IEEE Control Systems Society
Technical Committee on Discrete Event Systems

Newsletter **May 2020**

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Welcome to the 2020 May 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: 5, May 2020

- **Stochastic Control of Multidimensional Systems With Relative Optimization**
  Authors: Xi-Ren Cao
  Abstract: We derive the Tanaka formula for multidimensional semismooth functions with the local time on the semismooth curve along the gradient direction. With this formula, we extend the relative optimization based approach to stochastic control to multidimensional systems. Optimality conditions are derived for systems with semismooth value functions, and no viscosity solution is involved. This approach provides new insights and motivates the research on stochastic control and stochastic calculus, in particular, for problems with nonsmooth features and degenerate points.

- **Remote Estimation Over a Packet-Drop Channel With Markovian State**
  Authors: Jhelum Chakravorty ; Aditya Mahajan
  Abstract: We investigate a remote estimation problem in which a transmitter observes a Markov source and chooses the power level to transmit it over a time-varying packet-drop channel. The channel is modeled as a channel with Markovian state where the packet drop probability depends on the channel state and the transmit power. A receiver observes the channel output and the channel state and estimates the source realization. The receiver also feeds back the channel state and an acknowledgment for successful reception to the transmitter. We consider two models for the source—finite state Markov chains and first-order autoregressive processes. For the first model, using ideas from team theory, we establish the structure of optimal transmission and estimation strategies and identify a dynamic program to determine optimal strategies with that structure. For the second model, we assume that the noise process has unimodal and symmetric distribution. Using ideas from majorization theory, we show that the optimal transmission strategy is symmetric and monotonic and the optimal estimation strategy is like Kalman filter. Consequently, when there are a finite number of power levels, the optimal transmission strategy may be described using thresholds that depend on the channel state. Finally, we propose a simulation-based approach (renewal Monte Carlo) to compute the optimal thresholds and optimal performance and elucidate the algorithm with an example.

- **Gaussian Conditionally Markov Sequences: Singular/Nonsingular**
  Authors: Reza Rezaie ; X. Rong Li
  Abstract: Most existing results about modeling and characterizing Gaussian Markov, reciprocal, and conditionally Markov (CM) processes assume nonsingularity of the processes. This assumption makes the analysis easier, but restricts application of these processes. This paper studies, models, and characterizes the general (singular/nonsingular) Gaussian CM (including reciprocal and Markov) sequence. For example, to our knowledge, there is no dynamic model for the general (singular/nonsingular) Gaussian reciprocal sequence in the literature. We obtain two such models from the CM viewpoint. As a result, the significance of studying reciprocal sequences from the CM viewpoint is demonstrated. The results of this paper unify singular and nonsingular Gaussian CM (including reciprocal and Markov) sequences and provide tools for their application. An application of CM sequences in trajectory modeling with a destination is discussed, and illustrative examples are presented.

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1.2. Automatica

Volume: 115 May 2020

- **Event-triggered recursive state estimation for dynamical networks under randomly switching topologies and multiple missing measurements**
  Authors: Jun Hu ; Zidong Wang ; Guo-Ping Liu ; Chaoqing Jia ; Jonathan Williams

Abstract: In this paper, the design problem of recursive state estimator is discussed for a class of coupled nonlinear dynamical networks with randomly switching topologies and multiple missing measurements under the event-triggered mechanism. A sequence of random variables obeying the Bernoulli distribution with certain occurrence probabilities is adopted to model the multiple missing measurements and the random change manners of the network topologies. The event-based communication protocol is introduced to adjust the transmission frequency, thereby improving the energy utilization efficiencies of the communication networks. The objective of the addressed variance-constrained estimation problem is to construct a recursive state estimator such that, in the simultaneous presence of event-based transmission strategy, randomly switching topologies as well as multiple missing measurements, a locally optimal upper bound is guaranteed on the estimation error covariance by properly determining the estimator gain, where the desired estimator gain matrix is formulated via the solutions to certain recursive matrix equations. Besides, theoretical analysis is conducted on the monotonicity regarding the missing probabilities of degraded measurements and the obtained upper bound matrix. Finally, some simulations with comparisons are carried out to demonstrate the effectiveness and feasibility of proposed event-triggered state estimation method.

- **Synchronization of networks over finite fields**
  Authors: Min Meng ; Xiuxian Li ; Gaoxi Xiao
  Abstract: In this paper, the synchronization problem for networks over finite fields is investigated, which is a generalization of consensus and provides a new perspective for networks of agents with limited capacities of memory and communication. It is assumed that the states and communication weights can only attain values from a finite alphabet equipped with a prime number of integers, termed finite fields, and operations are processed relying on modular arithmetic. For this synchronization problem, necessary and sufficient conditions are derived based on the transition graph of the studied network. The large number of nodes in the transition graph, dependent on the numbers of integers in finite fields and the agents, may lead to high computational cost and difficulties in verifying synchronization. To avoid this, an equivalent condition for synchronization of networks is provided by the characteristic polynomial of the studied network matrix. Furthermore, in a synchronized network over finite fields, the periodic behavior can be determined by the network matrix and the initial state.

