PREFACE

Spatiotemporal dynamic systems, also known as distributed parameter systems, are dynamical systems whose state depends not only on time but also on spatial coordinates. They are frequently encountered in practical engineering problems. Examples of a thermal nature are furnaces for heating metal slabs or heat exchangers; examples of a mechanical nature are large flexible antennas, aircrafts and robot arms; examples of an electrical nature are energy transmission lines.

Appropriate mathematical modelling of such systems most often yields Partial Differential Equations (PDEs), but descriptions by integral or integro-differential equations can sometimes be considered. Clearly, such models involve using very sophisticated mathematical methods, but in recompense for this effort we are in a position to describe the process more accurately and to implement more effective control strategies. Early lumping, which means approximation of a PDE by ordinary differential equations of possibly high order, may completely mask the distributed nature of the system and therefore is not always satisfactory.

For the past fifty years spatiotemporal dynamic systems have occupied an important place in control and systems theory. This position has grown in relevance due to the ever-expanding classes of engineering systems which are distributed in nature, and for which estimation and control are desired. Spatiotemporal or, more generally, infinite-dimensional systems are now an established area of research with a long list of journal articles, conference proceedings and several textbooks to its credit, so the field of potential applications could hardly be considered complete.

In spite of many tremendous successes, analysis and control of complex spatiotemporal dynamic systems still remains a challenging task. It is a great pleasure for us to introduce this special section of the *International Journal of Applied Mathematics and Computer Science*, the journal that has a long tradition of highlighting particularly interesting and timely topics. It is a lasting result of a workshop that was held at the University of Zielona Góra, Poland, on 22 November 2010. This one-day technical meeting was organized jointly by the Polish Chapter of the IEEE Control Systems Society and the Commission for Engineering Cybernetics of the Poznań Branch of the Polish Academy of Sciences. The event brought together researchers from all over Poland. A total of seven speakers had the opportunity to present and discuss their latest results, as well as exchange ideas on new trends in the field of inifinite dimensional systems. Based on their talks, the participants decided to prepare full papers in which the conceptual development, experimentation and validation of their initial results were extended. These papers have undergone a complete review to ensure that extensions were significant and the manuscripts remain of high quality and clarity. As a result, six papers have been included in this special section.

The presented papers cover a large spectrum of topics that are all well aligned with the scope of the workshop. In the first paper, *Infinite-dimensional Sylvester equations: Basic theory and application to observers design*, Emirsajłow develops a mathematical framework for the infinite-dimensional Sylvester equation, both in differential and algebraic forms. He uses implemented semigroups as the main mathematical tool. This idea can be found in the literature on evolution equations occurring in mathematics and physics and is rather unknown in systems and control theory. The paper intends to provide a rigorous introduction to the subject. As an important example of applications, the problem of designing an asymptotic state observer for a linear infinite-dimensional control system with a bounded input operator and an unbounded output operator is studied.

In the paper *Ergodic theory approach to chaos: Remarks and computational aspects*, Mitkowski and Mitkowski discuss basic notions of the approach to chaos based on ergodic theory. Some characteristic features of ergodic and mixing behaviours are demonstrated through simple examples. What is more, an infinite dimensional model (a delay differential equation) of erythropoiesis (a red blood cell production process) set forth by Lasota is thoroughly discussed. The presented computational results suggest that this infinite dimensional model possesses an attractor of a non-simple structure, supporting invariant mixing measure. This observation backs the conjecture on nontrivial ergodic properties.

In his paper *Topology optimization of quasistatic contact problems*, Myśliński deals with a necessary optimality condition for a topology optimization problem regarding an elastic contact problem with Tresca friction. A quasistatic contact model is considered, rather than a stationary one used in the literature. The functional approximating the normal contact stress is chosen as the shape functional. The objective is to find an optimal material distribution inside the design domain occupied by a body in unilateral contact with the rigid foundation to obtain an optimal shape domain for which the normal contact stress along the contact boundary is minimized. Using the material derivative and asymptotic expansion methods, the topological derivative of the shape functional is calculated and the relevant necessary optimality condition results.

