

## INVESTIGATION OF MULTIVARIABLE AUTOMATIC CONTROL SYSTEMS FOR COMPLEX DYNAMIC OBJECTS BASED ON PETROV'S PARADIGM

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**Abstract.** This paper considers some approaches to studying the properties of multivariable automatic control systems (MACSs), particularly their stability, based on different descriptive models. The theory presented below extends the previously known ideas of Academician B. N. Petrov, which are fundamental in the classical theory of automatic control. Petrov's theory is based on the structural and functional decomposition of MACSs into separate real subsystems and multidimensional connections between them, described by a new model, and the study of system properties using frequency methods. Therefore, this theory is related to the physical (engineering) approach to dynamical systems analysis. A method for describing MACSs by the individual characteristics of subsystems and the elements of multidimensional connections is suggested. Stability criteria for linear MACSs with identical subsystems and a stability criterion for the system's equilibrium are established. A technology for finding the parameters of periodic motions and assessing their stability for nonlinear MACSs is introduced. Some numerical examples with technical objects illustrate this technology for studying the properties of MACSs.

**Keywords:** multivariable system, decomposition, frequency methods, linear system, nonlinear system.

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## INFORMATION COMMUNITIES IN SOCIAL NETWORKS. PART III: Applied Aspects of Detection and Analysis

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**Abstract.** This paper overviews the empirical studies of the formation and detection of information communities in social networks. In parts I and II of the survey, we outlined the concept of an information community and considered the relevant mathematical models describing the formation of private beliefs. Model identification, data gathering, and data analysis become highlighted areas of current research due to the uncertainty about social learning mechanisms and networked interaction structure. To solve the identification problem, researchers carry out behavioral experiments and field investigations. In practice, researchers analyze communities on available real-world data, applying methods based on the structural properties of the network of information interactions between agents, the individual characteristics of agents, and a combination of structural and individual characteristics. Part III of the survey presents studies on identifying learning models and discusses some practical aspects of analyzing information communities in social networks.

**Keywords:** social networks, information community, formation of information communities, belief formation, identification of information communities.

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## CONSTRUCTING POWER-EXPONENTIAL AND LINEAR-LOGARITHMIC REGRESSION MODELS

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**Abstract.** When using nonlinear regression models, the estimates of the resulting dependence are often difficult or even impossible to interpret. This paper develops nonlinear regression specifications in which any estimated parameter, except the free term, can always be given some practical interpretation. A multiplicative power-exponential regression generalizing the Cobb–Douglas production function and an additive linear-logarithmic regression are constructed. Three construction strategies are formulated for each of them, and the issues of interpreting their estimates are considered in detail. The construction strategies based on the least absolute deviations method are formalized as linear and partially Boolean linear programming problems. The mathematical apparatus developed in this paper is illustrated by modeling rail freight traffic in Irkutsk oblast.

**Keywords:** regression model, interpretation, multiplicative power-exponential regression, linear-logarithmic regression, feature selection, least absolute deviations, rail freight traffic.

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## DESIGN OF MULTIVARIABLE TRACKING SYSTEMS VIA ENGINEERING PERFORMANCE INDICES BASED ON $H_\infty$ -APPROACH

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**Abstract.** This paper proposes an algorithm for designing a measured output-feedback controller with given or achievable engineering performance indices for linear multivariable systems. The control plant is subjected to bounded external disturbances from the class of polyharmonic functions with an infinite number of harmonics and a bounded sum of their amplitudes for each disturbance component. As a result, additional tracking errors appear in controlled variables. The problem is to design a multivariable output-feedback controller ensuring given or achievable tracking errors, the settling time determined by a given or achievable degree of stability of the closed loop system, and a set of the oscillation indices  $M_i$  for the  $i$ th closed loop relating the  $i$ th reference signal  $g_i$  to the  $i$ th controlled variable  $z_i$ . In addition, the controller should ensure the conditions  $M_i \leq \gamma$ , where  $\gamma$  is a given value or the minimand. As shown below,  $H_\infty$  control methods are quite convenient for solving such problems. An illustrative example of designing an interconnected electric drive is presented.

