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Editorial

Preface to the Special Issue on "Identification, Knowledge Engineering and Digital Modeling for Adaptive and Intelligent Control"—Special Issue Book

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Starting our work on this Special Issue, we assumed that the research results presented here would reflect the solutions to various problems related to production management; however, the set of identified problems showed that their solutions could be useful for a wider range of applications. Therefore, we have presented 14 articles covering various aspects of the new trends in adaptive and intelligent control and identification.

The results of research on the theories and methodologies of identification are presented. New methods for solving the problems of parametric and non-parametric identification are proposed, and the possibilities of using data mining and knowledge engineering methods for identifying control systems and building digital models of dynamic processes in real time are studied. Various aspects of constructing intelligent control systems with an identifier and reinforcement learning are discussed and the possibilities of intelligent model predictive control and its application to control objects of various natures, as well as stability problems, are investigated. Approaches to building models of strategic decision making under informational control are also proposed.

A general complex model is presented in [1] for collective dynamical strategic decision making with explicitly interconnected factors reflecting both the psychic (internal state) and behavioral (external action, result of activity) components of agents' activity under specified environmental and control factors. This model unifies and generalizes the approaches of game theory, social psychology, and the theory of multi-agent systems and control in organizational systems through a simultaneous consideration of both the internal and external parameters of the agents. Article [2] carries out a comparative analysis of the known methods for the synthesis of various control laws ensuring the invariance of the output (controlled) variable with respect to external disturbances, under various assumptions about their type and channels of acting on the control plant. Synthesis methods are presented by the example of a third-order nonlinear system with a single input and single output (SISO-system). For the systems where the matching conditions are not satisfied, the paper draws a conclusion on the expediency of introducing smooth and bounded nonlinear local feedbacks. In Ref. [3], the stability of bilinear systems is investigated using spectral techniques such as selective modal analysis. Predictive models of bilinear systems based on inductive knowledge extracted by big data mining techniques are applied with associative search of statistical patterns. In Ref. [4], the intelligent computational algorithms of evolutionary computing paradigms (ECPs) are presented, which effectively solve complex nonlinear optimization problems. The maximum-likelihood-based adaptive differential evolution algorithm (ADEA) is investigated for the identification of nonlinear Hammerstein output error (HOE) systems that are widely used for modeling various nonlinear processes in engineering and applied sciences. In Ref. [5], the stability of a bilinear system is investigated by the Gramian method. The paper shows that the state of a bilinear control system can be split uniquely into generalized modes corresponding to the eigenvalues of the dynamics matrix. The Gramians of the controllability and observability of a bilinear system can be divided into parts (sub-Gramians) that characterize the measure of these generalized modes and their interactions. In Ref. [6], the system identification properties of Dynamic Mode Decomposition (DMD) are studied. DMD is a popular data-driven framework for extracting linear dynamics from complex high-dimensional systems. In Ref. [7], a direct method for the synthesis of robust systems operating under parametric uncertainty in a control plant model is proposed. The developed robust control procedures are based on the assumption that the structural properties of the nominal system survive over the entire range of parameter changes. The authors in [8] show that for simulators providing vestibular stimulus, the automatic vestibular–ocular reflex (VOR) bodily function can objectively measure the accuracy of motion simulation. This requires a model of ocular response to enforced accelerations, which is offered in the paper. The model corresponds to a single-layer spiking differential neural network; its activation functions are based on the dynamic Izhikevich model of neuron dynamics.

The authors in [9] discuss the analysis and optimization of stochastic systems based on canonical wavelet expansions. A wavelet model for the calibration of essentially nonstationary stochastic processes and parameters is developed. In Ref. [10], a new algorithm is proposed for constructing an integral model of an input–output-type nonlinear dynamic system in the form of a quadratic segment of the Volterra integro-power series (polynomial). It examines the nonparametric identification of models using physically realizable piecewise linear test signals in the time domain.

In Ref. [11], a multi-output soft sensor for the industrial reactive distillation process of methyl tert-butyl ether (MTBE) is developed. Unlike the existing approaches, the paper offers soft sensors with filters to predict model errors, which are further considered as corrections in the final output forecasts. The authors in [12] consider the mathematical aspects of the problem of the optimal interception of a mobile search vehicle moving along random tacks on a given route and searching for a target, which travels parallel to this route. The interception problem was formulated as an optimal stochastic control problem, which was transformed to a deterministic optimization one.

The article [13] is aimed at numerical studies of inverse problems of experiment processing (identification of unknown parameters of mathematical models from experimental data) based on balanced identification technology. This technology uses the cross-validation root-mean-square error to select the values of the regularization parameters. The authors in [14] discuss the identification of plasma equilibrium reconstruction in D-shaped tokamaks on the basis of external magnetic plasma measurements. Such identification methods are aimed at increasing the speed of response when plasma discharges are relatively short, such as in the spherical Globus-M2 tokamak.

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