IEEE CONTROL SYSTEMS SOCIETY TECHNICAL COMMITTEE ON DISCRETE EVENT SYSTEMS

Newsletter..... May 2018

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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/

2.3 Summer Short Course of interest to DES Community
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Summer Short Course of interest to DES Community:

Real-Time Optimization of Factory Operations

University of Michigan, Integrative Systems + Design (ISD), Non-credit professional course

June 14-15, 2018 (Thursday-Friday), North Campus of the University of Michigan, Ann Arbor

Web-site:
http://isd.engin.umich.edu/professional-programs/factory-operations/index.htm

Description:

As the chemical industry moves towards product diversification and customization, chemical manufacturing, as well as discrete parts manufacturing, is performed in multi-product facilities which are characterized by the production of a suite of products using shared resources according to a demand profile. The performance of these facilities is highly dependent on the quality of production planning and scheduling that directs their overall operation and on the

fidelity by which these plans are carried out in the manufacturing process. Human intervention is often necessary for monitoring the process to respond to circumstances that would require reworking plans and schedules to keep them feasible. This course will present a new methodology for addressing the integration of production planning and scheduling with the discrete logic of the process automation system, thereby closing a capability gap in achieving real-time optimization of factory operations. This new methodology, termed Manufacturing Execution Optimization (MEO), is the result of a collaborative effort involving The Dow Chemical Company, the University of Michigan, the University of Wisconsin, Siemens Corporation, and Kent Displays Inc., under funding from the Digital Manufacturing and Design Innovation Institute (DMDII).

This course is aimed at professional engineers and researchers in the chemical processing industry and in discrete manufacturing who are faced with real-time optimization challenges as a consequence of process variability and a wide range of disturbances. The integrated MEO methodology for real-time optimization that will be taught is composed of (i) a scheduling optimization model enhanced to consider automation logic and of (ii) a delay monitoring module that monitors the feasibility or lack thereof of the current schedule under the constraints of the automation logic and triggers, as necessary, schedule re-optimization in real time. The course will present the various steps of the integrated MEO methodology, along with demonstration of software tools that implement its key elements. In addition, the course will present a detailed simulation environment for chemical processes in plant operations, employing the tool SIMIT of Siemens Corp., that mimics both process dynamics and automation logic and can be used for high-fidelity analysis of system performance. To make the course as self-contained as possible, some fundamentals on chemical production scheduling and on automation logic in process control systems will also be introduced.

Instructors:

Stéphane Lafortune, Professor, University of Michigan
Bao Lin, Process Automation Manager, The Dow Chemical Company
Christos T. Maravelias, Professor, University of Wisconsin
Nareshkumar Nandola, Research Scientist, Siemens Corporation
Blake C. Rawlings, Research Fellow, University of Michigan
John M. Wassick, Research Fellow, The Dow Chemical Company

Schedule:

Day 1: 8:30am-4:30pm

Morning: (3 hours)

- Course description; presentation of test problem: Lafortune

- Primer on chemical production scheduling and factory operations: Maravelias and Wassick
- Simulation of factory operations using SIMIT: Nandola

Afternoon: (3 hours)

- Real-time optimization of schedules in factory operations: Maravelias
- Automation logic and its integration with real-time scheduling: Rawlings and Lafortune

Day 2: 8:30am-3:00pm

Morning: (3 hours)

- Demonstration of integrated approach on case study using software tools: Team
- Implementation of dynamic real-time optimization of full-scale factory operations: Dow's experience: Lin and Wassick

Afternoon: (up to 2 hours; end by 3pm)

- Discussion, more Q&A, wrap up: Team

Instructors' biographical sketches:

Dr. Stéphane Lafortune, University of Michigan, Ann Arbor: Stéphane is a professor in the department of electrical engineering and computer science. He is an expert on supervisory control and diagnosis of event-driven dynamic systems. He has supervised over 20 doctoral students, who now work in academia or industrial R&D. He is a Fellow of the Institute of Electrical and Electronics Engineers (IEEE) and of the International Federation of Automatic Control (IFAC).

Dr. Bao Lin, Process Automation Manager, The Dow Chemical Company. Bao is a Lead Process Automation Manager of Polyurethanes Envelope and Alkoxylation & Formulated Systems. He has over 20 years of experience in developing, implementing and managing modeling and operator training simulators products, advanced control & optimization projects in mining, cement, chemical and petrochemical industries.

