IEEE Control Systems Society
Technical Committee on Discrete Event Systems

Newsletter **March 2024**

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Welcome to the 2024 March issue of the newsletter, also available online at
https://ieeecss.org/tc/discrete-event-systems/newsletters

Editorial

You are welcome to submit new items to the newsletter (topics including schools, workshops, sessions, conferences, journals, books, software, positions). Also please encourage relevant colleagues and students to subscribe to this newsletter.

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Contents

1 Selections of Journal Publications

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

1.1. Discrete Event Dynamic Systems Theory and Applications

Volume: 34, Issue: 1, March 2024

- **Generation of mathematical programming representations for discrete event simulation models of timed petri nets**
  Authors: Mengyi Zhang ; Arianna Alfieri ; Andrea Matta
  Abstract: This work proposes a mathematical programming (MP) representation of discrete event simulation of timed Petri nets (TPN). Currently, mathematical programming techniques are not widely applied to optimize discrete event systems due to the difficulty of formulating models capable to correctly represent the system dynamics. This work connects the two fruitful research fields, i.e., mathematical programming and Timed Petri Nets. In the MP formalism, the decision variables of the model correspond to the transition firing times and the markings of the TPN, whereas the constraints represent the state transition logic and temporal sequences among events. The MP model and a simulation run of the TPN are then totally equivalent, and this equivalence has been validated through an application in the queuing network field. Using a TPN model as input, the MP model can be routinely generated and used as a white box for further tasks such as sensitivity analysis, cut generation in optimization procedures, and proof of formal properties.
- **Conflict-free electric vehicle routing problem: an improved compositional algorithm**
  Authors: Sabino Francesco Roselli ; Martin Fabian ; Knut Åkesson
  Abstract: The Conflict-Free Electric Vehicle Routing Problem (CF-EVRP) is a combinatorial optimization problem of designing routes for vehicles to execute tasks such that a cost function, typically the number of vehicles or the total travelled distance, is minimized. The CF-EVRP involves constraints such as time windows on the tasks' execution, limited operating range of the vehicles, and limited capacity on the number of vehicles that a road segment can simultaneously accommodate. In previous work, the compositional algorithm ComSat was introduced to solve the CF-EVRP by breaking it down into sub-problems and iteratively solve them to build an overall solution. Though ComSat showed good performance in general, some problem instances took significant time to solve due to the high number of iterations required to find solutions for two sub-problems, namely the Routing Problem, and the Paths Changing Problem. This paper addresses the bottlenecks of ComSat and presents new formulations for both sub-problems in order to reduce the number of iterations required to find feasible solutions to the CF-EVRP. Experiments on sets of benchmark instances show the effectiveness of the presented improvements.
- **Analysis and control of timed event graphs in $(\max, +)$ algebra for the active localization of time failures**
  Authors: Ibis Velasquez ; Yannick Pencolé ; Euriell Le Corronc
  Abstract: This paper addresses the problem of active diagnosis in Timed Event Graphs for the localization of time failures. Active diagnosis is the process of controlling the system in order to refine a previous diagnosis. A first algorithm is proposed which sets up a multi-input control policy that ensures that the system's observable response is informative enough to identify the source of the delay more precisely, with an analysis of the propagation paths through the TEG. A second algorithm extends the first one to improve the performance of the localization by adding a specific method to analyze the effect of circuits when a time failure propagates.
- **πHyFlow: formalism, semantics, and applications**
  Authors: Fernando Barros
  Abstract: Simulation models have been described using different perspectives, or worldviews. In the process interaction world view (PI), every entity is modeled by a sequence of actions describing its life cycle, offering a comprehensive model that groups the events involving each entity. In this paper we describe π HYFLOW, a formalism for representing hybrid models using a set of communicating processes. This set is dynamic, enabling processes to be created and destroyed at runtime. Processes are encapsulated into π HYFLOW base models and communicate through

shared memory. π HYFLOW, however, can guarantee modularity by enforcing that models can only communicate by input and output interfaces. π HYFLOW extends current PI approaches by providing support for HYFLOW concepts of sampling and dense (continuous) outputs, in addition to the more traditional event-based communication. Likewise HYFLOW, π HYFLOW is a modeling & simulation formalism driven by expressiveness and performance analysis. We present π HYFLOW semantics, and several applications to illustrate π HYFLOW ability to describe a diversity of systems.

