# IEEE Control Systems Society
# Technical Committee on Discrete Event Systems

**Newsletter** **November 2021**

Editor: Kai Cai
Chair, IEEE CSS Technical Committee on DES
Professor
Department of Electrical and Information Engineering, Osaka City University
3-3-138 Sugimoto, Sumiyoshi-ku, Osaka 558-8585, Japan

Phone: (+81) 6-6605-2703
Email: kai.cai@eng.osaka-cu.ac.jp
Website: https://www.control.eng.osaka-cu.ac.jp

Welcome to the 2021 November 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.
- To **unsubscribe**, please reply to this email with the subject line UNSUBSCRIBE.

**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. IEEE Transactions on Automatic Control

Volume: 66, Issue: 11, November 2021

- **Supervisory Control of Fair Discrete-Event Systems: A Canonical Temporal Logic Foundation**
  **Authors:** Kiam Tian Seow
  **Abstract:** This paper studies the linear-time temporal logic (LTL) control of a class of fair discrete-event systems (DESs). It is motivated by the curious extent in which the use of LTL can be strengthened and differentiated in control theory development. Over a fair DES model, a marker-progressive supervisory control problem is formulated in LTL. The problem formulation admits a more flexible specification of multiple markers to distinguish different DES tasks, and seeks to find a supervisor-a passive control function by convention for specified temporal safety-such that a fair DES under its control is guaranteed to make constant progress to these markers. The problem is studied in terms of DES marker-controllability-a new controllability concept formulation of temporal safety for constant marker progress. This new formulation sheds light on how event fairness in DESs coachieves such marker progress with supervision that exists. It is shown that a solution supervisor may be found by canonical LTL verification. Three examples are provided for illustration.

- **Closed-Loop Deadlock-Free Supervision for GMECs in Time Petri Net Systems**
  **Authors:** Liang Li ; Francesco Basile ; Zhiwu Li
  **Abstract:** This article investigates the enforcement of generalized mutual exclusion constraints (GMECs) and deadlock-freeness on a time Petri net (TPN) system with uncontrollable transitions, motivated by the fact that the existing methods enforcing GMECs may degrade the performance of a closed-loop system and lead to deadlock states. A supervisor enforcing a set of GMECs and deadlock-freeness on an underlying untimed Petri net system is assumed to be available. By exploiting timing information and mathematical programming, a control function is designed to restrict the firing intervals of transitions such that a TPN system can avoid entering forbidden states. The key idea behind the proposed approach is the online computation of a graph, called reduced modified state class graph (RMSCG), that is an extension of the partial modified state class graph recently introduced by the authors. Based on the RMSCG, an online control synthesis procedure is developed, which can enforce the originally given GMECs and deadlock-freeness in a maximally permissive way.

- **Control Theory Meets POMDPs: A Hybrid Systems Approach**
  **Authors:** Mohamadreza Ahmadi ; Nils Jansen ; Bo Wu ; Ufuk Topcu
  **Abstract:** Partially observable Markov decision processes (POMDPs) provide a modeling framework for a variety of sequential decision making under uncertainty scenarios in artificial intelligence (AI). Since the states are not directly observable in a POMDP, decision making has to be performed based on the output of a Bayesian filter (continuous beliefs); hence, making POMDPs intractable to solve and analyze. To overcome the complexity challenge of POMDPs, we apply techniques from the control theory. Our contributions are fourfold. 1) We begin by casting the problem of analyzing a POMDP into analyzing the behavior of a discrete-time switched system. 2) Then, in order to estimate the reachable belief space of a POMDP, i.e., the set of all possible evolutions given an initial belief distribution over the states and a set of actions and observations, we find overapproximations in terms of sublevel sets of Lyapunov-like functions. 3) Furthermore, in order to verify safety and performance requirements of a given POMDP, we formulate a barrier certificate theorem, wherein we show that if there exists a barrier certificate satisfying a set of inequalities along the solutions to the belief update equation of the POMDP, the safety and performance properties are guaranteed to hold. In both cases 2) and 3), the calculations can be decomposed and solved in parallel. 4) Finally, we show that the conditions we formulate can be computationally implemented as a set of sum-of-squares programs. We illustrate the applicability of our method by addressing two problems in active ad scheduling and machine teaching.

