IEEE Control Systems Society
Technical Committee on Discrete Event Systems

Newsletter **February 2021**

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Welcome to the 2021 February 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: 2, February 2021

- **Marking Estimation in Petri Nets Using Hierarchical Basis Reachability Graphs**
  Authors: Ziyue Ma ; Guanghui Zhu ; Zhiwu Li
  Abstract: In this article, we propose a two-layer-structure called hierarchical basis reachability graph that is useful for marking estimation in Petri nets that contain unobservable transitions. On the basis of a hierarchical partition of the set of observable transitions, a hierarchical basis reachability graph consists of a primary and a secondary structures. Simulation shows that the time-consumption to compute a hierarchical basis reachability graph is in general much less than that of computing the corresponding basis reachability graph. A marking estimation algorithm is proposed by the structural analysis of the corresponding hierarchical basis reachability graph.
- **Satisfaction of Linear Temporal Logic Specifications Through Recurrence Tools for Hybrid Systems**
  Authors: Andrea Bisoffi ; Dimos V. Dimarogonas
  Abstract: In this article, we formulate the problem of satisfying a linear temporal logic formula on a linear plant with output feedback, through a recent hybrid systems formalism. We relate this problem to the notion of recurrence introduced for the considered formalism, and we then extend Lyapunov-like conditions for recurrence of an open, unbounded set. One of the proposed relaxed conditions allows certifying recurrence of a suitable set, and this guarantees that the high-level evolution of the plant satisfies the formula, without relying on discretizations of the plant. Simulations illustrate the proposed approach.
- **Asymptotical Stability of Logic Dynamical Systems With Random Impulsive Disturbances**
  Authors: Yuqian Guo ; Yawen Shen ; Weihua Gui
  Abstract: This article presents an investigation of the asymptotical set stability (ASS) of logic dynamical systems (LDSs) with impulsive disturbances at random instants. Unlike ordinary probabilistic Boolean networks, such an impulsive LDS is not Markovian in general. In this article, an impulsive LDS is described by using a hybrid index model and the sequence of intervals between adjacent impulsive instants is assumed to be independent and identically distributed. Under this assumption, the subsequence of a solution obtained by sampling at impulsive instants is a Markov chain. The initial distribution, the transition probability matrix, and the reachable set of the Markovian subsequence are calculated. Calculations of different invariant subsets are discussed and a necessary and sufficient condition for the convergence of finite Markov chains to subsets is obtained. Based on these results, necessary conditions for the ASS of impulsive LDSs in the hybrid and time domains, respectively, are obtained. In addition, we prove that the necessary conditions become sufficient if the impulsive intervals and the initial impulsive instant are with bounded expectations and variances. An example is provided to show the application of the proposed results to node synchronization of logic dynamical networks.

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1.2. Automatica

Volume: 124, February 2021

- **An improved approach for verifying delayed detectability of discrete-event systems**
  Authors: Yang Liu ; Zhaocong Liu ; Xiang Yin ; Shaoyuan Li
  Abstract: In this paper, we investigate state estimation and detection problems with information delays in the context of partially-observed discrete-event systems. Specifically, we study the verification of an important detectability property called delayed detectability which is related to the state estimation problem with information delayed. Particularly, it requires that the state of the system after k1 observations can always be detected within another k2 observation delay; delayed

detectability is, therefore, referred to as (k1,k2)-detectability. In this paper, we provide a new verification algorithm for checking this property. The idea is to use the reversed dynamic of the system to efficiently estimate the delayed-state information. To this end, a new information structure called the two-way verifier is proposed. We show that our result improves the complexity of existing verification algorithms for the property. We also illustrate our result by simple examples.

- **Controllability and decentralized stabilization of the Kolmogorov forward equation for Markov chains**
  Authors: Karthik Elamvazhuthi ; Shiba Biswal ; Spring Berman
  Abstract: In this paper, we provide several results on controllability and stabilizability properties of the Kolmogorov forward equation of a continuous-time Markov chain (CTMC) evolving on a finite state space, with the transition rates defined as the control parameters. First, we show that any target probability distribution can be reached asymptotically using time-varying control parameters. Second, we characterize all stationary distributions that are stabilizable using time-independent control parameters. For bidirected graphs, we construct rational and polynomial density feedback laws that stabilize stationary distributions while satisfying the additional constraint that the feedback law takes zero value at equilibrium. This last result enables the construction of decentralized density feedback controllers, using tools from linear systems theory and sum-of-squares based polynomial optimization, that stabilize a swarm of robots modeled as a CTMC to a target state distribution with no state-switching at equilibrium. In addition to these results, we prove a sufficient condition under which the classical rank conditions for controllability can be generalized to forward equations with non-negativity constraints on the control inputs. We apply this result to prove local controllability of a forward equation in which only a small subset of the transition rates are the control inputs. Lastly, we extend our feedback stabilization results to stationary distributions that have a strongly connected support.

