IEEE Control Systems Society
Technical Committee on Discrete Event Systems

Newsletter **October 2023**

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Welcome to the 2023 October issue of the newsletter, also available online at
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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. Discrete Event Dynamic Systems Theory and Applications

Volume: 33, Issue: 3, October 2023

- **Extending the network calculus algorithmic toolbox for ultimately pseudo-periodic functions: pseudo-inverse and composition**
  Authors: Raffaele Zippo ; Paul Nikolaus ; Giovanni Stea
  Abstract: Network Calculus (NC) is an algebraic theory that represents traffic and service guarantees as curves in a Cartesian plane, in order to compute performance guarantees for flows traversing a network. NC uses transformation operations, e.g., min-plus convolution of two curves, to model how the traffic profile changes with the traversal of network nodes. Such operations, while mathematically well-defined, can quickly become unmanageable to compute using simple pen and paper for any non-trivial case, hence the need for algorithmic descriptions. Previous work identified the class of piecewise affine functions which are ultimately pseudo-periodic (UPP) as being closed under the main NC operations and able to be described finitely. Algorithms that embody NC operations taking as operands UPP curves have been defined and proved correct, thus enabling software implementations of these operations. However, recent advancements in NC make use of operations, namely the lower pseudo-inverse, upper pseudo-inverse, and composition, that are well-defined from an algebraic standpoint, but whose algorithmic aspects have not been addressed yet. In this paper, we introduce algorithms for the above operations when operands are UPP curves, thus extending the available algorithmic toolbox for NC. We discuss the algorithmic properties of these operations, providing formal proofs of correctness.
- **Average criteria in denumerable semi-Markov decision chains under risk-aversion**
  Authors: Rolando Cavazos-Cadena ; Hugo Cruz-Suárez ; Raúl Montes-De-Oca
  Abstract: This note concerns with semi-Markov decision chains evolving on a denumerable state space. The system is directed by a risk-averse controller with constant risk-sensitivity, and the performance of a decision policy is measured by a long-run average criterion associated with bounded holding cost rates and one-step cost function. Under mild conditions on the sojourn times and the transition law, restrictions on the cost structure are given to ensure that the optimal average cost can be characterized via a bounded solution of the optimality equation. Such a result is used to establish a general characterization of the optimal average cost in terms of an optimality inequality from which an optimal stationary policy can be derived.
- **Do what you know: coupling knowledge with action in discrete-event systems**
  Authors: K. Ritsuka ; K. Rudie
  Abstract: An epistemic model for decentralized discrete-event systems with non-binary control is presented. This framework combines existing work on inference-based control decisions with existing work on formal reasoning about knowledge in discrete-event systems. The novelty in the epistemic formalism is in providing an approach to derive problem solvability conditions and problem solutions. The derived expressions directly encapsulate the actions that supervisors must take.
- **A survey on compositional algorithms for verification and synthesis in supervisory control**
  Authors: Robi Malik ; Sahar Mohajerani ; Martin Fabian
  Abstract: This survey gives an overview of the current research on compositional algorithms for verification and synthesis of modular systems modelled as interacting finite-state machines. Compositional algorithms operate by repeatedly simplifying individual components of a large system, replacing them by smaller so-called abstractions, while preserving critical properties. In this way, the exponential growth of the state space can be limited, making it possible to analyse much bigger state spaces than possible by standard state space exploration. This paper gives an introduction to the principles underlying compositional methods, followed by a survey of algorithmic solutions from the recent literature that use compositional methods to analyse systems automatically. The

focus is on applications in supervisory control of discrete event systems, particularly on methods that verify critical properties or synthesise controllable and nonblocking supervisors.

- **Modeling and analysis of switching max-plus linear systems with discrete-event feedback**
  Authors: Alireza Mohamadkhani ; Marc Geilen ; Jeroen Voeten ; Twan Basten
  Abstract: Switching max-plus linear system (SMPLS) models are an apt formalism for performance analysis of discrete-event systems. SMPLS analysis is more scalable than analysis through other formalisms such as timed automata, because SMPLS abstract pieces of determinate concurrent system behavior into atomic modes with fixed timing. We consider discrete-event systems that are decomposed into a plant and a Supervisory Controller (SC) that controls the plant. The SC needs to react to events, concerning e.g. the successful completion or failure of an action, to determine the future behavior of the system, for example, to initiate a retrial of the action. To specify and analyze such system behavior and the impact of feedback on timing properties, we introduce an extension to SMPLS with discrete-event feedback. In this extension, we model the plant behavior with system modes and capture the timing of discrete-event feedback emission from plant to SC in the mode matrices. Furthermore, we use I/O automata to capture how the SC responds to discrete-event feedback with corresponding mode sequences of the SMPLS. We define the semantics of SMPLS with events using new state-space equations that are akin to classical SMPLS with dynamic state-vector sizes. To analyze the extended models, we formulate a transformation from SMPLS with events to classical SMPLS with equivalent semantics and properties such that performance properties can be analyzed using existing techniques. Our approach enables the specification of discrete-event feedback from the plant to the SC and its performance analysis. We demonstrate our approach by specifying and analyzing the makespan of a flexible manufacturing system.

