IEEE Control Systems Society
Technical Committee on Discrete Event Systems

Newsletter **June 2021**

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Welcome to the 2021 June 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. Discrete Event Dynamic Systems Theory and Applications

Volume: 31, Issue: 2, June 2021

- **A pseudo-linear time algorithm for the optimal discrete speed minimizing energy consumption**
  Authors: Bruno Gaujal ; Alain Girault ; Stéphan Plassart
  Abstract: We consider the classical problem of minimizing off-line the total energy consumption required to execute a set of n real-time jobs on a single processor with a finite number of available speeds. Each real-time job is defined by its release time, size, and deadline (all bounded integers). The goal is to find a processor speed schedule, such that no job misses its deadline and the energy consumption is minimal. We propose a pseudo-linear time algorithm that checks the schedulability of the given set of n jobs and computes an optimal speed schedule. The time complexity of our algorithm is in $\mathcal{O}(n)$, to be compared with $\mathcal{O}(n \log(n))$for the best known solution. Besides the complexity gain, the main interest of our algorithm is that it is based on a completely different idea: instead of computing the critical intervals, it sweeps the set of jobs and uses a dynamic programming approach to compute an optimal speed schedule. Our linear time algorithm is still valid (with some changes) with arbitrary (non-convex) power functions and when switching costs are taken into account.
- **Logical time control of concurrent DES**
  Authors: Jean-Luc Béchennec ; Didier Lime ; Olivier H. Roux
  Abstract: The synthesis of controllers for reactive systems can be done by computing winning strategies in two-player games. Timed (game) Automata are an appropriate formalism to model real-time embedded systems but are not easy to use for controller synthesis for two reasons: i) timed models require the knowledge of the precise timings of the system; for example, if an action must occur in the future, the deadline of this occurrence must be known, ii) in practice, the dense state space makes the computation of the controller often impossible for complex systems. This paper introduces an extension of untimed game automata with logical time. The new semantics introduces two new types of uncontrollable actions: delayed actions which are possibly avoidable, and ineluctable actions which will eventually happen if nothing is done to abort it. The controller synthesis problem is adapted to this new semantics. This paper focuses specifically on the reachability and safety objectives and gives algorithms to generate a controller. The paper then extends these results to Game Petri Nets which can express concurrent timed behaviors and where an avoidable transition can lose its avoidability by the elapsing of time. The usefulness of this new model is illustrated by a real device driver synthesis example.
- **Discrete event optimization of a vehicle charging station with multiple sockets**
  Authors: Giulio Ferro ; Riccardo Minciardi ; Luca Parodi ; Michela Robba
  Abstract: The relevance and presence of Electric Vehicles (EVs) are increasing all over the world since they seem an effective way to fight pollution and greenhouse gas emissions, especially in urban areas. One of the main issues related to EVs is the necessity of modifying the existing infrastructure to allow the installation of new charging stations (CSs). In this scenario, one of the most important problems is the definition of smart policies for the sequencing and scheduling of the vehicle charging process. The presence of intermittent energy sources and variable execution times represent just a few of the specific features concerning vehicle charging systems. Even though optimization problems regarding energy systems are usually considered within a discrete time setting, in this paper a discrete event approach is proposed. The fundamental reason for this choice is the necessity of limiting the number of the decision variables, which grows beyond reasonable values when a short time discretization step is chosen. The considered optimization problem regards the charging of a series of vehicles by a CS connected with a renewable energy source, a storage element, and the main grid. The objective function to be minimized results from the weighted sum of the (net) cost for purchasing energy from the external grid, the weighted tardiness of the services provided to the customers, and a cost related to the occupancy of the socket during the charging. The approach is

tested on a real case study. The limited computational burden allows also the implementation in real-case applications.

- **Commodification of accelerations for the Karp and Miller Construction**
  Authors: Alain Finkel ; Serge Haddad ; Igor Khmelnitsky
  Abstract: Karp and Miller's algorithm is based on an exploration of the reachability tree of a Petri net where, the sequences of transitions with positive incidence are accelerated. The tree nodes of Karp and Miller are labeled with ω-markings representing (potentially infinite) coverability sets. This set of ω-markings allows us to decide several properties of the Petri net, such as whether a marking is coverable or whether the reachability set is finite. The edges of the Karp and Miller tree are labeled by transitions but the associated semantic is unclear which yields to a complex proof of the algorithm correctness. In this work we introduce three concepts: abstraction, acceleration and exploration sequence. In particular, we generalize the definition of transitions to ω-transitions in order to represent accelerations by such transitions. The notion of abstraction makes it possible to greatly simplify the proof of the correctness. On the other hand, for an additional cost in memory, which we theoretically evaluated, we propose an "accelerated" variant of the Karp and Miller algorithm with an expected gain in execution time. Based on a similar idea we have accelerated (and made complete) the minimal coverability graph construction, implemented it in a tool and performed numerous promising benchmarks issued from realistic case studies and from a random generator of Petri nets.

