IEEE CONTROL SYSTEMS SOCIETY
TECHNICAL COMMITTEE ON DISCRETE EVENT SYSTEMS

Newsletter..... January 2019

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1. Editorial

Welcome to the 2019 January issue of the newsletter,
also available electronically at
http://discrete-event-systems.ieeecss.org/tc-discrete/newsletters

You are welcome to submit new items to the newsletter (topics including schools, workshops, sessions, conferences, journals, books, software, positions).
To submit a new item, please email to kai.cai@eng.osaka-cu.ac.jp.

To subscribe, please email to kai.cai@eng.osaka-cu.ac.jp.
To unsubscribe, please reply to this email with the subject line UNSUBSCRIBE.

2. Workshops and Invited Sessions

2.1 CfP: Invited Session at 2019 Conference on Control Technology and Applications (CCTA'19)

Contributed by: Kai Cai (kai.cai@eng.osaka-cu.ac.jp)

Dr. Eric Rutten and Dr. Kai Cai are planning to organize an invited session on Applications of DES at CCTA’19, to be held in Hong Kong, August 19-21. The principal objective of this invited session is to present the "state of the art" DES control applications, with special emphasis on real demonstrations (hardware or software). This session will be co-sponsored by IEEE CSS TC on Discrete Event Systems.

If you are interested, please contact Dr. Eric Rutten (eric.rutten@inria.fr) or Dr. Kai Cai (kai.cai@eng.osaka-cu.ac.jp) as soon as possible with the following information.

1. Tentative title of paper
2. Author list
3. Corresponding email
4. Affiliation

2.2 CfP: Invited Session or Workshop at 2019 Conference on Decision and Control (CDC'19)

Contributed by: Rong Su (rsu@ntu.edu.sg)

Dr. Rong Su and Dr. (Samuel) Qing-Shan Jia are planning to organize an invited session or a workshop on Resilient Discrete-Event Systems at CDC’19, to be held in Nice, France, December 11-13. The concept of "resilience” is in its broadest sense, e.g., fault tolerance,

performance optimization, opacity, cyber attacks, and advanced modeling for real-time system analysis. This session/workshop will be co-sponsored by IEEE CSS TC on Discrete Event Systems and TC on Smart Cities.

If you are interested or have questions, please contact Dr. Rong Su (rsu@ntu.edu.sg).

3. Selections of Journal Publications

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

3.1. SELECTIONS OF THE IEEE TRANSACTIONS ON AUTOMATIC CONTROL VOLUME: 64, ISSUE: 1, January 2019

(1) Detectability Measure for State Estimation of Discrete Event Systems

Authors: Pei Zhao ; Shaolong Shu ; Feng Lin ; Bo Zhang

Abstract: In this note, we investigate how to quantitatively evaluate the performance of state estimation for discrete event systems. We use a stochastic automaton to model a discrete event system. We say that an event sequence is detectable if we can determine the current and subsequent states after the occurrence of the sequence. We define the limit of the sum of probabilities of all detectable sequences when the length of the sequences goes to infinity as a quantitative indicator of goodness of state estimation. We call this indicator "detectability measure." In order to calculate the detectability measure, we augment the discrete event system to include the information of its state estimates and then convert it into a Markov chain by removing all the event labels. Calculation of the detectability measure is then translated to calculation of the sum of probabilities of some states in the Markov chain, which can be done effectively. Finally, a practical example is used to illustrate these results.

Full-text available at: https://ieeexplore.ieee.org/document/8370899

(2) Model Predictive Control for Stochastic Max-Plus Linear Systems With Chance Constraints

Authors: Jia Xu ; Ton van den Boom ; Bart De Schutter

Abstract: The topic of this paper is model predictive control (MPC) for max-plus linear systems with stochastic uncertainties the distribution of which is supposed to be known. We consider linear constraints on the inputs and the outputs. Due to the uncertainties, these linear constraints are formulated as probabilistic or chance constraints, i.e., the constraints are required to be satisfied with

a predefined probability level. The proposed chance constraints can be equivalently rewritten into a max-affine (i.e., the maximum of affine terms) form if the linear constraints are monotonically nondecreasing as a function of the outputs. Based on the resulting max-affine form, two methods are developed for solving the chance-constrained MPC problem for stochastic max-plus linear systems. Method 1 uses Boole's inequality to convert the multivariate chance constraint into univariate chance constraints for which the probability can be computed more efficiently. Method 2 employs Chebyshev's inequality and transforms the chance constraint into linear constraints on the inputs. The simulation results for a production system example show that the two proposed methods are faster than the Monte Carlo simulation method and yield lower closed-loop costs than the nominal MPC method.

