IEEE CONTROL SYSTEMS SOCIETY
TECHNICAL COMMITTEE ON DISCRETE EVENT SYSTEMS

Newsletter..... May 2019

Editor: Kai Cai
Chair, IEEE CSS Technical Committee on DES
Associate 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
Fax: (+81) 6-6605-2703
e-mail: kai.cai@eng.osaka-cu.ac.jp
Website: https://www.control.eng.osaka-cu.ac.jp

_.---.-_

Contents:

Systems: A Practical Guide for Engineers

1. Editorial

Welcome to the 2019 May issue of the newsletter,
also available electronically at
http://discrete-event-systems.ieeecss.org/tc-discrete/newsletters

You are welcome to submit new items to the newsletter (topics including schools, workshops, sessions, conferences, journals, books, software, positions).
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.

2. Technical Committee Meeting

Technical Committee on Discrete Event Systems will hold a meeting at American Control Conference 2019, Philadelphia, PA, USA.

Time: 12:00--13:30, July 12, Friday, 2019.
Location: TBD

All TC members who are going to attend ACC'19 are welcome to come to this meeting. Lunch is supplied (first come first served, due to limited amount).

3. Selections of Journal Publications

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

3.1. Selections of Discrete Event Dynamic Systems: Theory and Applications
VOLUME: 29, ISSUE: 1, March 2019

(1) A discrete MMAP for analysing the behaviour of a multi-state complex dynamic system subject to multiple events

Authors: Juan Eloy Ruiz-Castro ; M. Dawabsha

Abstract: A complex multi-state system subject to different types of failures, repairable and/or non-repairable, external shocks and preventive maintenance is modelled by considering a discrete Markovian arrival process with marked arrivals (D-MMAP). The internal performance of the system is composed of several degradation states partitioned into minor and major damage states according to the risk of failure. Random external events can produce failures throughout the system. If an external shock occurs, there may be an aggravation of the internal degradation, cumulative external damage or extreme external failure. The internal performance and the cumulative external damage are observed by random inspection. If major degradation is observed, the unit goes to the repair facility for preventive maintenance. If a repairable failure occurs then the system goes to corrective repair with different time distributions depending on the failure state. Time distributions for corrective repair and preventive maintenance depend on the failure state. Rewards and costs depending on the state at which the device failed or was inspected are introduced. The system is modelled and several measures of interest are built into transient and stationary regimes. A preventive maintenance policy is shown to determine the effectiveness of preventive maintenance and the optimum state of internal and cumulative external damage at which preventive maintenance should be taken into account. A numerical example is presented, revealing the efficacy of the model. Correlations between the numbers of different events over time and in non-overlapping intervals are calculated. The results are expressed in algorithmic-matrix form and are implemented computationally with Matlab.

Full-text available at: https://link.springer.com/article/10.1007/s10626-018-0274-0

(2) Approximated timed reachability graphs for the robust control of discrete event systems

Authors: Dimitri Lefebvre

Abstract: This paper is about control sequences design for Discrete Event Systems (DES) modeled with Time Petri nets (TPN) including a set of temporal specifications. Petri nets are known as efficient mathematical and graphical models that are widely used to describe distributed DES including choices, synchronizations and parallelisms. The domains of application include but are not restricted to manufacturing systems, computer science and transportation networks. Incorporating the time in the model is important to consider many control problems such as scheduling and planning. This paper solves some control issues in timed context and uncertain environments that include unexpected events modeled with uncontrollable transitions. To deal with such uncertainties, we propose first to build an Approximated Timed Reachability Graph that

includes the time specifications and model all feasible timed trajectories at a given accuracy under earliest firing policy. Then, this graph is used to search optimal paths by using an approach based on Markov Decision Processes that encode the environment uncertainties. Such optimal paths lead to near-optimal solutions for the TPN. Several simulations illustrate the benefit of the proposed method from the performance and computational points of view.

