IEEE Control Systems Society
Technical Committee on Discrete Event Systems

Newsletter **May 2021**

Editor: Kai Cai
Chair, IEEE CSS Technical Committee on DES
Professor
Department of Electrical and Information Engineering, Osaka City University
3-3-138 Sugimoto, Sumiyoshi-ku, Osaka 558-8585, Japan

Phone: (+81) 6-6605-2703
Email: kai.cai@eng.osaka-cu.ac.jp
Website: https://www.control.eng.osaka-cu.ac.jp

Welcome to the 2021 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.

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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: 66, Issue: 5, May 2021

- **Supervisory Control of Networked Discrete Event Systems With Timing Structure**
  Authors: Marcos V. S. Alves ; Lilian K. Carvalho ; João Carlos Basilio
  Abstract: In this article, we study the supervisory control problem of networked discrete event systems with timing structure assuming bounded communication delays and intermittent loss of observations. The communication between the plant and the supervisor is through a network that can have several channels, and so communication delays may change the order of event observations by the supervisor. We assume a priori knowledge of the minimal activation time of the plant transitions and the maximum communication delays, and propose an equivalent untimed model that takes into account all possible observation delays and also loss of observations. Based on this model, we formulate a networked supervisory control problem and show that it can be converted into an equivalent range control problem. We also address implementation, and, to this end, we present a representation for networked supervisors that is able to deal with possible loss of synchronization between event occurrence and its observation.

- **Lossless Event Compression of Discrete Event Systems**
  Authors: Lin Cao ; Shaolong Shu ; Feng Lin ; Lei Zhou
  Abstract: This article investigates the lossless event compression problem of discrete event systems which is, given a discrete event system and a source string generated by it, to find a minimal recoverable compressed string by removing as many events as possible. In order for the problem to be well post, two compression protocols are introduced. One requires that the last event is always kept. The other requires that, for any loop substring, at least one event is kept. We say a compressed string is recoverable if we can uniquely determine the source string based on the knowledge of the given discrete event system. We first construct an automaton to present all the possible source strings for a given compressed string. Based on the automaton, an algorithm is proposed to check whether the given compressed string is recoverable or not. We then propose an algorithm to calculate a minimal recoverable compressed string for a source string. The compressed string satisfies monotonicity which can significantly reduce the computational complexity of the algorithm. Finally, we use a practical example to illustrate these results.

- **Learning-Based Probabilistic LTL Motion Planning With Environment and Motion Uncertainties**
  Authors: Mingyu Cai ; Hao Peng ; Zhijun Li ; Zhen Kan
  Abstract: This article considers control synthesis of an autonomous agent with linear temporal logic (LTL) specifications subject to environment and motion uncertainties. Specifically, the probabilistic motion of the agent is modeled by a Markov decision process (MDP) with unknown transition probabilities. The operating environment is assumed to be partially known, where the desired LTL specifications might be partially infeasible. A relaxed product MDP is constructed that allows the agent to revise its motion plan without strictly following the desired LTL constraints. A utility function composed of violation cost and state rewards is developed. Rigorous analysis shows that, if there almost surely (i.e., with probability 1) exists a policy that satisfies the relaxed product MDP, any algorithm that optimizes the expected utility is guaranteed to find such a policy. A reinforcement learning-based approach is then developed to generate policies that fulfill the desired LTL specifications as much as possible by optimizing the expected discount utility of the relaxed product MDP.

- **An Efficient Fault Diagnosis Approach Based on Integer Linear Programming for Labeled Petri Nets**
  Authors: Guanghui Zhu ; Lei Feng ; Zhiwu Li ; Naiqi Wu
  Abstract: In this article, we present a fault diagnosis approach for discrete event systems using labeled Petri nets. In contrast to the existing works, a new fault class containing all the fault

transitions is additionally introduced in the diagnosis function, leading to a more informative and precise diagnosis result. An integer linear programming (ILP) problem is built according to an observed word. By specifying different objective functions to the ILP problem, the diagnosis result is obtained without enumerating all observable transition sequences consistent with the observed word, which is more efficient in comparison with the existing ILP-based approaches.

