IEEE Control Systems Society
Technical Committee on Discrete Event Systems

Newsletter **September 2020**

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Welcome to the 2020 September 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. Automatica

Volume: 118 September 2020

- **Approximate abstractions of control systems with an application to aggregation**
  Authors: Stanley W.Smith ; Murat Arcak ; Majid Zamani
  Abstract: Previous approaches to constructing abstractions for control systems rely on geometric conditions or, in the case of an interconnected control system, a condition on the interconnection topology. Since these conditions are not always satisfiable, we relax the restrictions on the choice of abstractions, instead opting to select ones which nearly satisfy such conditions via optimization-based approaches. To quantify the resulting effect on the error between the abstraction and concrete control system, we introduce the notions of practical simulation functions and practical storage functions. We show that our approach facilitates the procedure of aggregation, where one creates an abstraction by partitioning agents into aggregate areas. We demonstrate the results on an application where we regulate the temperature in three separate zones of a building.
- **Event-triggered tracking control for nonlinear systems subject to time-varying external disturbances**
  Authors: Ting Li ; Changyun Wen ; Jun Yang ; Shihua Li ; Lei Guo
  Abstract: Event-triggered tracking control for a class of nonlinear systems with disturbances is investigated in this paper. Compared to existing related results, the nonlinearities only need to satisfy a generalized Lipschitz condition, and the time-varying external disturbances are allowed to be unmatched. By using finite-time disturbance observers, the finite-time estimation of the steady states is achieved to reduce the complexity of tracking control design. The event-triggered controller is designed by a new feedback domination approach, which can dynamically compensate for both errors caused by disturbances and the sampled-data implementation of the controller. A new Lyapunov stability analysis is given to show that all the signals of the closed-loop system are globally bounded and the tracking error is ensured to converge to a set, which can be made as small as desired by adjusting control parameters. Finally, a numerical example demonstrates the effectiveness of the designed scheme.

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1.2. IEEE Transactions on Control Systems Technology

Volume: 17, Issue: 5, September 2020

- **A Bayesian Knock Event Controller**
  Authors: James C. Peyton Jones ; Saeed Shayestehmanesh ; Jesse Frey
  Abstract: A new Bayesian knock event control system is proposed in which the controller maintains the probabilities of different theories regarding the unknown spark angle of BorderLine audible knock, using them to select an optimal control move. Unlike previous controllers that reset every time a control move is made, the new controller incorporates all prior information, thereby giving improved control as more data arrives. Uncertainty can also be injected into the model to maintain transient performance and adaptability to real changes (as opposed to disturbances) that might occur as a result of changes in operating condition. This tradeoff and several variants of the new controller design are investigated using Monte Carlo simulations to obtain rigorous and repeatable statistical assessments of closed-loop behavior. The results show that the controller can deliver fast transient response with reduced cyclic variability and improved steady-state performance with respect to a classical control strategy.
- **Event-Triggered Approach to Dynamic State Estimation of a Synchronous Machine Using Cubature Kalman Filter**
  Authors: Marzieh Kooshkbaghi ; Horacio J. Marquez ; Wilsun Xu
  Abstract: In this brief, an online discrete-time event-triggered cubature Kalman filter (DECKF) is designed to estimate the state of a synchronous generator. First, we define a fourth-order nonlinear

model for a single synchronous generator, then we design an event-triggered mechanism to transfer data through the communication channel when the triggered error is above a certain preestablished threshold. We then design a nonlinear discrete-time CKF for the nonlinear system. We show that the data communication between the sensors and the state estimator is reduced, and the state estimation error is bounded if one selects a proper event-triggered threshold. An example is given to verify the performance of the proposed filter.

