IEEE Control Systems Society
Technical Committee on Discrete Event Systems

Newsletter December 2021

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Welcome to the 2021 December issue of the newsletter, also available online at
http://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.

- To **submit a new item**, please use the following website:
  https://www.control.eng.osaka-cu.ac.jp/miscellaneous/css-tc-des/submission
  or email to kai.cai@eng.osaka-cu.ac.jp.
- To **subscribe**, please email to kai.cai@eng.osaka-cu.ac.jp.
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TC virtual meeting at CDC 2021:

- Date/time: December 13 (Monday), UTC 12:30—13:30
- Zoom link:
  https://list-osaka-cu-ac-jp.zoom.us/j/81146424855?pwd=MmZQUHJyUjFoUHdFQllQeUViS0I3UT09
  Meeting ID: 811 4642 4855
  Passcode: 672439
- Tentative program:
  Kai Cai (chair report) 10min
  Anne-Kathrin Schmuck (co-chair report) 10min
  Michel Reniers (co-chair report) 10min
  Xiang Yin (co-chair report) 10min
  Free discussions 20min

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 4, December 2021

- **Counter approach for the estimation of optimal sequences in Partially Observable Untimed Petri Nets**
  Authors: P. Declerck
  Abstract: In this paper, we consider the on-line estimation of optimal current subsequences in Partially Observable Untimed Petri Nets. Applying the counter approach classically used in max-plus algebra for Timed Petri nets, the idea is to exploit the assumption of a non immediate consumption of the tokens for each place which introduces an order of precedence between events. The approach can estimate a global price depending on the costs and gains provided by the tasks. The estimation of optimal sequences is based on the determination of a time horizon necessary to describe the sequences. The estimation is relevant to a step defined by two successive occurrences of observable transition firings. We show that the approach can consider any optimization problem if the dates of the observations are known or, if a guaranteed horizon can be computed which is always possible when the unobservable subnet satisfies a weak assumption close to the structural boundedness (relaxed structurally boundedness). As the technique avoids the generation of sets, the approach does not depend on their cardinalities and is numerically efficient.
- **Failure detection and localization for timed event graphs in (max,+)-algebra**
  Authors: Euriell Le Corronc ; Yannick Pencolé ; Alexandre Sahuguède ; Claire Paya
  Abstract: In this paper, we address the problem of failure detection and localization in a Timed Discrete Event System (TDES) such (max,+)-linear system graphically modeled by a Timed Event Graph (TEG). The considered failures are changes on holding times or tokens of the TEG places that can provoke shifts between an observed outcoming timed flow and an expected outcoming timed flow (for a given incoming timed flow). Indicators are built to first detect such shifts relying on the (max,+) algebraic framework and the residuation theory. An analysis of the indicators values provides information about time or event failure that could have happen. Then, thanks to the knowledge of the behavior of the system through its corresponding TEG, sets of failures that could explain the detected shifts are obtained. It comes from matrices of signatures for each indicator built on each observable output of the system. An example of application is proposed to experiment exhaustively failures of type time and event on each place of the TEG.
- **Comparing the notions of opacity for discrete-event systems**
  Authors: Jiří Balun ; Tomáš Masopust
  Abstract: Opacity is an information flow property characterizing whether a system reveals its secret to a passive observer. Several notions of opacity have been introduced in the literature. We study the notions of language-based opacity, current-state opacity, initial-state opacity, initial-and-final-state opacity, K-step opacity, and infinite-step opacity. Comparing the notions is a natural question that has been investigated and summarized by Wu and Lafortune, who provided transformations among current-state opacity, initial-and-final-state opacity, and language-based opacity, and, for prefix-closed languages, also between language-based opacity and initial-state opacity. We extend these results by showing that all the discussed notions of opacity are transformable to each other. Besides a deeper insight into the differences among the notions, the transformations have applications in complexity results. In particular, the transformations are computable in polynomial time and preserve the number of observable events and determinism, and hence the computational complexities of the verification of the notions coincide. We provide a complete and improved complexity picture of the verification of the discussed notions of opacity, and improve the algorithmic complexity of deciding language-based opacity, infinite-step opacity, and K-step opacity.
- **Behaviour equivalent max-plus automata for timed petri nets under open-loop race-policy semantics**
  Authors: Lukas Triska Balun ; Thomas Moor