- **Compositional non-blockingness verification of finite automata with prioritised events**
  Authors: Yiheng Tang ; Thomas Moor
  Abstract: This paper addresses the verification of non-blockingness for modular discrete-event systems, i.e., discrete-event systems that are composed from component models. For such systems, the explicit construction of a monolithic representation turns out intractable for relevant applications, since such a construction in general is of exponential cost w.r.t. the number of components. One well established approach to circumvent the need for a monolithic representation for the verification task at hand is to alternate (a) the substitution of individual components by abstractions and (b) the composition of only a small number of strategically chosen components at a time. When successful, one ends up with a single moderately sized automaton which does not represent the overall behaviour in any detail but which does block if and only if the original modular system fails to be non-conflicting. This approach is referred to as compositional verification and originates from the field of process algebra with more recent adaptations to finite automata models. The main contribution of the present study is the development of a number of abstraction rules valid for compositional verification of non-conflictingness in the presence of global event priorities, i.e., where high priority events from one component possibly preempt events with lower priority of all components.

- **A modular synthesis approach for the coordination of multi-agent systems: the multiple team case**
  Authors: Marcelo Rosa ; José E. R. Cury ; Fabio L. Baldissera
  Abstract: In this paper, we deal with the problem of coordinating multiple agents to accomplish a global task. This problem consists of a set of agents divided into teams of homogeneous agents that interact with each other in order to autonomously complete a common global task. Due to the fact that agents in a team are exactly the same both in hardware and control software, the open-loop behavior of any agent in a team can be represented by a template, as well as its local control specifications. Our approach is based on the Supervisory Control Theory and it derives sufficient conditions that allow us to synthesize for each team a local supervisor template from templates associated with the team and the global task model in such a way that, when this supervisor template is instantiated for the other agents in the team, the global task can be completed by the coordinated action of all agents in the system. Our sufficient conditions also guarantee that a computed set of supervisor templates does not need to be recomputed or reconfigured whenever agents are added or removed from teams. An example of 3D robotic construction is provided to illustrate our approach.

- **Switched max-plus linear-dual inequalities: cycle time analysis and applications**
  Authors: Davide Zorzenon ; Jan Komenda ; Jörg Raisch
  Abstract: P-time event graphs are discrete event systems suitable for modeling processes in which tasks must be executed in predefined time windows. Their dynamics can be represented by max-plus linear-dual inequalities (LDIs), i.e., systems of linear dynamical inequalities in the primal and dual operations of the max-plus algebra. We define a new class of models called switched LDIs (SLDIs), which allow to switch between different modes of operation, each corresponding to a set of LDIs, according to a sequence of modes called schedule. In this paper, we focus on the analysis of SLDIs when the considered schedule is fixed and either periodic or intermittently periodic. We show that SLDIs can model a wide range of applications including single-robot multi-product processing networks, in which every product has different processing requirements and corresponds to a specific mode of operation. Based on the analysis of SLDIs, we propose algorithms to compute: i. minimum and maximum cycle times for these processes, improving the time complexity of other existing

approaches; ii. a complete trajectory of the robot including start-up and shut-down transients.

- **Cycle times in D/D/S series queues with single multi-server bottlenecks**
  Authors: Lonnie Turpin Jr. ; Morgan Turpin
  Abstract: In this work, we consider D/D/S series queues characterized by deterministic interarrival and service times, with a single multi-server bottleneck stage. When the arrival rate is greater than the bottleneck capacity—for a temporary window of time—the derivation of cycle time is not immediately clear, and warrants a formal proof.

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1.2. IEEE Transactions on Automatic Control