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1.3. IEEE Transactions on Control Systems Technology

Volume: 28, Issue: 3, May 2020

- **Reconfiguration Control of Dynamic Reconfigurable Discrete Event Systems Based on NCESs**
  Authors: Jiafeng Zhang ; Hongyi Li ; Georg Frey ; Zhiwu Li
  Abstract: In order to satisfy system specifications persistently in the cases of component failure, partial communication blocks, or energy deficiency, safety-critical systems need to apply system reconfigurations at runtime. Such systems can be considered as dynamic reconfigurable discrete event systems (DRDESs) if their logic behaviors are concerned only. A reconfiguration of a DRDES includes the switch of system structures and the update of system states. Based on the assumption that all configurations of a DRDES are designed in advance and dynamic reconfigurations can be implemented only at a few predefined reconfigurable states, a novel reconfiguration control method is proposed in this paper. The aim is to implement a required dynamic reconfiguration smoothly and rapidly. A DRDES is modeled by net condition/event systems (NCESs) under the firing rule “maximal single spontaneous transition steps." An integer linear programming-based method is developed to compute a shortest legal firing sequence (SLFS) from the state where a reconfiguration requirement arises to a reconfigurable state. Accordingly, a virtual controller for guiding the system to evolve along the obtained SLFS is proposed. The proposed method is able to implement a required reconfiguration before the maximum permissible reconfiguration delay if an SLFS exists. A simple reconfigurable assembly system is adopted to illustrate the method.

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1.4. IEEE Transactions on Automation Science and Engineering

Volume: 17, Issue: 2, April 2020

- **Synchronous Diagnosis of Discrete-Event Systems**
  Authors: Felipe Gomes Cabral ; Marcos Vicente Moreira
  Abstract: In general, systems are formed by the composition of several modules, local components, or subsystems, and may exhibit a large number of states. The growth of the composed model with the number of system components leads to high-computational costs for diagnosis techniques based on the composed plant model. We propose in this article a new approach for fault diagnosis that avoids the direct use of the composed system model for the diagnoser implementation, reducing the computational cost for diagnosis. The diagnosis strategy is based on the observation of the fault-free behavior of the system components. In this regard, we introduce the definition of synchronous diagnosability of the language of a discrete-event system (DES) with respect to the languages of its components and provide a method to verify this property. An algorithm that efficiently computes the fault-free behavior model of the system components is also proposed. We extend this approach to a decentralized architecture and introduce the definition of synchronous codiagnosability. Moreover, a comparison between the classical definition of diagnosability, synchronous diagnosability, synchronous codiagnosability, and modular diagnosability of DESs is established. The verification of synchronous diagnosability for a didactic automated system is presented to show the results of the article.
- **Reduction Rules for Diagnosability Analysis of Complex Systems Modeled by Labeled Petri Nets**
  Authors: Ben Li ; Manel Khlif-Bouassida ; Armand Toguyeni
  Abstract: This article addresses the combinatorial explosion problem for diagnosability analysis of discrete event systems (DESs) using bounded labeled Petri nets (LPNs). Some reduction rules are given to simplify a priori the LPN model before analyzing the diagnosability. When the conditions of these reduction rules are fulfilled, some regular unobservable transitions and some specific observable transitions are suppressed. It is proven that these rules preserve the diagnosability property of the LPN system. By using reduction rules, the memory cost for diagnosability analysis is reduced.
- **Alarm Event Prediction From Historical Alarm Flood Sequences Based on Bayesian Estimators**
  Authors: Yizhou Xu ; Jiandong Wang ; Yan Yu
  Abstract: A new method is proposed to predict upcoming alarm events for a current alarm sequence by exploiting similar historical alarm flood sequences. The proposed method is composed of two main steps. The first step sorts the historical alarm flood sequences in the descending order of similarity scores with respect to the current alarm sequence. The second step chooses some subsequence of recent alarm events in the current alarm sequence and predicts an upcoming alarm event based on these similar historical alarm flood sequences having the same subsequence. A Bayesian estimator is exploited to calculate the posterior probabilities and their confidence intervals for all the candidates of predicted alarm events. The optimal predicted alarm event is the one with the largest lower bound of posterior probability as a quantitative measurement of prediction reliabilities. The proposed method resolves a dilemma between a long (short) subsequence of the current alarm sequence and a small (large) number of the same subsequences in the historical alarm flood sequences. Numerical examples are provided to support the proposed method.

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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 (Postponed)
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 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 Call for Papers

5.1 PID Control for Discrete-Event, Switched, and Hybrid Systems

International Journal of Robust and Nonlinear Control

Guest Editors: Dan Ma ; Silviu-Iulian Niculescu ; Lei Guo ; Jie Chen

Call for Papers: This special issue seeks to respond to the recent trends of PID control and aims to report recent analytical studies and practical applications, with a focus on the robustness, performance, optimization and analytical design. All theoretical and practical aspects central to this theme will be of interest. Particularly welcomed is the latest progress of PID control to emerging problem areas such as hybrid, event-triggered control, networked and multi-agent control, to new control design methods such as data-driven design, model predictive control, and machine learning design, for new technological advances such as cyber-physical systems, cloud-based control, and to broad application areas such as biological systems, smart grid, and micro/nano-scale networks on chip. Potential topics include, but are not limited to the following:

- Robustness and fragility of PID control
- Performance and optimization of PID controllers
- Structural and improved PID control
- PID control for nonlinear systems
- PID control for distributed parameter systems
- PID control for discrete-event, switched, and hybrid systems
- Sampled-data/event-triggered PID control
- Distributed PID control over networks
- PID control design by data-driven methods
- PID control design by machine learning methods
- Applications of PID control

Prospective authors are invited to submit manuscripts prepared as per the International Journal of Robust and Nonlinear Control guidelines, no later than December 1, 2020. Manuscripts should be submitted electronically online at: https://mc.manuscriptcentral.com/rnc-wiley. For inquiries, authors may contact one of the four guest editors below.

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6 Software Tool

6.1 IDES: An Open-Source Software Tool

IDES, the discrete-event systems software tool in Karen Rudie's lab is now available as open-source software at https://github.com/krudie/IDES. More information on IDES can also be found at https://www.ece.queensu.ca/people/K-Rudie/qdes.html#fndtn-software.

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