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### 1.2. Automatica

Volume: 133, November 2021

- **Enforcing current-state opacity through shuffle and deletions of event observations**
  **Authors:** Raphael Julio Barcelos ; Joao Carlos Basilio
  **Abstract:** In this paper, we deal with current-state opacity, and propose an Opacity-Enforcer that is able to change, in an appropriate way, the order of observation of event occurrences in the system, and also to delete event observations, so as to mislead the Intruder to never be sure if the current state of the system is a secret state. We then present two necessary and sufficient conditions for the feasibility of current-state opacity enforceability (CSOE), i.e., if a current-state opacity enforcer that shuffles and deletes events can be synthesized for the system, and present an automaton-based verification test for CSOE and an algorithm to build the automaton that realizes the proposed opacity enforcement. We also present a protocol to mitigate the negative effect of opacity enforcement on the capability of a legitimate recipient to accurately estimate the current state of the system in the case when the information is also intended to be sent to some receiver that needs to be aware of the system evolution.
- **On verification of D-detectability for discrete event systems**
  **Authors:** Jiri Balun ; Tomas Masopust
  **Abstract:** Detectability is a state-estimation property asking whether the current and subsequent states of a system can be determined based on observations. To exactly determine the current and subsequent states may be, however, too strict in some applications. Therefore, Shu and Lin relaxed detectability to D-detectability distinguishing only certain pairs of states rather than all states. Four variants of D-detectability were defined: strong (periodic) D-detectability and weak (periodic) D-detectability. Deciding weak (periodic) D-detectability is PSpace-complete, while deciding strong (periodic) detectability or strong D-detectability is polynomial, and we show that it is NL-complete. To the best of our knowledge, it is an open problem whether there exists a polynomial-time algorithm deciding strong periodic D-detectability. We show that deciding strong periodic D-detectability is a PSpace-complete problem, which means that there is no polynomial-time algorithm, unless every problem solvable in polynomial space can be solved in polynomial time. We further show that there is no polynomial-time algorithm even for systems with a single observable event, unless P = NP. Finally, we propose a class of systems for which the problem is tractable.
- **Verification and enforcement of strong infinite- and $k$-step opacity using state recognizers**
  **Authors:** Ziyue Ma ; Xiang Yin ; Zhiwu Li
  **Abstract:** In this paper, we study the verification and enforcement problems of strong infinite-step opacity and $k$-step opacity for partially observed discrete-event systems modeled by finite state automata. Strong infinite-step opacity is a property such that the visit of a secret state cannot be inferred by an intruder at any instance along the entire observation trajectory, while strong $k$-step opacity is a property such that the visit of a secret state cannot be inferred within $k$ steps after the visit. We propose two information structures called an $\infty$-step recognizer and a $k$-step recognizer to verify these two properties. The complexities of our algorithms to verify strong infinite- and $k$-step opacity are $O(2^{(2\cdot|X|)}\cdot|E_o|)$ and $O^{(2(k+2)\cdot|X|}\cdot|E_o|)$, respectively, which are lower than that of existing methods in the literature ($|X|$ and $|E_o|$ are the numbers of states and observable events in a plant, respectively). We also derive an upper bound for the value of $k$ in strong $k$-step opacity, and propose an effective algorithm to determine the maximal value of $k$ for a given plant. Finally, we note that enforcement of strong infinite- and $k$-step opacity can be transformed into a language specification enforcement problem and hence be solved using supervisory control.

