Guest Editorial

We are witnessing a global financial and economic crisis, which may have far-reaching, and at least recently, unforeseeable consequences on the future and development of world science and technology. Control theory has always been an area of science driven by technology. From the statistical filtering solution formulated by R. Kalman in the early 1960s, devised for answering the needs of NASA’s space exploration projects, to the robustifying approaches of control and filtering relying on the \( H_{\infty} \) theory, stimulated by the various aircraft control problems in the 1980s, the symbiotic development of theory and practice has always been assessable. The first discernible effects of the crisis can be captured in the visible shift towards the rapid restructuring and accentuation of priorities among the fields of sciences. Traditional sciences may get new forms and establish new partnerships, some of them will rise and some of them descend. What is clearly seen today in all areas of control is the accession of the significance of the principles, such as distribution and cooperation, negotiation-based and consensus-seeking solutions, the dependence on shared resources, moreover, the widespread use of the underlying technologies upon which these principles may rely, such as communication and networking. Novel methods of control, getting stuck in these principles, seem to be promising in the treatment of the ever-increasing problem of complexity, for more efficient reconfiguration, better adaptation and optimality in the control of (large-scale) dynamical systems. Applications of systems and control theory and advanced control technology that are increasingly visible beyond the traditional control-driven domains, such as aerospace and process industries, include road vehicle and traffic automation systems, ad-hoc networks and bio-molecular systems and the various micro- and nano-applications mostly related to robotics.

This theme is well reflected in the articles we have selected for the edition of the Special Issue that contains the plenary and semiplenary papers and selected papers from the regular and tutorial program of the European Control Conference, held in Budapest, Hungary, between 23 and 26 August, 2009. The articles cover the subject fields from classical approaches of control to the latest streams of control theory by summarizing the most recent advances in this area. The Volume consists of the following articles:

The works, presented by P. Colaneri and Z. Szabó, consider special themes related to the controllability and weak stabilizability of switching dynamic systems. While Colaneri’s article presents an interesting view on the available results concerning dwell time analysis for switched linear systems, both in deterministic and stochastic settings where the switching operation affects the dynamics and the associated transition probability matrices of the system, Szabó emphasizes the fundamental role of the finite switching property of dynamical systems in obtaining results for controllability and stabilizability. Colaneri’s main result is a novel method for the determination of the minimum dwell time ensuring stability and an upper bound for stochastic stability, whereas, Szabó collects underlying
information that contributes to the better understanding of the results that still remain hidden in the literature published earlier.

System identification has always been a distinguished subject, important in control. In this Special Issue J. Schoukens and co-workers discuss a powerful tool for nonparametric preprocessing for system identification. The analysis presented is based on the recent insight that leakage errors in the frequency domain have a smooth nature that is completely similar to the initial transients experienced in the time domain. This recognition not only allows a better understanding of the existing methods, but also opens the road to the construction of new, better performing algorithms. The paper presented by H. Hjalmarsson deals with system identification in complex and structured systems well fitting into the future trends of control of large-scale and distributed systems.

J. Stoustrup presents an emerging new control concept, called ‘plug & play control’ where solutions are formulated in control systems that can automatically reconfigure themselves whenever a new component (e.g., an actuator or a sensor) is added or removed.

D. Nešić discusses an extremum-seeking optimal control approach that deals with situations when the plant model and/or the cost to be optimized are not available in design time. It is assumed, however, that access to plant input and output signals can be ensured by direct measurements. Using these measurements, one may design a controller that dynamically searches for the optimizing inputs. This method was successfully applied to biochemical reactors, ABS control in automotive brakes, variable cam timing engine operation, electromechanical valves, axial compressors, mobile robots, mobile sensor networks, optical fibre amplifiers and so on. The paper shows how the same results can be mutually utilized in interscience cooperation, such as in control engineering and biology.

The treatment presented in the paper by R. Mangoubi and co-workers may well demonstrate the methodological convergence of the approaches of estimation and detection in control and signal processing. It is shown how the connection between robust detection of signals using matched filters and robust detection of faults in dynamic systems is clearly established by pointing to similarities and tangencies between the individual approaches, which were considered distinct earlier, by gaining insight to the real nature of the problems and demonstrating how particular fields of sciences may benefit from each other’s results.

M. Muenchhof and co-workers give an overview on the status of research of fault diagnosis and fault tolerance in various mechatronic components and drive systems. Case studies of selected industrial and prototypical realizations of fault tolerant actuators are presented, comprising fault-tolerant electric drives, hydraulic systems and a steer-by-wire vehicle application.

Complexity is a potential issue in chemical and bio-molecular systems that can be treated by using smart control theoretic methods. D. Del Vecchio and E.D. Sontag present a nice example of interdisciplinary results in their tutorial program. Here, the authors focus on a novel concept of function decomposition in chemical systems, which they call retroactivity. A bio-molecular realization of the suggested methodology is given by demonstrating how the presented idea may contribute to the control of complexity in large-scale dynamic systems.

D. Angeli’s tutorial on chemical reaction networks dynamics illustrates various analytical tools available for modeling and analysis of chemical reaction networks, in connection with their potential applications in biochemical systems, which might contribute to the better understanding of the complex behavior of biochemical networks.

Inspired by the extended use of numerical analysis techniques in the detailed examination of dynamics of machines, the tutorial paper of G. Hulkó and co-workers present methods for modeling and designing of the discrete-time control of distributed parameter systems.

Downscaling is an advanced system design approach, focusing on the best use of product’s material and energy, is an increasingly preferred design principle in the vehicle and avionics industries. High-tech applications can potentially benefit from accounting for the saturation effects of the actuators, rather than oversizing them with conservatism. The program given in the leading tutorial paper of S. Galeani et al., deals with this problem by giving constructive linear and nonlinear anti-windup techniques that can contribute to dissemination of this new technology.

The remaining four articles deal with specific control applications related to some exciting new subjects and emerging fields of control technology. The article by A. Sinha et al., introduces a mechanism to detect and model the shape of a contaminant cloud boundary by using air borne sensor
swarms located on board of an Unmanned Air Vehicle (UAV). The paper presented by A. Matveev and A. Savkin targets the issue of the stabilization of networked control systems under computational power constraints, which is getting an increasingly important problem in embedded applications when the property of the resource-constrained implementation is a primary factor of control system design. The Model Predictive Control (MPC) solution, presented in Barbarisi et al., improves on the performance qualities of steering maneuvers of equipped vehicles by means of differential braking for yaw rate and side slip control in dynamically constrained environments. The adaptive, real-time optimal control solution for adaptive optics, presented by N. Doelman and co-workers, may improve on the performance properties of the increasingly used adaptive optics not only in astronomy but in medical imaging and other low-cost commercial applications as well.

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