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SPECIAL ISSUE

Introductory Remarks to the Special Issue Devoted to MLSD 2024

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This special issue of *Automation and Remote Control* presents selected papers of the 17th International Conference on Management of Large-Scale System Development (MLSD 2024). The conference was held on September 24–26, 2024, at the Trapeznikov Institute of Control Sciences, the Russian Academy of Sciences (ICS RAS), Moscow, Russia. The issue's papers are remarkable for their orientation toward solving topical control/management problems of large-scale systems. They demonstrate a progression from fundamental theoretical constructs (equations of mathematical physics and stability theory) through the development of new algorithms and methods (optimization, robust control, and machine learning) to the solution of particular applied problems in manufacturing, the energy sector, and the social sphere. In all the papers, the object of study is a system that can be characterized as large-scale:

- technical and technical-natural systems: power systems (analysis of oscillatory stability, I.B. Yadykin), oil and gas field development processes (two-phase filtration models, M.M. Volnykh and A.G. Kushner; well placement, A.I. Ermolaev et al.), chemical and oil refining enterprises (emergency response, A.F. Rezchikov et al.), and mechanical engineering enterprises (scheduling theory, E.N. Khobotov);
- organizational and socio-economic systems: research teams (labor productivity, A.S. Bogomolov et al.), the energy sector (forecasting indicators, V.A. Ivanyuk), and project programs (consideration of "soft dependencies," I.V. Burkova and A.V. Shchepkin).

The paper "A Mathematical Model for Increasing the Productivity of a Scientific Team" (A.S. Bogomolov, O.I. Dranko, V.A. Kushnikov, et al.) is at the focus of Russia's current scientific and technical policy. Here, the main novelty lies in formalizing the process of collective scientific research as an optimization problem. The authors treat the process of preparing publications not as an indivisible whole, but as a set of discrete tasks (writing the introduction, reviewing the previous results, performing computations, etc.) that can be distributed among team members with different efficiencies. Bogomolov et al. directly link their research work to "Labor Productivity," the National Project of the Russian Federation targeted at a significant growth of this indicator by 2030. The problem of increasing the productivity of intellectual/creative work is relevant for academic institutes, universities, corporate research centers, and any other organizations where the result depends on the efficiency of team-based research.

I.B. Yadykin's paper "Energy Stability Metrics of Linear Continuous Systems" is at the forefront of fundamental control theory, solving pressing problems of modern applications (the energy sector and complex networks). This research contains several major and interrelated original results: the concept of basic systems and invariant energy metrics, spectral decompositions for multiple roots, new frequency-domain formulas for solving Lyapunov equations, an efficient algorithm for computing the inverse Gramian, and a hybrid stability criterion. The author convincingly demonstrates the connection of his work with urgent applied problems, such as the analysis of oscillatory stability of electric power systems (weakly damped inter-area oscillations and the resonant interaction of

modes), controllability analysis of complex networks (social, transport, and biological), and the creation of digital twins. Therefore, the results are in demand in high-tech industries.

M.M. Volnykh and A.G. Kushner present the paper "Cauchy Problem for the Buckley–Leverette Equation of Two-Phase Filtration with Variable Porosity." It is distinguished by strongly pronounced applied (petroleum engineering) and theoretical (mathematical physics) components. The paper contains several original scientific results: a new formulation of the classical problem (variable porosity), the application of geometric apparatus for its analysis, and the derivation of explicit formulas for characteristics and a multi-valued solution in an important special case. The authors significantly contribute both to the theory of partial differential equations and to the mathematical modeling of oil production processes. The obtained results (parabolic characteristics instead of straight lines) qualitatively differ from the classical case, demonstrating the importance of variable porosity.

In the paper "Robust Approach to Dynamic Compensation of Disturbances," S.A. Kochetkov and V.A. Utkin address a key problem in control theory—ensuring robustness to disturbances—and confirm this on a modern and complex object (a UAV with a load). This research is characterized by a high level of novelty and provides several original scientific results. Note the major ones: 1) a synthesis of dynamic compensation and sliding mode-based methods to ensure robustness in nonlinear systems, and 2) a new conceptual formulation of the problem where part of the plant's model acts as a controlled generator of uncertainties. It makes a considerable contribution to the development of the theory of robust and invariant control.

The paper "Hybrid Controllers in Control Problems of Real Objects" (A.F. Pashchenko and E.S. Duvanov) responds to the industry's demand for adaptive and accurate control systems for complex plants, confirming this with experiments. This work possesses scientific novelty at the engineering and methodological level. The main result lies in the original design and comparative analysis of two hybrid approaches (NNPC and FQR), their detailed implementation in MATLAB/Simulink, and successful validation on real laboratory plants with different dynamics.

A.F. Rezchikov, O.I. Dranko, et al. devote their paper, entitled "Models for Managing the Elimination of Consequences of Critical Situations at Oil Refining and Chemical Enterprises," to the problem of industrial safety and protection of the population and territories from man-induced critical situations. This theme matches priorities established by federal legislation (in particular, Federal Law no. 68-FZ of December 21, 1994 (as amended on August 8, 2024)) and GOST (state) standards. A strong point of the conducted research is the combination of a comprehensive system-dynamic approach to the elimination of consequences of critical situations with an original model correction algorithm. The authors propose an iterative algorithm for maintaining the model error at an acceptable level ($\leqslant 10\%$).

E.N. Khobotov's paper "Methods of Construction and Features of Work Schedules for Mechanical Engineering enterprises" solves a key and long-standing problem of scheduling theory, i.e., the transition from optimization at the shopfloor level to real planning at the level of a large mechanical engineering enterprise. Its undeniable scientific novelty lies in an original, multi-level, and adaptive sequential aggregation/decomposition methodology, which can be practically used to solve problems of previously unattainable dimensions.

The value of the paper "Using Machine Learning Methods for Analyzing and Forecasting of Small Samples of Macroeconomic Indicators in the Energy Sector of the Russian Federation" (V.A. Ivanyuk) is an original applied analysis. The author compares three fundamentally different classes of models (the classical linear regression, the exponential smoothing method, and the neural network approach) on carefully processed data with application of Bayesian ensembling (averaging), thorough consideration of constraints, industry-level detailing, and identification of critical sectors.

The paper "Consideration of Soft Dependencies under Stochastic Uncertainty in Multi-Project Program Implementation" (I.V. Burkova and A.V. Shchepkin) has high practical significance. In modern project management, especially in complex programs (construction, IT development, and R&D), managers constantly face a choice: is it worth implementing additional (non-mandatory) measures that can accelerate or reduce the cost of subsequent stages? Such dependencies are termed "soft" by the authors. The novelty of this research consists in the in-depth analysis of the influence of the probabilistic nature of soft dependencies.

A.I. Ermolaev, A.V. Akhmetzyanov, and A.R. Latipov present the paper "Controlled Random Search and Likelihood Ratio in Boolean Programming Problems," where they develop and test an approximate algorithm for solving linear Boolean programming problems of high dimension. This research is topical since, for many applied problems, exact methods (e.g., branch-and-bound) require prohibitive computational resources, and the value of an exact solution is reduced due to initial data errors. The authors propose an iterative controlled random search algorithm that tests, at each step, one of two statistical hypotheses using the sequential probability ratio test (SPRT). The efficiency of this algorithm is demonstrated on a practically important problem of oil and gas field development, i.e., the optimal placement of a given number of wells. Computational experiments were carried out for different grid sizes (up to 400 blocks) and different numbers of wells.

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