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1.3. IEEE Transactions on Automation Science and Engineering

Issue: 1, February 2021

- **Optimal Scheduling of Human-Robot Collaborative Assembly Operations With Time Petri Nets**
  Authors: Andrea Casalino ; Andrea Maria Zanchettin ; Luigi Piroddi ; Paolo Rocco
  Abstract: The novel paradigm of collaborative automation, with machines and industrial robots that synergically share the same workspace with human workers, requires to rethink how activities are prioritized in order to account for possible variabilities in their durations. This article proposes a scheduling method for collaborative assembly tasks that allows to optimally plan assembly activities based on the knowledge acquired during runtime and so adapts to variations along the life cycle of a manufacturing process. The scheduler is based on time Petri nets and the output plan is optimized by minimizing the idle time of each agent. The experimental validation carried out on a realistic industrial use-case consisting of a small assembly line with two robots and a human operator confirms the effectiveness of the approach.
  Note to Practitioners – The optimization of manufacturing execution is a long standing problem in production engineering. Modern engineering tools are available to monitor and help decision-makers to reduce waste and schedule resources to optimize the efficiency of a manufacturing process. This article proposes a scheduling algorithm that continuously collects data from the manufacturing process and iteratively plans an optimal resource allocation strategy, trying to reduce the idle time of each agent. The approach is demonstrated on a realistic case study, where two robots and a human worker cooperate to assemble a USB/microSD adapter.

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1.4. IEEE Transactions on Cybernetics

Volume: 51, Issue: 2, February 2021

- **Feedback Strategies for a Reach-Avoid Game With a Single Evader and Multiple Pursuers**

Authors: Jhanani Selvakumar ; Efstathios Bakolas
Abstract: We address a planar multiagent pursuit-evasion game with a terminal constraint (reach-avoid game). Specifically, we consider the problem of steering a single evader to a target location, while avoiding capture by multiple pursuers. We propose a feasible control strategy for the evader, against a group of pursuers that adopts a semi-cooperative strategy. First, we characterize a partition of the game's state-space, that allows us to determine the existence of a solution to the game based on the initial conditions of the players. Next, based on the time-derivative of an appropriately defined risk metric, we develop a nonlinear state feedback strategy for the evader which provides a feasible solution to the game. This control strategy involves switching between different control laws in different parts of the state-space. We demonstrate the efficacy of our proposed feedback control in terms of the evader's performance, through numerical simulations. We also show that for the special case of the reach-avoid game with only one pursuer, the proposed control law is successful in guiding the evader to the target location from almost all initial conditions, and ensures that the evader will remain uncaptured.

- **Bit-Rate Conditions for the Consensus of Quantized Multiagent Systems With Network-Induced Delays Based on Event Triggering**
Authors: Jiayu Chen ; Qiang Ling
Abstract: This paper is mainly concerned with bit-rate conditions to guarantee the consensus of unstable scalar multiagent systems by event-triggering strategies. In such systems, state information is quantized and transmitted among agents through digital communication networks which suffer from network-induced delays. In order to save communication resources, we implement a periodic event-triggering scheme, under which agents quantize and transmit their own states when a predefined event is triggered. By introducing a well-designed internal saturation function, the proposed strategy can place a priori bounds on the control inputs of agents and guarantee the asymptotic consensus of agents at a finite bit rate, even under network-induced delays. By extracting extra information from the receive time instants of data packets, our strategy can require less information carried by data packets and a lower bit rate to maintain the desired asymptotic consensus than some state-of-the-art time-triggered consensus strategies. Under our strategy, the obtained bit-rate conditions depend on the network-induced delays, the unstable eigenvalue of agent dynamics, and the network topology. The simulation results are provided to illustrate the effectiveness of these bit-rate conditions.

- **Optimal Transmit Power Allocation for an Energy-Harvesting Sensor in Wireless Cyber-Physical Systems**
Authors: Lianghong Peng ; Xianghui Cao ; Changyin Sun
Abstract: In this article, we investigate optimal transmission power allocation at a sensor equipped with the energy-harvesting technology for remote state estimation in wireless cyber-physical systems. The sensor has access to an energy harvester, which can collect energy from the external environment and is an everlasting but unreliable energy source compared with conventional batteries. For the wireless dropping communication channel, the packet dropout rates depend on both the signal-to-noise ratio and the transmission power used by the sensor. We formulate the problem of the optimal transmission power allocation to minimize the remote estimation error covariances as a Markov decision processes (MDPs) subject to energy constraint of the sensor. By analyzing the MDP algorithm, we show that an optimal deterministic and stationary transmission power policy exists. Moreover, we show that the optimal policy has a threshold-type structure. A numerical simulation is provided to illustrate the performance of the transmission power allocation algorithm.