Volume: 69, Issue: 3, March 2024

- **Verification of Pattern–Pattern Diagnosability in Partially Observed Discrete Event Systems**
  Authors: Ziyue Ma ; Yin Tong ; Carla Seatzu
  Abstract: his work studies a new notion of diagnosability called the pattern–pattern diagnosability in discrete event systems modeled by partially observable finite state automata. Suppose that in the system there are some sequences of events that are undesirable to happen, which we call the fault pattern . We want to determine whether the occurrence of the fault pattern can be determined before some sequences—-which we call the critical pattern and may cause fatal consequences after the fault pattern—are completed. Both fault and critical patterns are assumed to be regular and, hence, are described by the languages accepted by finite automata. We propose a novel notion of pattern–pattern diagnosability (PP-diagnosability), which requires that the occurrence of a fault pattern can always be detected before the completion of a critical pattern thereafter. The properties of PP-diagnosability, and the relations between PP-diagnosability and conventional diagnosability are studied. Then, we propose a method to verify PP-diagnosability using a structure called the pattern–pattern verifier . The complexity of the proposed method is polynomial in the number of states of the plant and the two pattern automata.
- **On Decidability of Existence of Fortified Supervisors Against Covert Actuator Attackers**
  Authors: Ruochen Tai ; Liyong Lin ; Rong Su
  Abstract: This work investigates the existence of fortified supervisors against covert actuator attackers. For a supervisor S that is nonresilient against covert actuator attackers, a fortified supervisor S' satisfies two requirements: 1) S' is resilient against any covert actuator attacker, and 2) the original closed-behavior of the closed-loop system under S is preserved. We design a sound and complete procedure to show the problem of determining the existence of a fortified supervisor against covert actuator attackers is decidable. The decidability result is also extended to the case against the worst-case attacker.
- **Stochastic Hybrid Networks for Global Almost Sure Unanimous Decision Making**
  Authors: Andrew R. Teel
  Abstract: A stochastic, hybrid algorithm for global almost sure unanimous decision making in multiagent systems is introduced. Homogeneous agents communicate over an undirected connected graph to make a unanimous selection among a finite set of decision states. The agents have inertia corresponding to stable, linear, and continuous-time dynamics. The algorithm equips each agent with a logic variable and designs logic-variable reset rules to ensure eventual unanimity. These resets occur randomly in time. They are randomly assigned among those indices of the decision states that nearly minimize the value of a function that quantifies the mismatch between the average of the agent states, or a local estimate thereof, and the corresponding decision state. In order to satisfy regularity properties that confer robustness, the resulting update rule corresponds to an inclusion, i.e., a set-valued mapping. Global almost sure decision making is established using a classical Lyapunov function argument that has recently been extended to stochastic hybrid inclusions.

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1.3. Automatica

Volume: 161, March 2024

- **Identity concealment games: How I learned to stop revealing and love the coincidences**
  Authors: Mustafa O. Karabag ; Melkior Ornik ; Ufuk Topcu
  Abstract: In an adversarial environment, a hostile player performing a task may behave like a non-hostile one in order not to reveal its identity to an opponent. To model such a scenario, we define identity concealment games: zero-sum stochastic reachability games with a zero-sum objective of identity concealment. To measure the identity concealment of the player, we introduce the notion of an average player. The average player's policy represents the expected behavior of a non-hostile player. We show that there exists an equilibrium policy pair for every identity concealment game and give the optimality equations to synthesize an equilibrium policy pair. If the player's opponent follows a non-equilibrium policy, the player can hide its identity better. For this reason, we study how the hostile player may learn the opponent's policy. Since learning via exploration policies would quickly reveal the hostile player's identity to the opponent, we consider the problem of learning a near-optimal policy for the hostile player using the game runs collected under the average player's policy. Consequently, we propose an algorithm that provably learns a near-optimal policy and give an upper bound on the number of sample runs to be collected.
- **Attack-tolerant control for Markovian jump systems with stochastic sampling: A sliding mode scheme**
  Authors: Tianshu Xu ; Yugang Niu ; Zhiru Cao
  Abstract: This work discusses the sampled-data sliding mode control problem for Markovian jump systems in the presence of Denial-of-Service (DoS) attacks, where the state signals are sampled stochastically and transmitted via vulnerable communication networks. The successful transmitted sequence with double randomness is established, and the probability distribution on both the attacked signals and stochastic delays are given. With the aid of the coordinate transformation, a linear sliding surface is constructed and the mode-dependent sliding mode controller is designed by means of only successfully transmitted state signals. Moreover, the resultant closed-loop systems composed of partial state and sliding mode variable are described as a continuous time-delay system with double randomness depending on the probability distribution characteristics of both the sampling periods and DoS attacks. Both the mean-square exponential ultimate boundedness of the closed-loop system and the reachability of the sliding surface are analyzed and the corresponding sufficient conditions are derived. Meanwhile, an optimization problem with genetic algorithm is formulated for achieving fast convergence of the state trajectory, small ultimate bound of the system state and small sliding bound. Finally, the simulation results via the numerical example are provided to illustrate the proposed sampled-data sliding mode control scheme.
- **pth moment stability of discrete-time Markov jump systems by extended system method**
  Authors: Weihai Zhang ; Fangxu Su ; Panyu Wu
  Abstract: This paper studies the pth moment stability of discrete-time Markov jump systems by utilizing the extended system method, which is composed of the operator spectrum technique and the $\mathcal{H}$-representation technique. Firstly, some extended systems are constructed by the operator spectrum technique and the $\mathcal{H}$-representation technique to transform the discrete-time Markov jump systems into the extended systems. Furthermore, the relationship in pth moment stability between the extended systems and the stochastic systems is discussed. Next, with the help of the extended systems, the necessary and sufficient conditions for the even-order moment stability, and several sufficient conditions/necessary conditions for the odd-order moment stability are obtained, respectively. Additionally, as applications of the extended system method, observability and detectability in pth moment sense are discussed, and the necessary and sufficient conditions for observability and detectability in even-order moment are obtained, respectively. Finally, several examples are given to illustrate the validity of the results.