- **Due-date quotation model for manufacturing system scheduling under uncertainty**
  Authors: Zhiguo Wang ; Tsan Sheng Ng ; Chee Khiang Pang
  Abstract: This paper studies the scheduling problem for the manufacturing systems with uncertain job duration, and the possibility of planning due-date quotations for critical manufacturing tasks given a fixed contingency budget. We propose a due-date quotation model to measure the risk of delay in the manufacturing process in terms of the allocated contingency budget. The risk of delay is measured in the same unit as its corresponding milestone factor such that the decision makers could directly visualize and quantify the level of risks in units of hours or days. In addition, the proposed model possesses various great properties required by a convex risk measure and it represents a minimized certainty equivalent of the overall expected risk in achieving the manufacturing due-dates. Extensive computational experiments are conducted to evaluate the model performance. The results show that our proposed model, compared to various existing methods, provides a much more balanced performance in terms of success rate of due-date achievement, due-date quotation shortfall, as well as, robustness against uncertainties. The practical applicability of the proposed models are also tested with the job scheduling problem in a real stamping industry application.

- **Nonblocking and deterministic decentralized control for networked discrete event systems under communication delays**
  Authors: Pan Xu ; Shaolong Shu ; Feng Lin
  Abstract: Nonblocking is an important issue in supervisory control of discrete event systems. In this paper, we investigate nonblocking control for networked discrete event systems. In networked discrete event systems, there are two types of supervisory controls: nondeterministic control and deterministic control. Following the deterministic control, we investigate the nonblocking control problem in a decentralized control framework where communication among the plant and the local supervisors are subject to nondeterministic but bounded delays. We introduce delay co-observability to capture the nondeterminism caused by observation delays. With delay co-observability, we derive a necessary and sufficient condition for the existence of solutions of the nonblocking control problem. When the condition is satisfied, we propose to use state-estimate-based predictive local networked supervisors to control the plant. To illustrate the applications of the results, we consider a black start problem in micro grids.

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1.2. IEEE Transactions on Automatic Control

Volume: 66, Issue: 6, June 2021

- **Robust Dynamic Programming for Temporal Logic Control of Stochastic Systems**
  Authors: Sofie Haesaert ; Sadegh Soudjani
  Abstract: Discrete-time stochastic systems are an essential modeling tool for many engineering systems. We consider stochastic control systems that are evolving over continuous spaces. For this class of models, methods for the formal verification and synthesis of control strategies are computationally hard and generally rely on the use of approximate abstractions. Building on approximate abstractions, we compute control strategies with lower- and upper-bounds for satisfying unbounded temporal logic specifications. First, robust dynamic programming mappings over the abstract system are introduced to solve the control synthesis and verification problem. These mappings yield a control strategy and a unique lower bound on the satisfaction probability for temporal logic specifications that is robust to the incurred approximation errors. Second, upper-bounds on the satisfaction probability are quantified, and properties of the mappings are analyzed and discussed. Finally, we show the implications of these results to continuous state space of linear stochastic dynamic systems. This abstraction-based synthesis framework is shown to be able to handle infinite-horizon properties. Approximation errors expressed as deviations in the outputs of the models and as deviations in the probabilistic transitions are allowed and are quantified using approximate stochastic simulation relations.
- **Routing for Traffic Networks With Mixed Autonomy**
  Authors: Daniel A. Lazar ; Samuel Coogan ; Ramtin Pedarsani
  Abstract: In this article, we propose a macroscopic model for studying routing on networks shared between human-driven and autonomous vehicles that captures the effects of autonomous vehicles forming platoons. We use this to study inefficiency due to selfish routing and bound the price of anarchy (PoA), the maximum ratio between total delay experienced by selfish users and the minimum possible total delay. To do so, we establish two road capacity models, each corresponding to an assumption regarding the platooning capabilities of autonomous vehicles. Using these, we develop a class of road delay functions, parameterized by the road capacity, that are polynomial with respect to vehicle flow. We then bound the PoA and the bicriteria, another measure of the inefficiency due to selfish routing, for general networks with multiple source-destination pairs. We find these bounds depend on: the degree of the polynomial in the road delay function; and the degree of asymmetry, the difference in how human-driven and autonomous traffic affect road delay. We demonstrate that these bounds recover the classical bounds when no asymmetry exists. We show the bounds are tight in certain cases and that the PoA bound is order optimal with respect to the degree of asymmetry.
- **Jump LQR Systems With Unknown Transition Probabilities**
  Authors: Ioannis Tzortzis ; Charalambos D. Charalambous ; Christoforos N. Hadjicostis
  Abstract: This article develops a robust linear quadratic regulator (LQR) approach applicable to nonhomogeneous Markov jump linear systems with uncertain transition probability distributions. The stochastic control problem is investigated under two equivalent formulations, using i) minimax optimization theory, and ii) a total variation distance metric as a tool for codifying the level of uncertainty of the jump process. By following a dynamic programming approach, a robust optimal controller is derived, which in addition to minimizing the quadratic cost, it also restricts the influence of uncertainty. A solution procedure for the LQR problem is also proposed, and an illustrative example is presented. Numerical results indicate the applicability and effectiveness of the proposed approach.

