IEEE Control Systems Society
Technical Committee on Discrete Event Systems

Newsletter **August 2023**

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Welcome to the 2023 August issue of the newsletter, also available online at
https://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.

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1 Selections of Journal Publications

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

1.1. IEEE Transactions on Automatic Control

Volume: 68, Issue: 8, August 2023

- **Secure Your Intention: On Notions of Pre-Opacity in Discrete-Event Systems**
  Authors: Shuo Yang ; Xiang Yin
  Abstract: This article investigates an important inform- ation-flow security property called opacity in partially-observed discrete-event systems. We consider the presence of a passive intruder (eavesdropper) that knows the dynamic model of the system and can use the generated information flow to infer some secret of the system. A system is said to be opaque if it always holds the plausible deniability for its secret. Existing notions of opacity only consider secret either as currently visiting some secret states or as having visited some secret states in the past. In this article, we investigate information-flow security from a new angle by considering the secret of the system as the intention to execute some particular behavior of importance in the future. To this end, we propose a new class of opacity called pre-opacity that characterizes whether or not the intruder can predict the visit of secret states a certain number of steps ahead before the system actually does so. Depending the prediction task of the intruder, we propose two specific kinds of pre-opacity called K-step instant pre-opacity and K-step trajectory pre-opacity to specify this concept. For each notion of pre-opacity, we provide a necessary and sufficient condition as well as an effective verification algorithm. The complexity for the verification of pre-opacity is exponential in the size of the system as we show that pre-opacity is inherently PSPACE-hard. Finally, we generalize our setting to the case where the secret intention of the system is modeled as executing a particular sequence of events rather than visiting a secret state.
- **Efficient Strategy Synthesis for MDPs With Resource Constraints**
  Authors: Frantiek Blahoudek ; Petr Novotný ; Melkior Ornik ; Pranay Thangeda ; Ufuk Topcu
  Abstract: We consider qualitative strategy synthesis for the formalism called consumption Markov decision processes. This formalism can model the dynamics of an agent that operates under resource constraints in a stochastic environment. The presented algorithms work in time polynomial with respect to the representation of the model and they synthesize strategies ensuring that a given set of goal states will be reached (once or infinitely many times) with probability 1 without resource exhaustion. In particular, when the amount of resource becomes too low to safely continue in the mission, the strategy changes course of the agent toward one of a designated set of reload states where the agent replenishes the resource to full capacity; with a sufficient amount of resource, the agent attempts to fulfill the mission again. We also present two heuristics that attempt to reduce the expected time that the agent needs to fulfill the given mission, a parameter important in practical planning. The presented algorithms were implemented, and the numerical examples demonstrate the effectiveness (in terms of computation time) of the planning approach based on consumption Markov decision processes and the positive impact of the two heuristics on planning in a realistic example.
- **Structural Estimation of Partially Observable Markov Decision Processes**
  Authors: Yanling Chang ; Alfredo Garcia ; Zhide Wang ; Lu Sun
  Abstract: Partially observable Markov decision processes (POMDPs) is a well-developed framework for sequential decision-making under uncertainty and partial information. This article considers the (inverse) structural estimation of the primitives of a POMDP based upon data in the form of sequences of observables and implemented actions. We analyze the structural properties of an entropy regularized POMDP and specify conditions under which the model is identifiable without knowledge of the state dynamics. We consider a soft policy gradient algorithm to compute a maximum likelihood estimator, and illustrate the approach with an equipment replacement problem.
- **Abstraction of Continuous-Time Systems Based on Feedback Controllers and Mixed Monotonicity**

Authors: Vladimir Sinyakov ; Antoine Girard
Abstract: In this article, we consider the problem of the computation of efficient symbolic abstractions for continuous-time control systems. The new abstraction algorithm builds symbolic models with the same number of states but fewer transitions in comparison to the one produced by the standard algorithm. At the same time, the new abstract system is at least as controllable as the standard one. The proposed algorithm is based on the solution of a region-to-region control synthesis problem. This solution is formally obtained using the theory of viscosity solutions of the dynamic programming equation and the theory of differential equations with discontinuous righthand side. In the new abstraction algorithm, the symbolic controls are essentially the feedback controllers that solve this control synthesis problem. The improvement in the number of transitions is achieved by reducing the number of successors for each symbolic control. For a certain class of control systems, with a suitable set of discretization parameters, the new algorithm may even produce deterministic abstract systems or systems with a singleton input alphabet. The approach is illustrated by examples that compare the two abstraction algorithms.