Full-text available at: https://ieeexplore.ieee.org/document/8392382

(3) Further Results on the Controllability of Boolean Control Networks

Authors: Qunxi Zhu ; Yang Liu ; Jianquan Lu ; Jinde Cao

Abstract: This note presents further results based on the recent paper [J. Liang, H. Chen, and J. Lam,. 2017]. After some optimizations, the conventional method can be more efficient than the method used in the above paper. We also propose an improved method via combining the well known Tarjan's algorithm and depth-first search technique for the controllability analysis of Boolean control networks (BCNs). As a result, the computational complexity will not exceed O(N2) with N=2n, where n is the number of state-variables in a BCN.

Full-text available at: https://ieeexplore.ieee.org/document/8350282

(4) Regulation of Linear Systems Using Event-Based Detection Sensors

Authors: Prince Singh ; Sze Zheng Yong ; Emilio Frazzoli

Abstract: In this paper, we investigate the problem of regulating a continuous-time linear time-invariant (LTI) system to a desired point using discrete event measurements from signal change detection sensors with a logarithmic event generation threshold (trigger), which includes the recently developed neuromorphic vision sensors. Existing control algorithms typically only process periodic measurements, and thus, a new class of algorithms needs to be developed that can efficiently process the sensors' asynchronous discrete events for control tasks. Thus, we present a novel control design procedure that regulates the hybrid system, consisting of the continuous LTI system and a discrete-event signal change observation model, to a desired set point. Moreover, we provide the set of thresholds (sufficient conditions) for the given system to fulfill the regulation task. The effectiveness of our approach is

illustrated on an unstable system.

Full-text available at: https://ieeexplore.ieee.org/document/8500318

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3.2. SELECTIONS OF AUTOMATICA
VOLUME: 99, ISSUE: 1, January 2019

(1) Infinite-Step Opacity and K-step Opacity of Stochastic Discrete-Event Systems

Authors: Xiang Yin, Zhaojian Li, Weilin Wang, Shaoyuan Li

Abstract: Opacity is an important information-flow property that arises in security and privacy analysis of cyber-physical systems. Among many different notions of opacity, -step opacity requires that the intruder can never determine unambiguously that the system was at a secret state for any specific instant within steps prior to that particular instant. This notion becomes infinity-step opacity when goes to infinity. Existing works on the analysis of infinite-step opacity and -step opacity only provide a binary characterization, i.e., a system is either opaque or non-opaque. To analyze infinite-step and -step opacity more quantitatively, in this paper, we investigate the verification of infinite-step and -step opacity in the context of stochastic discrete-event systems. A new notion of opacity, called almost infinite-step opacity (respectively, almost-step opacity), is proposed to capture whether or not the probability of violating infinite-step opacity (respectively, -step opacity) is smaller than a given threshold. We also provide effective algorithms for the verification of almost infinite-step opacity and almost -step opacity.

Full-text available at: https://www.sciencedirect.com/science/article/pii/S0005109818305235

(2) Robust Event-Triggered State Estimation: A Risk-Sensitive Approach

Authors: Jiarao Huang, Dawei Shi, Tongwen Chen

Abstract: In this work, we investigate a robust event-triggered remote state estimation problem for linear Gaussian systems with a stochastic event-triggering condition. The reference measure approach is used to obtain a robust event-triggered estimate that minimizes the so-called risk-sensitive criterion, which refers to the expectation of the exponential of the sum of the squared estimation error. We introduce the reference measure, under which, the measurements are identically independently distributed (i.i.d.) and independent of the states, and propose a map to link the "real-world" measure to the reference measure so that the recursions of the information states under the reference measure can be obtained. Based on these results, the risk-sensitive criteria are reformulated

