IEEE Control Systems Society
Technical Committee on Discrete Event Systems

Newsletter **March 2022**

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Welcome to the 2022 March issue of the newsletter, also available online at
http://ieeecss.org/tc/discrete-event-systems/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: 67, Issue: 3, March 2022

- **Supervisory Control of Petri Nets in the Presence of Replacement Attacks**
  Authors: Dan You ; ShouGuang Wang ; MengChu Zhou ; Carla Seatzu
  Abstract: This article addresses the robust control problem of discrete event systems assuming that replacement attacks may occur, thus making it appear that an event that has occurred looks like another event. In particular, we assume that this is done by tampering with the sensor-readings in the sensor communication channel. Specifically, we use Petri nets as the reference formalism to model the plant and assume a control specification in terms of a generalized mutual exclusion constraint. We propose three different methods to derive a control policy that is robust to the possible replacement attacks. The first two methods lead to an optimal (i.e., maximally permissive) policy but are computationally inefficient when applied to large-size systems. On the contrary, the third method computes a policy more efficiently and reveals more easily implementable in practice. However, this is done at the expense of optimality.
- **Observer Construction for Polynomially Ambiguous Max-Plus Automata**
  Authors: Aiwen Lai ; Sébastien Lahaye ; Jan Komenda
  Abstract: In this article, we deal with state estimation of timed discrete event systems that are modeled by max-plus automata (MPAs), where only some events are observable. For a given MPA, a formal procedure is first proposed for constructing its observer by extending our previous concept of observer for unambiguous MPAs to polynomially ambiguous MPAs. As an application, we present a necessary and sufficient condition based on the constructed observer to check the critical observability of MPAs. The state set of an MPA is divided into two disjoint subsets, i.e., the set of critical states and the set of noncritical states. A system is critically observable if the set of all states that are consistent with any observation is either a subset of the critical states set or a subset of the noncritical states set.
- **A Unified Approach to Dynamic Decision Problems With Asymmetric Information: Nonstrategic Agents**
  Authors: Hamidreza Tavafoghi ; Yi Ouyang ; Demosthenis Teneketzis
  Abstract: We study a general class of dynamic multi- agent decision problems with asymmetric information and nonstrategic agents, which include dynamic teams as a special case. When agents are nonstrategic, an agent's strategy is known to the other agents. Nevertheless, the agents' strategy choices and beliefs are interdependent over times, a phenomenon known as signaling . We introduce the notion of sufficient information that effectively compresses the agents' information in a mutually consistent manner. Based on the notion of sufficient information, we propose an information state for each agent that is sufficient for decision-making purposes. We present instances of dynamic multiagent decision problems where we can determine an information state with a time-invariant domain for each agent. Furthermore, we present a generalization of the policy-independence property of belief in partially observed Markov decision processes (POMDP) to dynamic multiagent decision problems. Within the context of dynamic teams with asymmetric information, the proposed set of information states leads to a sequential decomposition that decouples the interdependence between the agents' strategies and beliefs over time and enables us to formulate a dynamic program to determine a globally optimal policy via backward induction.

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1.2. Automatica

Volume: 137, March 2022

- **Time based deadlock prevention for Petri nets**
  Authors: Hanifa Boucheneb ; Kamel Barkaoui ; Qian Xing ; KuangZe Wang ; GaiYun Liu ; ZhiWu Li

Abstract: This paper investigates the deadlock prevention problem for Petri nets (PN), in which the control is performed by appropriately setting time constraints on transitions, in terms of firing intervals. We show that this time based deadlock prevention (TBDP) problem is decidable for bounded PN and can be formalised as a parametric model checking problem. However, in this context, the parametric model checking faces a severe state explosion problem. To deal with this limitation, we propose a symbolic approach that abstracts firing order constraints and bypasses the use of parameter domains with their associated very costly operations. Both approaches can handle, as an input model, a (time) PN with controllable/uncontrollable transitions. In such a case, they expose whether or not the firing intervals of the controllable transitions of the input model can be restricted so as to force the deadlock freeness (i.e., there is no marking with no enabled transitions).

