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Editorial

Special issue on the IFAC World Congress 2011

This special issue originates from the presentations at the IFAC World Congress held in Milan, Italy, from August 20 to September 2, 2011, where the IFAC Technical Committee 1.3 on Discrete Event and Hybrid Systems organized a track composed of 74 papers. Out of these papers, 16 among the best papers focusing on hybrid systems were shortlisted for a special issue of the IFAC affiliated journal *Nonlinear Analysis: Hybrid Systems*, and their authors were invited to submit an original manuscript extending the results presented at the World Congress. Eight of these papers were submitted by the authors and all of them have been accepted for this special issue after a meticulous peer-reviewing process.

This special issue addresses a wide range of topics that include stability analysis of impulsive systems, control of communicating systems, digital signal reconstruction, analysis of self-synchronizing dynamical systems motivated by cryptographic applications, optimal abstractions of polynomial dynamical systems by timed automata, and, finally, a modeling approach for robotic walking based on the reconstruction of the temporal ordering of discrete events. In the following, the content of each paper is briefly described.

Hetel et al. consider a class of impulsive systems constituted by a continuous-time linear dynamics for all times, except at a sequence of distinct time instants. When such a discrete time occurs, the state undergoes a jump, or, more precisely, follows a discrete linear dynamics. The sequence of time instants at which a discrete dynamics occurs is only nearly periodic, i.e. it is distant from a periodic sequence by an uncertain error. This paper succeeds in stating tractable conditions for analyzing the stability, and for designing reset matrices such that the hybrid system is globally exponentially stable to the origin. The approach is based on a polytopic embedding of the uncertain dynamics. Some examples illustrate the main results.

Cosentino et al. consider a class of impulsive systems described by a continuous-time dynamics defined by a nonlinear quadratic system and exhibiting discrete jumps in the state trajectory. In the paper, sufficient conditions for the design of both static state-feedback and dynamical output-feedback controllers are provided. The proposed conditions guarantee, for the closed-loop system, the local asymptotic stability of the zero equilibrium point, and the inclusion of a given polytopic region into the domain of attraction of the equilibrium itself. Specialized conditions are provided for the case of time-dependent quadratic impulsive systems with prescribed resetting times. The proposed results require the solution of a feasibility problem involving linear matrix inequalities.

Haimovich and Osella consider a setting where a centralized controller/scheduler is in charge of the control of several processes and also of administering access to the shared communications network. In this setting, the controller may perform online variations of the rate of sampling of all processes in order to accommodate new processes requiring access to the network and to maximize performance when processes finish operation. The authors refer to this as the controller-driven varying-sampling-rate (VSR) setting. They regard a continuous-time system sampled at varying rates as a discrete-time switched system (DTSS), and aim at devising sampling-rate-dependent feedback to ensure stability irrespective of the way in which the sampling rate is varied. Their feedback design strategy is based on Lie-algebraic solvability. The paper presents two main contributions: a) it demonstrates that control design based on Lie-algebraic solvability is much less restrictive when applied to the controller-driven VSR setting than when applied to DTSSs of arbitrary form; and b) it gives sufficient conditions for the stabilizability of the VSR-DTSS by means of the Lie-algebraic-solvability condition. As opposed to previous conditions obtained, these sufficient conditions do not impose a restriction on the number of subsystems of the DTSS.

Wang et al. consider the problem of reaching a desired final state from a given initial one in large scale systems described by choice-free continuous Petri nets. The original system is partitioned into disconnected subsystems by means of a set of buffer places and local control laws are computed independently in each subsystem. In the process, two problems arise: firstly, disconnected subsystems can exhibit different behaviors to the original ones; secondly, since the buffer places are essentially shared by more than one subsystem, there must be an agreement among the neighboring local controllers. The first problem can be overcome by complementing the disconnected subsystems with an abstraction of the parts that are missing. For the second problem, a coordinator controller is introduced, and several algorithms are proposed for reaching the agreement. The coordinator design is rather simple, because it does not need to know the detailed states and structures

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of subsystems. Finally, it is shown that by applying an ON–OFF control strategy in each subsystem, the final state can be reached in minimum time.