under the reference measure and closed-form expressions of the risk-sensitive event-triggered posterior and prior estimates are presented, which are shown to evolve in simple recursive Kalman-like structures. Moreover, two sufficient stability conditions for the proposed estimators are given, where the first requires the solution of a time-varying Riccati equation to be positive-definite and satisfy a specific inequality, which can be further extended to the scenario when the weighting matrix in the risk-sensitive criterion is time-variant; the second gives the range of values of the risk-sensitive parameter and covariance of the initial state for which the proposed estimators are stable. Comparative simulation results demonstrate that the proposed risk-sensitive event-triggered estimator is more robust to model uncertainties compared with a typical minimum mean squared error (MMSE) estimator with stochastic event-triggered sensor scheduling.

Full-text available at: https://www.sciencedirect.com/science/article/pii/S0005109818305181

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3.3. SELECTIONS OF IEEE Transactions on Automation Science and Engineering
VOLUME: 16 ISSUE: 1, January 2019

(1) Dynamic Insertion of Emergency Surgeries With Different Waiting Time Targets

Authors: Roberto Bargetto ; Thierry Garaix ; Xiaolan Xie

Abstract: This paper addresses the problem of emergency surgery insertion into a given elective surgery schedule of an operating theater (OT) composed of multiple operating rooms (ORs). Emergency surgeries with different emergency levels characterized by waiting time targets (WTTs) arrive according to a nonhomogeneous Poisson process and can be inserted into any OR. An event-based stochastic programming model is proposed to minimize the total cost incurred by exceeding WTTs of emergency surgeries, elective surgery delay, and surgery team overtime. A perfect information-based lower bound is proposed and the properties of the optimal policies are proved. Simple heuristic policies and a stochastic optimization (SO) approach derived from the simple policies by policy improvement are proposed. Numerical experiments show that the SO significantly outperforms the others and efficient emergency insertion significantly improves the system performance. A principal component analysis is performed to show how near-optimal policies differ from simple heuristic policies. Note to Practitioners -- This paper is motivated by enhancing the efficiency of OTs by sharing the surgery capacity between the elective and emergency surgeries. More specifically, we consider the problem of inserting nonelective surgeries of different emergency levels in the execution of a given elective surgery schedule. An SO approach is proposed to dynamically prioritize emergency and elective surgeries in order to best balance meeting emergency surgery requirement, perturbation of elective

schedule, and surgery team overtime. Numerical experiments based on the data collected from Saint-Joseph Hospital in Paris show the significant benefit of efficient emergency insertion over the current hospital practice. Elective surgery schedule is shown to have the most important impact on the system performance but efficient emergency insertion always adds significant improvement.

Full-text available at: https://ieeexplore.ieee.org/document/8413091

(2) Predictability of Failure Event Occurrences in Decentralized Discrete-Event Systems and Polynomial-Time Verification

Author: Fuchun Liu

Abstract: Due to the practical and theoretical importance, failure prediction of discrete-event systems (DESs) has received increasing attention recently. In this paper, the predictability of failure events in decentralized DESs is investigated. The main contributions are as follows. First, the notion of copredictability of DESs is formalized under the decentralized framework to capture the feature that the occurrences of failure events can be predicted based on at least one local observation. It is deducted that the copredictability is weaker than the predictability but stronger than the codiagnosability. Second, in order to achieve the performance of prediction, a nondeterministic automaton called coverifier is constructed from the given system. Third, the necessary and sufficient condition for verifying the copredictability of DESs based on the coverifier is presented, which generalizes the main results by Genc and Lafortune from the centralized systems to the decentralized setting. It is worth noting that both constructing the coverifier and verifying the copredictability can be realized with polynomial complexity in the number of states and events of the system. Note to Practitioners -- The research in this paper is motivated by the following practical problem. Before failure events occur in a manufacturing system, can engineers predict the occurrences based on the observation record of the system? This paper aims to investigate the predictability issue of discrete-event systems under a decentralized framework by introducing the notion of copredictability. In order to verify the copredictability of systems, an approach is proposed by constructing the coverifier. In particular, the verification is polynomial-time.