- **Necessary and sufficient vertex partition conditions for input–output decoupling of Boolean control networks**
  Authors: Yifeng Li ; Jiandong Zhu
  Abstract: There are two different definitions of input–output decoupling of Boolean control networks (BCNs), one of which depends on system decomposition and the other does not. In this paper, input–output decoupling of BCNs is investigated under the algebraic representation frame of BCNs. Necessary and sufficient vertex partition conditions for both the definitions of input–output decoupling of BCNs are proposed. Based on the vertex partition conditions, the essential difference between the two concepts of input–output decoupling is revealed for the first time. Finally, three illustrative examples are provided to validate the obtained theoretical results.
- **Learning hidden Markov models from aggregate observations**
  Authors: Rahul Singh ; Qinsheng Zhang ; Yongxin Chen
  Abstract: In this paper, we propose an algorithm for estimating the parameters of a time-homogeneous hidden Markov model (HMM) from aggregate observations. This problem arises when only the population level counts of the number of individuals at each time step are available, and one seeks to learn the individual HMM from these observations. Our algorithm is built upon the classical expectation–maximization algorithm and the recently proposed aggregate inference algorithm (Sinkhorn belief propagation). We present the parameter learning algorithm for two different settings of HMMs: one with discrete observations and one with continuous observations, and the algorithm exhibits convergence guarantees in both cases. Moreover, our learning framework naturally reduces to the standard Baum–Welch learning algorithm for HMMs when the population size is 1. The efficacy of our algorithm is demonstrated through several numerical experiments.

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1.3. IEEE Control Systems Letter

Volume: 6, Issue: 2, Febrary 2021

- **Maximally Permissive Modular Similarity Control of Composite Nondeterministic Discrete Event Systems**
  Authors: Jinglun Li ; Shigemasa Takai
  Abstract: We solve a maximally permissive modular similarity control problem in this letter. The composite system under consideration consists of multiple local subsystems, each of which is assigned a nondeterministic subspecification. For each subsystem, we synthesize a local supervisor using an existing method, so that the entire specification is modularly achieved in the sense that the supervised system is simulated by the specification. We provide a condition under which the same permissiveness as a maximally permissive monolithic supervisor can be achieved by these local supervisors.

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

Volume: 52, Issue: 3, March 2022

- **Extended Place-Invariant Control in Automated Manufacturing Systems Using Petri**

Nets

Authors: Chen Chen ; Hesuan Hu

Abstract: In supervisory control of Petri nets (PNs), the place-invariant (P-invariant) control principle is the most typical and principal method to deal with the siphon control problem. Although it has a relatively narrow application, this principle is widely acknowledged due to its simplicity and efficiency. In this article, we first propose the extended P-invariant control principle in order to extend the application of P-invariants and provide a general methodology for the control of siphons. Second, three types of P-invariants, from the special to the general, are developed to implicitly or explicitly invariant control the siphons. In the most general case, the virtual P-invariants are constructed in the PNs. Third, the extended principle is further applied to the supervisor simplification. In the paradigm of the extended principle, it presents the redundancy from a structural perspective in contrast to several typical methods, and shows the significant importance of structural analysis in PNs, especially the important role of P-invariants. As a consequence, the extended P-invariant control principle can be considered as the fundamental principle of siphon control as well as its supervisor simplification.

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2 Conferences

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

2.1 **2022 ACM International Conference on Hybrid Systems: Computation and Control (HSCC)**
Milan, Italy, May 4-6, 2022
https://hscc.acm.org/2022/

2.2 **2022 IEEE Conference on Robotics and Automation (ICRA)**
Philadelphia, USA, May 23-27, 2022
https://www.icra2022.org/

2.3 **2022 American Control Conference (ACC)**
Atlanta, Georgia, USA, June 8-10, 2022
https://acc2022.a2c2.org/

2.4 **2022 IEEE Conference on Control Technology and Applications (CCTA)**
Stazione Marittima, Trieste, Italy, August 23-25, 2022
https://acc2022.a2c2.org/

2.5 **2022 IEEE International Conference on Automation Science and Engineering (CASE)**
Mexico City, Mexico, August 20-24, 2022
http://www.case2022.org/

2.6 **2022 International Workshop on Discrete Event Systems (WODES)**
Prague, Czechia, September 7-9, 2022
https://wodes2022.math.cas.cz

2.7 **2022 IEEE International Conference on Systems, Man, and Cybernetics (SMC)**
Prague, Czech Republic, October 9-12, 2022
https://ieeesmc2022.org/