Fosson considers the problem of recovering the digital input of a discrete-time linear system from its (noisy) output: this is a significant challenge in the fields of data transmission, deconvolution, channel equalization, and inverse modeling. A variety of algorithms have been developed for this purpose in the last few decades, tailored to different models and with different performance/complexity requirements. In this paper, a novel algorithm for reconstructing the binary input of a one-dimensional linear system with known probabilistic properties is discussed. Although suboptimal, this algorithm presents two main advantages: it works online and has very low complexity. Moreover, using results on the convergence of probability measures, Markov processes, and iterated random functions it is possible to evaluate its long-time behavior in terms of mean square error.

Parriaux and Millérioux address the analysis of self-synchronizing dynamical systems in a so-called master–slave configuration. The study is motivated by potential cryptographic applications. It is shown that the notion of flatness is central for guaranteeing self-synchronization and that the concept of transmission zero also plays an important role. The assertion that switched linear systems are of great interest in this context is motivated. Next, the finite-time synchronization is relaxed to give rise to a so-called statistical self-synchronization, a mode of operation which makes sense in classical cryptography, and which operates over finite fields.

Sloth and Wisniewski consider the generation of complete abstractions of polynomial dynamical systems by timed automata. For the proposed abstraction, the state space is divided into cells by means of sublevel sets of functions. By identifying a relation between these functions and their directional derivatives along the vector field, it is possible to generate a complete abstraction. To compute the functions that define the subdivision of the state space in an algorithm, a sum of squares optimization problem is formulated. This optimization problem finds the best sub-divisioning functions, with respect to the ability to approximate the dynamical system, in a subset of admissible sub-divisioning functions.

Vasudevan et al. address a challenging problem in robotic walking research. Although the generation of anthropomorphic gait is considered an important objective, the community as a whole has struggled to agree even upon the correct ordering of discrete events during walking. In this paper, a universal temporal ordering of discrete events for bipedal walking is proposed: the ordering is based on motion capture data collected from a nine-subject straight line walking experiment. Surprisingly, the findings of this work are that every subject, regardless of age, sex, weight and height, in the experiment had an identical temporal ordering of such events. This result allows for the development of a universal anthropomorphic bipedal robotic walking model, because the temporal ordering of events together with the Lagrangian modeling of the robot completely determines the mathematical model of the system. Importantly, this universal ordering allows the authors to propose a cost function based on human data: the human-based cost, which is used to gauge the “human-like” quality of robotic walking.

Finally, we express our sincere thanks to the reviewers for their valuable assistance and contribution to the reviewing process for this special section.

Ordered list of papers

1	NAHS-D-11-00110	Stabilization of linear impulsive systems through nearly periodic reset	Laurentiu Hetel, Ph.D.
2	NAHS-D-11-00117	Stabilization of impulsive quadratic systems over polytopic sets	Carlo Cosentino, Ph.D.
3	NAHS-D-11-00113	On controller-driven varying-sampling-rate stabilization via Lie-algebraic solvability	Hernan Haimovich
4	NAHS-D-11-00116	Minimum-time decentralized control of choice-free continuous Petri nets	Liewei Wang
5	NAHS-D-11-00112	An algorithm for the deconvolution of one-dimensional quantized-input linear systems	Sophie Marie Fosson, Ph.D.
6	NAHS-D-11-00114	Designing self-synchronizing switched linear systems: An application to communications	Jérémy Parriaux
7	NAHS-D-11-00115	Complete abstractions of dynamical systems by timed automata	Christoffer Sloth
8	NAHS-D-11-00111	Persistent homology for automatic determination of the human-data-based cost of bipedal walking	Ramanarayan Vasudevan, Ph.D.

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