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1.2. IEEE Transactions on Automatic Control

Volume: 68, Issue: 10, October 2023

- **Composition of Behavioural Assume-Guarantee Contracts**
  Authors: Brayan M. Shali ; Arjan van der Schaft ; Bart Besselink
  Abstract: The growing complexity of modern engineering systems necessitates a method for design and analysis that is inherently modular. Methods based on using contracts for system design have successfully tackled this issue for a variety of system classes, but mostly in the context of discrete software systems. Motivated by this, we present assume-guarantee contracts for continuous linear dynamical systems with inputs and outputs. Such contracts serve as system specifications through two aspects. The assumptions specify the dynamic behavior of the environment of the system, which provides inputs for it, whereas, the guarantees specify the desired dynamic behavior of the output of the system when interconnected with a relevant environment. This is formalized by utilizing the behavioral approach to system theory. We define and characterize notions of contract implementation and contract refinement, where the latter is used to compare contracts. We also define and characterize two notions of contract composition that allow one to reason about two types of system interconnections: series and feedback. The properties of refinement and composition allow contracts to be used for modular design and analysis.
- **A Framework for Output-Feedback Symbolic Control**
  Authors: Mahmoud Khaled ; Kuize Zhang ; Majid Zamani
  Abstract: Symbolic control is an abstraction-based controller synthesis approach that provides, algorithmically, certifiable-by-construction controllers for cyber-physical systems. Symbolic control approaches usually assume that full-state information is available, which is not suitable for many real-world applications with partially observable states or output information. This article introduces a framework for output-feedback symbolic control. We propose relations between original systems and their symbolic models based on outputs. They enable designing symbolic controllers and refining them to enforce complex requirements on original systems. We provide an example methodology to synthesize and refine output-feedback symbolic controllers.

- **Joint Estimation of Continuous and Discrete States in Randomly Switched Linear Systems With Unobservable Subsystems**
  Authors: Le Yi Wang ; George Yin ; Feng Lin ; Michael P. Polis ; Wen Chen
  Abstract: This article investigates the problem of joint continuous and discrete state estimation of randomly switched linear systems in which subsystems may not be observable. Estimation of both continuous state and discrete sequence simultaneously based on the same output observations is a challenging task that is inherently nonlinear and often infinite dimensional. This article presents necessary and sufficient conditions when joint estimation is possible without using a probing input. When such conditions are not satisfied, a suitably designed input must be used to achieve the goal of jointly detecting the subsystem and estimating the internal state. This article employs certain structures of randomly switched linear systems to develop algorithms that use finite-dimensional estimators for continuous states and sampled data for detecting the discrete states. The convergence analysis shows that this framework can achieve convergence. Examples and simulation case studies are presented to illustrate the main results of this article. The findings of this article can be used to form a supporting foundation for robust control.

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1.3. Automatica

Volume: 156, October 2023

- **Online prognosis of stochastic discrete event systems with guaranteed performance bound**
  Authors: Yu Liu ; Shaolong Shu ; Feng Lin ; Qijun Chen ; Chengju Liu ; Fengjiao Lian
  Abstract: In this paper, we consider the online prognosis of stochastic discrete event systems. Even though it is easy to predict the occurrence of faults in advance accurately for a prognosable discrete event system, it is much more difficult to do so for systems that are not prognosable. In this paper, we solve the online prognosis problem in a stochastic discrete event system framework. Our idea is to calculate the probability of the occurrence of faults in the future when a no-fault observable string is observed. We say an observable string is no-fault if no faults have occurred when it is observed. We then compare the probability with a pre-set threshold to decide whether to issue an alert or not. We develop a method to calculate the lower bound for possible thresholds, which has the fewest false alerts and no missed alerts of faults. For a given threshold, we use the rate of missed fault alerts and the rate of false fault alerts to evaluate the performance of fault prognosis. We formally define these two rates and develop algorithms to calculate them. These results can guide us in choosing a proper threshold to achieve the best trade-off between false fault alerts and missed alerts of faults.

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1.4. IEEE Transactions on Automation Science and Engineering