Dr. Christos T. Maravelias, University of Wisconsin - Madison. Christos is a Vilas Distinguished Achievement Professor at the Department of Chemical and Biological Engineering at UW. He is the recipient of an NSF CAREER award, the 2008 Smith and the 2013 Outstanding Young Researcher Awards from the Computing and Systems Technology division of the American

Institute of Chemical Engineers. His research interests lie in the areas of (1) production planning and scheduling, (2) supply chain optimization, and (3) chemical process synthesis and analysis.

Dr. Nareshkumar Nandola, Siemens Corp.: Naresh is a research scientist in the Autonomous Systems & Control group at Siemens Corporate Technology in Princeton, NJ. Before joining Siemens, he was a Principal Scientist at ABB corporate research center, Bangalore, India. Naresh has 13 years of research experience in control and optimization and he has developed advanced control and scheduling solutions for various industrial applications such as upstream oil & gas, iron & steel industries, and data center cooling control.

Dr. Blake C. Rawlings, the University of Michigan-Ann Arbor: Blake is a postdoctoral research fellow at U-M. For his Ph.D. project, he collaborated with Dow to apply theoretical results from the field of discrete event systems to analyze the discrete dynamics in chemical plants. His desire to advance the application of these tools in the chemical processing industry and other manufacturing industries has led to his current position at U-M and his involvement in this course.

Dr. John Wassick, The Dow Chemical Company: John is a research fellow in Dow Chemical's Supply Chain Center of Excellence. He has guided many innovative ideas through the R&D process to successful industrial application. John was awarded the 2014 Computing Practice Award by the American Institute of Chemical Engineering in recognition of his outstanding contributions in the practice or application of computing and systems technology to process control, planning and scheduling of batch and continuous processes, and supply chain optimization.

Selections of Journal Publications

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

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SELECTIONS OF THE IEEE TRANSACTIONS ON AUTOMATIC CONTROL
VOLUME: 63 ISSUE: 5
May 2018

(1) Safe Markov Chains for ON/OFF Density Control With Observed Transitions

Author: Nazlı Demirer ; Mahmoud El Chamie ; Behçet Açıkmeşe

Abstract

This paper presents a convex optimization approach to control the density distribution of autonomous mobile agents (single or multiple) in a stochastic environment with two control modes: ON and OFF. The main new characteristic distinguishing this model from standard Markov decision models is the existence of the ON control mode and its observed actions. During the ON mode, the instantaneous outcome of one of the actions of the ON mode is measured and a decision is made to whether this action is taken or not based on this new observation. If this action is not taken, the OFF mode is activated where a transition occurs based on a predetermined set of transitional probabilities, without making any additional observations. In this decision-making model, an agent acts autonomously according to an ON/OFF decision policy, and the discrete probability distribution for the agent's state evolves according to a discrete-time Markov chain that is a linear function of the stochastic environment and the ON/OFF decision policy. The relevant policy synthesis is formulated as a convex optimization problem where safety and convergence constraints are imposed on the resulting Markov matrix.

Full-text available at: https://ieeexplore.ieee.org/document/8047979/

(2) Synthesis of Similarity Enforcing Supervisors for Nondeterministic Discrete Event Systems

Author: Naoki Kushi ; Shigemasa Takai

Abstract

In this paper, we consider a similarity control problem for the plant and the specification modeled as nondeterministic automata. This problem requires us to synthesize a nondeterministic supervisor such that the supervised plant is simulated by the specification. We show that a state-controllable subautomaton of the synchronous composition of the observer automaton of the plant and the specification can be used as a solution to the similarity control problem. It is desirable that a supervisor be as permissive as possible. Thus, to synthesize a similarity enforcing supervisor, we construct the largest state-controllable subautomaton of the synchronous composition of the observer automaton of the plant and the specification.