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1.2. Automatica

Volume: 154, August 2023

- **On decidability of existence of nonblocking supervisors resilient to smart sensor attacks**
  Authors: Rong Su
  Abstract: Cybersecurity of discrete event systems (DES) has been gaining more and more attention recently, due to its high relevance to the so-called 4th industrial revolution that heavily relies on data communication among networked systems. One key challenge is how to ensure system resilience to sensor and/or actuator attacks, which may tamper data integrity and service availability. In this paper we focus on some key decidability issues related to smart sensor attacks. We first present a sufficient and necessary condition that ensures the existence of a smart sensor attack, which reveals a novel demandsupply relationship between an attacker and a controlled plant, represented as a set of risky pairs. Each risky pair consists of a damage string desired by the attacker and an observable sequence feasible in the supervisor such that the latter induces a sequence of control patterns, which allows the damage string to happen. It turns out that each risky pair can induce a smart weak sensor attack. Next, we show that, when the plant, supervisor and damage language are regular, it is possible to remove all such risky pairs from the plant behaviour, via a genuine encoding scheme, upon which we are able to establish our key result that the existence of a nonblocking supervisor resilient to smart sensor attacks is decidable. To the best of our knowledge, this is the first result of its kind in the DES literature on cyber attacks. The proposed decision process renders a specific synthesis procedure that guarantees to compute a resilient supervisor whenever it exists, which so far has not been achieved in the literature.
- **A language-based diagnosis framework for permanent and intermittent faults**
  Authors: Rong Su
  Abstract: In this paper we present a language-based fault diagnosis framework for both permanent and intermittent faults, where each fault is associated with two events, describing respectively the activation and deactivation of the fault. We first introduce the concept of F-diagnosability, which requires a fault to be identifiable before it may disappear owing to recovery. Then we present a language-based sufficient and necessary condition to ensure F-diagnosability. Considering the PSPACE-hard nature of verifying F-diagnosability, our key contribution is to present a verifiable condition called F-consistency and a polynomial-time verification algorithm, relying on a novel state-weight updating strategy. If the plant is not F-diagnosable for a specific fault, then the algorithm will output false, which means the algorithm ensures no missing alarms, in the sense of misclassifying a non- -diagnosable plant as an F-diagnosable one. But if the plant is F-diagnosable, then the algorithm will guarantee to output true, if the plant is F-consistent for the fault . In other words, the proposed verification algorithm attains a tradeoff between computational complexity and quality of verification by reducing the original PSPACE-complete complexity to a polynomial-time complexity, and at the same time allowing possible false alarms, i.e., misclassifying an F-diagnosable plant as a non- -diagnosable one, unless the proposed F-consistency property for the fault holds in

the plant. Theoretically speaking, our work identifies a subclass of plants that are F-consistent for a fault , upon which the problem of verifying F-diagnosability becomes polynomial-time solvable instead of being PSPACE-complete.

- **Reactive synthesis for relay-explorer consensus with intermittent communication**
  Authors: Runhan Sun ; Suda Bharadwaj ; Zhe Xu ; Ufuk Topcu ; Warren E. Dixon
  Abstract: A distributed multi-agent system architecture is explored to reach approximate consensus with intermittent communication. The multi-agent system is cast as a relay-explorer problem, where a relay agent intermittently provides navigational feedback to multiple explorer agents that do not have on-board absolute navigational sensors in a pre-defined sub-region. Within each sub-region, there is one relay agent responsible for servicing the corresponding explorer agents, and the estimated trajectory of an explorer agent can cross the boundary and enter another sub-region. We develop a reactive synthesis approach to formulate the mission specifications, while the statespace system dynamics provide real-time information for state corrections. Specifically, we pre-synthesize a set of planning strategies corresponding to candidate instantiations (i.e., pre-specified representative information scenarios) to dynamically switch among the explorers, and the planning strategies enable transfer of the servicing responsibility between relay agents. To guarantee stability of the switching strategies and the approximate consensus of the explorer agents, we develop maximum dwell-time conditions using a Lyapunov-based analysis to allow the explorer agents to drift for a pre-defined period without requiring servicing from the relay agents. Finally, we include a simulation study to demonstrate the performance of the developed method.