Full-text available at: https://ieeexplore.ieee.org/document/8481482

(3) Advisory Temporal Logic Inference and Controller Design for Semiautonomous Robots

Authors: Zhe Xu ; Sayan Saha ; Botao Hu ; Sandipan Mishra ; A. Agung Julius

Abstract: In this paper, we present a method to learn (infer) and refine a set of advices from the trajectories generated in the

successful and failed attempts in a task or game, in the form of advisory signal temporal logic (STL) formulas. Each advice consists of an advisory motion STL formula that characterizes the spatial-temporal pattern of the motion as a feature of success and an advisory selection STL formula as a criterion for the environment to select the advice. For the inference of advisory STL formulas, we provide a theoretical framework of perfect classification with a labeled set of trajectories with different time lengths. We design an advisory controller that can drive the robots to satisfy an advisory motion STL formula based on the advice selected according to the advisory selection STL formula. The advisory controller can advise or guide the human operators or the robots for better performance with the shared autonomy between the human operator and the controller. We provide two case studies to test the effectiveness of the advisory controller, one with a Baxter-On-Wheels simulator and the other with two quadrotors in an experimental testbed in iteratively improving the success rates of completing the tasks with the help of the designed advisory controller. Note to Practitioners -- The method described in this paper can be used to obtain knowledge or patterns of the environment based on the trajectories generated by the human operators/ demonstrators and utilize the obtained knowledge or patterns for improving the performance of the future operators. The obtained information is the logical statements about the waypoints or subgoals to be reached, and obstacles or dangerous regions to be avoided during certain time intervals, when the environment satisfies certain conditions also expressed in the form of logical statements. The methodology of inferring knowledge from data and designing advisory controllers for guiding or helping future practices is potentially useful in many applications where the dynamic mathematical model of the external environment is unknown.

Full-text available at: https://ieeexplore.ieee.org/document/8374930

(4) Optimized Multiagent Routing for a Class of Guidepath-Based Transport Systems

Authors: Greyson Daugherty ; Spyros Reveliotis ; Greg Mohler

Abstract: This paper presents a heuristic algorithm for minimizing the makespan required to route a set of agents inhabiting a shared guidepath network from their initial locations to their respective destinations while observing a set of regulations that seek to ensure the safety and the integrity of the generated traffic. From an application standpoint, the presented developments are motivated by the traffic coordination challenges that arise in the context of many automated unit-load material handling systems and also in the transport of the ionized atoms that takes place in the context of quantum computing. From a methodological standpoint, our developments constitute a customization of the general "local-search" framework of combinatorial optimization theory to the traffic management problem that is considered in this paper. Hence, the presented results include a rigorous characterization of the

considered problem and its solution space, detailed algorithms for the construction of the necessary initial solutions and the improving step for the pursued search, a complexity analysis of these algorithms, and a set of computational experiments that reveal and assess the computational efficiency of the presented algorithms and the efficacy of the derived solutions. The paper concludes with some suggestions for potential extensions of the presented results. Note to Practitioners -- In many contemporary applications of automation science and engineering, a number of entities -- or "agents" -- must be transported expediently from their initial locations to certain destinations using a set of links that define the underlying "guidepath network." Furthermore, various safety considerations require that the agents must be adequately separated during these transports, and the imposed restrictions turn the corresponding traffic coordination problem into a complex resource allocation problem, where the contested resources are the guidepath-network links. This paper presents a set of algorithms that can provide high-quality schedules for the resulting traffic-scheduling problems in a computationally efficient manner. These properties of our algorithms are established through the necessary theoretical analysis, but they are also demonstrated through a series of numerical experiments where they are shown capable to provide near-optimal solutions for some very complex problem instances in no more than a few seconds. In addition, our algorithms are "complete," i.e., they will always provide a feasible schedule for any instantiation of the traffic-scheduling problem considered in this paper. Hence, they can effectively address the needs for "real-time" traffic management that arise in the context of the considered applications.