Full-text available at: https://ieeexplore.ieee.org/document/8022870/

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SELECTIONS OF AUTOMATICA
VOLUME: 91
May 2018

(1) Redefined observability matrix for Boolean networks and distinguishable partitions of state space

Author: Yuqian Guo, Weihua Gui, Chunhua Yang

Abstract

This paper redefines the observability matrix and defines the observability index for Boolean networks (BNs). In the new definition, a BN is observable if and only if the observability matrix is of full rank. The observability matrix is calculated by a simple algorithm and is applied to the problem of distinguishability of partitions. A partition of the state space is said to be distinguishable if any two distinct subsets are distinguishable, and the finest distinguishable partition (FDP) is finer than any other distinguishable partition. A necessary and sufficient condition is proposed for checking the distinguishability of any given partition, and an algorithm is proposed for calculating the FDP. The proposed results are illustrated by examples.

Full-text available at: https://www.sciencedirect.com/science/article/pii/S0005109818300207

(2) Finite-horizon covariance control for discrete-time stochastic linear systems subject to input constraints

Author: Efstathios Bakolas

Abstract

This work deals with a finite-horizon covariance control problem for discrete-time, stochastic linear systems with complete state information subject to input constraints. First, we present the main steps for the transcription of the covariance control problem, which is originally formulated as a stochastic optimal control problem, into a deterministic nonlinear program (NLP) with a convex performance index and with both convex and non-convex constraints. In particular, the convex constraints in this nonlinear program are induced by the input constraints of the stochastic optimal control problem, whereas the non-convex constraints are induced by the requirement that the terminal state covariance be equal to a prescribed positive definite matrix. Subsequently, we associate this nonlinear program, via a simple convex relaxation

technique, with a (convex) semi-definite program, which can be solved numerically by means of modern computational tools of convex optimization. Although, in general, the endpoints of a representative sample of closed-loop trajectories generated by the control policy that corresponds to the solution of the relaxed convex program are not expected to follow exactly the goal terminal Gaussian distribution, they are more likely to be concentrated near the mean of this distribution than if they were drawn from the latter, which is a desirable feature in practice. Numerical simulations that illustrate the key ideas of this work are also presented.

Full-text available at: https://www.sciencedirect.com/science/article/pii/S0005109818300384

(3) Transmission scheduling for remote state estimation and control with an energy harvesting sensor

Author: Alex S.Leong, Subhrakanti Dey, Daniel E.Quevedo

Abstract

This paper studies a remote state estimation problem where a sensor, equipped with energy harvesting capabilities, observes a dynamical process and transmits local state estimates over a packet dropping channel to a remote estimator. The objective is to decide, at every discrete time instant, whether the sensor should transmit or not, in order to minimize the expected estimation error covariance at the remote estimator over a finite horizon, subject to constraints on the sensor's battery energy governed by an energy harvesting process. We establish structural results on the optimal scheduling which show that, for a given battery energy level and a given harvested energy, the optimal policy is a threshold policy on the error covariance. Similarly, for a given error covariance and a given harvested energy, the optimal policy is a threshold policy on the current battery level. An extension to the problem of transmission scheduling and control with an energy harvesting sensor is also considered.

Full-text available at: https://www.sciencedirect.com/science/article/pii/S0005109818300360

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SELECTIONS OF IEEE Transactions on Control Systems Technology
VOLUME: 26 ISSUE: 3
May 2018

(1) Multiobjective Optimal Control With Safety as a Priority

Author: Kendra Lesser ; Alessandro Abate

Abstract

This paper develops a lexicographic approach to multiobjective optimal control on models for cyber-physical systems, encompassing in particular stochasticity, limited access to model variables (partial observations), and possibly hybrid (continuous and discrete) dynamics (with the finite-state partially observable Markov decision process framework as a known special instance). The technique is showcased in two new case studies in the area of smart buildings. Technically, the main achievements of this paper are as follows: the application of the lexicographic framework to multiobjective optimization including quantitative probabilistic safety requirements, thus leading to a principled and scalable integration of correct-by-design synthesis for safety and optimal synthesis for performance, the novel extension of the lexicographic framework to partially observed stochastic models with continuous (possibly hybrid) dynamics, and the emphasis on computational aspects, including the use of compact and approximate representations of value functions combined with the quantification of error bounds on model abstractions.