Abstract: Timed Petri nets and max-plus automata are well known modelling frameworks for timed discrete-event systems. In this paper we present an iterative procedure that constructs a max-plus automaton from a timed Petri net while retaining the timed behaviour. Regarding the Petri net, we essentially impose three assumptions: (a) the Petri net must be bounded, i.e, the reachability graph must be finite; (b) we interpret the Petri net with single server semantics; and (c) the Petri net operates according to the race policy, i.e., the earliest possible transition will fire and thereby possibly consume tokens required by other competing transitions. Under these assumptions we show that the proposed procedure terminates with a finite deterministic max-plus automaton that realises the same timed behaviour as the Petri net. As a variation of the plain race policy, we also consider that a subsequently designed supervisor may temporarily disable distinguished transitions. Again, we present a terminating procedure that constructs a behaviour equivalent deterministic max-plus automaton. We demonstrate by example how the latter automaton can be utilised as an open-loop model in the context of supervisor control.

- **Formal specification and verification of decentralized self-adaptive systems using symmetric nets**
  Authors: Matteo Camilli ; Lorenzo Capra
  Abstract: Engineering distributed self-adaptive systems is challenging due to multiple interacting components, some of which monitor and possibly modify the behavior of managed components that operate in highly dynamic settings. Formalizing such systems having a decentralized adaptation control has been recognized as a hard task. In this article, we introduce a formal framework based on Symmetric Nets (a well-established subclass of Colored Petri nets) for modeling and analyzing distributed self-adaptive discrete-event systems. Even though Petri Nets represent a sound and expressive formal model of concurrency and distribution, they cannot specify in a natural way structural changes enacted by adaptation procedures. We overcome this limitation by means of a two-layer modeling approach that enables clear separation of concerns and allows multiple decentralized adaptation procedures to be specified, validated, and verified against formal requirements. Validation and verification techniques are supported by powerful off-the-shelf tools tailored to Symmetric Nets. A self-healing manufacturing system case study is used to show applicability, advantages, and shortcomings of the approach. In particular, complexity issues are thoroughly discussed and mitigated by adopting complementary approaches based on interleaving reduction and behavioral symmetries exploitation.
- **Optimal Modular Control of Discrete Event Systems with Distinguishers and Approximations**
  Authors: Robi Malik ; Marcelo Teixeira
  Abstract: This paper proposes algorithms for supervisor synthesis in discrete event system models with distinguishers. Distinguishers are special components responsible to select an enabled event from a group of related refined events. They are a helpful modelling tool, but their use increases the state space and makes supervisor synthesis more difficult. The paper shows how general algorithms for modular or compositional synthesis can be enhanced by considering the special properties of distinguishers. This gives rise to systematic algorithms that compute least restrictive controllable and nonblocking supervisors, while working with only a part of the distinguisher model. A worked case study of a bottling plant demonstrates the efficacy of the approach.

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1.2. IEEE Transactions on Automatic Control

Volume: 66, Issue: 12, December 2021

- **Exposure and Revelation Times as a Measure of Opacity in Timed Stochastic Discrete Event Systems**
  Authors: Dimitri Lefebvre ; Christoforos N. Hadjicostis
  Abstract: Opacity is a security notion that focuses on determining whether a given system's behavior is kept secret to intruders. Various notions of opacity have received significant attention during the last decade including current state opacity and initial state opacity, which have been studied for deterministic and probabilistic systems in untimed contexts. In timed systems, opacity

requirements may vary with time and one could also be interested in knowing the time duration for which opacity requirements are violated or preserved. The main contribution of this article is to introduce and analyze opacity exposure and opacity revelation times as measures of vulnerability in timed discrete event system (DES) that behave according to Markovian dynamics (i.e., at any given time, all enabled events are independent and distributed in time with exponential probability density functions). Labeled stochastic Petri nets (LSPNs) are used to model timed stochastic DESs, and appropriate constructions (involving current and initial state observers) are used to evaluate exposure and revelation times for a given LSPN.

