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Editorial

Control under limited information: Special issue (part II)

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1. INTRODUCTION

This is the second part for the Special Issue *Control under Limited Information*.

This second part emphasizes networked control systems (NCSs). These systems are defined as feedback control systems whose control loops are closed through a real-time network, see [1, 2]. Although these systems have the advantage of low cost and simplified maintenance and diagnosis, the assumptions of classical control may need to be revisited. New problems arise because the sensed data and the control signals no longer have infinite precision, but are instead connected through a packet network that has finite data rate (finite precision), a propagation delay, and may be shared by many other systems.

Several of these issues are topics dealt with by the authors of this second part of the Special Issue.

2. SPECIAL ISSUE CONTENT

The first article is titled 'Kalman filter based adaptive control for networked systems with unknown parameters and randomly missing output' by Shi, Fang and Yan. This work investigates the problem

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of adaptive control for NCSs with unknown model parameters and randomly missing outputs. For a system with the ARX model placed in a network environment, the randomly missing output feature is modeled as a Bernoulli process. The authors propose an output to online estimate the missing output measurements and then a Kalman filter-based method for parameter estimation. Based on the estimated output or the available output, and the estimated model parameters, an adaptive control is designed to make the output track the desired signal. Convergence properties of the proposed algorithms are analyzed in detail. The effectiveness of the proposed method is illustrated by simulations.

The second article is titled ‘Kalman filtering over wireless fading channels—How to handle packet drop’, by Mostofi and Murray. This work addresses the estimation problem of dynamical systems over wireless fading communication channels using a Kalman filter. The authors show that the communication protocols suitable for other already-existing applications (such as data networks) may not be entirely applicable for the estimation and control of a rapidly changing dynamical system. The authors then develop new design paradigms for such delay-sensitive applications. More specifically, this work shows how noisy packets should be handled in the receiver. The optimum receiver design will also depend on the availability of a cross-layer information path, which we shall study. To provide new design paradigms, the authors reformulate the estimation problem to include the impact of stochastic communication noise in the noisy packets. The paper looks at both stability and performance of the estimation, and finally prove that in the absence of a cross-layer information path, packet drop should be designed to balance information loss and communication noise in order to optimize the performance. In the presence of a cross-layer path, it is shown that keeping all the packets will minimize the average estimation error covariance. Finally, the authors also derive the stability condition in the presence of noisy packets and prove that it is independent of the shape of the communication noise variance or availability of a cross-layer information path.

The third article is titled ‘Wireless digital control of continuous passive plants over token ring networks’ by Kottenstette and Antsaklis. This work extends the concept of wave variables to interconnect passive plants with passive controllers that was introduced in an earlier work. The present paper further enhances the previous results by providing a detailed model that captures time-varying delays, data dropouts and network capacity for wireless ring token networks. It also provides a new theorem showing how an asynchronous controller can be implemented that maintains an L2-stable system. The paper uses simulations to show that asynchronous control of a passive motor reduces the overall distortion when compared with a synchronous controller, which relies on the lossy data reduction techniques. The main contribution is that these two distinct results pave the way to study high-performance rate adaptive control schemes, which minimize their control rate in order to match the network capacity.

The fourth paper is titled ‘Semiautonomous control of multiple networked Lagrangian Systems’ by Hokayem, Stipanovi and Spong. The authors study the problem of synchronizing the positions of a group of Lagrangian systems with communication constraints exhibited through delays and limited data rates. Their work shows that in a bidirectional connected communication graph structure, it is possible to design PD-type control laws that render the overall networked system input-to-state stable. An important contribution is that the authors exploit the robustness property of these control laws along with a small-gain condition on the allowable delays to infer the stability of the overall networked system. Finally, the authors provide an explanation on how the obtained results can be specialized to handle the problem of position–position control for three networked 2DOF manipulators as well as teleoperation of robotic swarms.

The last paper of this Special Issue is titled 'Rate limited stabilization: Sub-optimal encoder–decoder schemes' by Lopez and Abdallah. The authors extend in this paper results from packet-based control theory and present sufficient conditions on the rate of a packet network to guarantee asymptotic stabilizability of unstable discrete LTI systems with less inputs than states. The authors propose to use a truncation-based encoder/decoder scheme for two different types of Network Control Systems in the absence of communication delays; then for one of the two types, the case of a constant time delay is discussed. Another contribution of this work is a zoom-in-type dynamic quantizer scheme with lower data rate but a more complex encoding scheme than the truncation-based one. The new dynamic quantizer requires a lower data rate to achieve stabilization, and while it does not achieve the minimum data rate given by the Data Rate Theorem, it uses an encoding algorithm that is simpler than others reported in the literature. Finally, the validity of the results is demonstrated by numerical simulations.

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