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1.3. Annual Reviews in Control

Volume: 56, August 2023

- **A unified concurrent-composition method to state/event inference and concealment in labeled finite-state automata as discrete-event systems**
  Authors: Kuize Zhang
  Abstract: Discrete-event systems (DESs) usually consist of discrete states and transitions between them caused by spontaneous occurrences of labeled events. In this review article, we study DESs modeled by labeled (nondeterministic) finite-state automata (LFSAs). Due to the partially-observed feature of DESs, fundamental properties therein can be classified into two categories: state/event-inference-based properties (e.g., strong detectability, diagnosability, and predictability) and state-concealment-based properties (e.g., opacity). Intuitively, the former category describe whether one can use observed output sequences to infer the current and subsequent states, past occurrences of faulty events, or future certain occurrences of faulty events; while the latter describe whether one cannot use observed output sequences to infer whether secret states have been visited (that is, whether the DES can conceal the status that its secret states have been visited). Over the past two decades these properties were studied separately using different methods, and particularly, in most works inference-based properties were verified based on two fundamental assumptions of deadlock-freeness and divergence-freeness, where the former implies that an automaton will always run, the latter implies that an automaton has no reachable unobservable cycle, hence the running of such an automaton will always be eventually observed. In this article, for LFSAs, a unified concurrent-composition method is shown to verify all above inference-based and concealment-based properties, resulting in a unified mathematical framework for the two categories of properties. In addition, compared with the previous methods in the literature, the concurrent-composition method does not depend on assumptions and is currently the most efficient. Finally, based on concurrent composition, we represent the negations of the above inference-based properties as linear temporal logic (LTL) formulae; by combining the concurrent composition and an additional tool called observer (i.e., the classical powerset construction for LFSAs), we also represent the above concealment-based properties as LTL formulae. Although LTL formulae model checking algorithms do not provide more efficient verification for these inference-based and concealment-based properties, the obtained LTL formulae show common similarities among these properties.

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

Volume: 53, Issue: 8, August 2023

- **A State-Equation-Based Backward Approach to a Legal Firing Sequence Existence Problem in Petri Nets**
  Authors: Liang Qi ; Yue Su ; MengChu Zhou ; Abdullah Abusorrah
  Abstract: Reachability is the basis for studying other dynamic properties of Petri nets (PNs). When a state equation is used to determine the reachability of a marking, we need to judge whether there is a corresponding legal firing sequence (LFS) for a non-negative integer solution (NIS), i.e., a firing count vector, of the state equation. The search for an LFS is an NP-hard problem, and previous work cannot always find an LFS for any NISs. This article proposes that transition-dependent circuits or firing-dependent circuits are the root cause that a state equation has an NIS but the marking is nonreachable, i.e., there is no LFS corresponding to an NIS in PNs. Based on this, we propose a state-equation-based backward algorithm (SBA) to determine whether there is an LFS corresponding to an NIS of the state equation in a PN. The correctness and effectiveness of SBA are verified by a case study on a PN-based flexible manufacturing system and through simulation on an S^4PR net. The experimental results show that the time required for SBA to determine the existence of an LFS increases linearly with the transition firing count in NISs. When the number of NISs of a state equation is finite, we can efficiently determine the reachability of a marking. This represents an important result in theory and applications of PNs.

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1.5. IEEE/CAA Journal of Automatica Sinica

Volume: 10, Issue: 8, August 2021

- **Scheduling Dual-Arm Multi-Cluster Tools With Regulation of Post-Processing Time**
  Authors: Qinghua Zhu ; Bin Li ; Yan Hou ; Hongpeng Li ; Naiqi Wu
  Abstract: As wafer circuit width shrinks down to less than ten nanometers in recent years, stringent quality control in the wafer manufacturing process is increasingly important. Thanks to the coupling of neighboring cluster tools and coordination of multiple robots in a multi-cluster tool, wafer production scheduling becomes rather complicated. After a wafer is processed, due to high-temperature chemical reactions in a chamber, the robot should be controlled to take it out of the processing chamber at the right time. In order to ensure the uniformity of integrated circuits on wafers, it is highly desirable to make the differences in wafer post-processing time among the individual tools in a multi-cluster tool as small as possible. To achieve this goal, for the first time, this work aims to find an optimal schedule for a dual-arm multi-cluster tool to regulate the wafer post-processing time. To do so, we propose polynomial-time algorithms to find an optimal schedule, which can achieve the highest throughput, and minimize the total post-processing time of the processing steps. We propose a linear program model and another algorithm to balance the differences in the post-processing time between any pair of adjacent cluster tools. Two industrial examples are given to illustrate the application and effectiveness of the proposed method.