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### 1.3. IEEE Transactions on Automation Science and Engineering

Volume: 18, Issue: 4, November 2021

- **Robust Deadlock Detection and Control of Automated Manufacturing Systems With Multiple Unreliable Resources Using Petri Nets**

  **Authors:** Nan Du ; Hesuan Hu

  **Abstract:** In recent years, the research on robust deadlock control has become increasingly popular in automated manufacturing systems (AMSs) because resource failures may lead any system to stagnation, e.g., deadlock. In this article, we study robust supervisory control issues in AMSs with multiple unreliable resources. Petri nets are used to model the considered AMSs that allow multi-quantity and multi-type of resource acquisitions. A set of integer linear programming formulations are introduced to detect a class of deadlocks that have the maximal number of dead transitions. By analysis, a deadlock is characterized by a saturated circuit, which only consists of a set of unmarked resources and a set of critical transitions. Based on the circuit, a linear marking constraint is developed to prevent such circuits from being saturated. A control place (monitor) with its control variable is thus designed for the constraint to prevent the deadlock from appearing even if some resource failures occur. Therefore, we can synthesize a robust deadlock supervisor, which can guarantee that the controlled system can implement the continual operations even if some unreliable resources fail. Finally, the theoretical analysis and comparative study are provided to elucidate the effectiveness and efficiency of our proposed method.

  **Note to Practitioners:** In practice, resource failures in automated manufacturing systems (AMSs) are common. Deadlock prevention control in AMSs allowing resource failures has gained more and more attention from researchers and practitioners. Most prior research is based on the enumeration of either siphons or perfect resource transition circuits whose number exponentially increases with the system scale. This means that the synthesized supervisor has a much complex structure. In this article, based on a special kind of circuits at a deadlock marking detected by using a set of mathematical formulations, we develop an effective and efficient method for AMSs with multiple unreliable resources to iteratively control deadlocks such that the controlled system can continue to operate smoothly even if some unreliable resources fail. The computational and comparative results show that our proposed approach can acquire more permissive states with a simpler supervisor.

- **Partially Observable Markov Decision Process for Monitoring Multilayer Wafer Fabrication**

  **Authors:** Marzieh Khakifirooz ; Mahdi Fathi ; Chen-Fu Chien

  **Abstract:** The properties of a learning-based system are particularly relevant to the process study of the unknown behavior of a system or environment. In the semiconductor industry, there is regularly a partially observable system in which the entire state of the process is not directly or fully visible due to uncertainties or disturbances. The model for studying such a system that permits uncertainties regarding the stochastic (Markov) process for state information acquisition is called a partially observable Markov decision process (POMDP). This study aims to deal with the optimization issue of compensation control bias of a dynamic multilayer lithography process in wafer fabrication with prior information, the existence of high-dimensionality, and unmeasurable uncertainties. We show how the POMDP on a linear state-space model with uncertainties can encode the information from past runs and layers, and deal with accumulated overlay error at the current run and layer. The Gibbs sampling is applied to optimize the belief function of POMDP optimization approach.

  **Note to Practitioners:** The multilayer overlay error of the photolithography process is one of the remarkable and challenging issues in wafer fabrication. In a multilevel manufacturing process, errors occur at each level, which would be accumulated in the upstream operations. The optimization objective will be even more critical in a high-mixed fabrication process. In this study, the learning-based control system emerged with the state-space model compensates the multilayer overlay error. The Gibbs sampling as a Bayesian approach as a core structure of optimization algorithm is utilized, which can be updated with information from engineering's domain knowledge or estimated information about previous runs. The robustness of the proposed optimization algorithm is shown by comparing the distribution of overlay error with conventional methods and with a fast

convergence rate of the learning algorithm.