Full-text available at: https://ieeexplore.ieee.org/document/7940041/

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SELECTIONS OF IEEE Transactions on Industrial Informatics
VOLUME: 14 ISSUE: 4
April 2018

(1) Supervisory Control-Based Navigation Architecture: A New Framework for Autonomous Robots in Industry 4.0 Environments

Author: Antonio G. C. Gonzalez ; Marcos V. S. Alves ; Gustavo S. Viana ; Lilian K. Carvalho ; João C. Basilio

Abstract

Industry 4.0 is characterized by an increasing dependence on automation and interconnection of systems due to the need for more efficient, autonomous, and customizable processes, and so, mobile robot navigation becomes an important tool. In this paper, we present a general methodology for mobile robot navigation in industrial environments in which the open-loop behavior of the robot and the specifications are based on automata. We build a modular supervisor, which is the conjunction of two supervisors: the first one that enforces the robot to follow the path defined by a planner and the second one that guarantees the satisfaction of the specifications such as prevention of collisions and task and movement management. The proposed navigation architecture allows decentralized implementation, in which the modular supervisor is embedded in the mobile robot, whereas the planner runs in an external agent.

Such a feature makes the adaptation of the proposed navigation architecture to different environments easy. The navigation architecture proposed in this paper is illustrated by means of a simulation in a hypothetical environment that resembles a smart factory.

Full-text available at: https://ieeexplore.ieee.org/document/8241718/

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SELECTIONS OF IEEE/CAA Journal of Automatica Sinica
VOLUME: 5
MAY 2018

(1) Collision-free Scheduling of Multi-bridge Machining Systems: A Colored Traveling Salesman Problem-based Approach

Author: Jun Li ; Xianghu Meng; Xing Dai

Abstract

Multi-bridge machining systems (MBMS) have gained wide applications in industry due to their high production capacity and efficiency. They contain multiple bridge machines working in parallel within their partially overlapping workspaces. Their scheduling problems can be abstracted into a serial-colored travelling salesman problem in which each salesman has some exclusive cities and some cities shared with its neighbor (s). To solve it, we develop a greedy algorithm that selects a neighboring city satisfying proximity. The algorithm allows a salesman to select randomly its shared cities and runs accordingly many times. It can thus be used to solve job scheduling problems for MBMS. Subsequently, a collision-free scheduling method is proposed to address both job scheduling and collision resolution issues of MBMS. It is an extension of the greedy algorithm by introducing time window constraints and a collision resolution mechanism. Thus, the augmented greedy algorithm can try its best to select stepwise a job for an individual machine such that no time overlaps exist between it and the job sequence of the neighboring machine dealt in the corresponding overlapping workspace; and remove such a time overlap only when it is inevitable. Finally, we conduct a case study of a large triplebridge waterjet cutting system by applying the proposed method.

Full-text available at: https://ieeexplore.ieee.org/document/7833264/

(2) Event-triggered MPC Design for Distributed Systems With Network Communications

Author: Xiaoxiao Mi ; Shaoyuan Li

Abstract

This paper deals with the communication problem in the distributed system, considering the limited battery power in the wireless network and redundant transmission among nodes. We design an event-triggered model predictive control (ET-MPC) strategy to reduce the unnecessary communication while promising the system performance. On one hand, for a linear discrete time-invariant system, a triggering condition is derived based on the Lyapunov stability. Here, in order to further reduce the communication rate, we enforce a triggering condition only when the Lyapunov function will exceed its value at the last triggered time, but an average decrease is guaranteed. On the other hand, the feasibility is ensured by minimizing and optimizing the terminal constrained set between the maximal control invariant set and the target terminal set. Finally, we provide a simulation to verify the theoretical results. It is shown that the proposed strategy achieves a good trade-off between the closed-loop system performance and communication rate.

Full-text available at: https://ieeexplore.ieee.org/document/7739888/

(3) Detecting Data-flow Errors Based on Petri Nets With Data Operations

Author: Dongming Xiang ; Guanjun Liu ; Chungang Yan ; Changjun Jiang

Abstract

In order to guarantee the correctness of business processes, not only control-flow errors but also data-flow errors should be considered. The control-flow errors mainly focus on deadlock, livelock, soundness, and so on. However, there are not too many methods for detecting data-flow errors. This paper defines Petri nets with data operations (PN-DO) that can model the operations on data such as read, write and delete. Based on PN-DO, we define some data-flow errors in this paper. We construct a reachability graph with data operations for each PN-DO, and then propose a method to reduce the reachability graph. Based on the reduced reachability graph, data-flow errors can be detected rapidly. A case study is given to illustrate the effectiveness of our methods.

