary) optimal policy. Our main results are illustrated by examples.
- **Symbolic models for retarded jump-diffusion systems**
  **Authors:** Pushpak Jagtap ; Majid Zamani
  **Abstract:** In this paper, we provide for the first time an automated, correct-by-construction, controller synthesis scheme for a class of infinite dimensional stochastic systems, namely, retarded jump-diffusion systems. First, we construct finite abstractions approximately bisimilar to non-probabilistic retarded systems corresponding to the original systems having some stability property, namely, incremental input-to-state stability. Then, we provide a result on quantifying the distance between output trajectory of the obtained finite abstraction and that of the original retarded jump-diffusion system in a probabilistic setting. Using the proposed result, one can refine the control policy synthesized using finite abstractions to the original systems while providing guarantee on the probability of satisfaction of high-level requirements. Moreover, we provide sufficient conditions for the proposed notion of incremental stability in terms of the existence of incremental Lyapunov functions which reduce to some matrix inequalities for the linear systems. Finally, the effectiveness of the proposed results is illustrated by synthesizing a controller regulating the temperatures in a ten-room building modeled as a delayed jump-diffusion system.
- **Event-triggered control of discrete-time switched linear systems with network transmission delays**
  **Authors:** Xiaoqing Xiao ; Ju H. Park ; Lei Zhou ; Guoping Lu
  **Abstract:** The event-triggered control problem for discrete-time switched linear systems with network transmission delays is investigated in this paper. It is assumed that the controller can only access the transmitted information of system state and mode at each event-triggered instant. A mode dependent event-triggered transmission scheme is proposed and the closed-loop system is modeled as a switched system with delayed state and augmented switching signal. Then based on the multiple Lyapunov functional method, an exponential stability condition and design method for state feedback controller gains are obtained. The proposed approach leads an important step to study the event-triggered control for discrete-time switched systems. Finally, the effectiveness and improvement of the proposed approach are illustrated by a numerical example.
- **Observability of Boolean networks via matrix equations**
  **Authors:** Yongyuan Yu ; Min Meng ; Jun-e Feng

**Abstract:** From the new perspective of logical matrix equations, observability of Boolean networks (BNs) is investigated in this paper. First, it is shown that one BN is locally observable on the set of reachable states if and only if the constructed matrix equations have a unique canonical solution. Then, combining with an equivalence relation, a novel condition is established to verify global observability. Finally, an example is worked out to illustrate the obtained results.

- **Boolean Kalman filter and smoother under model uncertainty**
  **Authors:** Mahdi Imani ; Edward R. Dougherty; Ulisses Braga-Neto
  **Abstract:** Partially-observed Boolean dynamical systems (POBDS) are a general class of nonlinear state-space models that provide a rich framework for modeling many complex dynamical systems. The model consists of a hidden Boolean state process, observed through an arbitrary noisy mapping to a measurement space. The optimal minimum mean-square error (MMSE) POBDS state estimators are the Boolean Kalman Filter and Smoother. However, in many practical problems, the system parameters are not fully known and must be estimated. In this paper, for POBDS under model uncertainty, we derive an optimal Bayesian estimator for state and parameter estimation. The exact algorithms are derived for the case of discrete and finite parameter space, and for general parameter spaces, an approximate Markov-Chain Monte-Carlo (MCMC) implementation is introduced. We demonstrate the performance of the proposed methodology by means of numerical experiments with POBDS models of gene regulatory networks observed through noisy measurements.

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### 1.3. IEEE Transactions on Systems, Man, and Cybernetics: Systems

Volume: 50, Issue: 1, January 2020

- **Supervisory Control of Blockchain Networks**
  **Authors:** Kiam Tian Seow
  **Abstract:** Blockchain is an open distributed ledger technology that enables ledger-maintainers on a network to collaboratively synchronize and update their own distributed copies of a single global ledger, with the goal of keeping the ledger copies consistent. This paper presents a theoretical control-model formulation of the founding Satoshi Nakamoto blockchain, aimed at enhancing our operational understanding and development of blockchain systems. The control model is generic of every honest ledger-maintainer's local operations on a blockchain network. The presented research is a logical systematization of operational knowledge that is understandable and explainable for blockchain system engineering and research. Using a software tool supporting a supervisory control theory applied in the formulation, the control model is synthesized and logically validated.