Full-text available at: https://link.springer.com/article/10.1007/s10626-019-00275-z

(3) Moment estimators for the parameters of Ornstein-Uhlenbeck processes driven by compound Poisson processes

Authors: Yanfeng Wu ; Jianqiang Hu ; Xinsheng Zhang

Abstract: We develop new estimators for the parameters of Ornstein-Uhlenbeck processes driven by compound Poisson processes, which can be considered as a class of stochastic hybrid systems. Our estimators are derived based on the method of moments. We also establish the central limit theorem for the proposed estimators. Numerical experiments are provided to show that our method performs better when compared with the existing methods, especially in cases when the jumps of the compound Poisson process are relatively rare.

Full-text available at: https://link.springer.com/article/10.1007/s10626-019-00276-y

(4) Optimal on-off control for a class of discrete event systems with real-time constraints

Authors: Lei Miao ; Lijian Xu ; Dingde Jiang

Abstract: This paper studies an optimal ON-OFF control problem for a class of discrete event systems with real-time constraints. Our goal is to minimize the overall costs, including the operating cost and the wake-up cost, while still guaranteeing the deadline of each individual task. In particular, we consider the homogeneous case in which it takes the same amount of time to serve each task and each task needs to be served by d seconds upon arrival. The problem involves two subproblems: (i) finding the best time to wake up the system and (ii) finding the best time to let the system go to sleep. We study the two subproblems in both off-line and on-line settings. In the off-line case that all task information is known a priori, we combine sample path analysis and dynamic programming to come up with the optimal solution. In the on-line scenario where future task information is completely unknown, we show that the optimal time to wake up the system can be obtained without relying on future task arrivals. We also perform competitive analysis for on-line control and derive the competitive ratios for both deterministic and random controllers.

Full-text available at: https://link.springer.com/article/10.1007/s10626-019-00277-x

(5) Toward a decision support system for the clinical pathways assessment

Authors: Simona Bernardi ; Cristian Mahulea ; Jorge Albareda

Abstract: This paper presents a decision support system to be used in hospital management tasks which is based on the clinical pathways. We propose a very simple graphical modeling language based on a small number of primitive elements through which the medical doctors could introduce a clinical pathway for a specific disease. Three essential aspects related to a clinical pathway can be specified in this language: (1) patient flow; (2) resource utilization; and (3) information interchange. This high-level language is a domain specific modeling language called Healthcare System Specification (HSS), and it is defined as an Unified Modeling Language (UML) profile. A model to model transformation is also proposed in order to obtain, from the pathways HSS specification, a Stochastic Well-formed Net (SWN) model that enables a formal analysis of the modeled system and, if needed, to apply synthesis methods enforcing specified requirements. The transformation is based on the application of local rules. The clinical pathway of hip fracture from the °∞Lozano Blesa°± University hospital in Zaragoza is taken as an example.

Full-text available at: https://link.springer.com/article/10.1007/s10626-019-00279-9

==========

3.2. Selections of Automatica
VOLUME: 103, May 2019

(1) Markov decision processes with sequential sensor measurements

Authors: Mahmoud El Chamie ; Dylan Janak; Behcet Acikmese

Abstract: Markov decision processes (MDPs) have been used to formulate many decision-making problems in science and engineering. The objective is to synthesize the best decision (action selection) policies to maximize expected rewards (or minimize costs) for a stochastic dynamical system. In this paper, we introduce a new type of sensor measurement to the MDP model that provides additional information about the stochastic process, and hence that information can be incorporated in the decision policy to increase the performance. The new model is tailored for environments with high uncertainty. With the additional measurements, more refined information on the possible state transition is provided in real-time before taking an action. This new MDP model with sequential measurements is referred to as sequentially-observed MDP (SO-MDP). We show that the SO-MDP shares some similar properties with a

standard MDP; among randomized history dependent policies, deterministic Markovian policies are still optimal. Optimal SO-MDP policies have the advantage of producing better total rewards than standard MDP policies due to the additional measurements, however computing these policies is more complex. We present two algorithms for solving the finite-horizon SO-MDP problem: the first algorithm is based on linear-programming, and the second algorithm is based on dynamic programming. We show that the complexity of computing optimal policies of the SO-MDP model with perfect sensors is the same as standard MDP. Simulations demonstrate that the SO-MDP model outperforms the standard MDP model in the presence of high environmental uncertainty.