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

Volume: 50, Issue: 9, September 2020

- **Model-Based Monitoring and Adaptation of Pacemaker Behavior Using Hierarchical Fuzzy Colored Petri-Nets**
  Authors: Negar Majma ; Seyed Morteza Babamir
  Abstract: A pacemaker is an embedded device that is sited in the chest to regulate irregular heartbeats known as arrhythmias. Since such devices are directed by software, a software failure may cause a serious hazard such as patient death. Runtime monitoring and adaptation of the device software behavior offers a solution for preventing device hazards. We have already obtained some experiences from monitoring medical devices like: 1) insulin pump using fuzzy Petri net and 2) cardiac pacemaker using colored Petri-net (CPN) and hierarchical fuzzy CPN (HFCPN). However, these studies did not present an adaptation method for software runtime faults. This paper, extending our previous work, presents an automatic runtime method for continuous verification of the behavior of the implanted pacemaker using a software agent. The autonomy and the intelligence characteristics of the software agent are used to control the behavior of the cardiac pacemaker software by drawing inferences from a knowledge base where HFCPN is used by the agent as the inference engine. Compared to a flat inference engine, the HFCPN is able to cover the concurrent states initiated by input fuzzy values and improve the running time for finding a suitable rule by up to 92%. In addition, the intelligent software agent checks the runtime operation accuracy of the pacemaker software in vital and unexpected situations, and redirects the software decision if it finds an unacceptable value. To demonstrate the HFCPN's behavior and decision-making in different situations, three different scenarios are presented.
- **Diagnosis of Structural and Temporal Faults for k-Bounded Non-Markovian Stochastic Petri Nets**
  Authors: Dimitri Lefebvre ; Sara Rachidi ; Edouard Leclercq ; Yoann Pigne
  Abstract: This paper concerns the diagnosis of faults for stochastic discrete event systems that behave according to non-Markovian dynamics. k-bounded partially observed Petri nets are used to model the system structure and the sensors. Stochastic processes with probability density functions (pdf) of finite support define the dynamics. Structural and temporal faults are considered. Structural faults correspond to specific sequences of events that should satisfy precedence conditions defined with patterns. Temporal faults are defined with time constraints that must be fulfilled by the firing durations. The probabilities of consistent trajectories are computed with a numerical scheme from the collected timed measurements. The advantage of the proposed scheme is that it can be used for a large variety of pdf that may be defined either with an analytical or a numerical description. It works also for various time semantics. Diagnosis in terms of probability for faulty patterns and temporal constraints is established as a consequence.
- **Event-Based Tracking Control of Mobile Robot With Denial-of-Service Attacks**
  Authors: Yang Tang ; Dandan Zhang ; Daniel W.C. Ho ; Wen Yang ; Bing Wang
  Abstract: In the presence of malicious denial-of-service (DoS) attacks, this paper investigates the tracking control of mobile robots. Some explicit characterizations are presented for frequency and duration properties of malicious DoS attacks. A hybrid model is established by considering malicious DoS attacks and event-triggering control. The significance of this paper is to develop a set of event-triggering conditions to ensure the tracking convergence. As well, these conditions can guarantee the existence of uniformly positively minimum interval between any two successive transmissions. Finally, a practical experiment is presented by considering the tracking control of an

Amigobot mobile robot over a wireless network with DoS attacks, which verifies the effectiveness of the derived results.

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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, 2020 (Postponed)
https://wodes2020.eventos.ufrj.br https://codit2020.com

2.2 **2020 IEEE International Conference on Control & Automation**
Sapporo, Hokkaido, Japan, July 6-9, 2020 (Postponed)
http://www.ieee-icca.org

2.3 **2020 IEEE Conference on Decision and Control**
Jeju Island, Republic of Korea, December 8-11, 2020 (Virtual)
https://cdc2020.ieeecss.org

2.4 **2021 Mediterranean Conference on Control and Automation**
Specchiolla (Carovigno), Brindisi, Italia, June 22-25, 2021.
http://med2021.poliba.it/

2.5 **2021 American Control Conference**
New Orleans, Louisiana, USA, May 26-28, 2021.
http://acc2021.a2c2.org/

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3 Books

3.1 **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

3.2 **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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4 Call for Papers

4.1 Security, Privacy and Safety of Cyber-Physical Systems

Nonlinear Analysis: Hybrid Systems

Guest Editors: Kai Cai ; Maria Prandini ; Xiang Yin ; Majid Zamani

Call for Papers: Cyber-physical systems are engineered systems that are built from and depend upon the synergy of computational and physical components. They are pervasive in today's technological society. Cyber-physical systems usually involve complex interactions of continuous dynamics with discrete logic, referred to as "hybrid" behavior. The development of controller design and verification algorithms for such complex systems are crucial and challenging tasks, due in particular to the theoretical difficulties of analyzing hybrid behavior and to the computational challenges associated with the synthesis of hybrid controllers.

Ever-increasing demands for safety, privacy, security and certification of cyber-physical systems put stringent constraints on their analysis and design, and necessitate the use of formal model-based approaches. In recent years, we have witnessed a substantial increase in the use of formal techniques for the verification and design of privacy-sensitive, safety-critical cyber-physical systems.

The main objective of this special issue to gather recently developed novel approaches devoted to analysis and enforcement of security, privacy and safety of cyber-physical systems using formal techniques. We seek submissions including but not limited to the following topics:

- Security and privacy analysis of cyber-physical systems, including opacity, differential privacy, non-interference and other related notions
- Fault diagnosis, intrusion detection, and attack mitigation of cyber-physical systems
- Supervisory control for safety of discrete-event systems
- Formal methods and reactive synthesis for safety of cyber-physical systems
- Data-driven verification and synthesis of cyber-physical systems
- Distributed approaches for large scale cyber-physical systems and hybrid systems
- Algorithms and tools for verification and synthesis of safety-critical systems
- Applications in security and/or safety of manufacturing systems, transportation systems, energy systems, robotic networks, telecommunications, and computer networks.