- **Secure Control in Partially Observable Environments to Satisfy LTL Specifications**
  Authors: Bhaskar Ramasubramanian ; Luyao Niu ; Andrew Clark ; Linda Bushnell ; Radha Poovendran
  Abstract: This article studies the synthesis of control policies for an agent that has to satisfy a temporal logic specification in a partially observable environment, in the presence of an adversary. The interaction of the agent (defender) with the adversary is modeled as a partially observable stochastic game. The goal is to generate a defender policy to maximize satisfaction of a given temporal logic specification under any adversary policy. The search for policies is limited to the space of finite-state controllers, which leads to a tractable approach to determine policies. We relate the satisfaction of the specification to reaching (a subset of) recurrent states of a Markov chain. We present an algorithm to determine a set of defender and adversary finite-state controllers of fixed sizes that will satisfy the temporal logic specification and prove that it is sound. We then propose a value-iteration algorithm to maximize the probability of satisfying the temporal logic specification under finite-state controllers of fixed sizes. Finally, we extend this setting to the scenario where the size of the finite-state controller of the defender can be increased to improve the satisfaction probability. We illustrate our approach with an example.

- **Chance-Constrained Multilayered Sampling-Based Path Planning for Temporal Logic-Based Missions**
  Authors: Yoonseon Oh ; Kyunghoon Cho ; Yunho Choi ; Songhwai Oh
  Abstract: This article introduces a robust and safe path planning algorithm in order to satisfy mission requirements specified in linear temporal logic (LTL). When a path is planned to accomplish a mission, it is possible for a robot to fail to complete the mission or collide with obstacles due to noises and disturbances in the system. Hence, we need to find a robust path against possible disturbances. We introduce a robust path planning algorithm, which maximizes the probability of success in accomplishing a given mission by considering disturbances, while minimizing the moving distance of a robot. The proposed method can guarantee the safety of the planned trajectory by incorporating an LTL formula and chance constraints in a hierarchical manner. A high-level planner generates a discrete plan satisfying the mission requirements specified in LTL. A low-level planner builds a sampling-based rapidly exploring random tree search tree to minimize both the mission failure probability and the moving distance while guaranteeing the probability of collision with obstacles to be below a specified threshold. We have analyzed properties of the proposed algorithm theoretically and validated the robustness and safety of paths generated by the algorithm in simulation and experiments using a quadrotor.

- **Intersection-Based Decentralized Supervisory Control of Probabilistic Discrete Event Systems**
  Authors: Weilin Deng ; Daowen Qiu ; Jingkai Yang
  Abstract: In our previous article, we have considered the supervisory control of the probabilistic discrete event systems (PDESs) under the centralized framework. In this article, we continue to investigate the decentralized probabilistic supervisory control issue of PDESs. The intersection-based control architecture is adopted, and the notion of the probabilistic intersection-based coobservability and its verification algorithm are presented. It is shown that this observability and the probabilistic controllability act as the necessary and sufficient conditions for the existence of the intersection-based decentralized probabilistic supervisors. Moreover, a working example is provided to illustrate the proposed concepts, the obtained results, and the potential application of the proposed control approaches.