Full-text available at: https://www.sciencedirect.com/science/article/pii/S0005109819300767

(2) Recovering Markov models from closed-loop data

Authors: Jonathan P.Epperlein ; Sergiy Zhuk ; Robert Shorten

Abstract: Situations in which recommender systems are used to augment decision making are becoming prevalent in many application domains. Almost always, these prediction tools (recommenders) are created with a view to affecting behavioural change. Clearly, successful applications actuating behavioural change, affect the original model underpinning the predictor, leading to an inconsistency. This feedback loop is often not considered in standard machine learning techniques which rely upon machine learning/statistical learning machinery. The objective of this paper is to develop tools that recover unbiased user models in the presence of recommenders. More specifically, we assume that we observe a time series which is a trajectory of a Markov chain modulated by another Markov chain , i.e. the transition matrix of is unknown and depends on the current state of . The transition matrix of the latter is also unknown. In other words, at each time instant, selects a transition matrix for within a given set which consists of known and unknown matrices. The state of , in turn, depends on the current state of thus introducing a feedback loop. We propose an Expectation®CMaximisation (EM) type algorithm, which estimates the transition matrices of and . Experimental results are given to demonstrate the efficacy of the approach.

Full-text available at: https://www.sciencedirect.com/science/article/pii/S0005109819300299

(3) An information aware event-triggered scheme for particle filter based remote state estimation

Authors: Wenshuo Li ; Zidong Wang ; Qinyuan Liu ; LeiGuo

Abstract: We consider a coproduction system that uses a common input to produce multiple products in multiple periods. The demands for

these products are stochastic in every period. We determine the optimal production plan in order to minimize the total expected discounted cost over a finite time horizon. Using L-convexity, we demonstrate that the optimal production quantity is state dependent and obeys several structural properties, such as monotonicity, threshold, and boundedness.

Full-text available at: https://www.sciencedirect.com/science/article/pii/S0005109819300275

==========

3.3. Selections of the IEEE Transactions on Automatic Control
VOLUME: 64, ISSUE: 5, May 2019

(1) Observation-Based Optimization for POMDPs With Continuous State, Observation, and Action Spaces

Authors: Xiaofeng Jiang ; Jian Yang ; Xiaobin Tan ; Hongsheng Xi

Abstract: This paper considers the optimization problem for partially observable Markov decision processes (POMDPs) with the continuous state, observation, and action spaces. POMDPs with the discrete spaces have emerged as a promising approach to the decision systems with imperfect state information. However, in recent applications of POMDPs, there are many problems that have continuous states, observations, and actions. For such problems, due to the infinite dimensionality of the belief space, the existing studies usually discretize the continuous spaces with the sufficient or nonsufficient statistics, which may cause the curse of dimensionality and performance degradation. In this paper, based on the sensitivity analysis of the performance criteria, we have developed a simulation-based policy iteration algorithm to find the local optimal observation-based policy for POMDPs with the continuous spaces. The proposed algorithm needs none of the specific assumptions and prior information, and has a low computational complexity. One numerical example of the complicated multiple-input multiple-output beamforming problem shows that the algorithm has a significant performance improvement.

Full-text available at: https://ieeexplore.ieee.org/document/8424016

(2) A Nonsmooth Hybrid Invariance Principle Applied to Robust Event-Triggered Design

Authors: Alexandre Seuret ; Christophe Prieur ; Sophie Tarbouriech ; Andrew R. Teel ; Luca Zaccarian

Abstract: We first propose a nonsmooth hybrid invariance principle with relaxed conditions stemming from the fact that flowing solutions evolve only in the tangent cone, and complete jumping solutions cannot jump outside the jump and flow sets. We then show an application consisting in the design of event-triggered rules to

stabilize a class of uncertain linear control systems. The event-triggering rule depends only on local information, that is it uses only the output signals available to the controller. The approach proposed combines hybrid and sampled-data tools. The proposed design conditions are formulated in terms of linear matrix inequalities (LMIs) ensuring global robust asymptotic stability of the closed-loop system. A tunable parameter is also available to guarantee an adjustable dwell-time property of the solutions. The effectiveness of the approach is evaluated through an example borrowed from the literature.