2.8 **2022 IEEE Conference on Decision and Control (CDC)**
Cancun, Mexico, December 6-9, 2022
https://cdc2022.ieeecss.org/

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3 Books

3.1 Analysis and Control for Resilience of Discrete Event Systems

Authors: Joao Carlos Basilio, Christoforos N. Hadjicostis and Rong Su

Description: System resilience captures the ability of the system to withstand a major disruption within acceptable performance degradation and to recover within an acceptable time frame. In this monograph we consider two possible sources of major disruptions, i.e., component faults and cyber intrusions. A component fault is an indigenous activity that renders unavailability or inaccessibility of certain functions within a component, either permanently or temporarily. It typically generates safety and performance concerns. Cyber intrusion on the other hand is an exogenous activity that tampers privacy, confidentiality, availability, or integrity of the system. These two sources are not always independent from each other. For example, a cyber intrusion may trigger a component fault, whereas a component fault may open a door for cyber intrusion, e.g., by keeping it undetected. For cyber intrusion, we will focus on opacity, which describes the system's ability to hide certain secrets from an external observer (or eavesdropper), and sensor and actuator attacks that exploit the system's existing controller to generate undesirable behaviours.

In this monograph, we provide a detailed account of most recent research outcomes on fault diagnosis, opacity analysis and enhancement, and cyber security analysis and enforcement, within suitable discrete event system modelling frameworks. In each case, we describe basic problem statements and key concepts, and then point out the key challenges in each research area. After that, we present a thorough review of state-of-the-art techniques, and discuss their advantages and disadvantages. Finally, we highlight key research directions for further exploration.

ISBN: 978-1-68083-856-5
https://www.nowpublishers.com/article/Details/SYS-024

3.2 Introduction to Discrete Event Systems

Authors: Christos Cassandras and Stéphane Lafortune

Description: Christos Cassandras and Stéphane Lafortune are happy to announce the publication of the third edition of their textbook, Introduction to Discrete Event Systems, by Springer in November 2021. The first two editions of this popular textbook were published in 1999 (Kluwer Academic Publishers) and 2008 (Springer), respectively. This unique textbook comprehensively introduces the field of discrete event systems, offering a breadth of coverage that makes the material accessible to readers of varied backgrounds. The book emphasizes a unified modeling framework that transcends specific application areas, linking the following topics in a coherent manner: language and automata theory, supervisory control, Petri net theory, Markov chains and queueing theory, discrete-event simulation, and perturbation analysis and concurrent estimation techniques. The third edition is a "superset" of the second one, with new material added based on our teaching of discrete event systems courses at Boston University and at the University of Michigan, and they reflect active research trends in discrete event systems since the publication of the second edition.

Topics and features:
- detailed treatment of automata and language theory in the context of discrete event systems, including application to state estimation and diagnosis
- comprehensive coverage of centralized and decentralized supervisory control
- timed models, including timed automata and hybrid automata - stochastic models for discrete event systems and controlled Markov chains
- discrete event simulation - an introduction to stochastic hybrid systems
- sensitivity analysis and optimization of discrete event and hybrid systems
- new in the third edition: opacity properties, enhanced coverage of event diagnosis and of supervisory control under partial observation, overview of latest software tools, updated treatment of Infinitesimal Perturbation Analysis and of concurrent estimation

This proven textbook is essential to students and researchers in a variety of disciplines where the study of discrete event systems is relevant: control, communications, computer engineering, computer science, manufacturing engineering, transportation networks, operations research, and industrial engineering. This book is available through SpringerLink as an e-book (PDF and EPUB formats) or as a print-on-demand hard cover at https://link.springer.com/book/10.1007/978-3-030-72274-6 The e-book is available for free download at Springer subscribing institutions.

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https://doi.org/10.1007/978-3-030-72274-6

3.3 Hybrid Dynamical Systems – Fundamentals and Methods

Authors: Hai Lin and Panos Antsaklis

Description: This book is based on courses on hybrid systems, cyber-physical systems, and formal methods taught by the authors in the past years. It is a graduate level textbook and provides an accessible and comprehensive introduction to the theory of hybrid systems with a balanced treatment on fundamentals and methods from both control theory and computer science. It also serves as a reference book for researchers in the fields of hybrid dynamical systems, cyber-physical systems, formal methods and robotics.

