

IEEE CONTROL SYSTEMS SOCIETY TECHNICAL COMMITTEE ON DISCRETE EVENT SYSTEMS

Newsletter..... July 2018

Editor: Hai Lin

Chair, IEEE CSS Technical Committee on DES

Associate Professor

Distributed Cooperative Systems Research (DISCOVER) Lab

Department of Electrical Engineering

University of Notre Dame

Notre Dame, IN 46556, USA

Phone: (+1) 574-631-3177

Fax: (+1) 574-631-4393

e-mail: [hlin1@nd.edu](mailto:hlin1@nd.edu)

Website: <http://www3.nd.edu/~hlin1/>

It is the responsibility of the contributor to ensure that they have the necessary permissions/clearance required for the transmittal of their news item.

---

Contents:

1. Editorial

2. Recent Activities of the CSS

2.1 Sponsored Activities

2.2 Technically Co-Sponsored activities

3. Journals

3.1 Selections from the IEEE Transactions on Automatic Control Volume: 63, Issue: 7, July 2018

3.2 Selections from Automatica Volume: 93, July 2018

3.3 Selections from the IEEE Transactions on Automation Science and Engineering Volume: 15, Issue: 3, July 2018

3.4 Selections from the IEEE Transactions on Systems, Man, and Cybernetics: Systems Volume: 48, Issue: 7, July 2018

---

Editorial

---

Welcome to the newsletter of the IEEE Control Systems Technical Committee on Discrete Event

Systems!

---

Activities

---

2.1 Sponsored Activities

=====  
=====

2018 American Control Conference  
Milwaukee, Wisconsin, United States, June 27–29, 2018  
<http://acc2018.a2c2.org/>

2018 Conference on Control Technology and Applications  
Copenhagen, Denmark, August 21-24, 2018  
<http://ccta2018.ieeecss.org/>

2018 Conference on Decision and Control  
Miami Beach, FL, USA, December 17-19, 2018  
<https://cdc2018.ieeecss.org/>

2.2 Technically Co-Sponsored activities

=====  
=====

2018 SICE International Symposium on Control Systems  
Tokyo, Japan, March 9-11, 2018  
<http://iscs2018.sice-ctrl.jp/>

The 14th Workshop on Discrete Event Systems  
Sorrento Coast, Italy, May 30 - June 1, 2018  
<http://wodes2018.unisa.it/>

30th Chinese Control and Decision Conference (2018 CCDC)  
Shenyang, China, June 9-11, 2018  
<http://www.ccdc.neu.edu.cn/>

2018 International Conference on Unmanned Aircraft Systems

Dallas, TX, USA, June 12-15, 2018

<http://www.uasconferences.com/>

37th Chinese Control Conference (CCC2018)

Wuhan, China, July 25-27, 2018

<http://ccc2018.cug.edu.cn/>

23rd International Conference on Methods and Models in Automation and Robotics

Międzyzdroje, Poland, August 27-30, 2018

<http://mmar.edu.pl/>

22nd International Conference on System Theory, Control and Computing

Sinaia, Romania, October 10-12, 2018

<http://www.icstcc.ugal.ro/2018/>

-----  
-

#### Selections of Journal Publications

-----  
-

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

=====  
=====

SELECTIONS OF THE IEEE TRANSACTIONS ON AUTOMATIC CONTROL

VOLUME: 63 ISSUE: 7

July 2018

(1) Bisimulation Equivalence of Discrete-Time Stochastic Linear Control Systems

Author: Giordano Pola ; Costanzo Manes ; Arjan J. van der Schaft ; Maria Domenica Di Benedetto

Abstract

In this paper, we propose a definition of equivalence via stochastic bisimulation for the class of discrete-time stochastic linear control systems with possibly degenerate normally distributed disturbances. The notion is inspired by the notion of probabilistic bisimulation for probabilistic chains. Geometric necessary and sufficient conditions for checking this notion are derived. Model reduction via Kalman-like decomposition is also proposed. Connections with stochastic

reachability are discussed and with finite horizon stochastic safety problems established. A discussion on the use of stochastic bisimulation equivalence for control design is given, and an application to optimal control problems with stochastic reachability specifications is finally presented.