Full-text available at: https://ieeexplore.ieee.org/document/8292889

(5) A New Class of Sequences Without Interferences for Cluster Tools With Tight Wafer Delay Constraints

Authors: Yuchul Lim ; Tae-Sun Yu ; Tae-Eog Lee

Abstract: Robotized cluster tools for semiconductor wafer fabrication may have a wafer wait within a processing chamber after processing there until the wafer is unloaded from the chamber by a robot. Such wafer delays cause wafer quality degradation or variability due to residual gases and heats within the chamber. There have been numerous works on characterizing wafer delays and scheduling under upper limits on wafer delays while presuming that the tools are operated by well-known simple robot task sequences such as swap or backward sequences. However, when the wafer delay constraints are tight, there may not be feasible schedules for such sequences. We wish to know whether there can be alternative robot task sequences which can satisfy such tight wafer delay constraints. In this paper, we identify a new class of robot task sequences that can better satisfy tight wafer delay constraints than the conventional swap or backward sequences while keeping the same minimum tool cycle time. By examining the circuits of timed event

graph (TEG) models for the tool operation behaviors in many different robot task sequences, we identify that such robot task sequences do not make interferences between the work cycles of the resources such as the robot and chambers. The resource interference can cause delays in the work cycles, and hence increase the wafer delays or the tool cycle time. To prove this, we examine circuits in an extended TEG model, a negative event graph, which incorporates time constraints as negative places and tokens. From this, we derive closed-form conditions for which such sequences are feasible against given wafer delay constraints. By experiments, we show that the proposed new sequences have shorter wafer delays, and hence better satisfy tight wafer delay constraints than conventional sequences. Note to Practitioners -- As circuit widths shrink down to several nanometers, cluster tools for semiconductor fabrication require extreme process quality control. Even wafer delays within processing chambers of cluster tools can cause wafer quality degradation and variability. Therefore, it is desirable for cluster tools to have much shorter wafer delays. However, conventional sequences such as the swap and backward sequences, which are being prevalently used in practice, may not satisfy tight wafer delay constraints. Our proposed sequences, which are as simple as the conventional sequences, have much shorter wafer delays while keeping the same minimum tool cycle time.

Full-text available at: https://ieeexplore.ieee.org/document/8329263

(6) Scheduling Dual-Armed Cluster Tools With Chamber Cleaning Operations

Authors: Tae-Sun Yu ; Tae-Eog Lee

Abstract: Circuit widths and nodes of semiconductor wafers have been continually shrinking down to less than 20 nm. Therefore, modern wafer fabs enforce extremely strict process control to prevent wafer quality failures. A wafer processing chamber is now frequently cleaned to remove residual chemicals and impurities. Yu et al. show that such cleaning operations significantly change the tool operation of single-armed cluster tools, and they suggest an idea of partial wafer loading to improve the tool throughput under cleaning requirements. However, little is known about how a dual-armed tool could be effectively scheduled when chamber cleaning exists. A dual-armed robot allows more flexible tool operational sequences, and hence, the scheduling problem becomes further complicated and challenging. In this paper, we propose a scheduling method by which the dual arms can be properly exploited for better tool productivity. We show that the suggested hybrid sequence significantly reduces the tool cycle time as compared to previously developed scheduling methods. Through this research, we conclude that the productivity gain of the dual arms against single arm is more significant when chambers are cleaned. Note to Practitioners -- This paper is motivated by the scheduling issues of cluster tools with chamber cleaning requirements. Though an efficient scheduling method for single-armed cluster tools is presented by Yu et al., its

performance is not sufficiently close to the optimal when a dual-armed robot is considered. More specifically, we cannot expect any productivity improvement from adopting a dual-armed robot, although it allows more flexible tool operations and is known to have higher throughput than a single-armed robot. Thus, we propose a novel scheduling method for dual-armed cluster tools that require chamber cleaning operations. The experimental results show that the suggested method achieves optimal tool throughput in most of the practical tool conditions.