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1.4. IEEE Control Systems Letter

Volume: 8, Issue: 2, February 2024

- **Distributed MPC With Continuous-Time STL Constraint Satisfaction Guarantees**
  Authors: Maria Charitidou ; Dimos V. Dimarogonas
  Abstract: In this letter a distributed model predictive control scheme (dMPC) is proposed for a multi-agent team that is subject to a set of time-constrained spatial tasks encoded in Signal Temporal Logic (STL). Here, the agents are subject to both individual and collaborative STL tasks. In order to ensure the satisfaction of the collaborative tasks while avoiding the computational burden of a centralized problem, we propose a sequential dMPC scheme and show the recursive feasibility property of the framework given appropriately designed terminal ingredients. The resulting MPC problems are solved in discrete-time yet continuous-time satisfaction of the STL tasks is ensured with appropriate tightening of the constraint sets.

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1.5. Control Engineering Practice

Volume: 144, March 2024

- **Assessment of Petri nets Regulation Control methodologies for automation systems**
  Authors: Carlos A. Anguiano-Gijón ; José M. Chávez ; Anibal Cid-Gaona ; Carlos R. Vázquez
  Abstract: Industry 4.0 and smart manufacturing bring new interesting possibilities and challenges, a particular one is the large-scale automation with minimal set-up time and flexibility. To face this challenge, control approaches based on Discrete Event Systems (DES), such as Supervisory Control Theory (SCT), Generalized Mutual Exclusions Constraints (GMEC) and Petri net-based Regulation Control (RC), may provide convenient solutions; however, few works have been reported in the literature describing the application of these approaches. In this work, the RC approach based on Petri nets is applied to three case studies: (1) an electro-pneumatic cell controlled by a Programming Logic Controller device (PLC); (2) a simulated hydraulic process controlled by a PLC (a virtual commissioning scheme); (3) a simulated robotic manufacturing cell controlled by a software tool. In addition, an assessment of the existing methodologies in RC for modelling, specification, control synthesis and control implementation is conducted. The findings of this work provide three contributions: (1) a practical validation of the applied methodologies and the identification of required extensions; (2) a discussion about the validity of frequently considered assumptions and hypotheses in DES; (3) a reference for practitioners on the implementation of the RC approach, as well as its limitations and advantages.

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1.6. IEEE Transactions on Control Systems Technology

Volume: 32, Issue: 2, March 2024

- **Supervisory Control of Discrete Event Systems With Dynamic Control Specifications by Petri Nets**
  Authors: Chengzong Li ; Yufeng Chen ; Zhiwu Li
  Abstract: Supervisory control can enforce a desired control specification for discrete event systems (DESs). If the specification of a system is changed over time, i.e., the system is subject to dynamic control specifications, control reconfiguration methods are proposed to implement the new specification. However, the existing reconfiguration methods require redesigning and adding controllers for the new specification. In this article, we propose a dynamic control policy for a Petri net model with dynamic control specifications. First, a fully functional supervisor is designed for the net model, which is dynamically optimal since it can dynamically adjust control actions for the net model and prevent all illegal markings, while all legal markings are permitted for each specification. Then, by the dynamically optimal supervisor, the dynamic control policy consists of two steps: 1) guide the system from the current illegal state to a marking that satisfies the new specification and 2) switch control actions of the supervisor. By using the proposed method, the system can satisfy the dynamically changeable specifications. Finally, some examples are used to illustrate the proposed method.