Full-text available at: <https://ieeexplore.ieee.org/document/8062782/>

## (2) Liveness-Enforcing Supervision in AMS-Oriented HAMGs: An Approach Based on New Characterization of Siphons Using Petri Nets

Author: Chen Chen ; Hesuan Hu

### Abstract

In the context of automated manufacturing systems, flexibility and synchronization are two main representative formations. Supervisory control techniques for flexibility have gained increasing attention, but those for synchronization operations have received little notice. Based on their comparison, our work makes threefold contributions. First, we propose a novel characterization of siphons, i.e., type I and type II, based on a special kind of Petri nets, namely, hierarchical augmented marked graphs (HAMGs), which integrate multilevel synchronization into a system. This characterization of siphons is further proved to be a crucial and essential description for both synchronization and flexibility. Second, event circular-wait is proposed to describe the occurrence of deadlocks in HAMGs. Its counterpart is resource circular-wait in flexibility. Ours is a more general and accurate characterization of deadlocks. The liveness of HAMGs can be attributed to the absence of undermarked siphons. Third, a unified liveness-enforcing supervisory control is established based on new characterization of siphons with the aid of generalized mutual exclusion constraints. Supervisor simplification based on inequality analysis is provided for structure simplicity. An experimental study illustrates the correctness of such characterization and the effectiveness of our proposed control method.

Full-text available at: <https://ieeexplore.ieee.org/document/8055595/>

## (3) Robust Controllability of Switched Asynchronous Sequential Machines

Author: Jung-Min Yang

### Abstract

This paper investigates robust controllability of switched asynchronous sequential machines (ASMs) with permanent faults. A switched ASM can change its mode through a number of submachines in an asynchronous mechanism. The main objective is to develop a condition for the corrective control scheme that makes the closed-loop system robust against permanent

faults while matching its stable-state behavior to that of a reference model. The reachability degradation of the switched ASM caused by faults is described in terms of a matrix expression. In the proposed methodology, each submachine serves as a structural redundancy of the switched ASM allowing robust corrective control of the closed-loop system.

Full-text available at: <https://ieeexplore.ieee.org/document/8047981/>

#### (4) Robot Planning Based on Boolean Specifications Using Petri Net Models

Author: Cristian Mahulea ; Marius Kloetzer

##### Abstract

In this paper, we propose an automated method for planning a team of mobile robots such that a Boolean-based mission is accomplished. The task consists of logical requirements over some regions of interest for the agents' trajectories and for their final states. In other words, we allow combinatorial specifications defining desired final states whose attainment includes visits to, avoidance of, and ending in certain regions. The path planning approach should select such final states that optimize a certain global cost function. In particular, we consider minimum expected traveling distance of the team and reduce congestions. A Petri net (PN) with outputs models the movement capabilities of the team and the regions of interest. The imposed specification is translated to a set of linear restrictions for some binary variables, the robot movement capabilities are formulated as linear constraints on PN markings, and the evaluations of the binary variables are linked with PN markings via linear inequalities. This allows us to solve an integer linear programming problem whose solution yields robotic trajectories satisfying the task.

Full-text available at: <https://ieeexplore.ieee.org/document/8062807/>

#### (5) Distributed Subgradient Method With Edge-Based Event-Triggered Communication

Author: Yuichi Kajiyama ; Naoki Hayashi ; Shigemasa Takai

##### Abstract

This paper proposes a distributed subgradient method for constrained optimization with event-triggered communications. In the proposed method, each agent has an estimate of an optimal solution as a state and iteratively updates it by a consensus-based subgradient algorithm with a projection to a common constraint set. The local communications are carried out by the edge-based triggering mechanism when the difference between the current state and the last triggered state exceeds a threshold. We show that the states of all agents asymptotically converge to one of the optimal solutions under a diminishing and summability condition on a

stepsize and a threshold for a trigger condition. We also investigate the convergence rate with respect to the time-averaged state of each agent. The simulation results show that the proposed event-triggered algorithm can reduce the number of communications compared to the time-triggered algorithms.