Full-text available at: https://ieeexplore.ieee.org/document/8424868

==========

3.4. Selections of the IEEE Transactions on Automation Science and Engineering
VOLUME: 16, ISSUE: 2, April 2019

(1) Synthesis of Supervisory Control With Partial Observation on Normal State-Tree Structures

Authors: Chan Gu ; Xi Wang ; Zhiwu Li

Abstract: Supervisory control theory (SCT) of a discrete-event system (DES) is well developed to find its maximally permissive supervisor. As an extension of SCT, a new framework, statetree structures (STS), has been deployed to manage the state explosion problem of SCT. The supervisory control with partial observation is investigated in SCT, of which the state explosion issue remains to be explored. This paper dwells upon an approach to the synthesis of supervisory control with partial observation in the normal STS framework, requiring that the conjunction of any two projected subpredicates should be false. First, following the definition of the observability based on STS, it is proven that there does not exist the supremal observable subpredicate. Second, we construct a subclass of observable subpredicates of a given predicate (obtained as a specification) on the basis of normal STS. Third, a largest element is proven to exist in the subclass, and thus a weakly controllable, coreachable, and observable subpredicate is computed to solve the supervisory control problem of the normal STS by an iterative algorithm. An illustrative example with state size over 109 is given to show that the proposed algorithm based on STS is superior to the approach based on SCT, which leads to the program crashes in SCT.

Full-text available at: https://ieeexplore.ieee.org/document/8594632

(2) Throughput Maximization of Capacitated Re-Entrant Lines Through Fluid Relaxation

Authors: Michael Ibrahim ; Spyros Reveliotis

Abstract: This paper extends the scheduling methodology for complex stochastic networks that is based on the solution of a °∞fluid°± relaxation (FR) at each decision point of the original scheduling problem to stochastic networks with blocking and deadlocking effects. For a clearer and more concrete treatment, the presented results are developed in the operational context of a re-entrant line (RL) with finite buffering capacity at each workstation; these RLs are characterized as °∞capacitated RLs (CRLs).°± From a methodological standpoint, the paper results are enabled by a pre-established ability to control the underlying resource allocation for deadlock freedom and by the further ability to express the corresponding deadlock avoidance policy as a set of linear inequalities on the system state. Also, the employed FR for this new regime differs from the FRs that have been employed in past implementations of the method since it must account for the blocking effects that take place in the considered CRLs. The efficacy of the presented scheduling method is assessed through numerical experimentation that compares, for a set of °∞benchmark°± CRLs, the performance of the scheduling policies obtained through this method to 1) the performance of the corresponding optimal scheduling policies and also to 2) the performance of some other heuristic scheduling policies for these systems that are adapted from the relevant literature. Finally, an additional set of experiments demonstrates and assesses the scalability of the presented method by applying it to some pretty large system configurations.

Full-text available at: https://ieeexplore.ieee.org/document/8449125

(3) Modified Dynamic Programming Algorithm for Optimization of Total Energy Consumption in Flexible Manufacturing Systems

Authors: Xiaoling Li ; Keyi Xing ; MengChu Zhou ; Xinnian Wang ; Yunchao Wu

Abstract: Based on the Petri net (PN) models of the flexible manufacturing systems (FMSs), this paper focuses on solving the scheduling problem of minimizing the total energy consumption of FMSs. In the view of different energy consumption rates of resources under different working statuses, two energy consumption functions are considered. The dynamic programming (DP) models of the scheduling problems based on PNs are established, where a reachable marking of a PN model, start processing time vector, route vector, and the transition sequence leading to the reachable marking from the initial one, is regarded as a state, and the Bellman equation is based on transition firing. For small-size scheduling problems, their optimal solutions can be obtained by the presented DP algorithm. However, it is difficult to solve larger-scale ones since the number of explored states increases exponentially with the problem size, which makes DP computationally infeasible. To obtain an optimal or suboptimal schedule in an acceptable time, modified DP (MDP) algorithm is proposed, in which fewer states are explored. In MDP, two ways are introduced through which only the most promising states are explored. One is keeping only one transition sequence for