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### 1.4. IEEE Transactions on Cybernetics

Volume: 50, Issue: 1, January 2020

- **Bi-objective Elite Differential Evolution Algorithm for Multivalued Logic Networks**
  **Authors:** Jian Sun ; Shangce Gao ; Hongwei Dai ; Jiujun Cheng ; MengChu Zhou ; Jiahai Wang
  **Abstract:** In this paper, a novel algorithm called bi-objective elite differential evolution (BOEDE) is proposed to optimize multivalued logic (MVL) networks. It is a multiobjective algorithm completely different from all previous single-objective optimization ones. The two objective functions, error and optimality, are put into evaluating the fitness of individuals in evolution simultaneously. BOEDE innovatively uses an archive population with different ranks to store elite individuals and offsprings. Moreover, a characteristic updating method based on this archive structure is designed to produce the parent population. Because of the particularity of MVL network problems, the performance of BOEDE to solve them is further improved by strictly distinguishing elite solutions and Pareto optimal solutions, and by modifying the method of dealing with illegal variables. The simulations show that BOEDE can collect a great number of solutions to provide decision support for a variety of applications. The comparison results also indicate that BOEDE is significantly better than the existing algorithms.

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## 2 Conferences

Contributed by: Xiang Yin (yinxiang@sjtu.edu.cn)

2.1 **2020 International Workshop on Discrete Event Systems**
Rio de Janeiro, Brazil, May 13-15, 2020
https://wodes2020.eventos.ufrj.br

2.2 **2020 International Conference on Control, Decision and Information Technologies**
Prague, Czech Republic, June 29 - July 02, 2020
https://codit2020.com

2.3 **2020 American Control Conference**
Denver, Colorado, USA, July 1-3, 2020
http://acc2020.a2c2.org

2.4 **2020 IEEE International Conference on Control & Automation**
Sapporo, Hokkaido, Japan, July 6-9, 2020
http://www.ieee-icca.org

2.5 **2020 IFAC World Congress**
Berlin, Germany, July 12-17, 2020
https://www.ifac2020.org

2.6 **2020 IEEE Conference on Automation Science and Engineering**
Hong Kong, China, August 20-24, 2020
https://www.imse.hku.hk/case2020

2.7 **2020 IEEE Conference on Control Technology and Applications**
Montréal, Canada, August 24-26, 2020
https://ccta2020.ieeecss.org

2.8 **2020 IEEE Conference on Conference on Decision and Control**
Jeju Island, Republic of Korea, December 8-11, 2020
https://cdc2020.ieeecss.org

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## 3 International Graduate School on Control

**Introduction to Discrete Event Systems**

**Lecturers:** Stéphane Lafortune, Christos Cassandras

**Location:** Marseille, France, June 8-12, 2020

**Message from Lecturers:**
Dear Colleagues,

We are pleased to inform you that we will be the main lecturers for a module of 21 hours on "Introduction to Discrete Event Systems", to be offered as part of the European Embedded Control Institute (EECI) International Graduate School on Control in 2020. This course will be held from June 8 to 12, 2020 in Marseilles, France. See: http://www.eeci-igsc.eu/venues/

While the area of discrete event systems started as a sub-discipline in control engineering almost 40 years ago, the study of discrete event systems (DES) remains highly relevant to control engineering problems nowadays, such as in cyber-physical systems, transportation, software engineering, and in the study of privacy and security in engineered systems. In fact, DES form the centerpiece of the event-driven (cyber) component in the hybrid systems that comprise much of today's technology, complementing the time-driven (physical) components.

This course will strike a balance between introducing the students to the key concepts, models, and results of discrete-event control theory for logical and stochastic models, while at the same time emphasizing current research trends in DES theory and applications.

More details about the program can be found at:
https://www.web-events.net//doc/users/395/bib/2019-2020/eeciigsc2020summariesvf31oct.pdf
Students can apply to get financial support. The registration is open at:
http://www.eeci-igsc.eu/registration/
The early registration deadline is March 8. Please register by that date to ensure participation.