- **Discrete Component Prognosis for Hybrid Systems Under Intermittent Faults**
  **Authors:** Chenyu Xiao ; Ming Yu ; Bin Zhang ; Hai Wang ; Canghua Jiang
  **Abstract:** Prognosis of discrete component with intermittent fault in hybrid systems is challenging since the component has only two states (i.e., ON and OFF) and no associated physical parameter in the model can quantify the degradation. This article aims to solve the discrete component prognosis problem under the model-based paradigm. First, the fault detection and isolation module help find the possible faulty discrete components. Based on the isolated possible faulty discrete components, Levy flight biogeography-based optimization is proposed to identify the faulty discrete component states, as well as the fault appearing and fault disappearing instants. Second, a Weibull function-based degradation model which can capture the duration evolution of intermittent fault of discrete component in observation window (OW) is developed using coordinate reconstruction approach, and the degradation model coefficients can be calculated from the fault identification results. After that, the concept of failure threshold for faulty discrete component is defined based on the ratio of fault duration to OW, which enables the prognosis of intermittent fault in discrete component. Finally, the proposed methodologies are validated by experiment results.
  **Note to Practitioners:** This article is motivated by the intermittent fault prognosis problem of discrete components (e.g., relays and hydraulic valves) in hybrid systems. Existing fault prognosis researches do not consider discrete component which is an important part of hybrid systems. For the intermittent fault prognosis of discrete component, the observation window (OW) concept and coordinate reconstruction (CR) method are proposed to establish the degradation model, and the ratio of fault duration to OW is used to define the failure threshold of discrete component. To show the effectiveness of the proposed methods, an application on a hybrid circuit system is considered. It is noted that the degradation pattern (e.g., increase of frequency or duration of intermittent fault) of discrete components may vary in different systems, while the degradation process can be quantified by the OW and CR methods developed in this article, which enables the prognosis of intermittent fault in discrete component for various hybrid industrial systems. The proposed approach can be applied to industrial hybrid systems if the following conditions are satisfied: 1) the hybrid bond graph model of the monitored system can be established, based on which the fault detection and isolation can be implemented and 2) the monitored system contains multiple discrete components suffering from intermittent faults whose appearing and disappearing instants can be identified by certain method.

- **Reducing Wafer Delay Time by Robot Idle Time Regulation for Single-Arm Cluster Tools**
  **Authors:** WenQing Xiong ; ChunRong Pan ; Yan Qiao ; NaiQi Wu ; MingXin Chen ; PinHui Hsieh
  **Abstract:** Nowadays, wafer fabrication in semiconductor manufacturing is highly dependent on cluster tools. A cluster tool is equipped with several process modules (PMs) and a wafer handling robot. When the tool is operating, generally each PM is processing a wafer, and the robot is responsible for delivering the wafers from one PM to another. Thus, when a wafer is completed in a PM, the robot may be busy for performing other tasks such that it cannot immediately unload the completed wafer in the PM, resulting in that the wafer has to stay there for some extra time. The processing time of a wafer together with its delay time for waiting for the robot's arrival for unloading is defined as wafer residency time in a PM. However, a long wafer delay time may deteriorate its quality. Therefore, it is highly desired and important to reduce the wafer delay time at each step as much as possible. This work aims to tackle this important issue for single-arm cluster tools (SACTs). Specifically, by using a Petri net model, this work analyzes the steady-state operational behavior of an SACT under the backward and earliest starting strategies. It is found that there must exist wafer delay time at the steps in the upstream of the bottleneck step, and such wafer delay time can be reduced by properly adjusting the robot waiting time. Thus, three algorithms are developed to reduce the wafer delay time at each step as much as possible by properly assigning the robot idle time. Finally, the application of the proposed method is illustrated by using examples.

**Note to Practitioners:** In a modern semiconductor fab, there are hundreds of cluster tools for wafer fabrication. To ensure wafer quality, it is important to reduce the wafer delay time in PMs of cluster tools after a wafer is processed since the high temperature, chemical gas, and particles in the PMs may damage the wafer. To do so, this work proposes three algorithms with polynomial complexity to assign the robot idle time as robot waiting time such that the wafer delay time in PMs can be reduced as much as possible. Furthermore, the obtained schedule by these algorithms is optimal in terms of the cycle time. Besides, the developed algorithms can be easily embedded into the controller of cluster tools by facility engineers. Therefore, this work has a practical value.