each marking through an evaluation function. Another is selecting the most promising states in each stage for further exploration through a heuristic function. To guarantee that the generated states are safe, a deadlock controller is applied in the recursion procedure of MDP. Experimental results on manufacturing systems and comparisons with existing works are provided to show the effectiveness of MDP. Note to Practitioners—This paper is motivated by the need of optimizing the energy consumption of manufacturing systems, considering the increasing energy cost and environmental concerns. Existing studies on energy optimization rarely focus on flexible manufacturing systems (FMSs) which exhibit a high degree of resource sharing and route flexibility and can be highly adaptable to various production plans and goals. Scheduling becomes more challenging when facing deadlock-prone FMSs. This paper provides a method to solve this complex scheduling problem efficiently. In this paper, dynamic programming (DP) is formulated for it, and the optimal energy consumption schedules are found. Considering the computational burden of implementing DP in the scheduling of large-size FMSs, a novel scheduling method named modified DP (MDP) is proposed. Experimental tests on an FMS and a stamping system suggest that MDP can successfully find feasible solutions. Besides, it can be applied to other FMS scheduling problems and industrial cases, once their processing time of operations and energy consumption of resources per unit time are known.

Full-text available at: https://ieeexplore.ieee.org/document/8413154

(4) Automatic Composition and Optimization of Multicomponent Predictive Systems With an Extended Auto-WEKA

Authors: Manuel Martin Salvador ; Marcin Budka ; Bogdan Gabrys

Abstract: Composition and parameterization of multicomponent predictive systems (MCPSs) consisting of chains of data transformation steps are a challenging task. Auto-WEKA is a tool to automate the combined algorithm selection and hyperparameter (CASH) optimization problem. In this paper, we extend the CASH problem and Auto-WEKA to support the MCPS, including preprocessing steps for both classification and regression tasks. We define the optimization problem in which the search space consists of suitably parameterized Petri nets forming the sought MCPS solutions. In the experimental analysis, we focus on examining the impact of considerably extending the search space (from approximately 22000 to 812 billion possible combinations of methods and categorical hyperparameters). In a range of extensive experiments, three different optimization strategies are used to automatically compose MCPSs for 21 publicly available data sets. The diversity of the composed MCPSs found is an indication that fully and automatically exploiting different combinations of data cleaning and preprocessing techniques is possible and highly beneficial for different predictive models. We also present the results on seven data sets from real chemical production processes. Our findings can have a major impact on the development of high-quality predictive models as well as their

maintenance and scalability aspects needed in modern applications and deployment scenarios. Note to Practitioners—The extension of Auto-WEKA to compose and optimize multicomponent predictive systems (MCPSs) developed as part of this paper is freely available on GitHub under GPL license, and we encourage practitioners to use it on a broad variety of classification and regression problems. The software can either be used as a blackbox—where search space is made of all possible WEKA filters, predictors, and metapredictors (e.g., ensembles)—or as an optimization tool on a subset of preselected machine learning methods. The application has a graphical user interface, but it can also run from command line and can be embedded in any project as a Java library. There are three main outputs once an Auto-WEKA run has finished: 1) the trained MCPS ready to make predictions on unseen data; 2) the WEKA configuration (i.e., parameterized components); and 3) the Petri net in a Petri Net Markup Language format that can be analyzed using any tool supporting this standard language. There are, however, some practical considerations affecting the quality of the results that must be taken into consideration, such as the CPU time budget or the search starting point. These are extensively discussed in this paper.

Full-text available at: https://ieeexplore.ieee.org/document/8550732

==========

3.5. Selections of the IEEE Transactions on Systems, Man, and Cybernetics: Systems
VOLUME: 49, ISSUE: 5, May 2019

(1) Supervisor Synthesis for FMS Based on Critical Activity Places

Author: Bo Huang ; Mengchu Zhou ; Yisheng Huang ; Yuwang Yang

Abstract: Solving states separation problems is an important technique to obtain liveness-enforcing and optimal or near-optimal supervisors for flexible manufacturing systems based on Petri nets. It first generates the model°Øs reachability graph and partitions it into a live zone (LZ) and a deadlock zone (DZ). Then, first-met bad markings (FBMs), which exist in DZ and are the very first entries from LZ to DZ, are forbidden by some designed place invariants (PIs) to prevent the system from entering DZ. This paper studies the reduction of the number of places to be considered in such PI designs. First, the concepts of critical transitions and critical activity places are defined, and a fast algorithm is provided to compute them. Then, the proofs of that only critical activity places need to be considered in such PI designs to forbid all FBMs and/or permit all legal markings in LZ are established.