In *Localization in wireless sensor networks: Classification and evaluation of techniques*, Niewiadomska-Szynkiewicz discusses observation of spatiotemporal dynamic systems and provides a concise introduction to applications of wireless sensor networks (properties, limitations and design). She focuses her attention on one important key aspect of

the design, namely, accurate localization of devices that form a network. The paper presents an overview of localization strategies and attempts to classify various techniques. A set of properties by which location systems are evaluated are examined. A number of existing localization systems are discussed along with the results of the performance evaluation of some of them through simulation and experiments using a testbed implementation.

In his paper *Distributed scheduling of sensor networks for identification of spatio-temporal processes*, Patan outlines an approach to determine a scheduling policy for a sensor network monitoring some spatial domain in order to identify unknown parameters of a spatiotemporal dynamic system. Given a finite number of possible sites at which sensors are located, an activation schedule for scanning sensors is provided so as to maximize a criterion defined on the Fisher information matrix associated with the estimated parameters. The associated combinatorial problem is relaxed through operating on the density of sensors in lieu of individual sensor positions. Based on the adaptation of pairwise communication algorithms and the idea of running consensus, a numerical scheme is developed, which distributes the computational burden between many network nodes. As a result, a simple exchange algorithm is outlined to solve the design problem in a decentralized fashion.

Finally, in their paper *A modified filter SQP method as a tool for optimal control of nonlinar systems with spatio-temporal dynamics*, Rafajłowicz, Styczeń and Rafajłowicz adapt Fletcher's filter approach to solving optimal control problems of systems described by nonlinear PDEs subject to state constraints. They report a number of modifications of the original filter approach, which are well suited for their purposes. What is more, they discuss possible ways of cooperation between the filter method and a PDE solver. One of them is selected and thoroughly tested.

In our personal opinion, the papers in this special section make notable contributions to the state of the art in the field of systems with spatiotemporal dynamics. We hope the reader will share our point of view and find this special section very useful. We would like to acknowledge all the authors for their efforts in submitting high-quality papers. Last, but not least, we are also very grateful to the reviewers for their thorough and critical reviews of the papers within the short stipulated time.

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June 2012

Dariusz Uciński was born in 1965. He received the M.Sc. degree in electrical engineering from the Higher College of Engineering in Zielona Góra, Poland, in 1989, and the Ph.D. and D.Sc. degrees in automatic control and robotics from the Technical University of Wrocław, Poland, in 1992 and 2000, respectively. In 2007 he was conferred the title of state professor, the highest scientific degree in Poland. He is currently a professor at the University of Zielona Góra, Poland. His research interests are in the area of measurement optimization for distributed parameter systems. He authored a book entitled *Optimal Measurement Methods for Distributed Parameter System Identification* (Boca Raton, FL: CRC Press, 2005). Other areas of his expertise include optimum experimental design, algorithmic optimal control, and robotics and parallel computing. Since 1992 he has been serving as the deputy editor of the *International Journal of Applied Mathematics and Computer Science*. In the period of 2008–2011 he was the chair of the Control Systems Society Chapter of the IEEE Poland Section. Since 2012, he has been its vice-chair.

Józef Korbicz has been a full-rank professor of automatic control at the University of Zielona Góra, Poland, since 1994, and a corresponding member of the Polish Academy of Sciences since 2007. He currently heads the Institute of Control and Computation Engineering of his home university. His research interests include computational intelligence, fault detection and isolation, and control theory. The primary aim of his research group is to contribute to the diagnosis of dynamical systems. He has published more than 360 technical papers, 58 of which in international journals. He is a co-author of eight monographs and textbooks and a co-editor of four books, e.g., *Fault Diagnosis. Models, Artificial Intelligence, Applications* (Springer-Verlag, 2004) and *Modeling, Diagnostics and Process Control. Implementation in the DiaSter System* (Springer, 2010). He served as the IPC chairman of the IFAC Symposium *SAFEPROCESS* (China, 2006) and of the Workshop on *Advanced Control and Diagnosis*, *ACD* (Poland, 2009). Currently he is a general vice-chair of the International Conference on *Control and Fault-Tolerant Systems, SysTol'13* (France, 2013). He is a senior member of the IEEE, and a member of the IFAC SAFEPROCESS TC.