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1.3. Automatica

Volume: 134, December 2021

- **Greedy initialization for distributed persistent monitoring in network systems**
  Authors: Shirantha Welikala ; Christos G.Cassandras
  Abstract: This paper considers the optimal multi-agent persistent monitoring problem defined for a team of agents on a set of nodes (targets) interconnected according to a fixed network topology. The aim is to control this team so as to minimize a measure of overall node state uncertainty evaluated over a finite time interval. A class of distributed threshold-based parametric controllers has been proposed in prior work to control agent dwell times at nodes and next-node destinations by enforcing thresholds on the respective node states. Under such a Threshold Control Policy (TCP), an on-line gradient technique was used to determine optimal threshold values. However, due to the non-convexity of the problem, this approach often leads to a poor local optima highly dependent on the initial thresholds used. To overcome this initialization challenge, we develop a computationally efficient off-line greedy technique based on the asymptotic analysis of the network system. This analysis is then used to generate a high-performing set of initial thresholds. Extensive numerical results show that such initial thresholds are almost immediately (locally) optimal or quickly lead to optimal values. In all cases, they perform significantly better than the locally optimal solutions known to date.
- **Event-triggered smoothing for hidden Markov models: Risk-sensitive and MMSE results**
  Authors: Meiqi Cheng ; Dawei Shi ; Tongwen Chen
  Abstract: An event-triggered smoothing problem for hidden Markov models (HMMs) is investigated in this paper. The transmission of the measurements is jointly determined by a stochastic event-triggering condition and a GilbertElliott communication channel. Firstly, the event-triggered risk-sensitive smoothed estimate is characterized by constructing an augmented processing of the smoothed information state, which is given by the product of the forward recursive information state and the backward recursive information state under a reference measure. Secondly, the risk-neutral smoothed estimate (namely, the MMSE smoother) is proved to be a special case of the obtained risk-sensitive one when the risk-sensitive parameter approaches zero. The implementation issues of the obtained results are discussed by introducing an alternative smoothing algorithm that is numerically equivalent to the original algorithm. The effectiveness of the proposed results is evaluated through a numerical example and comparative simulations with a naive risk-sensitive smoother that treats unreceived information as packet dropout.
- **Data-driven controller synthesis for abstract systems with regular language specifications**
  Authors: Giordano Pola ; Tommaso Masciulli ; Elena De Santis ; Maria Domenica ; Di Benedetto
  Abstract: In this paper we address data-driven control design with regular language specifications for plants described as abstract systems, i.e. as collections of input-state functions. The abstract system is assumed to be suffix and concatenation closed, causal, deterministic and time-invariant. The system is unknown, apart from a collected finite set of experiments. Given a specification expressed as a regular language defined over an alphabet consisting of a finite set of states of the plant, a controller based on the finite set of experiments is designed, which guarantees that the specification is met up to an arbitrarily small error. Maximality, convergence and adaptivity of the controller as the set of experiments gets bigger are discussed. Controller performance on trajectories of the plant different from those in the set of experiments and in the presence of state measurement errors is analyzed. An example related to the artificial pancreas illustrates the results.

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1.4. IEEE Control Systems Letter
Volume: 5, Issue: 6, December 2021

- **Specifying User Preferences Using Weighted Signal Temporal Logic**
  Authors: Noushin Mehdipour; Cristian-Ioan Vasile; Calin Belta
  Abstract: We extend Signal Temporal Logic (STL) to enable the specification of importance and priorities. The extension, called Weighted STL (wSTL), has the same qualitative (Boolean) semantics as STL, but additionally defines weights associated with Boolean and temporal operators that modulate its quantitative semantics (robustness). We show that the robustness of wSTL can be defined as weighted generalizations of all known compatible robustness functionals (i.e., robustness scores that are recursively defined over formulae) that can take into account the weights in wSTL formulae. We utilize this weighted robustness to distinguish signals with respect to a desired wSTL formula that has subformulae with different importance or priorities and time preferences, and demonstrate its usefulness in problems with conflicting tasks where satisfaction of all tasks cannot be achieved. We also employ wSTL robustness in an optimization framework to synthesize controllers that maximize satisfaction of a specification with user specified preferences.

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1.5. Nonlinear Analysis: Hybrid Systems
Volume: 43, December 2021