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1.7. Systems & Control Letters

Volume: 185, December 2024

- **Reinforcement learning in non-Markovian environments**
  Authors: Siddharth Chandak ; Pratik Shah ; Vivek S. Borkar ; Parth Dodhia
  Abstract: Motivated by the novel paradigm developed by Van Roy and coauthors for reinforcement learning in arbitrary non-Markovian environments, we propose a related formulation and explicitly pin down the error caused by non-Markovianity of observations when the Q-learning algorithm is applied to this formulation. Based on this observation, we propose that the criterion for agent design should be to seek good approximations for certain conditional laws. Inspired by classical stochastic control, we show that our problem reduces to that of recursive computation of approximate sufficient statistics. This leads to an autoencoder-based scheme for agent design which is then numerically tested on partially observed reinforcement learning environments.

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2 Call for Participants

2.1 EECI-IGSC Course: Introduction to Discrete Event Systems

Dear Colleagues,

We would like to remind you of the course titled "**Introduction to Discrete Event Systems**", to be taught by **Christos Cassandras** (Boston University, USA) and **Stéphane Lafortune** (University of Michigan, USA), which will be held from **June 3 to June 7, 2024, at the Campus Saint Charles, in Marseille, France**. Isabel Demongodin is the local organizer.

The registration is open as "M13-MARSEILLE-03/06/2024-07/06/2024" at: http://www.eeci-igsc.eu/earlyregistrationm03tom18/. The early registration deadline is **March 15**, 2024. Please register as "Administration fee" (20€) as soon as possible, but no later than March 15, to ensure that the course is offered (a minimum number of registrations is required by March 15). *Please note the change of the registration deadline from April 1 to March 15.*

This course of 21 hours, offered as part of the European Embedded Control Institute-International Graduate School on Control (M13 of EECI-IGSC-2024), is especially designed for doctoral students, post-docs and junior researchers, who will have the opportunity to learn the main concepts and recent results in the theory and application of discrete event systems.

This course will strike a balance between introducing the students to the key concepts, models, and results of discrete-event control theory for logical and stochastic models, while at the same time emphasizing current research trends in DES theory and applications.

Please see the EECI's webpage, http://www.eeci-igsc.eu/, for further details.

Students can apply to get financial support. Pour les doctorants inscrits dans une Université française hors Ile-de-France, voir : http://www.eeci-igsc.eu/igsc-grant-registration-france/. For Female PhD Students & PhD Students from countries with Low Education Priorities, see http://www.eeci-igsc.eu/igsc-grant-registration-overseas/.

Looking forward to seeing many of you in Marseille in June!

Best regards,

Isabel Demongodin, Christos Cassandras and Stéphane Lafortune

2.2 Invited Session at CASE'24–AI Enabled Discrete Event Dynamic Systems

Conference: 2024 IEEE 20th International Conference on Automation Science and Engineering
August 28 - September 1, 2024 | Bari, Italy

Organizer

- Qianchuan Zhao, Tsinghua University
- Kai Cai, Osaka Metropolitan University
- Xiang Yin, Shanghai Jiao Tong University
- Li Xia, Sun Yat-sen University

Summary Statement
Discrete event dynamic systems (DEDS) aim at studying the man-made systems driven by events, such as the systems of manufacturing, transportation, computer, communication, energy, robots, etc. The foundation of DEDS is built on mathematical models, such as Markov models, Petri net, automata, queueing models, etc. The decision and control of DEDS is fundamental to improve the operation efficiency of those man-made systems, which involves the optimization theory such as Markov decision process (MDP), optimal control, supervisory control, etc. Recently, the remarkable successes of AI attract intensive attention on the study of data-driven learning and optimization. One of the main research streams of AI is to handle the dynamic decision-making problem with reinforcement learning, whose mathematical foundation is MDP. Therefore, with these facts, the research development of DEDS theory encounters a crossroad, combining the techniques of AI and enabling the study of DEDS in a manner of data-driven learning and optimization.

This special session aims to bring together the international scholars and industry practitioners to discuss the recent progress of DEDS in the background of big development of AI techniques, while focusing on the field of automation science and engineering. The potential topics include but are not limited to the development of DEDS theory such as Markov systems, Petri net, automata, the development of reinforcement learning & MDP decision theory, the AI enabled solution to dynamic games & multi-agent systems, and the application of above theories to solve engineering problems in the field of automation science and engineering.