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2 Call for Participants

2.1 Workshop at CDC'23 Singapore: Formal Methods in System Resilience: From Analysis to Control

Dear colleagues,

We would like to bring your attention to the workshop on the topic of **"Formal Methods in System Resilience: From Analysis to Control" at IEEE CDC 2023, to take place in Singapore, December 12, 2013**, organized by Rong Su (Nanyang Technological University), and Xiang Yin (Shanghai Jiao Tong University).

The workshop will feature invited talks from Alessandro Abate (University of Oxford), Alessandro Giua (University of Cagliari), Christoforos Hadjicostis (University of Cyprus), Zhiwu Li (Macau University of Science and Technology), Rong Su (Nanyang Technological University), Xiang Yin (Shanghai Jiao Tong University), and Majid Zamani (University of Colorado, Boulder); as well as a panel discussion.

For more details on the talks will be updated at https://sites.google.com/view/cdc23workshop.

Registration information of the workshop can be found at https://cdc2023.ieeecss.org/registration.

3 Conferences

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

3.1 **2023 IEEE Conference on Control Technology and Applications (CCTA)**
Bridgetown, Barbados, August 16-18, 2023.
https://ieeeccta.org/

3.2 **2023 IEEE International Conference on Automation Science and Engineering (CASE)**
Auckland, New Zealand, August 26-29, 2023.
https://case2023.org/

3.3 **2023 IEEE International Conference on Systems, Man, and Cybernetics (SMC)**
Maui, Hawaii, October 14, 2023.
https://ieeesmc2023.org/

3.4 **2023 IEEE Conference on Decision and Control (CDC)**
Singapore, December 13-15, 2023.
https://cdc2023.ieeecss.org/

3.5 **2024 IFAC Workshop on Discrete Event Systems (WODES)**
Rio de Janeiro, Brazil, April 29-May 1, 2024.
https://wodes2024.eventos.ufrj.br

3.6 **2024 IFAC Conference on Analysis and Design of Hybrid Systems (ADHS)**
Boulder, Colorado, July 1-3, 2024.
https://www.colorado.edu/conference/adhs2024/

3.7 **2024 American Control Conference (ACC)**
Toronto, Canada, July 8-12, 2024.
https://acc2024.a2c2.org/

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4 Books

4.1 Safe Autonomy with Control Barrier Functions: Theory and Applications

Authors: Wei Xiao, Christos G. Cassandras, and Calin Belta

Description: The book presents the concept of Control Barrier Function (CBF), which captures the evolution of safety requirements during the execution of a system and can be used to enforce safety. Safety is central to autonomous systems since they are intended to operate with minimal or no human supervision. The book includes both theoretical and application perspectives on how safety can be guaranteed. It explains how the CBF approach is computationally efficient and can easily deal with nonlinear models and complex constraints used in a wide spectrum of applications, including autonomous driving, robotics, and traffic control. Safety guarantees can be integrated into the operation of such autonomous systems, including typical safety requirements that involve collision avoidance, technological system limitations, and bounds on real-time executions. Adaptive and event-driven approaches for safety are also discussed for time-varying execution bounds and noisy dynamics, as well as for systems with unknown dynamics.

Additional information on the book can be found at
https://link.springer.com/book/10.1007/978-3-031-27576-0
where an eBook version can also be downloaded (free for some educational institutions).

4.2 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 systems ability to hide certain secrets from an external observer (or eavesdropper), and sensor and actuator attacks that exploit the systems 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

4.3 Introduction to Discrete Event Systems (Third Edition)

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

4.4 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 books Springer webpage:

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

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5 Software Tools

5.1 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.

5.2 Eclipse ESCET™ version 0.10 release

The Eclipse Supervisory Control Engineering Toolkit (Eclipse ESCET) project provides a model-based approach and toolkit for the development of supervisory controllers. It includes the languages CIF, Chi and ToolDef. ESCET, initially developed by Eindhoven University of Technology, is since January 2020 an Eclipse Foundation open-source project. More information can be found on the toolkits website at https://www.eclipse.org/escet/.