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

Volume: 51, Issue: 2, February 2021

- **Fuzzy Encoded Markov Chains: Overview, Observer Theory, and Applications**
Authors: Nan Li ; Ilya Kolmanovsky ; Anouck Girard ; Dimitar Filev
Abstract: This article provides an overview of fuzzy encoded Markov chains (FEMCs), which are finite-state Markov chains applied to transitions between fuzzy sets that encode signal or variable values. FEMCs can be used for modeling of dynamic systems, predicting/forecasting future signal

values, for state estimation, and for the development of fuzzy rules for control. Under suitable assumptions, the state possibility distribution can be propagated using FEMC models in a similar manner as the state probability distribution using conventional Markov chain models. The article first discusses FEMC theory, procedures to identify FEMCs from data, and the use of FEMCs for forecasting and control. Then, we introduce, for the first time, observers for partially observable FEMCs. The observer theory is developed and computational approaches are presented. Finally, we briefly review some FEMC applications in the automotive domain.

- **The Graph Model for Conflict Resolution and Decision Support**
  Authors: Keith W. Hipel ; Liping Fang
  Abstract: A survey of the design, development and implementation of a flexible decision technology called the graph model for conflict resolution (GMCR) is discussed for systematically investigating real world conflicts within a system of systems engineering outlook. This encompassing GMCR methodology has been constructed during the past three decades by the authors, their colleagues and students from many countries for addressing a rich range of conflict situations. GMCR can be used for studying large and small conflicts and includes methods for preference elicitation, preference uncertainty (unknown, fuzzy, grey numbers and probabilistic). Many kinds of definitions exist for possible human behavior under pure competition which can be transformed for utilization in coalition analysis. GMCR can handle emotions, attitudes, and misperceptions. Within inverse GMCR, one can calculate the preferences needed by decision makers (DMs) to reach a desirable equilibrium. Under behavioral GMCR one can ascertain the strategic thinking of DMs when the input and output are known. Decision support systems can be built for implementing the array of GMCR advancements. Future expansions of GMCR can be guided by key characteristics of actual disputes. Artificial intelligence (AI) GMCR is a promising subfield of study within GMCR.

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1.6. IEEE/CAA Journal of Automatica Sinica

Volume: 8, Issue: 2, February 2021

- **Multiagent Reinforcement Learning: Rollout and Policy Iteration**
  Authors: Dimitri Bertsekas
  Abstract: We discuss the solution of complex multistage decision problems using methods that are based on the idea of policy iteration (PI), i.e., start from some base policy and generate an improved policy. Rollout is the simplest method of this type, where just one improved policy is generated. We can view PI as repeated application of rollout, where the rollout policy at each iteration serves as the base policy for the next iteration. In contrast with PI, rollout has a robustness property: it can be applied on-line and is suitable for on-line replanning. Moreover, rollout can use as base policy one of the policies produced by PI, thereby improving on that policy. This is the type of scheme underlying the prominently successful AlphaZero chess program. In this paper we focus on rollout and PI-like methods for problems where the control consists of multiple components each selected (conceptually) by a separate agent. This is the class of multiagent problems where the agents have a shared objective function, and a shared and perfect state information. Based on a problem reformulation that trades off control space complexity with state space complexity, we develop an approach, whereby at every stage, the agents sequentially (one-at-a-time) execute a local rollout algorithm that uses a base policy, together with some coordinating information from the other agents. The amount of total computation required at every stage grows linearly with the number of agents. By contrast, in the standard rollout algorithm, the amount of total computation grows exponentially with the number of agents. Despite the dramatic reduction in required computation, we show that our multiagent rollout algorithm has the fundamental cost improvement property of standard rollout: it guarantees an improved performance relative to the base policy. We also discuss autonomous multiagent rollout schemes that allow the agents to make decisions autonomously through the use of precomputed signaling information, which is sufficient to maintain the cost improvement property, without any on-line coordination of control selection between the agents. For discounted and other infinite horizon problems, we also consider exact and approximate PI algorithms involving a new type of one-agent-at-a-time policy improvement operation. For one of our PI algorithms, we prove convergence to an agent-by-agent optimal policy,

thus establishing a connection with the theory of teams. For another PI algorithm, which is executed over a more complex state space, we prove convergence to an optimal policy. Approximate forms of these algorithms are also given, based on the use of policy and value neural networks. These PI algorithms, in both their exact and their approximate form are strictly off-line methods, but they can be used to provide a base policy for use in an on-line multiagent rollout scheme.