Best regards,

Stéphane Lafortune and Christos Cassandras

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## 4 Books

4.1 **Estimation and Inference in Discrete Event Systems — A Model-Based Approach with Finite Automata**

**Author:** Christoforos N. Hadjicostis

**Description:** Estimation and Inference in Discrete Event Systems chooses a popular model for emerging automation systems—finite automata under partial observation—and focuses on a comprehensive study of the key problems of state estimation and event inference. The text includes treatment of current, delayed, and initial state estimation. Related applications for assessing and enforcing resiliency—fault detection and diagnosis—and security—privacy and opacity—properties are discussed, enabling the reader to apply these techniques in a variety of emerging applications, among them automated manufacturing processes, intelligent vehicle/highway systems, and autonomous vehicles.

The book provides a systematic development of recursive algorithms for state estimation and event inference. The author also deals with the verification of pertinent properties such as:
• the ability to determine the exact state of a system, "detectability";
• the ability to ensure that certain classes of faults can be detected/identified, "diagnosability"; and
• the ability to ensure that certain internal state variables of the system remain "hidden" from the outside world regardless of the type of activity that is taking place, "opacity".
This book allows students, researchers and practicing engineers alike to grasp basic aspects of state estimation in discrete event systems, aspects like distributivity and probabilistic inference, quickly and without having to master the entire breadth of models that are available in the literature.

More details: https://www.springer.com/gp/book/9783030308209

4.2 **Path Planning and Control of Cooperative Mobile Robots Using Discrete Event Models**

**Authors:** Cristian Mahulea, Marius Kloetzer, Ramon Gonzalez
ISBN: 978-1-119-48632-9, January 2020, Wiley-IEEE Press, 240 Pages
https://bit.ly/2MYphKe

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## 5 Positions

### 5.1 Singapore NRF Fellowship

**Description:** Singapore National Research Foundation Fellowship (NRFF) is a highly prestigious research position in Singapore. It will offer a five-year research grant of up to SGD 3 million (approximately USD 2.15 million, based on the exchange rate of 1.4 SGD/USD), inclusive of general overheads, and each winner will be treated as a faculty member in his/her hosting institute, and most previous candidates joined either NUS or NTU as tenured faculty members, after successfully completing their fellowship projects.

If you are interested in this fellowship and NTU as your host institute, please contact Dr. Rong Su directly (rsu@ntu.edu.sg). Dr. Rong Su will inform the school committee to contact those candidates directly and assist their applications.

### 4.2 Professor or Assistant Professor (Tenure Track) of Cyber-Physical and Embedded Systems

**Description:** The Department of Information Technology and Electrical Engineering at ETH Zurich invites applications for the above-mentioned position.

The successful candidate is expected to develop a strong and visible research programme in the area of embedded systems. He or she has a strong background in areas such as cyber physical systems, real-time systems, embedded systems, embedded control, sensor networks, systems on chip (SoC), or related fields. An engineering approach to these topics as well as a research profile showing synergies with other research areas in the Department of Information Technology and Electrical Engineering is welcomed.

The new professor must be committed to innovative and engaging teaching at the bachelor's level on cyber physical systems/embedded systems and computer engineering as well as advanced classes in the Master programme on related topics such as hardware/software codesign of digital systems. Generally, at ETH Zurich undergraduate level courses are taught in German or English and graduate level courses in English.

Assistant professorships have been established to promote the careers of younger scientists. ETH Zurich implements a tenure track system equivalent to other top international universities. The level of the appointment will depend on the successful candidate's qualifications.

Applications should include a curriculum vitae, a list of publications, a statement of future research and teaching interests, a description of the three most important achievements*, and the names of five references. The letter of application should be addressed to the President of ETH Zurich, Prof. Dr. Joël Mesot. The closing date for applications is 31 January 2020. ETH Zurich is an equal opportunity and family friendly employer, strives to increase the number of women professors, and is responsive to the needs of dual career couples.

For online application, see:
https://ethz.ch/en/the-eth-zurich/working-teaching-and-research/faculty-affairs/ausgeschriebene-p
ingenieurwissenschaften/professor-or-assistant-professor--tenure-track--of-cyber-physica.
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