**Keywords:** linear multivariable systems, bounded external disturbances, tracking errors, settling time, degree of stability, oscillation index of the  $i$ th loop.

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## PRICING MECHANISMS FOR COST REDUCTION UNDER BUDGET CONSTRAINTS

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**Abstract.** The problem of evaluating the prices (cost) of individual projects of a megaproject or program is considered. The megaproject manager evaluates the cost of each project based on its planned cost reported by the project executors under the budget constraint on the total cost of the program. The executor of each project is a monopolist in the relevant area and cannot be replaced by another executor. In the deterministic case, the executors know the exact actual cost of their project; the manipulability of the mechanism for forming the cost of projects is investigated. In the stochastic case, the executors do not know the actual cost of their projects; when evaluating the planned cost, they estimate a probable value of the actual cost. For this estimate, the distribution function of the project's actual cost is used. The paper proposes a pricing mechanism for cost reduction under the budget constraint on the total cost of the program and a given probability distribution of the project's actual cost.

**Keywords:** cost price, limit price, profit, mathematical expectation, manipulability, counter-expensive property.

## STUDYING THE INDICATORS OF REGIONAL SPORTS DEVELOPMENT IN RUSSIAN FEDERATION

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**Abstract.** The indicators of regional sports development in the Russian Federation are analyzed to find regions with a similar sports development strategy (according to the chosen methodology and measures of closeness) and to identify dynamic groups in a four-year period. Some clustering and pattern analysis methods are described, and their use in the study is validated. The results obtained by classical clustering and ordinal-invariant pattern clustering methods are compared. The main state programs in the field of sports in the Russian Federation are highlighted and analyzed. The key aspects and problems of the state regulation of sports activities in the Russian Federation are indicated. Some ways for improving the existing regulatory and legal acts based on the dynamic analysis of regional patterns are proposed.

**Keywords:** sports, sport life, physical education, state regulation, cluster analysis, pattern analysis, ordinal-invariant pattern clustering.

## AN UPDATING METHOD FOR THE DYNAMIC MIMO MODEL OF A CONTROLLED TECHNOLOGICAL OBJECT

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**Abstract.** This paper considers the degradation of MIMO models of controlled industrial processes. We propose a method for solving a nonlinear programming problem with an objective function formed by the least squares method according to technological object data. The method involves dynamic process modeling algorithms based on the imposition of the step response of the process. The advantage of this method is the possibility of using passive experiment data to construct an appropriate multichannel model of a technological object. The method is applied to update the multiparameter controller model for the Advanced Process Control system of butyraldehydes oxo synthesis. For real controlled technological objects, this method allows improving the accuracy of process modeling and the performance of automatic control, reducing the human factor, and increasing the overall economic efficiency of the production process.

**Keywords:** MIMO system, transfer function, Model Predictive Control, Advanced Process Control.

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## A COMPUTER SIMULATION COMPLEX FOR ANALYSIS OF MAGNETIC GRADIOMETRY SYSTEMS

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**Abstract.** A computer simulation complex for magnetic gradiometry systems is described. This complex simulates the estimation procedure for the magnetic dipole moment of a moving object according to the magnetic gradiometry data. The paper considers the software architecture and intended purpose of the complex and the algorithms of its modules, including the magnetic field module, the ambient magnetic field module (the object magnetic field, the geomagnetic field, and industrial magnetic noise), and the magnetic dipole moment module. Some numerical experiments with the simulation complex are briefly described. This complex can be used to design control systems for the magnetic field of moving objects.

**Keywords:** numerical modeling, magnetic gradiometry, magnetic dipole moment.

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## 13th INTERNATIONAL CONFERENCE «MANAGEMENT OF LARGE-SCALE SYSTEM DEVELOPMENT» MLSD'2020

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**Abstract.** We introduce scientific results of participants of the conference. The event took place online in September of 2020. Four hundred authors presented their theses and papers. The analysis of section papers showed that they can be grouped according to seven management directions of large-scale system development. These directions are optimal investments into resource development, intelligent computer modeling, sustainable development, nonlinear systems control, robotics, risk management theory, intelligent analysis of massive datasets.

**Keywords:** conference, large-scale systems, investments.