- **Using Event-Based Method to Estimate Cybersecurity Equilibrium**
  Authors: Zhaofeng Liu ; Ren Zheng ; Wenlian Lu ; Shouhuai Xu
  Abstract: Estimating the global state of a networked system is an important problem in many application domains. The classical approach to tackling this problem is the periodic (observation) method, which is inefficient because it often observes states at a very high frequency. This inefficiency has motivated the idea of event-based method, which leverages the evolution dynamics in question and makes observations only when some rules are triggered (i.e., only when certain conditions hold). This paper initiates the investigation of using the event-based method to estimate the equilibrium in the new application domain of cybersecurity, where equilibrium is an important metric that has no closed-form solutions. More specifically, the paper presents an event-based method for estimating cybersecurity equilibrium in the preventive and reactive cyber defense dynamics, which has been proven globally convergent. The presented study proves that the estimated equilibrium from our trigger rule i) indeed converges to the equilibrium of the dynamics and ii) is Zeno-free, which assures the usefulness of the event-based method. Numerical examples show that the event-based method can reduce 98% of the observation cost incurred by the periodic method. In order to use the event-based method in practice, this paper investigates how to bridge the gap between i) the continuous state in the dynamics model, which is dubbed probability-state because it measures the probability that a node is in the secure or compromised state, and ii) the discrete state that is often encountered in practice, dubbed sample-state because it is sampled from some nodes. This bridge may be of independent value because probability-state models have been widely used to approximate exponentially-many discrete state systems.

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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.
https://hscc.acm.org/2021/

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

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

2.4 **2021 Mediterranean Conference on Control and Automation**
Bari, Italy, June 22-25, 2021 (Hybrid)
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 Call for Papers

4.1 CDC'21: Security, Safety and Resilience of Discrete Event Systems

The 60th IEEE conference on Decision and Control

Proposed by: Xiang Yin (Shanghai Jiao Tong University, China)

Call for Papers: The objective of this invited session is to present recently developed novel approaches devoted to the analysis and design of safety-critical networked control systems using DES models. The focus of this session is on the following topics:

- Modeling and analysis of cyber-security of discrete event system
- Supervisory control and fault-tolerant control of networked discrete event systems
- Opacity, diagnosability, observability analysis of discrete event systems
- Analysis and design of discrete-event system under cyber-attacks
- Performance analysis and enhancement techniques for discrete event systems

If you are considering to submit a paper, please contact Dr. Xiang Yin (yinxiang@sjtu.edu.cn) with the tentative title of the paper before February 28.

4.2 CDC'21: Reactive Synthesis for Control

The 60th IEEE conference on Decision and Control

Proposed by: A. Schmuck (MPI-SWS, Kaiserlautern, Germany)

Call for Papers: The aim of the proposed session is to collect contributions where formal synthesis methods (originating broadly from the field of reactive synthesis in computer science) are integrated into controller synthesis techniques for either continuous or discrete-event dynamical systems. Examples of possible topics include:

- Abstraction-Based Control Design for continuous systems with discrete specifications
- Supervisory Control of discrete-event systems with temporal specifications
- Coordination control for hierarchical or distributed system architectures
- Symbolic algorithms for discrete control design

To estimate the overall interest in contributing to this session, please contact Dr. A. Schmuck (akschmuck@mpi-sws.org) with the topic and/or title of this submission. In order to propose the above invited session, your final commitment is needed by March 2nd.

4.3 CASE'21: Applications of Discrete Event Systems

The 17th IEEE International Conference on Automation Science and Engineering

Proposed by: Michel Reniers (Eindhoven University of Technology)

Call for Papers: The objective of this special session is to present the state of the art DES control applications. Our aim is to show that DES analysis, verification, and control methods are effective in dealing with a range of practically important issues in real complex engineering systems; these include safety, efficiency, adaptivity, and flexibility.

If you are considering to submit a paper, please contact Dr. Michel Reniers (m.a.reniers@tue.nl) with the title of the paper before February 14.

4.4 Security, Privacy and Safety of Cyber-Physical Systems

Nonlinear Analysis: Hybrid Systems

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

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

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

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

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

Submission Information

- Extended deadline: February 14, 2021 (no further extension)
- Website: https://www.editorialmanager.com/NAHS/default.asp
- Article type (identifier of this special issue): VSI: Security

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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