1.3. Automatica

Volume: 128, June 2021

- **Learning hidden Markov models for linear Gaussian systems with applications to event-based state estimation**
  Authors: Kaikai Zheng ; Dawei Shi ; Ling Shi
  Abstract: This work attempts to approximate a linear Gaussian system with a finite-state hidden Markov model (HMM), which is found useful in dealing with challenges in designing networked control systems An indirect approach is developed, where a state-space model (SSM) is firstly identified for a Gaussian system and the SSM is then used as an emulator for learning an HMM. In the proposed method, the training data for the HMM are obtained from the data generated by the SSM through building a quantization mapping. Parameter learning algorithms are designed to learn the parameters of the HMM, through exploiting the periodical structural characteristics of the HMM. The convergence and asymptotic properties of the proposed algorithms are analyzed. The HMM learned using the proposed algorithms is applied to event-triggered state estimation, and numerical results on model learning and state estimation demonstrate the validity of the proposed algorithms.
- **Performance safety enforcement in strongly connected timed event graphs**
  Authors: Zhou He ; Ziyue Ma ; Wei Tang
  Abstract: In this paper, we tackle the performance safety enforcing problem in plants modeled by timed event graphs that are a subclass of timed Petri nets. We assume that a malicious intruder can increase the firing delay of transitions by adding delay in communication, or corrupt the transmitted data. Our target is to design a transition protecting policy to guarantee that the global performance does not drop below a given lower-bound threshold. Two classes of situations are considered: (1) the operator does not know the capability of the intruder, which means that all possible attacks must be taken into account; (2) the operator knows the upper bound of the capability of the intruder, e.g., the maximal number of transitions that can be simultaneously attacked. For the former case, we develop an algorithm using mixed integer linear programming to obtain an optimal protecting policy. For the latter situation, we develop a heuristic method to compute a protecting policy that is locally optimal.

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1.4. IEEE Control Systems Letter

Volume: 5, Issue: 3, June 2021

- **Formal Synthesis of Lyapunov Neural Networks**
  Authors: Alessandro Abate ; Daniele Ahmed ; Mirco Giacobbe ; Andrea Peruffo
  Abstract: We propose an automatic and formally sound method for synthesising Lyapunov functions for the asymptotic stability of autonomous non-linear systems. Traditional methods are either analytical and require manual effort or are numerical but lack of formal soundness. Symbolic computational methods for Lyapunov functions, which are in between, give formal guarantees but are typically semi-automatic because they rely on the user to provide appropriate function templates. We propose a method that finds Lyapunov functions fully automatically-using machine learning-while also providing formal guarantees-using satisfiability modulo theories (SMT). We employ a counterexample-guided approach where a numerical learner and a symbolic verifier interact to construct provably correct Lyapunov neural networks (LNNs). The learner trains a neural network that satisfies the Lyapunov criteria for asymptotic stability over a samples set; the verifier proves via SMT solving that the criteria are satisfied over the whole domain or augments the samples set with counterexamples. Our method supports neural networks with polynomial activation functions and multiple depth and width, which display wide learning capabilities. We demonstrate our method over several non-trivial benchmarks and compare it favourably against a numerical optimisation-based approach, a symbolic template-based approach, and a cognate LNN-based approach. Our method synthesises Lyapunov functions faster and over wider spatial domains than the alternatives, yet providing stronger or equal guarantees.