Important Submission Dates:

- Open: early October, 2020
- Due: January 31, 2021

Manuscript should be submitted to https://ees.elsevier.com/nahs

4.2 Modeling, Analysis and Control for Cybersecurity of Discrete Event Systems

Discrete Event Dynamic Systems: Theory and Applications

Guest Editors: Rong Su ; Joao Carlos Basilio

Call for Papers: The recent advancement of information and communication technologies and Internet-of-Things infrastructure make a fully connected society a reality, leading to much improved living quality and production efficiency. However, the price paid for such unprecedented connectivity is an increase in cybercrime and violations, making cybersecurity a key research focus in many different research communities. Generally speaking, cybersecurity is the protection of computer systems and networks from the theft of or damage to their hardware, software, or electronic data, as well as from the disruption or misdirection of the services they provide. Discrete event systems (DES) are particularly vulnerable to cyber intrusions, because their enumerative and typically qualitative formal models lack of necessary details and effective representations of (temporal) correlation among data, and they heavily depend on the accuracy of data to ensure absolutely correct interpretation of actions in the system to achieve correct tracking, analysis and control, making it difficult for them to handle data corruptions. An intruder to a DES may intercept sensor and/or command signals and interrupt the execution order of events (or functions). This special topical collection focuses on two key cybersecurity concerns, i.e., cyber attacks and privacy/confidentiality breaching (including but not limited to opacity violations), and aims to report the latest DES research and application results pertinent to cybersecurity.

This special topical collection solicits papers, addressing relevant theoretical issues and important application issues related to cybersecurity, with an evident DES model and relevant technical treatments, possibly complemented with other frameworks to deal with interdisciplinary issues. A non-exhaustive list of some potential topics is provided below:

- New modeling frameworks for cyber attacks
- Analysis of impacts of attacks on closed-loop system behaviors
- Formal synthesis of attack models
- New concepts and models of resilience of supervisors
- Formal synthesis of supervisors resilient to specific attacks
- Game theoretical frameworks for analysis and resilient control
- Fault diagnosis in the presence of cyber attacks
- New modeling frameworks for privacy and confidentiality (e.g., opacity)
- New analysis methods to determine system ability of preserving privacy and confidentiality (e.g., new opacity analysis methods)
- Formal synthesis of supervisors for privacy/confidentiality preservation
- Applications of cybersecurity methods in real discrete event systems

Important Submission Dates:

- Open: July 15, 2020
- Due: December 15, 2020

Manuscript should be submitted to `http://DISC.edmgr.com` Back to the contents

5 Software Tool

5.1 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.

5.2 Supremica 2.6, New Version

The development team has just released a new version of Supremica, Waters/Supremica IDE 2.6.

Supremica is a DES and SCT drawing and calculation tool, that includes a multitude of efficient algorithms for modeling, verification, and synthesis of maximally permissive supervisors. In addition there are general algorithms for standard operations like synchronization, minimization, determinization, etc. Supremica also handles finite automata extended with bounded discrete variables. A feature-full simulation tool is also included.

New in this version:

- Scaling of the GUI
- Revamped configuration dialog
- New analyzer user interface
- Logging can now be done directly to file, in addition to the log output pane
- Automaton variables have been introduced, so that guards and actions can refer to the state of an automaton
- The normalizing compiler is now the default
- Plenty of bug fixes, including more graceful termination when out of memory

Supremica is free to use for education and research; for commercial use, please contact fabian@chalmers.se. Download from www.supremica.org.

5.3 UltraDES 2.2 Release

UltraDES is an open-source library to the modeling, analysis and control of DES, written using C# in .NET Standard 2.0, which allows its use in multiple platforms, such as Windows, Linux, Mac, IOS, Android, so on. The library is under development at LACSED (Laboratory of Analysis and Control of Discrete Event Systems, at the Universidade Federal de Minas Gerais, Brazil) and has basic operations with automata as long as the monolithic, modular and local modular supervisory control (Alves et. al., 2017).

The main improvements of the UltraDES 2.2 version are:

- Supervisor Reduction Algorithm (Su and Wonham, 2004)
- Supervisor Localization (Cai and Wonham, 2010)
- Basic Petri Nets Functions (incidence matrix, coverability/reachability graph, Petri Net marking simulation, etc.)

Knowing that many researchers/students are not familiar with the C# language, we created an experimental python wrapper, that is less object oriented and easier to use.

Another initiative to improve the usability of UltraDES was the creation of a Web Application, developed using Blazor/WebAssembly, that allows the use of UltraDES online. This version is more limited in processing power and memory but it is useful for small examples and teaching.

We invite the community to download and contribute. Algorithms implemented may be integrated to the main distribution. Just let us know. Contact Lucas Alves lucasvra@ufmg.br or Patricia Pena ppena@ufmg.br for more information. Bugs should be informed using the UltraDES GitHub page.
Link: https://github.com/lacsed/UltraDES.

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