Full-text available at: https://ieeexplore.ieee.org/document/8010898

(2) Design and Verification of an NDN-Based Safety-Critical Application: A Case Study With Smart Healthcare

Author: Divya Saxena ; Vaskar Raychoudhury

Abstract: Internet of Things (IoT) is an emerging networking paradigm where smart devices generate, aggregate, and seamlessly exchange data over the predominantly wireless medium. The Internet, so far, has played a significant role in connecting the world, but still, IoT-based solutions are suffering from two primary challenges: 1) how to secure the sensors data and 2) how to provide efficient local and global communication among various heterogeneous devices. Recently, named data networking (NDN), a future Internet paradigm is proposed to improve and simplify such IoT communication issues. NDN allowed users to fetch data by names irrespective of the actual hosting entity connected through a host-specific IP address. NDN well suits the content-centric pattern of machine-to-machine (M2M) communications predominantly used in IoT. In this paper, we leverage the basic feats of NDN architecture for designing and verification of an NDN-based smart health IoT (NHealthIoT) system. NHealthIoT uses pure-NDN-based M2M communication for capturing and transmission of raw sensor data to the home server which can detect emergency healthcare events using Hidden Markov Model. Emergency events are notified to the cloud server using a novel context-aware adaptive forwarding (Cdf) strategy. Post emergency notifications, and user health information is periodically pulled by the cloud server and by other interested parties using NDN-based publish/subscribe paradigm. The cloud server carries out long-term decision making using probabilistic modeling for detecting the possibility of chronic diseases at the early stage. We extend the workflows intuitive formal approach model for verifying the correctness of NHealthIoT during the emergency. We evaluate the cdf strategy using ndnSIM. Moreover, to validate and to show the usability of NHealthIoT, we develop a proof-of-concept prototype testbed and evaluate it extensively. We also identify some research challenges of the NDN-IoT for researchers.

Full-text available at: https://ieeexplore.ieee.org/document/7990549

4. Conferences

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

4.1 2019 European Control Conference
Naples, Italy, Jun 25 - Jun 28, 2019
https://ecc19.eu/

4.2 27th Mediterranean Conference on Control and Automation
Akko, Israel, Jul 1 - Jul 4, 2019
https://med19.net.technion.ac.il/

4.3 2019 American Control Conference
Philadelphia, Pennsylvania, United States, Jul 10 - Jul 12, 2019

http://acc2019.a2c2.org/

4.4 38th Chinese Control Conference (CCC 2019)
Guangzhou, China, Jul 27 - Jul 30, 2019
http://www.ccc2019.cn/en/index.html

4.5 2019 Conference on Control Technology and Applications
Hong Kong, China, Aug 19 - Aug 21, 2019
http://ccta2019.ieeecss.org/

4.6 15th International Conference on Automation Science and Engineering
Vancouver, British Columbia, Canada, Aug 22 - Aug 26, 2019
http://case2019.hust.edu.cn/index.htm

4.7 57th Annual Allerton Conference on Communication, Control, and Computing
Allerton Park, United States, Sep 24 - Sep 27, 2019

4.8 2019 Conference on Decision and Control
Nice, France, December 11-13, 2019
https://cdc2019.ieeecss.org/

5. Books

5.1 Supervisory Control of Discrete-Event Systems
Authors: W.Murray Wonham, Kai Cai
Publisher: Springer International Publishing
Series: Communications and Control Engineering
Date: 2019
Number of pages: 489
Website: https://www.springer.com/in/book/9783319774510

5.2 A Relaxation-Based Approach to Optimal Control of Hybrid Systems: A Practical Guide for Engineers
Author: Vadim Azhmyakov
Publisher: Butterworth-Heinemann
Date: February 2019
Number of pages: 434
Website: https://www.elsevier.com/books/a-relaxation-based-approach-to-optimal-control-of-hybrid-and-switched- systems/azhmyakov/978-0-12-814788-7