Full-text available at: https://ieeexplore.ieee.org/document/8103912

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3.4. SELECTIONS OF SYSTEMS & CONTROL LETTERS
VOLUME: 123, ISSUE: 1, January 2019

(1) Synthesis of Minimally Restrictive Optimal Stability-Enforcing Supervisors for Nondeterministic Discrete Event Systems

Authors: Xiaoguang Han, Zengqiang Chen, Rong Su

Abstract: In this paper, we investigate stability-enforcing supervisory control of nondeterministic discrete event systems (DESs) from a brand-new angle. First, the dynamics of a discrete event system (DES) are converted into an algebraic equation in the framework of Boolean semi-tensor product. Using it, several necessary and sufficient conditions are presented to verify whether a DES is stable or not. Second, effective verification criteria are provided for the stabilization problem of DESs. Further, a cost function of disabling controllable events at corresponding states is defined. A matrix-based methodology of finding all minimally restrictive optimal stability-enforcing supervisors is presented. Finally, two examples are provided to illustrate the theoretical results.In this paper, we investigate stability-enforcing supervisory control of nondeterministic discrete event systems (DESs) from a brand-new angle. First, the dynamics of a discrete event system (DES) are converted into an algebraic equation in the framework of Boolean semi-tensor product. Using it, several necessary and sufficient conditions are presented to verify whether a DES is stable or not. Second, effective verification criteria are provided for the stabilization problem of DESs. Further, a cost function of disabling controllable events at corresponding states is defined. A matrix-based methodology of finding all minimally restrictive optimal stability-enforcing supervisors is presented. Finally, two examples are provided to illustrate the theoretical results.

Full-text available at: https://www.sciencedirect.com/science/article/pii/S0167691118301944

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4. Conferences

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

4.1 2019 European Control Conference
Naples, Italy, Jun 25 - Jun 28, 2019
https://ecc19.eu/

4.2 27th Mediterranean Conference on Control and Automation
Akko, Israel, Jul 1 - Jul 4, 2019
https://med19.net.technion.ac.il/

4.3 2019 American Control Conference
Philadelphia, Pennsylvania, United States, Jul 10 - Jul 12, 2019
http://acc2019.a2c2.org/

4.4 38th Chinese Control Conference (CCC 2019)
Guangzhou, China, Jul 27 - Jul 30, 2019
http://www.ccc2019.cn/en/index.html

4.5 2019 Conference on Control Technology and Applications
Hong Kong, China, Aug 19 - Aug 21, 2019
http://ccta2019.ieeecss.org/

4.6 15th International Conference on Automation Science and Engineering
Vancouver, British Columbia, Canada, Aug 22 - Aug 26, 2019
http://case2019.hust.edu.cn/index.htm

4.7 2019 Conference on Decision and Control
Nice, France, December 11-13, 2019
https://cdc2019.ieeecss.org/

5. Positions

5.1. Postdoc: Czech Academy of Sciences, Czech Republic
Contributed by: Jan Komenda (komenda@ipm.cz, komenda@math.cas.cz)

A postdoc position is available in Institute of Mathematics, Czech Academy of Sciences (Brno, Czech Republic) on Control of Concurrent Timed Discrete-Event Systems.

Position Description: A three year postdoc position is available for a candidate with background in discrete-event systems or similar area, and interest in modeling, analysis, and control of timed discrete-event systems. The successful candidate must hold a Ph.D. in a relevant area of engineering, computer science or applied mathematics, and will join a cooperation project (2019-2021) between Czech Academy of Sciences and German Universities TU Berlin and FAU Erlangen that aims at developing novel and scalable methods

for supervisory control of concurrent timed discrete-event systems.

Applications including a detailed CV should be emailed to Dr. Jan Komenda (komenda@ipm.cz or komenda@math.cas.cz). If you need more details about the position please do not hesitate to contact Dr. Jan Komenda (komenda@ipm.cz, komenda@math.cas.cz).

5.2 Postdoc: Queen's University, Canada
Contributed by: Karen Rudie (karen.rudie@queensu.ca)

Postdoctoral Fellowship Competition: Dr. Karen Rudie is seeking a candidate whose application can be put forth for a postdoctoral research opportunity. This is a competition at Queen’s University and the successful candidate would receive funding for one year but with the expectation that they would aid in grant writing that would ideally lead to further funding for subsequent years.

Job Description: postdoctoral research in discrete-event systems with an emphasis on opacity and cyber-resilience problems.

Required skills:
· strong problem-solving skills
· a background in Control of Discrete-Event Systems (or something close enough that you could easily hit the ground running)
· good people skills and good communication skills
· an eagerness to write up our work into publications
· leadership skills and able to train more junior researchers (i.e., graduate students or undergraduate summer researchers).