In June 2023, ESCET version 0.10 has been released and can be downloaded from https://www.eclipse.org/escet/download.html. The main changes in this version are

- Switch expressions with only a single case or else are now deprecated. Furthermore, several previously deprecated features are now removed from the CIF language. See full release notes for these cases and supported alternatives.
- The CIF data-based synthesis tool has a new Edge granularity option to configure the granularity of edges to use during synthesis. The new edge granularity has been shown to reduce both the memory usage and time required to perform synthesis, but this may depend on the model being synthesized.
- The CIF data-based synthesis tool has a new Fixed-point computations order option to configure the order in which the fixed-point computations are to be performed during synthesis. This may significantly improve synthesis performance, but the effect greatly depends on the model being synthesized.
- Several CIF command line script fixes preventing crashes.
- The CIF data-based synthesis tool no longer prints the number of states in the controlled system as part of its debug output. Instead, this information is now one of the statistics of the Statistics options.

The full ESCET release notes, including links to the language specific release notes and release notes from previous versions, are available from https://www.eclipse.org/escet/release-notes.html.

5.3 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.

5.4 MDESops

MDESops is an open-source tool written in Python for analysis and control of discrete event systems modeled as finite-state automata. It includes a growing set of operations on automata, including: (i) manipulation of models (e.g., parallel composition, observer); (ii) diagnosis and opacity verification; (iii) common supervisory control functions (e.g., computation of supremal controllable and normal sublanguages); and (iv) more advanced functions on synthesis of attackers and of resilient supervisors in the presence of sensor deception attacks. The repository is a Git server maintained by the EECS Department at the University of Michigan, USA. Download from https://gitlab.eecs.umich.edu/M-DES-tools/desops.

5.5 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.

5.6 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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6 Open Positions

6.1 Open PhD position in Centre Automatique et Systemes (MINES Paris, France) and IFPEN (Lyon, France)

PhD Title: Control strategies for a wind farm based on a simplified dynamical wake modeling for optimal management of energy management and fatigue mitigation

Department: Digital Science and Technology Division, in Solaize (Lyon, France)

FPEN advisors:

- Main advisor: COLLET David (david.collet@ifpen.fr), control, signal, and systems department
- Co-advisors:
  Olivier Lepreux, PhD, solid mechanics department
  Frédéric Blondel, PhD, fluid mechanics department

Academic advisors:

- Florent Di Meglio, HDR, Head of Centre Automatique et Systèmes, MINES Paris PSL (florent.di_meglio@minesparis.psl.eu)
- Delphine Bresch-Pietri, Professor at Centre Automatique et Systèmes, MINES Paris PSL (delphine.bresch-pietri@minesparis.psl.eu)

IFP Energies nouvelles (IFPEN) is a major research and training player in the fields of energy, transport and the environment. From research to industry, technological innovation is central to all its activities, structured around three strategic priorities: sustainable mobility, new energies and responsible oil and gas.

In the field of wind energy, operators are now focusing on using wind turbines located in wind farms in the best possible way, to either produce the maximum energy possible, or produce the right amount of energy at the right time, to meet power grid requirements while limiting the wind turbine mechanical stress, in order to eventually minimize the cost of energy. It is possible to limit the interactions between a turbine wake and the downwind turbines by controlling its yaw angle and power produced, and thus alleviating the production losses and mechanical fatigue. In this context, our central question will be How to robustly minimize a wind farm cost of energy via a control algorithm using a dynamic wind farm flow model, and how to implement it in real world?. Indeed, the implementation in real world, dynamic wind farm flow model and cost of energy minimization aspect of things are very important.

On one hand, most of current works focus on cases where the farm is operated in normal conditions, whereas it is of primal importance to detect and manage cases where the farm is in abnormal operating conditions, for a robust real-world implementation.

On the other hand, most of the works are using steady state models for wind farm control. Therefore, the capacity to derive an optimal control problem, relying on innovative dynamic wind farm flow models, constitutes an important contribution of the thesis.

Eventually, some recent works had as an objective to either maximize energy production, either regulate power production with wind turbines load alleviation as secondary objective. However, very few contributions focused on the explicit minimization of energy cost, which is one of the main drivers for operators.

The PhD results will contribute to three majors advances:

1. Develop wind farm control strategies based on a time-varying wake modeling and evaluate their added value;
2. Define a cost criterion allowing to efficiently minimize the cost of energy over long time horizons.
3. Contribute to the implementation and deployment of the developed control algorithms and prove and illustrate their robustness and efficiency.

The candidate must be graduated of a master's degree in mathematics or mechanical engineering with a preferred specialization in automatic, optimization or signal processing.

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