- **Robust and Stochastic Optimization With a Hybrid Coherent Risk Measure With an Application to Supervised Learning**
  Authors: Shutian Liu ; Quanyan Zhu
  Abstract: This letter considers a hybrid risk measure for decision-making under uncertainties that tradeoffs between the solutions obtained from the robust optimization and the stochastic optimization techniques. In the proposed framework, the risk measure is shown to satisfy the properties of coherent risk measures. We can control the level of guaranteed robustness using a parameter. We formulate the stochastic and robust optimization problem under the proposed risk measure and show its equivalent formulation and sensitivity result. We introduce the sample approximation of our technique by combining scenario program and sample average approximation, making our framework amenable for practical usage. We present a supervised learning problem as a case study to corroborate our results and show the implications of the proposed method in machine learning.
- **Deceptive Labeling: Hypergames on Graphs for Stealthy Deception**
  Authors: Abhishek N. Kulkarni ; Huan Luo ; Nandi O. Leslie ; Charles A. Kamhoua ; Jie Fu
  Abstract: With the increasing sophistication of attacks on cyber-physical systems, deception has emerged as an effective tool to improve system security and safety by obfuscating the attacker's perception. In this letter, we present a solution to the deceptive game in which a control agent is to satisfy a Boolean objective specified by a co-safe temporal logic formula in the presence of an adversary. The agent intentionally introduces asymmetric information to create payoff misperception, which manifests as the misperception of the labeling function in the game model. Thus, the adversary is unable to accurately determine which logical formula is satisfied by a given outcome of the game. We introduce a model called hypergame on graph to capture the asymmetrical information with one-sided payoff misperception. Based on this model, we present the solution of such a hypergame and use the solution to synthesize stealthy deceptive strategies. Specifically, deceptive sure winning and deceptive almost-sure winning strategies are developed by reducing the hypergame to a two-player game and one-player stochastic game with reachability objectives. A running example is introduced to demonstrate the game model and the solution concept used for strategy synthesis.

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1.5. International Journal of Control

Volume: 94, Issue: 6, June 2021

- **On the index of convergence of a class of Boolean matrices with structural properties**
  Authors: Guilherme Ramos ; Sérgio Pequito ; Carlos Caleiro
  Abstract: Boolean matrices are of prime importance in the study of discrete event systems (DES), which allow us to model systems across a variety of applications. The index of convergence (i.e. the number of distinct powers of a Boolean matrix) is a crucial characteristic in that it assesses the transient behaviour of the system until reaching a periodic course. In this paper, adopting a graph-theoretic approach, we present bounds for the index of convergence of Boolean matrices for a diverse class of systems, with a certain decomposition. The presented bounds are an extension of the bound on irreducible Boolean matrices, and we provide non-trivial bounds that were unknown for classes of systems. Furthermore, the proposed method is able to determine the bounds in polynomial time. Lastly, we illustrate how the new bounds compare with the previously known bounds and we show their effectiveness in cases such as the benchmark IEEE 5-bus power system.

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

Volume: 51, Issue: 6, June 2021

- **Distributed Diagnostic Problem Solving With Colored Behavioral Petri Nets**
  Authors: Soumia Mancer ; Hammadi Bennoui
  Abstract: With the profound diffusion of technological systems in the real world, fault diagnosis

has become a major requirement due to its importance in terms of system reliability, security, and efficiency. In this paper, we focus on the problem of causal model-based diagnosis (MBD) of spatially distributed systems in terms of colored Petri nets (CPNs). First, we introduce the colored behavioral Petri net (CBPN) model as a particular CPN intended for the description of a system's causal behavior where each transition is associated with a matrix describing the possible ways it may fire. On the basis of such matrices, we define a particular technique that we call CW-analysis as a backward reachability analysis of CBPNs. With no need to expressions inversion, which is particularly required for original CPNs, the CW-analysis can be realized by a simple manipulation of the net transition matrices. Second, we propose a new approach for distributed systems, where the diagnostic process is captured within a framework based on the formalism of CBPNs. The systems we consider consist of a set of interacting subsystems. Hence, the overall system model is given as a set of place-bordered CBPNs. The interactions between the subsystems are captured by tokens that may pass from one net model to another via bordered places. The diagnostic system is defined as a multiagent system, each agent is in charge of diagnosing an associated subsystem, by having its local CBPN and receiving only the observations generated by its elements. We show how the formalization of the diagnostic process at the level of each agent can be obtained in terms of reachability in a CBPN and can be implemented by exploiting the CW-analysis technique. Once local diagnoses are obtained by the different agents, a cooperation process should be initiated to ensure global consistency of such diagnoses.

