IEEE Control Systems Society
Technical Committee on Discrete Event Systems

Newsletter September 2021

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Welcome to the 2021 September issue of the newsletter, also available online at
http://discrete-event-systems.ieeecss.org/tc-discrete/newsletters

Editorial

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

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

Contents

1 Selections of Journal Publications

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

1.1. IEEE Transactions on Automatic Control

Volume: 66, Issue: 9, September 2021

- **Maximal Linear Deadlock Avoidance Policies for Sequential Resource Allocation Systems: Characterization, Computation, and Approximation**
  Authors: Michael Ibrahim ; Spyros Reveliotis ; Ahmed Nazeem
  Abstract: The problem of maximally permissive deadlock avoidance for sequential resource allocation systems (RAS) is a well-defined problem in the current controls literature. The corresponding supervisor is known as the maximally permissive deadlock avoidance policy (DAP), and it can be perceived as a classifier effecting the dichotomy of the underlying state space into its safe and unsafe subspaces. In the deployment of the maximally permissive DAP, an important issue is the selection of an effective and computationally efficient representation of the aforementioned dichotomy. A popular such representation is the linear classifier, where the admissibility of any given RAS state is resolved based on its ability to satisfy a given set of linear inequalities. However, linear classifiers cannot provide effective representation of the maximally permissive DAP for all RAS instantiations. Hence, this article provides a methodology for synthesizing linear DAPs for any given RAS instance that might not be maximally permissive in the original sense of this term, but observe a more relaxed notion of maximality that is defined within the particular space of the DAPs that admit a linear representation. The presented developments formally define this new DAP class, and provide the necessary algorithms for the synthesis or the systematic approximation of maximal linear DAPs for any given RAS instance.
- **Embedded Insertion Functions for Opacity Enforcement**
  Authors: Christoforos Keroglou ; Stéphane Lafortune
  Abstract: We investigate the enforcement of opacity, an information-flow privacy property, using insertion sequences that modify the output of the system by event insertions. Previous work considered the problem of enforcing the opacity under the assumption that the insertion functions were based on the observed system strings. Now, we investigate the more powerful method of insertion sequences based on the exact system states and events. In this case, the insertion function would be embedded into the system itself, rather than being an output interface. In this article, we develop methods that verify if a valid insertion function exists in this setting; if one exists, synthesize one using a computationally effective algorithm; and investigate a special case where it is possible to verify and synthesize a valid embedded insertion function with polynomial complexity in the size of the system.
- **Real-Time Scheduling Based on Nonblocking Supervisory Control of State-Tree Structures**
  Authors: Xi Wang ; Zhiwu Li ; W. M. Wonham
  Abstract: This article presents a novel framework for the modeling and scheduling of real-time systems (RTS) processing both sporadic and (multiperiod) periodic tasks, based on nonblocking supervisory control of state-tree structures. Instead of assigning static priorities, a real-time scheduling mechanism, namely priority-free conditionally preemptive scheduling, is used to describe the preemption relation among the tasks processed in an RTS. As a dynamic priority scheduling mechanism, partially preemptive or nonpreemptive earliest-deadline first scheduling is also addressed in this article. Finally, the scheduling strategies are illustrated by real-world examples.

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1.2. Automatica

Volume: 131, September 2021

- **Marking diagnosability verification in labeled Petri nets**
  Authors: Ziyue Ma ; Xiang Yin ; Zhiwu Li
  Abstract: This paper studies the marking diagnosability verification problem in labeled Petri nets. Marking diagnosability is a property implying the fact that a plant Petri net has ever reached a pre-defined set of faulty markings can be detected in a finite number of future steps. We first show that the conventional basis-reachability-graph-based methods cannot be used due to the existence of partially faulty basis markings. To overcome such a problem, we propose a transition partition rule to obtain two particular graphs called the positive basis reachability graph and the negative basis reachability graph. Then we develop an information structure, called a dual verifier, that is a parallel composition of the two basis reachability graphs and can be used to determine the marking diagnosability of a plant net. The proposed method has polynomial complexity in the number of basis markings.
- **Compositional synthesis of opacity-preserving finite abstractions for interconnected systems**
  Authors: Siyuan Liu ; Majid Zamani
  Abstract: In this paper, we propose a compositional approach to construct opacity-preserving finite abstractions (a.k.a symbolic models) for networks of discrete-time nonlinear control systems. Particularly, we introduce new notions of simulation functions that characterize the distance between control systems while preserving opacity properties across them. Instead of treating large-scale systems in a monolithic manner, we develop a compositional scheme to construct the finite abstractions together with the overall opacity-preserving simulation functions based on those of the smaller subsystems. For a network of incrementally input-to-state stable control subsystems and under some small-gain type condition, an algorithm for designing local quantization parameters is presented to orderly build the local symbolic models of subsystems. We show that the network of those constructed symbolic models simulates the original network for an a-priori defined abstraction accuracy while preserving its opacity properties.
- **Formal controller synthesis from specifications given by discrete-time hybrid automata**
  Authors: Vladimir Sinyakov ; Antoine Girard
  Abstract: This paper deals with formal controller synthesis for discrete-time dynamical systems. We consider a specification provided under the form of a discrete-time hybrid automaton with external inputs, which can represent, for instance, instructions or informations received from a human user or from another system. The hybrid automaton describes the intended behavior of the system and we first consider the problem of synthesizing a controller such that the maximal trajectories of the closed-loop system are also maximal trajectories of the hybrid automaton. We show that the existence of an alternating simulation relation from the specification to the open-loop system is a necessary and sufficient condition for the existence of such controllers. To be able to solve this problem using symbolic (i.e. finite-state) abstractions, we provide a method to compute a symbolic specification that under-approximates the behavior of the hybrid automata. Then, we extend our approach to consider additional safety or reachability requirements so that some unsafe (e.g. blocking) states are avoided or some target states are reached, respectively. The originality of the problem is that these additional requirements are not formulated over the states of the system but over the states of the specification. Finally, we demonstrate the effectiveness of our approach with two illustrative examples from autonomous vehicle control.
- **Diagnosability enforcement in labeled Petri nets using supervisory control**
  Authors: Yihui Hu ; Ziyue Ma ; Zhiwu Li ; Alessandro Giua
  Abstract: In this article, we deal with the active diagnosis problem in labeled Petri nets by developing a supervisor for a plant such that the closed-loop system is diagnosable. Since control actions may introduce deadlocks even if an original plant is deadlock-free, we first generalize the classical notion of diagnosability in labeled Petri nets to the nets that may contain potential deadlocks. To avoid enumerating all reachable markings of a plant, we develop a structure called quiescent basis reachability graph, and accordingly propose a structure named Q-diagnoser to verify the di-