Full-text available at: https://ieeexplore.ieee.org/document/8232598/

(4) Polynomial Approach to Optimal One-wafer Cyclic Scheduling of Treelike Hybrid Multi-Cluster Tools via Petri Nets

Author: Fajun Yang ; Naiqi Wu ; Yan Qiao ; Rong Su

Abstract

A treelike hybrid multi-cluster tool is composed of both single-arm and dual-arm cluster tools with a treelike topology. Scheduling such a tool is challenging. For a hybrid treelike multi-cluster tool whose bottleneck individual tool is process-bound, this work aims at finding its optimal one-wafer cyclic schedule. It is modeled with Petri nets such that a one-wafer cyclic schedule is parameterized as its robots' waiting time. Based on the model, this work proves the existence of its one-wafer cyclic schedule that features with the ease of industrial implementation. Then, computationally efficient algorithms are proposed to find the minimal cycle time and optimal one-wafer cyclic schedule. Multi-cluster tool examples are given to illustrate the proposed approach. The use of the found schedules enables industrial multi-cluster tools to operate with their highest productivity.

Full-text available at: https://ieeexplore.ieee.org/document/8232600/

(5) Behavior consistency computation for workflow nets with unknown correspondence

Author: Mimi Wang ; Guanjun Liu ; Peihai Zhao ; Chungang Yan ; Changjun Jiang

Abstract

Consistency degree calculation is established on the basis of known correspondence, but in real life, the correspondence is generally unknown, so how to calculate consistency of two models under unknown correspondence has become a problem. For this condition, we should analyze unknown correspondence due to the influence of different correspondences. In this paper we obtain the relations of transitions based on event relations using branching processes, and build a behavioral matrix of relations. Based on the permutation of behavioral matrix, we express different correspondences, and define a new formula to compute the maximal consistency degree of two workflow nets. Additionally, this paper utilizes an example to show these definitions, computation as well as the advantages.

Full-text available at: https://ieeexplore.ieee.org/document/8232601/

(6) Decomposition methods for manufacturing system scheduling: a survey

Author: Fajun Yang ; Kaizhou Gao ; Ian Ware Simon ; Yuting Zhu ; Rong Su

Abstract
Manufacturing is the application of labor, tools, machines, chemical and biological processing, to an original raw material by changing its physical and geometrical characteristics, in order to make finished products. Since the first industrial revolution, to accommodate the large-scale production, tremendous changes have happened to manufacturing through the innovations of technology, organization, management, transportation and communication. This work first reviews the high-volume low-mix process by focusing on the quantity production, transfer line

and single model assembly line. Then, it reviews the high-volume high-mix process. For such a process type, mixed/multi model assembly line is usually adopted. Hence, two main decisions on them, i.e., balancing and, sequencing are reviewed. Thereafter, it discusses the low-volume high-mix process in detail. Then, technology gap and future work is discussed, and at last, conclusions are given.

Full-text available at: https://ieeexplore.ieee.org/document/8283967/

(7) Nonlinear Bayesian estimation: from Kalman filtering to a broader horizon

Author: Huazhen Fang ; Ning Tian ; Yebin Wang ; MengChu Zhou ; Mulugeta A. Haile

Abstract

This article presents an up-to-date tutorial review of nonlinear Bayesian estimation. State estimation for nonlinear systems has been a challenge encountered in a wide range of engineering fields, attracting decades of research effort. To date, one of the most promising and popular approaches is to view and address the problem from a Bayesian probabilistic perspective, which enables estimation of the unknown state variables by tracking their probabilistic distribution or statistics (e.g., mean and covariance) conditioned on a system's measurement data. This article offers a systematic introduction to the Bayesian state estimation framework and reviews various Kalman filtering (KF) techniques, progressively from the standard KF for linear systems to extended KF, unscented KF and ensemble KF for nonlinear systems. It also overviews other prominent or emerging Bayesian estimation methods including Gaussian filtering, Gaussian-sum filtering, particle filtering and moving horizon estimation and extends the discussion of state estimation to more complicated problems such as simultaneous state and parameter/input estimation.

Full-text available at: https://ieeexplore.ieee.org/document/8283968/

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