Full-text available at: <https://ieeexplore.ieee.org/document/8278147/>

## (6) Invariance Control Synthesis for Switched Nonlinear Systems: An Interval Analysis Approach

Author: Yinan Li ; Jun Liu

### Abstract

This note proposes an interval analysis approach to invariance control synthesis for switched nonlinear systems without assuming that the subsystems are stable or have common equilibrium points. Partition-based controllers are extracted via iterative computation of controlled invariant sets based on an interval branch-and-bound scheme. This method is guaranteed to be finitely determined and complete, provided that the switched system satisfies a robustly controlled invariance condition. Two examples drawn from practical applications are provided to show the effectiveness and efficiency of the proposed method.

Full-text available at: <https://ieeexplore.ieee.org/document/8062786/>

=====  
=====

=====  
=====

SELECTIONS OF AUTOMATICA

VOLUME: 93

July 2018

## (1) Enforcement of opacity by public and private insertion functions

Author: Yiding Ji ; Yi-Chin Wu ; Stéphane Lafortune

### Abstract

We study the enforcement of opacity, an information-flow security property, using insertion functions that insert fictitious events at the output of the system. The intruder is characterized as a passive external observer whose malicious goal is to infer system secrets from observed traces of system events. We consider the problems of enforcing opacity under the assumption that the intruder either knows or does not know the structure of the insertion function; we term

this requirement as public–private enforceability. The case of private enforceability alone, where the intruder does not know the form of the insertion function, is solved in our prior work. In this paper, we address the stronger requirement of public–private enforceability, that requires opacity be preserved even if the intruder knows or discovers the structure of the insertion function. We formulate the concept of public–private enforceability by defining the notion of public safety. This leads to the notion of public–private enforcing (PP-enforcing) insertion functions. We then identify a necessary and sufficient condition for an insertion function to be PP-enforcing. We further show that if opacity is privately enforceable by the insertion mechanism, then it is also public–private enforceable. Using these results, we present a new algorithm to synthesize PP-enforcing insertion functions by a greedy-maximal strategy. This algorithm is the first of its kind to guarantee opacity when insertion functions are made public or discovered by the intruder.

Full-text available at: <https://www.sciencedirect.com/science/article/pii/S0005109818301286>

## (2) Complexity of deciding detectability in discrete event systems

Author: Tomáš Masopust

### Abstract

Detectability of discrete event systems (DESs) is a question whether the current and subsequent states can be determined based on observations. Shu and Lin designed a polynomial-time algorithm to check strong (periodic) detectability and an exponential-time (polynomial-space) algorithm to check weak (periodic) detectability. Zhang showed that checking weak (periodic) detectability is PSpace-complete. This intractable complexity opens a question whether there are structurally simpler DESs for which the problem is tractable. In this paper, we show that it is not the case by considering DESs represented as deterministic finite automata without non-trivial cycles, which are structurally the simplest deadlock-free DESs. We show that even for such very simple DESs, checking weak (periodic) detectability remains intractable. On the contrary, we show that strong (periodic) detectability of DESs can be efficiently verified on a parallel computer.

Full-text available at: <https://www.sciencedirect.com/science/article/pii/S0005109818301730>

## (3) Guaranteed model-based fault detection in cyber–physical systems: A model invalidation approach

Author: Farshad Harirchi ; Necmiye Ozay

### Abstract

This paper presents a sound and complete fault detection approach for cyber–physical systems represented by hidden-mode switched affine models with time varying parametric uncertainty. The fault detection approach builds upon techniques from model invalidation. In particular, a set-membership approach is taken where the noisy input–output data is compared to the set of behaviors of a nominal model. As we show, this set-membership check can be reduced to the feasibility of a mixed-integer linear programming (MILP) problem, which can be solved efficiently by leveraging the state-of-the-art MILP solvers. In the second part of the paper, given a system model and a fault model, the concept of -detectability is introduced. If a pair of system and fault models satisfies -detectability property for a finite , this allows the model invalidation algorithm to be implemented in a receding horizon manner, without compromising detection guarantees. In addition, the concept of weak-detectability is introduced which extends the proposed approach to a more expressive class of fault models that capture language constraints on the mode sequences. Finally, the efficiency of the approach is illustrated with numerical examples motivated by smart building radiant systems.