More information may be found at the book's Springer webpage:

https://link.springer.com/book/10.1007/978-3-030-78731-8

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4 Call for Papers

4.1 Advanced Robotics: Special Issue on Control Technology for Networked and Distributed Robotics

Guest Editors:

- Prof. Masaaki Nagahara (The University of Kitakyushu, Japan)
- Prof. Kai Cai (Osaka City University, Japan)
- Prof. Takeshi Hatanaka (Tokyo Institute of Technology, Japan)
- Prof. Yutaka Hori (Keio University, Japan)
- Prof. Hideaki Ishii (Tokyo Institute of Technology, Japan)

Lead Guest Editor

- Prof. Debasish Chatterjee (Indian Institute of Technology Bombay, India)
- Prof. Nikhil Chopra (The University of Maryland, USA)
- Prof. Daniel E. Quevedo (Queensland University of Technology, Australia)
- Prof. Michel Reniers (Eindhoven University of Technology, Netherlands)

Publication in Vol. 37, Issue 1 (January 2023)

Submission deadline (extended): 31 March 2022 (no further extension)

Control technology is one of the fundamental disciplines of robotics. The technology has been developed for more than 100 years and expanded in many research areas. In particular, control technology for networked and distributed robotics has been recently emerging thanks to the development of embedded systems and wireless communications. An example of networked and distributed robotics is a drone light show, which was presented in the opening ceremony of Tokyo Olympic Games 2020, where multiple drones are operated from the main computer located on the ground that controls multiple drones through wireless networks. The purpose of this special issue is to present recent theory and practice of control technology that can be effectively applied to networked and distributed robotics. It aims at collecting a representative body of innovative theoretical contributions that have potential applications to networked and distributed robotics as well as applicative robotics researches that show successful implementation of recent theory of networked and distributed control. Prospective contributed papers are invited to cover, but are not limited to, theoretical and applicative researches on the following topics

- control of multi-agent systems (e.g. consensus control, coverage control, formation)
- networked control systems
- discrete-event systems and hybrid systems
- resource-aware control (e.g. event-triggered control, sparse control)
- secure, resilient, and safe control
- machine learning and data driven methods for networked robotics
- human-in-the-loop and human-machine interaction

The full-length manuscript (either PDF or Microsoft Word file) should be sent to the office of Advanced Robotics, Robotics Society of Japan, through its homepage at: https://www.rsj.or.jp/pub/ar/submission.html. Templates for the manuscript as well as instructions for the Authors are available at the homepage.

Further information will be provided via the following website: https://ct4ndr.wordpress.com/

4 Software Tools

4.1 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.

4.2 Supremica 2.7, New Version

The development team has just released a new version of Supremica, Waters/Supremica IDE 2.7.

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:

- Conditional blocks or IF statements can now be created in the components list or on label blocks to allow conditional compilation of automata or events. They can also be used as an alternative to guard/action blocks.
- Update to Log4j 2.17.1 to avoid the Log4shell vulnerability.

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

4.3 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.

4.4 DESpot 1.10.0 Released

DESpot is a discrete-event system (DES) software, research tool. It supports both flat projects (collection of plant and supervisor DES), and Hierarchical Interface-Based Supervisory Control (HISC) projects.

DESpot 1.10.0 supports a number of new Features:

- DESpot now targets version 4.8.7 of the Qt libraries, RedHat Enterprise Linux 7.x, and MS Windows 10 with MS Visual Studios 2019.
- Support for defining template DES, and then instantiating multiple copies for flat or HISC projects.
- Now includes curved transition arrows for DES diagrams, and the ability to export DES diagrams to EPS.
- Support for verification of timed controllability, including BDD-based algorithms.
- Support for Fault-Tolerant (FT) Supervisory Control, including both timed and untimed controllability and nonblocking BDD-based algorithms, for several fault scenarios.
- Support for specifying decentralized supervisory control structure for a project, and verifying co-observability.

To find out more information and to download a copy, see: http://www.cas.mcmaster.ca/~leduc/DESpot.html

DESpot is open source software, released under the GNU General Public license (GPL), version 2.

DESpot is written in C++ and uses the QT GUI libraries. At the moment, DESpot is available as source code and as a Windows' installer. It runs under Linux, and Windows.

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