Volume: 20, Issue: 4, October 2023

- **Modeling and Analysis of Three Properties of Mobile Interactive Systems Based on Variable Petri Nets**
  Authors: Ru Yang ; Zhijun Ding ; Changjun Jiang ; MengChu Zhou
  Abstract: In mobile interactive systems, there exist several components that can move and interact with each other. The current methods fail to give a comprehensive description of their properties and have inadequate modeling and analysis capacity for them. This paper concludes three system properties called system connectivity, interaction soundness and data validity, and focuses on their modeling and analysis based on Variable Petri Nets (VPNs), which have recently been proposed and are able to describe their dynamic interactions. A VPN- based model including component nets and interaction structure nets is constructed given a mobile interactive system. It depicts its structure and event-driven dynamics. Three properties and their related analysis methods of a VPN-based model are presented. An example is given to demonstrate the proposed concepts and methods.
  Note to Practitioners: Due to the mobility and frequent disconnections, the correctness of mobile interaction systems, such as mobile robot systems and mobile payment systems, are often difficult to analyze. This paper introduces three critical properties of systems, called system connectivity,

interaction soundness and data validity, and presents a related modeling and analysis method, based on a kind of Petri net called VPN. For a given system, a model including component nets and interaction structure nets is constructed by using VPNs. The component net describes the internal process of each component, while the interaction structure net reflects the dynamic interaction between components. Based on this model, three properties are defined and analyzed. The case study of a practical mobile payment system shows the effectiveness of the proposed method.

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1.5. IEEE Transactions on Cybernetics

Volume: 53, Issue: 10, October 2023

- **Empirical Policy Optimization for n-Player Markov Games**
  Authors: Yuanheng Zhu ; Weifan Li ; Mengchen Zhao ; Jianye Hao ; Dongbin Zhao
  Abstract: In single-agent Markov decision processes, an agent can optimize its policy based on the interaction with the environment. In multiplayer Markov games (MGs), however, the interaction is nonstationary due to the behaviors of other players, so the agent has no fixed optimization objective. The challenge becomes finding equilibrium policies for all players. In this research, we treat the evolution of player policies as a dynamical process and propose a novel learning scheme for Nash equilibrium. The core is to evolve ones policy according to not just its current in-game performance, but an aggregation of its performance over history. We show that for a variety of MGs, players in our learning scheme will provably converge to a point that is an approximation to Nash equilibrium. Combined with neural networks, we develop an empirical policy optimization algorithm, which is implemented in a reinforcement-learning framework and runs in a distributed way, with each player optimizing its policy based on own observations. We use two numerical examples to validate the convergence property on small-scale MGs, and a pong example to show the potential on large games.

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

Volume: 53, Issue: 10, October 2022

- **Optimal Strategy Model Checking in Possibilistic Decision Processes**
  Authors: Wuniu Liu ; Yongming Li
  Abstract: Probabilistic model checking has received increasing attention in formal verification. Meanwhile, in the fuzzy setting, the possibilistic model checking has been well studied by Li et al. in recent years. However, nondeterminism of choices was not considered in previous work. The nondeterminism is crucial for modeling open systems interacting with the environment. To fill the gap, we propose the possibilistic decision processes (PDPs) to model fuzzy systems with nondeterminism and introduce possibilistic strategy computation tree logic (PoSCTL) to specify properties with nondeterministic choices. More importantly, optimal strategy model checking over PDPs has been investigated, which is an important formal verification method for quantitatively checking the degree of satisfiability of properties in a model. We give mathematical methods to calculate the maximum and minimum possibilities for a system modeled by PDPs satisfies a property specified by PoSCTL when ranging over all strategies. We prove memoryless strategies are sufficient for PoSCTL model checking without the step-bounded until operator, and give the algorithms to output the corresponding optimal strategy. Finally, an illustrative example of robots moving is given to explain the methods presented in this article.

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

3.2 **2024 IFAC Workshop on Discrete Event Systems (WODES)**
Rio de Janeiro, Brazil, April 29-May 1, 2024.
https://wodes2024.eventos.ufrj.br

3.3 **2024 IFAC Conference on Analysis and Design of Hybrid Systems (ADHS)**
Boulder, Colorado, July 1-3, 2024.
https://www.colorado.edu/conference/adhs2024/

3.4 **2024 American Control Conference (ACC)**
Toronto, Canada, July 8-12, 2024.
https://acc2024.a2c2.org/

3.5 **2024 International Conference on Automation Science and Engineering (CASE)**
Bari, Italy, August 28-September 1, 2024.
https://2024.ieeecase.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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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 1.0 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 September 2023, ESCET version 1.0 has been released and can be downloaded from https://www.eclipse.org/escet/download.html. The main changes in this version are

- The Eclipse ESCET project has graduated. The project has left the 'incubation' phase, and has entered the 'mature' phase. In honor of this occasion, we leave the '0.x' version numbering behind. All indications of the incubation phase have been removed. This also leads to changes in download filenames.
- The CIF language now features annotations that can be used to annotate elements of the specification with extra information. The CIF toolset now comes bundled with the doc annotation. Annotations are currently an experimental work-in-progress language feature. Their design may change in a backward incompatible manner.
- The CIF controller checker had a performance regression since version 0.7 in case finite response is checked and confluence is not checked. This performance regression has been fixed.
- The CIF to Supremica transformation now correctly transforms multiple guards on an edge. Multiple guards are now combined into a single conjunction.
- The CIF data-based synthesis tools workset algorithm now has improved edge selection heuristics, improving the performance of the workset algorithm. Its documentation has been improved to better explain when to use and not to use the workset algorithm. Also, the workset algorithm is no longer considered experimental.

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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