1.2. Automatica

Volume: 127, May 2021

- **Initial-state detectability and initial-state opacity of unambiguous weighted automata**
  Authors: Aiwen Lai ; Sébastien Lahaye ; Zhiwu Li
  Abstract: In this paper, we investigate the verification problem of initial-state detectability (I-detectability) and initial-state opacity (I-opacity) in discrete event systems modeled by unambiguous weighted automata. An I-observer is constructed so as to derive necessary and sufficient conditions for checking strong I-detectability, weak I-detectability, and I-opacity, with exponential complexity. In addition, an approach based on diagnosability analysis is proposed for verifying strong I-detectability. Compared with an I-observer-based approach, the diagnosability-based approach has a lower complexity, and in the case where all the unobservable events in an unambiguous weighted automaton are represented by a unique symbol, the diagnosability-based approach has polynomial complexity.
- **Event-driven receding horizon control for distributed persistent monitoring in network systems**
  Authors: Shirantha Welikala ; Christos G. Cassandras
  Abstract: We address the multi-agent persistent monitoring problem defined on a set of nodes (targets) interconnected over a network topology. A measure of mean overall node state uncertainty evaluated over a finite period is to be minimized by controlling the motion of a cooperating team of agents. To address this problem, we propose an event-driven receding horizon control approach that is computationally efficient, distributed and on-line. The proposed controller differs from the existing on-line gradient-based parametric controllers and off-line greedy cycle search methods that often lead to either low-performing local optima or computationally intensive centralized solutions. A critical novel element in this controller is that it automatically optimizes its planning horizon length, thus making it parameter-free. We show that explicit globally optimal solutions can be obtained for every distributed optimization problem encountered at each event where the receding horizon controller is invoked. Numerical results are provided showing improvements compared to state of the art distributed on-line parametric control solutions.
- **Multi-hop sensor network scheduling for optimal remote estimation**
  Authors: Takuya Iwaki ; Junfeng Wu ; Yuchi Wu ; Henrik Sandberg ; Karl Henrik Johansson
  Abstract: This paper studies a design problem of how a group of wireless sensors are selected and scheduled to transmit data efficiently over a multi-hop network subject to energy considerations, when the sensors are observing multiple independent discrete-time linear systems. Each time instant, a subset of sensors is selected to transmit their measurements to a remote estimator. We formulate an optimization problem, in which a network schedule is searched to minimize a linear combination of the averaged estimation error and the averaged transmission energy consumption. It is shown that the optimal network schedule forms a tree with root at the gateway node. From this observation, we manage to separate the optimization problem into two subproblems: tree planning and sensor selection. We solve the sensor selection subproblem by a Markov decision process, showing that the optimal solution admits a periodic structure when the transmission cost is sufficiently low. Efficient algorithms are proposed and they are shown to reduce the computational complexity of the original optimization problem. Numerical studies illustrate the effectiveness of the proposed algorithms, and show that they are scalable to large networks.

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1.3. IEEE/CAA Journal of Automatica Sinica

Volume: 8, Issue: 5, May 2021

- **Control of Non-Deterministic Systems With μ-Calculus Specifications Using Quotienting**
  Authors: Samik Basu ; Ratnesh Kumar
  Abstract: The supervisory control problem for discrete event system (DES) under control involves identifying the supervisor, if one exists, which, when synchronously composed with the DES, results in a system that conforms to the control specification. In this context, we consider a nondeterministic DES under complete observation and control specification expressed in action-based propositional μ-calculus. The key to our solution is the process of quotienting the control specification against the plan resulting in a new μ-calculus formula such that a model for the formula is the supervisor. Thus the task of control synthesis is reduced a problem of μ-calculus satisfiability. In contrast to the existing μ-calculus quotienting-based techniques that are developed in deterministic setting, our quotienting rules can handle nondeterminism in the plant models. Another distinguishing feature of our technique is that while existing techniques use a separate μ-calculus formula to describe the controllability constraint (that uncontrollable events of plants are never disabled by a supervisor), we absorb this constraint as part of quotienting which allows us to directly capture more general state-dependent controllability constraints. Finally, we develop a tableau-based technique for verifying satisfiability of quotiented formula and model generation. The runtime for the technique is exponential in terms of the size of the plan and the control specification. A better complexity result that is polynomial to plant size and exponential to specification size is obtained when the controllability property is state-independent. A prototype implementation in a tabled logic programming language as well as some experimental results are presented.