Full-text available at: <https://www.sciencedirect.com/science/article/pii/S0005109818301274>

(4) Coupling based estimation approaches for the average reward performance potential in Markov chains

Author: Yanjie Li ; Xinyu Wu ; Yunjiang Lou ; Haoyao Chen ; Jiangang Li

Abstract

Performance potential is an important concept in the sensitivity analysis of Markov chains. The estimation of performance potential provides the basis for the simulation-based optimization and sensitivity analysis of Markov chains. In this study, we present novel estimation approaches for the average reward (or cost) performance potential by combining perturbation realization factors and coupling techniques for Markov chains with finite state space. These approaches can effectively implement estimation with geometric variance reduction for average reward performance potential. Meanwhile, a number of coupling methods, including two optimal coupling methods, can be applied to further reduce estimation variance or simulation time. The numerical tests show that our approaches can significantly enhance the simulation efficiency

Full-text available at: <https://www.sciencedirect.com/science/article/pii/S0005109818300980>

(5) A distributed Kalman filter with event-triggered communication and guaranteed stability

Author: Giorgio Battistelli ; Luigi Chisci ; Daniela Selvi

Abstract



The paper addresses Kalman filtering over a peer-to-peer sensor network with a careful eye towards data transmission scheduling for reduced communication bandwidth and, consequently, enhanced energy efficiency and prolonged network lifetime. A novel consensus Kalman filter algorithm with event-triggered communication is developed by enforcing each node to transmit its local information to the neighbors only when this is considered as particularly significant for estimation purposes, in the sense that it notably deviates from the information that can be predicted from the last transmitted one. Further, it is proved how the filter guarantees stability (mean-square boundedness of the estimation error in each node) under network connectivity and system collective observability. Finally, numerical simulations are provided to demonstrate practical effectiveness of the distributed filter for trading off estimation performance versus transmission rate.

Full-text available at: <https://www.sciencedirect.com/science/article/pii/S0005109818300852>

=====

=====

SELECTIONS OF IEEE Transactions on Automation Science and Engineering

VOLUME: 15 ISSUE: 3

July 2018

(1) Discovering Petri Net Models of Discrete-Event Processes by Computing T-Invariants

Author: Tonatiuh Tapia-Flores ; Ernesto López-Mellado ; Ana Paula Estrada-Vargas ; Jean-Jacques Lesage

Abstract

This paper addresses the problem of discovering a Petri Net (PN) from a long event sequence representing the behavior of discrete-event processes. A method for building a 1-bounded PN able to execute the events sequence is presented; it is based on determining causality and concurrence relations between events and computing the t-invariants. This novel method determines the structure and the initial marking of an ordinary PN, which reproduces the behavior in S. The algorithms derived from the method are efficient and have been implemented and tested on numerous examples of diverse complexity.

Full-text available at: <https://ieeexplore.ieee.org/document/7930508/>

(2) Exploiting Distinguishers in Local Modular Control of Discrete-Event Systems

Author: Marcelo Teixeira ; José E. R. Cury ; Max H. de Queiroz

## Abstract

Local modular control (LMC) is an approach to the supervisory control theory (SCT) of discrete-event systems that exploits the modularity of plant and specifications. Recently, distinguishers and approximations have been associated with SCT to simplify modeling and reduce synthesis effort. This paper shows how advantages from LMC, distinguishers, and approximations can be combined. Sufficient conditions are presented to guarantee that local supervisors computed by our approach lead to the same global closed-loop behavior as the solution obtained with the original LMC, in which the modeling is entirely handled without distinguishers. A further contribution presents a modular way to design distinguishers and a straightforward way to construct approximations to be used in local synthesis. An example of manufacturing system illustrates our approach.

