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GUEST EDITORIAL INTRODUCTION TO THE TWO SPECIAL ISSUES ON ADVANCES IN ANALYSIS AND CONTROL OF TIME–DELAY SYSTEMS

Jean–Michel Dion, Luc Dugard and Silviu–Iulian Niculescu

1. INTRODUCTION

Delay systems represent a class of infinite-dimensional systems [1, 2, 3] largely used to describe various types of processes such as transport and propagation phenomena [5, 6] or population dynamics [4, 7, 8].

Roughly speaking, any *interconnection* of physical systems handling and transferring material, energy or information is intrinsically subject to *delays*. If, at the origin, such a phenomenon was related to developments specific to control engineering and if, in most cases, the *delay effects* were neglected or approximated, it becomes more and more involved in characterizing and/or improving various performances in dynamical systems. Thus, for example, in communication systems, data transmission is always accompanied by some non-zero time-interval between the initiation and the delivery of the corresponding message or signal, which can be 'transferred' with or without any processing. In such a case, huge transmission delays will reduce the qualitative behavior of the system, as, for example, its 'ability' to treat large amount of data, and thus the performances of the transmission systems.

A distinguishing feature of such systems is that their evolution rate can be described by *differential equations* including information on the *past history* of the system. In a mathematical framework, such systems may be described in several ways, let us mention, for example: differential equations on abstract or functional spaces, rings of operators. Concerning the delays, one can encounter constant or time-varying, discrete or distributed, finite or infinite, state-dependent or not, etc.

All these aspects show that the study and the analysis of such systems are not an easy task due to the complexity of representation, among other things. However, a lot of techniques and methods have been developed in the control literature to handle such systems. Based on the numerical algorithms and control methods in feedback theory, some 'classical' and known as 'very difficult' problems have found new formulations, simplifications, and, in some cases, interesting solutions in the last decade. Important advances have then been recently made in analysis and control of time delay systems. We think that it is the right time for editing special issues on the matter, collecting for control audience representation that reflect recent advances on time delay systems.

2. ON THESE ISSUES

The two special issues are devoted to the *analysis* and *control* of delay systems, using one of the approaches cited above, for systems operating in open or closed-loop. The papers found in these two special issues cover a wide range of topics including stability and stabilization, observers, non linear and infinite dimensional aspects, algebraic tools, discretization and numerical aspects. In order to tend to *self-contained* special issues, some of the contributions are 'large' overviews in the corresponding field. Note that these two issues were originated on the occasion of the *Summer school* devoted to the subject and organized by the *Editors* of these issues at the beginning of September 2000 in Grenoble [9], and during the second IFAC Workshop "Linear Time Delay Systems" in Ancona [10]. Some of the authors are with a French – USA *CNRS* and *NSF* project and/or with a working group of the French *GDR CNRS 'Automatic Control'*.

3. ISSUES CONTENTS

In preparing these two special issues, we intended to present on one hand, some overviews on the field and on the other hand, more specialized papers that would give a non exhaustive panorama of the research lines concerning the time delay systems. The 17 invited papers of these issues have been written by well known specialists in the field of time delay systems and have been rigorously reviewed. The content of the two special issues is as follows:

Three papers deal more specifically with stability issues:

— E. Verriest presents qualitative approaches based on Lyapunov methods to study the stability of delay systems.

— J. Louisell considers specific problems linked to the presence of time-varying delays and demonstrates a new instability phenomenon.

— S.-I. Niculescu gives sufficient conditions for the robust stability of a class of neutral systems.

Three papers deal with control and stabilization issues:

— J. J. Loiseau studies the invariant factor assignment of a class of time-delay systems in an algebraic setting. The control law includes distributed delays.

— J.-P. Richard, F. Gouaisbaut and W. Perruquetti consider the stabilization of time delay systems via sliding mode controllers and propose an easy to implement controller.

— M. Fliess and H. Mounier study the tracking control problem based on a new algebraic property named π-freeness.

Four papers consider robustness issues:

— C. E. de Souza addresses the problems of stabilization and decentralized control of interconnected linear time-delay systems. Decentralized robust stabilization is also discussed.

— D. Ivanescu, S.-I. Niculescu, J.-M. Dion and L. Dugard deal with robust stabilization of distributed delay systems using a generalized Popov theory approach.

— C. Bonnet and J. R. Partington analyze the robust stabilization of a large class of fractional exponential delay systems through coprime factorizations.

— C. Abdallah, M. Ariola and V. Koltchinskii present an efficient statistical algorithm that determines the optimal gain of a controller when time delays are uncertain.

Two papers are concerned with non linear aspects:

— L. A. Marquez–Martinez and C. Moog consider the trajectory tracking problem for nonlinear systems with constant and commensurate time delays.

— G. Garcia and S. Tarbouriech develop a method to derive a nonlinear bounded state feedback controller for linear time delay systems.

One paper focuses on the behavioural approach:

— H. Gluesing–Luerssen, P. Vettori and S. Zampieri present a survey on the recent contributions to linear time-invariant delay differential systems in the behavioural approach.

Two papers deal with observers:

— O. Sename presents a survey on recent advances on the design of observers leading to tractable observers in practical situations.

— A. Germani, C. Manes and P. Pepe develop a state observer for non linear delay systems ensuring exponential decay of observation error.

Two papers are focused on discretization and numerical aspects:

— K. Gu gives an overview of discretized Lyapunov functional methods for linear time delay systems. A new discretization technique reducing the conservatism is proposed.

— K. Ikeda, T. Azuma and K. Uchida develop an infinite dimensional LMI approach to analysis and synthesis for linear time delay systems including distributed delays. A technique is presented to reduce the infinite dimensional LMIs to a finite number of LMIs.

Papers devoted to stability, control, stabilization and robustness are accommodated in the present issue. The remaining seven papers devoted to non linear aspects, behavioural approach, observers, discretization and numerical aspects will appear in the next issue of Kybernetika.

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Prof. Dr. Jean–Michel Dion and Prof. Dr. Luc Dugard, Laboratoire d'Automatique de Grenoble (UMR CNRS 5528), ENSIEG, BP 46, 38402, Saint Martin d'Herès. France.
e-mail: dion,dugard@lag.ensieg.inpg.fr

Dr. Silviu–Iulian Niculescu, HeuDiaSyC (UMR CNRS 6599), Université de Technologie de Compiègne, Centre de Recherche de Royallieu, BP 20529, 60205, Compiègne. France.
e-mail: silviu@hds.utc.fr