- **Symbolic models for infinite networks of control systems: A compositional approach**
  Authors: Siyuan Liu ; Navid Noroozi ; Majid Zamani
  Abstract: This paper presents a compositional framework for the construction of symbolic models for a network composed of a countably infinite number of finite-dimensional discrete-time control subsystems. We refer to such a network as infinite network. The proposed approach is based on the notion of alternating simulation functions. This notion relates a concrete network to its symbolic model with guaranteed mismatch bounds between their output behaviors. We propose a compositional approach to construct a symbolic model for an infinite network, together with an alternating simulation function, by composing symbolic models and alternating simulation functions constructed for subsystems. Assuming that each subsystem is incrementally input-to-state stable and under some small-gain type conditions, we present an algorithm for orderly constructing local symbolic models with properly designed quantization parameters. In this way, the proposed compositional approach can provide us a guideline for constructing an overall symbolic model with any desired approximation accuracy. A compositional controller synthesis scheme is also provided to enforce safety properties on the infinite network in a decentralized fashion. The effectiveness of our result is illustrated through a road traffic network consisting of infinitely many road cells.
- **Usability aware secret protection with minimum cost**
  Authors: Shoma Matsui ; Kai Cai
  Abstract: In this paper we study a cybersecurity problem of protecting systems secrets with multiple protections and a required security level, while minimizing the associated cost due to implementation/maintenance of these protections as well as the affected system usability. The target system is modeled as a discrete-event system (DES) in which there are a subset of marker states denoting the services/functions provided to regular users, a subset of secret states, and multiple subsets of protectable events with different security levels. We first introduce usability-aware cost levels for the protectable events, and then formulate the security problem as to ensure that every system trajectory that reaches a secret state contains a specified number of protectable events with at least a certain security level, and the highest usability-aware cost level of these events is minimum. We first provide a necessary and sufficient condition under which this security problem is solvable, and when this condition holds we propose an algorithm to solve the problem based on the supervisory control theory of DES. Moreover, we extend the problem to the case of heterogeneous secrets with different levels of importance, and develop an algorithm to solve this extended problem. Finally, we demonstrate the effectiveness of our solutions with a network security example.
- **Safe-visor architecture for sandboxing (AI-based) unverified controllers in stochastic**

cyberphysical systems

Authors: Bingzhuo Zhong ; Abolfazl Lavaei ; Hongpeng Cao ; Majid Zamani ; Marco Caccamo

Abstract: High performance but unverified controllers, e.g., artificial intelligence-based (a.k.a. AI-based) controllers, are widely employed in cyberphysical systems (CPSs) to accomplish complex control missions. However, guaranteeing the safety and reliability of CPSs with this kind of controllers is currently very challenging, which is of vital importance in many real-life safety-critical applications. To cope with this difficulty, we propose in this work a Safe-visor architecture for sandboxing unverified controllers in CPSs operating in noisy environments (a.k.a. stochastic CPSs). The proposed architecture contains a history-based supervisor, which checks inputs from the unverified controller and makes a compromise between functionality and safety of the system, and a safety advisor that provides fallback when the unverified controller endangers the safety of the system. Both the history-based supervisor and the safety advisor are designed based on an approximate probabilistic relation between the original system and its finite abstraction. By employing this architecture, we provide formal probabilistic guarantees on preserving the safety specifications expressed by accepting languages of deterministic finite automata (DFA). Meanwhile, the unverified controllers can still be employed in the control loop even though they are not reliable. We demonstrate the effectiveness of our proposed results by applying them to two (physical) case studies.

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

Volume: 51, Issue: 12, December 2021

- **Integrated Scheduling of a Dual-Armed Cluster Tool for Maximizing Steady Schedule Patterns**

  Authors: Woojin Kim ; Tae-Sun Yu ; Tae-Eog Lee

  Abstract: A cluster tool consists of several single-wafer processing chambers and a wafer handling robot. A wafer has to wait within a chamber after being processed there until it is unloaded by the robot. Such wafer delays may cause wafer quality degradation or variability due to residual gases and heat in the chamber. The tool operation schedule has to maintain identical timing patterns or schedules for each cycle so as to keep wafer delays constant for every wafer. However, at the beginning of the tool operation, the tool is in an empty state and hence we need to make the tool reach such steady schedule by loading wafers into the tool. In this article, we develop a method of scheduling the robot tasks during the start-up period of a cluster tool to reach a target steady schedule quickly as possible. To do this, we model the behaviors of a cluster tool using timed Petri nets and linear system matrices in the max-plus algebra. By analyzing the matrices, we first identify a class of steady schedules which can be reached from the empty tool. We develop the matrices that explain the schedule evolution of the start-up period before reaching the steady period. By examining the matrices, we develop a method of choosing the most desirable one from such class of reachable steady schedules that can be achieved in the minimum time. We also prove that the schedule also minimizes the time duration of the close-down. Finally, we present computational experiments.