agnosability of a net. We prove that a plant is diagnosable if and only if there does not exist any indeterminate cycle in its Q-diagnoser. Finally, for an undiagnosable plant, we introduce a diagnosability enforcing supervisor to enforce the diagnosability by trimming a Q-diagnoser. Moreover, our approach guarantees that the closed-loop system cannot reach a dead marking unless a fault transition has fired.

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1.3. IEEE Transactions on Control Systems Technology

Volume: 29, Issue: 5, September 2021

- **Reachability-Based Decision-Making for Autonomous Driving: Theory and Experiments**
  Authors: Heejin Ahn ; Karl Berntorp ; Pranav Inani ; Arjun Jagdish Ram ; Stefano Di Cairano
  Abstract: We describe the design and validation of a decision-making system in the guidance and control architecture for automated driving. The decision-making system determines the timing of transitions through a sequence of driving modes, such as lane following and stopping, for the vehicle to eventually arrive at the destination without colliding with obstacles, hence achieving safety and liveness. The decision-making system commands a transition to the next mode only when it is possible for an underlying motion planner to generate a feasible trajectory that reaches the target region of such next mode. Using forward and backward reachable sets based on a simplified dynamical model, the decision-making system determines the existence of a trajectory that reaches the target region, without actually computing it. Thus, the decision-making system achieves fast computation, resulting in reactivity to a varying environment and reduced computational burden. To handle the discrepancy between the dynamical model and the actual vehicle motion, we model it as a bounded disturbance set and guarantee robustness against it. We prove the safety and liveness of the decision-making system and validate it using small-scale car-like robots.

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1.4. International Journal of Control

Volume: 94, Issue: 9, September 2021

- **On the invariance property of reduced supervisors from the perspective of vector discrete-event systems**
  Authors: Ting Jiao ; Ru Chang ; Xueli Nan
  Abstract: The relabelling mechanism is employed in symmetric discrete-event systems to obtain a control-equivalent supervisor in the relabelled level. If we apply procedure supreduce to this supervisor, with buffer sizes fixed, the result is a reduced supervisor independent of the numbers of components in each group of symmetric discrete-event systems. In this paper, we show the invariance property of reduced supervisors by utilising the semantics of vector discrete-event systems. Namely, a control congruence is generated based on the results to achieve optimal supervisory control of vector discrete-event systems. The approach is applied to two representative manufacturing facilities.
- **Developing a democratic progress model based on discrete event systems**
  Authors: Seong-Jin Park; Jung-Min Yang
  Abstract: In this paper, we model and analyze democratic progress and regression in the framework of discrete event systems. Since democratic progress strongly correlates with the growing number of people who meet their economic interests and political rights, it can be represented as an event-driven dynamical system evolved by local agents that make a decision to enable or disable the progress and regression events according to their private objectives. The final decision on enabling/disabling an event is made by the majority rule, which also complies with the feature of democracy. Based on majority-based supervisory control, we investigate the conditions for the democratic progress model to be progressive or regressive under full observation. Moreover, we present a scheme that can modify the characteristics of the model by designing masks for agents, i.e. the regressive system under full observation is changed to a progressive one under partial observation via masks, and vice versa.

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2 Conferences

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

2.1 **2021 IEEE International Conference on Systems, Man, and Cybernetics**
South Wharf, Victoria, Australia, October 17-20, 2021
http://ieeesmc2021.org/

2.2 **2021 IEEE Conference on Decision and Control**
Austin, Texas, USA. December 13-15, 2021
https://cdc2021.ieeecss.org

2.3 **2022 IEEE Conference on Robotics and Automation**
Philadelphia, USA, May 23-27, 2022
https://www.icra2022.org/

2.4 **2022 American Control Conference**
Atlanta, Georgia, USA, June 8-10, 2022
https://acc2022.a2c2.org/

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3 Books

3.1 Analysis and Control for Resilience of Discrete Event Systems

Authors: João 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

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4 Positions

4.1 PhD Position at the University of Salerno

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

"Resilient control against cyber-attack"

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

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

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

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

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

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

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

4.2 **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)

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6 Software Tool

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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