Full-text available at: <https://ieeexplore.ieee.org/document/8286848/>

## (3) Analytical Approach to Estimate Efficiency of Series Machines in Production Lines

Author: Chao-Bo Yan ; Qianchuan Zhao

## Abstract

Series machines, i.e., machines (which are usually unreliable) arranged in series with no buffering, are pervasive in production systems. In the analysis, design, and optimization of the series-machine system, the efficiency analysis is one of the most fundamental issues. There are not a lot of researches analyzing the efficiency of the series-machine system, and almost all of them assume that the system operates under type-I failure mechanisms (i.e., the breakdown of a machine could make all other series machines forced down) rather than under type-II mechanisms (i.e., the breakdown of a machine does not make any other series machines forced down). The reason that the type-I failure mechanisms are usually assumed in the literature is that the analysis of the series-machine system under type-II mechanisms is much more complex than under type-I mechanisms, although type-II mechanisms are more common in practice. To thoroughly and systematically estimate the efficiency of the series-machine system, in this paper, we propose a unified analytical approach to investigate the efficiency under both type-I and type-II failure mechanisms. Both cases of deterministic and random cycle times are considered. Different from under type-I failure mechanisms, analytical expressions of the efficiency of series-machine systems under type-II failure mechanisms are extremely hard to obtain, and thus, limit bounds of the efficiency are derived and algorithms are developed to calculate its exact value. Results show that the series-machine system under type-II failure mechanisms is more efficient than under type-I mechanisms, which, intuitively making sense, is the reason that type-II mechanisms are more common in the industry.

Full-text available at: <https://ieeexplore.ieee.org/document/7944569/>

#### (4) Time-Aware Multi-Application Task Scheduling With Guaranteed Delay Constraints in Green Data Center

Author: Haitao Yuan ; Jing Bi ; MengChu Zhou ; Ahmed Chiheb Ammari

##### Abstract

A growing number of companies deploy their applications in green data centers (GDCs) and provide services to tasks of global users. Currently, a growing number of GDC providers aim to maximize their profit by deploying green energy facilities and decreasing brown energy consumption. However, the temporal variation in the revenue, price of grid, and green energy in tasks' delay bounds makes it challenging for GDC providers to achieve profit maximization while strictly guaranteeing delay constraints of all admitted tasks. Unlike existing studies, a time-aware task scheduling (TATS) algorithm that investigates the temporal variation and schedules all admitted tasks to execute in GDC meeting their delay bounds is proposed. In addition, this paper provides the mathematical modeling of task refusal and service rates. In each iteration, TATS solves the formulated profit maximization problem by hybrid chaotic particle swarm optimization based on simulated annealing. Compared with several existing scheduling algorithms, TATS can increase profit and throughput without violating delay constraints of all admitted tasks.

Full-text available at: <https://ieeexplore.ieee.org/document/8048035/>

#### (5) Stability Analysis of Discrete Event Systems Modeled by Petri Nets Using Unfoldings

Author: Alberto Lutz-Ley ; Ernesto López-Mellado

##### Abstract

The stability of discrete event systems (DESs) is a property related to its robustness; a stable DES is guaranteed to reach a set of desired states in a finite number of steps. Algorithms proposed in the literature are useful for analyzing the stability of DES modeled either by finite automata or a constrained subclass of Petri nets (PNs). In this paper, a novel method to decide the stability of safe PNs is presented. It is based on the analysis of the finite complete prefix of the net unfolding rather than the reachability graph. For concurrent systems, the prefix is usually smaller than the reachability graph and then the analysis using the proposed algorithm is more efficient than analyzing the reachability set of the PN.

Full-text available at: <https://ieeexplore.ieee.org/document/8358019/>

=====  
=====

=====

=====

SELECTIONS OF IEEE Transactions on Systems, Man, and Cybernetics: Systems  
VOLUME: 48 ISSUE: 7  
July 2018

(1) Modeling and Race Detection of Ladder Diagrams via Ordinary Petri Nets

Author: Jiliang Luo ; Qi Zhang ; Xuekun Chen ; MengChu Zhou

Abstract

This paper presents an ordinary Petri net (PN)-based approach to the modeling and race-detection problems of programs for programmable logic controllers (PLCs). First, a PLC program is formalized by a graph where nodes represent contacts and coils. Second, an algorithm is proposed to translate this graph into an ordinary PN. Third, a method is presented to detect whether there exists a race in a program by using a reachability graph technique, to locate a race by introducing the race path, and to correct a race by analyzing the subnet that contains it. An example is utilized to illustrate the theoretic results.

Full-text available at: <https://ieeexplore.ieee.org/document/7878664/>

=====

=====