- **Deadlock Prevention Controller for Automated Manufacturing Systems Modeled by S^4PR**

  Authors: Yanxiang Feng ; Mengchu Zhou ; Feng Tian ; Chao-Bo Yan ; Keyi Xing

  Abstract: This article focuses on the problem of deadlock for sequential automated manufacturing systems (AMSs) that allow for the general resource allocation and flexible routings. A class of Petri nets, systems of sequential systems with shared resources (S^4PR), are used to model these considered AMSs. Our previous work has showed that deadlocks in S^4PR are characterized by saturated perfect activity-circuit (PA-circuit). In this article, we divide all saturable PA-circuits into two categories: 1) dependent and 2) independent. An algorithm is proposed to compute all independent saturable PA-circuits. We prove that by adding a monitor for each independent PA-circuit to ensure that it is not saturated, all dependent PA-circuits cannot be saturated either and deadlocks in S^4PR are successfully prevented. The presented method simplifies the structure of the deadlock controller without imposing tight constraints on the system. Finally, the proposed controller is illustrated by

some examples.

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2 Conferences

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

2.1 **2021 IEEE Conference on Decision and Control (CDC)**
Austin, Texas, USA. December 13-15, 2021
https://cdc2021.ieeecss.org

2.2 **2022 IEEE Conference on Robotics and Automation (ICRA)**
Philadelphia, USA, May 23-27, 2022
https://www.icra2022.org/

2.3 **2022 American Control Conference (ACC)**
Atlanta, Georgia, USA, June 8-10, 2022
https://acc2022.a2c2.org/

2.4 **2022 IEEE Conference on Control Technology and Applications (CCTA)**
Stazione Marittima, Trieste, Italy, August 23-25, 2022
https://acc2022.a2c2.org/

2.5 **2022 International Workshop on Discrete Event Systems (WODES)**
Prague, Czechia, September 7-9, 2022
https://wodes2022.math.cas.cz

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3 Books

3.1 Analysis and Control for Resilience of Discrete Event Systems

Authors: Joao Carlos Basilio, Christoforos N. Hadjicostis and Rong Su

Description: System resilience captures the ability of the system to withstand a major disruption within acceptable performance degradation and to recover within an acceptable time frame. In this monograph we consider two possible sources of major disruptions, i.e., component faults and cyber intrusions. A component fault is an indigenous activity that renders unavailability or inaccessibility of certain functions within a component, either permanently or temporarily. It typically generates safety and performance concerns. Cyber intrusion on the other hand is an exogenous activity that tampers privacy, confidentiality, availability, or integrity of the system. These two sources are not always independent from each other. For example, a cyber intrusion may trigger a component fault, whereas a component fault may open a door for cyber intrusion, e.g., by keeping it undetected. For cyber intrusion, we will focus on opacity, which describes the systems ability to hide certain secrets from an external observer (or eavesdropper), and sensor and actuator attacks that exploit the systems existing controller to generate undesirable behaviours.

In this monograph, we provide a detailed account of most recent research outcomes on fault diagnosis, opacity analysis and enhancement, and cyber security analysis and enforcement, within suitable discrete event system modelling frameworks. In each case, we describe basic problem statements and key concepts, and then point out the key challenges in each research area. After that, we present a thorough review of state-of-the-art techniques, and discuss their advantages and disadvantages. Finally, we highlight key research directions for further exploration.

ISBN: 978-1-68083-856-5
https://www.nowpublishers.com/article/Details/SYS-024

3.2 Introduction to Discrete Event Systems

Authors: Christos Cassandras and Stéphane Lafortune

Description: Christos Cassandras and Stéphane Lafortune are happy to announce the publication of the third edition of their textbook, Introduction to Discrete Event Systems, by Springer in November 2021. The first two editions of this popular textbook were published in 1999 (Kluwer Academic Publishers) and 2008 (Springer), respectively. This unique textbook comprehensively introduces the field of discrete event systems, offering a breadth of coverage that makes the material accessible to readers of varied backgrounds. The book emphasizes a unified modeling framework that transcends specific application areas, linking the following topics in a coherent manner: language and automata theory, supervisory control, Petri net theory, Markov chains and queueing theory, discrete-event simulation, and perturbation analysis and concurrent estimation techniques. The third edition is a superset of the second one, with new material added based on our teaching of discrete event systems courses at Boston University and at the University of Michigan, and they reflect active research trends in discrete event systems since the publication of the second edition.