- Fundamental theory development of DEDS
- Controlled Markov systems
- Control in reinforcement learning
- Petri Nets for Automation Control
- Formal Methods in Robotics and Automation
- New advancement in automata
- Security control and Supervisory control
- Control and management in queueing models

Session Code: **41pkv**

2.3 **Invited Session at CASE'24–Applications and Tools of DES**

Conference: 2024 IEEE 20th International Conference on Automation Science and Engineering
August 28 - September 1, 2024 | Bari, Italy

Organizer

- Kai Cai, Osaka Metropolitan University
- Michel Reniers, Eindhoven University of Technology
- Martin Fabian, Chalmers University of Technology

Dear Colleagues,

We are organizing a special session on "Applications and Tools of DES" at the IEEE International Conference on Automation Science and Engineering (CASE 2024), Bari, Italy. (https://2024.ieeecase.org/)

We warmly welcome your contributions. The submission code for this special session is: **1911f**

3 Conferences

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

3.1 **2024 IFAC Workshop on Discrete Event Systems (WODES)**
Rio de Janeiro, Brazil, April 29-May 1, 2024.
https://wodes2024.eventos.ufrj.br

3.2 **2024 IFAC Conference on Analysis and Design of Hybrid Systems (ADHS)**
Boulder, Colorado, July 1-3, 2024.
https://www.colorado.edu/conference/adhs2024/

3.3 **2024 American Control Conference (ACC)**
Toronto, Canada, July 8-12, 2024.
https://acc2024.a2c2.org/

3.4 **The IEEE Conference on Control Technology and Applications (CCTA)**
Newcastle upon Tyne, UK, August 21-24, 2024.
https://ccta2024.ieeecss.org/

3.5 **2024 International Conference on Automation Science and Engineering (CASE)**
Bari, Italy, August 28-September 1, 2024.
https://www.ieeesmc2024.org/

3.6 **2024 International Conference on Systems, Man, and Cybernetics (SMC)**
Sarawak, Malaysia, October 7-10, 2024.
https://www.ieeesmc2024.org/

3.7 **2023 IEEE Conference on Decision and Control (CDC)**
Milan, Italy, December 16-19, 2024.
https://cdc2024.ieeecss.org/

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4 Books

4.1 Graph-Theoretical Methods in Systems Theory and Control

Author: Jan Lunze, Ruhr-University, Germany

Description: The book describes for numerous scenarios how to use the structural properties of a system represented by a graph to simplify modelling, analysis, and design tasks. For example, block diagrams and coupling graphs can be used to decompose systems, automata graphs to analyse discrete-event systems and Markov chains, structure graphs to find generic properties of linear systems or communication graphs to design networked control systems. The book includes many examples derived from diverse fields of application, exercises with solutions and MATLAB scripts to implement graph-theoretical methods for systems analysis

Additional information on the book can be found at
www.editionmora.de/gmsc

The book is produced as "print-on-demand" and can be ordered directly at the printer:
https://publish.bookmundo.de/books/349971

4.2 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).

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5 Software Tools

5.1 Eclipse ESCET™ version 2.0 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 toolkit's website at https://www.eclipse.org/escet/.

In December 2023, ESCET version 2.0 has been released and can be downloaded from https://www.eclipse.org/escet/download.html. The main changes in this version are

- A new CIF PLC code generator has been added to the CIF toolset. The new PLC code generator is currently being developed, and should be considered experimental. In due time, it will replace the current stable CIF PLC code generator.
- The CIF code generator can now generate HTML files and JavaScript code. The HTML files allow executing the model in a browser. Both are currently an experimental feature.
- The CIF explorer and the tools from the event-based toolset that output CIF models, now generate CIF models with state annotations. These state annotations indicate the current location of each automaton and the current value of each variable of the input CIF models. The generation of state annotations can be disabled using the tool's new Add state annotations option
- The CIF type checker now warns about certain duplicate state invariants. Furthermore, the CIF type checker now produces improved error messages in case of a mismatch between an argument of a component instantiation and the corresponding parameter of the instantiated component definition.
- The Eclipse ESCET project now deploys 'nightlies', in-development versions of the ESCET website and toolkit. See the nightly website at https://eclipse.dev/escet/nightly/. From the nightly website the nightly releases can be downloaded.

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.

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