- **AB&B: An Anytime Branch and Bound Algorithm for Scheduling of Deadlock-Prone Flexible Manufacturing Systems**
  **Authors:** Jianchao Luo ; Mengchu Zhou ; Jun-Qiang Wang
  **Abstract:** This work investigates a scheduling problem of deadlock-prone flexible manufacturing systems modeled by place-timed Petri nets. It proposes an anytime branch and bound (AB&B) algorithm for it to minimize system makespan based on the branch tree of a net model and a highly permissive deadlock controller. The proposed algorithm searches a sequence of transitions in the branch tree that evolves the model from the initial marking to the final one. In order to prune the branch tree and increase search speed, this work develops two pruning rules, a lower bound of makespan, and a novel branching strategy. Their usage ensures AB&B's high search efficiency. Experimental results demonstrate that the proposed algorithm surpasses the state-of-the-art ones.
  **Note to Practitioners:** In practice, scheduling is one of the most important issues for production managers to address. Existing approaches to deadlock-prone flexible manufacturing system (FMS) scheduling have multiparameters. Their settings can impact the scheduling results greatly. Since their turning is a challenging task, it is difficult to find the best parameter settings. This article proposes an anytime branch and bound (AB&B) algorithm for minimizing the makespan of deadlock-prone FMSs. It has only one parameter, i.e., maximal CPU time, which needs no turning. When it is highly tight, AB&B can output a feasible and decent schedule. If it is larger and larger, AB&B can output a better and better schedule. Comparison studies show that AB&B outclasses existing ones significantly. It is suitable for real-time scheduling cases in which satisfied schedules must be offered in a very short time.

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### 1.4. Nonlinear Analysis: Hybrid Systems

Volume: 42, November 2021

- **Analysis of strong and strong periodic detectability of bounded labeled Petri nets**
  **Authors:** Hao Lana ; Yin Tong ; Carla Seatzu
  **Abstract:** Detectability describes the property of a system to uniquely determine, after a finite number of observations, the current and the subsequent states. Different notions of detectability have been proposed in the literature. In this paper, we formalize and analyze strong detectability and strong periodic detectability for systems that are modeled as labeled Petri nets with partial observation on their transitions. We provide three new approaches for the verification of such detectability properties using three different structures. The computational complexity of the proposed approaches is analyzed and the three methods are compared. The main feature of all the three approaches is that they do not require the calculation of the entire reachability space or the construction of an observer. As a result, they have lower computational complexity than other methods in the literature.

- **Verification of approximate opacity for switched systems: A compositional approach**
  **Authors:** Siyuan Liu ; Abdalla Swikir ; Majid Zamani
  **Abstract:** The security in information-flow has become a major concern for cyber-physical systems (CPSs). In this work, we focus on the analysis of an information-flow security property, called opacity. Opacity characterizes the plausible deniability of a system's secret in the presence of a malicious outside intruder. We propose a methodology of checking a notion of opacity, called approximate opacity, for networks of discrete-time switched systems. Our framework relies on compositional constructions of finite abstractions for networks of switched systems and their ap-

proximate opacity-preserving simulation functions. Those functions characterize how close concrete networks and their finite abstractions are in terms of the satisfaction of approximate opacity. We show that such simulation functions can be obtained compositionally by assuming some small-gain type conditions and composing local simulation functions constructed for each switched subsystem separately. Additionally, assuming certain stability property of switched systems, we also provide a technique on constructing their finite abstractions together with the corresponding local simulation functions. Finally, we illustrate the effectiveness of our results through an example.