Topics and features:
- detailed treatment of automata and language theory in the context of discrete event systems, including application to state estimation and diagnosis
- comprehensive coverage of centralized and decentralized supervisory control
- timed models, including timed automata and hybrid automata - stochastic models for discrete event systems and controlled Markov chains
- discrete event simulation - an introduction to stochastic hybrid systems
- sensitivity analysis and optimization of discrete event and hybrid systems
- new in the third edition: opacity properties, enhanced coverage of event diagnosis and of supervisory control under partial observation, overview of latest software tools, updated treatment of Infinitesimal Perturbation Analysis and of concurrent estimation

This proven textbook is essential to students and researchers in a variety of disciplines where the study of discrete event systems is relevant: control, communications, computer engineering, computer science, manufacturing engineering, transportation networks, operations research, and industrial engineering. This book is available through SpringerLink as an e-book (PDF and EPUB formats) or as a print-on-demand hard cover at https://link.springer.com/book/10.1007/978-3-030-72274-6 The e-book is available for free download at Springer subscribing institutions.

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4 Positions

4.1 Post-Doctoral Positions at ACCESS Laboratory

The Autonomous Cooperative Control of Emergent Systems of Systems (ACCESS) Laboratory at NC A&T State University, invites applications for two full-time, post-doctoral research associate positions in the following areas:

1. **Fault Tolerant Control Systems** (Position number: 009736): This position will carry out research on modeling and control of autonomous vehicles under faulty and normal conditions to enhance the safety of vehicles.
Application link: https://jobs.ncat.edu/postings/22884

2. **Formal Methods for Autonomous Systems** (Position Number: 009774): This position will carry out research on Model Checking and Formal Methods for verification and control of autonomous vehicles for Urban Air Mobility (UAM) applications.
Application link: https://jobs.ncat.edu/postings/22885

The applicants are expected to have a strong theoretical and experimental background with evidence of skills related to discrete event systems, formal methods, and their applications to robotic systems. The ideal candidate should have also experience with related software tools for model checking, modeling, and control of robotic systems, as well as good programming skills in Python, C++, and ROS.

These two positions are non-tenure-track, year-to-year appointment, renewable annually for up to two years subjected to satisfactory performance, availability of resources, and the needs of the Lab. The candidate will enjoy a dynamic and collaborative working environment, supporting projects through conducting original research, collaboration with other team members, development external and internal evaluation of reports, facilitating the research meetings within the team, mentoring of students, and technically overseeing projects milestones. The employee will also contribute to additional proposal efforts, thereby strengthening North Carolina A & T State Universitys ability to attract external funding.

If interested, please apply by submitting Cover Letter, Curriculum Vitae, Research Statement, Copy of PhD transcripts via the provided application links and send a copy of your CV to Dr. Karimoddini (akarimod@ncat.edu). Please feel free to contact Dr. Karimoddini (akarimod@ncat.edu) for any questions about these positions. Back to the contents

5 Call for Papers

5.1 Advanced Robotics: Special Issue on Control Technology for Networked and Distributed Robotics

Guest Editors:

- Prof. Masaaki Nagahara (The University of Kitakyushu, Japan)
- Prof. Kai Cai (Osaka City University, Japan)
- Prof. Takeshi Hatanaka (Tokyo Institute of Technology, Japan)
- Prof. Yutaka Hori (Keio University, Japan)
- Prof. Hideaki Ishii (Tokyo Institute of Technology, Japan)

Lead Guest Editor

- Prof. Debasish Chatterjee (Indian Institute of Technology Bombay, India)
- Prof. Nikhil Chopra (The University of Maryland, USA)
- Prof. Daniel E. Quevedo (Queensland University of Technology, Australia)
- Prof. Michel Reniers (Eindhoven University of Technology, Netherlands)