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2 Conferences

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

2.1 **2021 ACM International Conference on Hybrid Systems: Computation and Control**
Nashville, USA, May 19-21, 2021. (Virtual)
https://hscc.acm.org/2021/

2.2 **2021 American Control Conference**
New Orleans, Louisiana, USA, May 26-28, 2021. (Virtual)
http://acc2021.a2c2.org/

2.3 **2021 Learning for Dynamics and Control**
ETH Zurich, Switzerland, June 7-8, 2021. (Virtual)
https://l4dc.ethz.ch/

2.4 **2021 Mediterranean Conference on Control and Automation**
Bari, Italy, June 22-25, 2021. (Virtual)
http://med2021.poliba.it/

2.5 **2021 Chinese Control Conference**
Shanghai, China, July 26-28, 2021
https://conf2021.shu.edu.cn/index.htm

2.6 **2021 IEEE Conference on Control Technology and Applications**
San Diego, August 8-11, 2021
https://ccta2021.ieeecss.org/

2.7 **2021 IEEE International Conference on Automation Science and Engineering**
Lyon Centre de Congres, Lyon, France, August 23-27, 2021
https://www.ieee-ras.org/component/rseventspro/event/1935-case-2021

2.8 **2021 IEEE International Conference on Systems, Man, and Cybernetics**
South Wharf, Victoria, Australia, October 17-20, 2021
http://ieeesmc2021.org/

2.9 **2021 IEEE Conference on Decision and Control**
Austin, Texas, USA. December 13-15, 2021
https://cdc2021.ieeecss.org

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3 Books

3.1 **Foundations of Average-Cost Nonhomogeneous Controlled Markov Chains**
Authors: Xi-Ren Cao
Description: This Springer brief addresses the challenges encountered in the study of the optimization of time-nonhomogeneous Markov chains. It develops new insights and new methodologies for systems in which concepts such as stationarity, ergodicity, periodicity and connectivity do not apply.

This brief introduces the novel concept of confluencity and applies a relative optimization approach. It develops a comprehensive theory for optimization of the long-run average of time-nonhomogeneous Markov chains. The book shows that confluencity is the most fundamental concept in optimization, and that relative optimization is more suitable for treating the systems under consideration than standard ideas of dynamic programming. Using confluencity and relative optimization, the author classifies states as confluent or branching and shows how the under-selectivity issue of the long-run average can be easily addressed, multi-class optimization implemented, and Nth biases and Blackwell optimality conditions derived. These results are presented in a book for the first time and so may enhance the understanding of optimization and motivate new research ideas in the area.

ISBN: 978-3-030-56678-4
https://www.springer.com/gp/book/9783030566777

3.2 **Discrete-Time and Discrete-Space Dynamical Systems**
Authors: Kuize Zhang, Lijun Zhang, Lihua Xie
ISBN: 978-3-030-25971-6, Springer
https://link.springer.com/book/10.1007/978-3-030-25972-3

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4 Positions

4.1 PhD Position at the University of Salerno

The Department of Information and Electric Engineering and Applied Mathematics at the University of Salerno has openings for fully-funded PhD researchers. The Automatic Control Group at the University of Salerno is looking for outstanding candidates in the area

"Resilient control against cyber-attack"

We are looking for a talented, outstanding PhD researcher with a Master degree (or close to completion) in Systems and Control, or Computer Science, Complex Systems, or related field, with interests in distributed control of cyber-physical systems (CPSs).

General project description: the candidate will conduct theoretical and algorithmic research on enforcing safety specifications on spatially distributed control systems. Specifically, there is a great potential in this area for developing novel approaches using methodologies that pertain to discrete event systems (DESs). Indeed, cyber-attacks act essentially at the higher levels of the control architecture, where the discrete event view of the system is the most effective description of the system dynamics. The project aims not only at extending the current state of the art from a systems theory point of view with novel contributions, but also to apply and validate the proposed methodologies in the context of CPSs using case studies that emphasize the social and economic impact.

Additional information: while knowledge of the Italian language is not mandatory (all doctorate courses are in English), to facilitate international students in settling down, an introductory Italian language course will be offered. Moreover, based on the outcome of the interviews students might be offered a free accommodation at the University of Salerno Campus and a free meal per day at University canteen. Other benefits include:

- funding for 3.000,00 euros to support his/her research needs;
- financial support to spend research periods at other international institutions.

The main referent for each project is Prof. Francesco Basile (see https://docenti.unisa.it/005630/en/home).

To apply, please email to fbasile@unisa.it with subject line "PHD positions" and attach:

- curriculum vitae;
- statement of motivation and research interests (1-page max);
- transcripts of all exams taken and obtained degrees (in English);
- names and contact information of up to two references.

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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.

5.4 **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 coobservability.

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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