- **Modelling framework for artificial hybrid dynamical systems**
  **Authors:** Stefanie Winkler ; Andreas KÃűrner ; Felix Breitenecker
  **Abstract:** Many current industry branches use hybrid approaches to solve complex application problems. Over the last decades, different tools for the simulation of such hybrid systems (e.g. Hysdel and YAMLIP) as well as the identification of hybrid systems (e.g. HIT, MLP and OAF NN) have been developed. The framework presented in this work facilitates the integration of artificial feed-forward neural networks in the modelling process of hybrid dynamical systems (HDS). Additionally, the framework provides a structured language for characterising these feed-forward networks itself. Therefore, an interdisciplinary exchange in the field of neural networks and its integration into hybrid dynamical systems is enabled. Focusing on hybrid systems with autonomous events, two different approaches, namely the artificial hybrid model and the artificial hybrid dynamics, are introduced. Challenges of the modelling process of HDS are reflected and advantages as well as disadvantages are discussed. The case study includes two common examples of HDS and analyses the simulation results and examines limitations of the modelling framework.
- **Three kinds of coprognosability for partially-observed discrete event systems via a matrix approach**
  **Authors:** Yingrui Zhou ; Zengqiang Chen ; Zhongxin Liu ; Zhipeng Zhang
  **Abstract:** Due to the important application in security and safety analysis, fault prognosis of discrete event systems (DESs) plays a more vital role in study of Cyber-physical systems. In this work, we study the problem of decentralized fault prognosis in the context of partially-observed DESs. Different from existing results, we establish algebraic structures of given systems under decentralized agents by semi-tensor product rather than observers or verifiers based on formal language methods. The structure matrices of decentralized partially-observed DESs are polynomial in the size of a given system and linear about the number of agents. Besides, combining the formal method and algebraic state space approach, we discuss three kinds of coprognosability, called (M,K)-disjunctive-coprognosability aiming at disjunctive architectures, (M,K)-conjunctive-coprognosability for conjunctive architectures and (M,K)-strongly-coprognosability focusing on general structures, respectively. Here, (M,K) is the performance bound of a given prognostic system. In order to take both fault prediction and isolation into consideration, the decentralized prognoser is required to issue the “j" alarm for the jth type of fault and “0" means no fault alarm. Meanwhile, we propose a polynomial-time algorithm to verify each kind of coprognosability based on the structure matrix approach and show that each verification is not separate.
- **Falsification of hybrid systems with symbolic reachability analysis and trajectory splicing**
  **Authors:** Sergiy Bogomolov ; Goran Frehse ; Amit Gurung ; Dongxu Li ; Georg Martius ; Rajarshi Ray
  **Abstract:** The falsification of a hybrid system aims at finding trajectories that violate a given safety property. This is a challenging problem, and the practical applicability of current falsification algorithms still suffers from their high time complexity. In contrast to falsification, verification algorithms aim at providing guarantees that no such trajectories exist. Recent symbolic reachability techniques are capable of efficiently computing linear constraints that enclose all trajectories of the system with reasonable precision. In this paper, we leverage the power of symbolic reachability algorithms to improve the scalability of falsification techniques. Recent approaches to falsification reduce the problem to a nonlinear optimization problem. We propose to reduce the search space of the optimization problem by adding linear state constraints obtained with a reachability algorithm. An empirical study of how varying abstractions during symbolic reachability analysis affect the

performance of solving a falsification problem is presented. In addition, for solving a falsification problem, we propose an alternating minimization algorithm that solves a linear programming problem and a non-linear programming problem in alternation finitely many times. We showcase the efficacy of our algorithms on a number of standard hybrid systems benchmarks demonstrating the performance increase and number of falsifyable instances.

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

Volume: 51, Issue: 11, November 2021

- **Closing-Down Optimization for Single-Arm Cluster Tools Subject to Wafer Residency Time Constraints**

  **Authors:** Yan Qiao ; Mengchu Zhou ; Naiqi Wu ; Zhiwu Li ; Qinghua Zhu

  **Abstract:** A kind of facilities for wafer fabrication, cluster tools (CTs) need to close down to an idle state from time to time because of periodical maintenance and switches from one type of lots to another, which is called a normal close-down process (NCDP). It is crucial to optimize such a transient process since it tends to occur more and more frequently due to customization. Also, process modules (PMs) in CTs are known to be failure-prone. Once a PM failure occurs, a tool needs to close down to an idle state as well, which is different from NCDP and is called a failure close-down process (FCDP). With wafer residency time constraints (WRTCs) being imposed, close-down process optimization for such a tool is challenging, since one needs to not only finish this process as soon as possible but also meet WRTCs during this transient process. In order to tackle this problem, this article first introduces steady state scheduling problems. Then, with a presented backward robot task sequence, a linear programming model is first proposed to optimize NCDP. To deal with the PM failures, efficient PM failure response policies are formulated for the cases in which a PM fails. Then, four linear programs are proposed to optimize an FCDP. Finally, industrial case studies are given to show the usefulness of the proposed approaches.

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## 2 Conferences

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

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

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

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

2.4 **2022 International Workshop on Discrete Event Systems**
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 systemâĂŹs ability to hide certain secrets from an external observer (or eavesdropper), and sensor and actuator attacks that exploit the systemâĂŹs 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

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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 projectsâĂŹ milestones. The employee will also contribute to additional proposal efforts, thereby strengthening North Carolina A & T State UniversityâĂŹs 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. StÃľphane 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 âĂIJsmartâĂİ 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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