- **Topological Structure, Reachability, and Stabilization of Constrained Boolean Control Networks via Event-Triggered Control**
  Authors: Lin Lin ; Jinde Cao ; Mahmoud Abdel-Aty ; Udai Ali Al-Juboori
  Abstract: This paper is concerned with the topological structure, reachability, and stabilization for Boolean control networks (BCNs) with state constraints via event-triggered control (ETC) scheme. In the first part, the topological structure of BCNs with state constraints is studied. Under the framework of state constrain, the definitions of fixed point and cycle are first defined. A novel phenomenon is that there may exist two kinds constrained fixed points, which are, respectively, named as the livelock and deadlock ones. It is different with the traditional fixed point. Accordingly, a formula is presented to calculate the number of constrained fixed points and constrained cycles. In the second part, the constrained reachability and stabilization problem of the event-triggered controlled BCNs are investigated. Two necessary and sufficient criteria are, respectively, obtained. Furthermore, an algorithm is developed to design all feasible controllers. Finally, a reduced model of the lac operon in the Escherichia coli is shown to illustrate the efficiency of the obtained results.

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2 Conferences

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

2.1 **2021 Learning for Dynamics and Control**
ETH Zurich, Switzerland, June 7-8, 2021 (Virtual)
https://l4dc.ethz.ch/

2.2 **2021 Mediterranean Conference on Control and Automation**
Bari, Italy, June 22-25, 2021 (Virtual)
http://med2021.poliba.it/

2.3 **2021 Chinese Control Conference**
Shanghai, China, July 26-28, 2021
https://conf2021.shu.edu.cn/index.htm

2.4 **2021 IEEE Conference on Control Technology and Applications**
San Diego, August 8-11, 2021
https://ccta2021.ieeecss.org/

2.5 **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

2.6 **2021 IEEE International Conference on Systems, Man, and Cybernetics**
South Wharf, Victoria, Australia, October 17-20, 2021
http://ieeesmc2021.org/

2.7 **2021 IEEE Conference on Decision and Control**
Austin, Texas, USA. December 13-15, 2021
https://cdc2021.ieeecss.org

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3 Books

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

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

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

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

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4 Positions

4.1 PhD Position at the University of Salerno

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

"Resilient control against cyber-attack"

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

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

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

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

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

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

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

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5 Software Tool

5.1 IDES: An Open-Source Software Tool

IDES, the discrete-event systems software tool in Karen Rudie's lab is now available as open-source software at https://github.com/krudie/IDES. More information on IDES can also be found at https://www.ece.queensu.ca/people/K-Rudie/qdes.html#fndtn-software.

5.2 Supremica 2.6, New Version

The development team has just released a new version of Supremica, Waters/Supremica IDE 2.6.

Supremica is a DES and SCT drawing and calculation tool, that includes a multitude of efficient algorithms for modeling, verification, and synthesis of maximally permissive supervisors. In addition there are general algorithms for standard operations like synchronization, minimization, determinization, etc. Supremica also handles finite automata extended with bounded discrete variables. A feature-full simulation tool is also included.

New in this version:

- Scaling of the GUI
- Revamped configuration dialog
- New analyzer user interface
- Logging can now be done directly to file, in addition to the log output pane
- Automaton variables have been introduced, so that guards and actions can refer to the state of an automaton
- The normalizing compiler is now the default
- Plenty of bug fixes, including more graceful termination when out of memory

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

5.3 UltraDES 2.2 Release

UltraDES is an open-source library to the modeling, analysis and control of DES, written using C# in .NET Standard 2.0, which allows its use in multiple platforms, such as Windows, Linux, Mac, IOS, Android, so on. The library is under development at LACSED (Laboratory of Analysis and Control of Discrete Event Systems, at the Universidade Federal de Minas Gerais, Brazil) and has basic operations with automata as long as the monolithic, modular and local modular supervisory control (Alves et. al., 2017).

The main improvements of the UltraDES 2.2 version are:

- Supervisor Reduction Algorithm (Su and Wonham, 2004)
- Supervisor Localization (Cai and Wonham, 2010)
- Basic Petri Nets Functions (incidence matrix, coverability/reachability graph, Petri Net marking simulation, etc.)

Knowing that many researchers/students are not familiar with the C# language, we created an experimental python wrapper, that is less object oriented and easier to use.

Another initiative to improve the usability of UltraDES was the creation of a Web Application, developed using Blazor/WebAssembly, that allows the use of UltraDES online. This version is more limited in processing power and memory but it is useful for small examples and teaching.

We invite the community to download and contribute. Algorithms implemented may be integrated to the main distribution. Just let us know. Contact Lucas Alves lucasvra@ufmg.br or Patricia Pena ppena@ufmg.br for more information. Bugs should be informed using the UltraDES GitHub page.
Link: https://github.com/lacsed/UltraDES.

5.4 DESpot 1.10.0 Released

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

DESpot 1.10.0 supports a number of new Features:

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

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

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

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

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