Publication in Vol. 37, Issue 1 (January 2023)

Submission deadline: 28 February 2022

Control technology is one of the fundamental disciplines of robotics. The technology has been developed for more than 100 years and expanded in many research areas. In particular, control technology for networked and distributed robotics has been recently emerging thanks to the development of embedded systems and wireless communications. An example of networked and distributed robotics is a drone light show, which was presented in the opening ceremony of Tokyo Olympic Games 2020, where multiple drones are operated from the main computer located on the ground that controls multiple drones through wireless networks. The purpose of this special issue is to present recent theory and practice of control technology that can be effectively applied to networked and distributed robotics. It aims at collecting a representative body of innovative theoretical contributions that have potential applications to networked and distributed robotics as well as applicative robotics researches that show successful implementation of recent theory of networked and distributed control. Prospective contributed papers are invited to cover, but are not limited to, theoretical and applicative researches on the following topics

- control of multi-agent systems (e.g. consensus control, coverage control, formation)
- networked control systems
- discrete-event systems and hybrid systems
- resource-aware control (e.g. event-triggered control, sparse control)
- secure, resilient, and safe control
- machine learning and data driven methods for networked robotics
- human-in-the-loop and human-machine interaction

The full-length manuscript (either PDF or Microsoft Word file) should be sent to the office of Advanced Robotics, Robotics Society of Japan, through its homepage at: https://www.rsj.or.jp/pub/ar/submission.html. Templates for the manuscript as well as instructions for the Authors are available at the homepage.

Further information will be provided via the following website: (to be opened soon)

5.2 IEEE Control Systems Letters
Fragility and Resiliency in Cyber-Physical Discrete Event Systems

Guest Editors:

- Prof. Christoforos N. Hadjicostis (University of Cyprus, Cyprus)
- Prof. Stéphane Lafortune (University of Michigan, USA)
- Prof. Carla Seatzu (University of Cagliari, Italy)

The proliferation of digital technologies and interconnectivity has led to emergence of cyber-physical systems (CPS) in numerous applications, ranging from automated manufacturing systems and chemical processes to traffic networks and healthcare/information systems. CPS typically involve computation, networking and physical processes, by increasingly deploying sensors and actuators into smart feedback loops that connect the cyber and physical worlds to a multitude of computing and storage devices. These approaches have revolutionized numerous aspects of the scientific and commercial worlds (e.g., smart grids and microgrids, traffic networks, automated or autonomous transportation systems, water networks, etc.), and have led to systems (with discrete, continuous, or hybrid dynamics) of unprecedented interconnectivity. Apart from challenges due to the sheer size, complexity, and distributed nature of CPS, some of the most pressing open questions are issues of fragility and resiliency. Fragility is a term used to characterize situations where cumulative mild abnormalities (e.g., certain combinations of sensor failures, delays/losses in the transmission of sensory information and actuation commands, and/or malicious actions) result in large degradation in system performance or even unacceptable violations of system requirements. Resiliency is the ability of the system to cope with such abnormalities. Fragility analysis and resiliency provision are particularly important in CPS that involve critical infrastructures where human lives may be at risk.

The focus of this special issue is on models that comprise (compositions of) discrete event systems (DES), such as finite automata and Petri nets. In more detail, the goal of the special issue is that of collecting contributions that address fundamental research challenges that directly influence fragility and resiliency, such as losses, delays or malicious manipulations of sensory information or control commands. The primary aspect of any contribution should be novelty and originality. Also, the results should be presented in a mathematical language, according to the L-CSS standard. Specific topics of interest for this special issue include, but are not limited to:

- Cyber-physical DES fragility analysis
- Cyber-physical DES resiliency provision
- Supervisory control
- State estimation
- Detectability analysis
- Detectability analysis
- Opacity verification and enforcement
- Prognosability analysis

Submission Information

- Submission for the special issue start: December 20, 2021
- Submission deadline: January 20, 2022

Submission instructions can be found in the L-CSS website at http://ieee-cssletters.dei.unipd.it/Page_authors.php?p=1

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6 Software Tools

6.1 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.

6.2 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.

6.3 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.

6.4 **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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