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DEEP NEURAL NETWORKS: ORIGINS, DEVELOPMENT, CURRENT STATUS

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Abstract. The article covers the development of neural networks, from their origin in the form of the McCulloch–Pitts neuron to modern deep architectures. Major "neural network crises" are listed together with reasons that led to these crises. The main attention is paid to neural architectures that are trained with supervision learning using labeled datasets. References are given to original publications and mathematical theorems that lay the theoretical foundation for artificial neural networks. An analysis was carried out of the challenges in building effective deep neural architectures, ways to address these challenges are considered, success factors are identified. Main layers are listed for convolutional and recurrent neural networks, as well as their architectural combinations. Examples are given with references to demonstrate that deep neural networks are effective not only in applications with distinct structural patterns in the data (images, voice, music, etc.) but also applications with signals of stochastic/chaotic nature. A major direction of convolutional network development is identified too, which is the implementation of trainable integral transforms into the layers. A basic overview is provided for the modern Transformer architecture, which has become mainstream for sequence processing tasks (including tasks of computational linguistics). A scope of key goals and objectives is defined for the current theory of artificial neural networks.

Keywords: deep learning, convolutional neural networks, recurrent neural networks.

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STABILITY ANALYSIS OF AIRPLANE WITH MIMO CONTROL SYSTEM BASED ON FREQUENCY METHODS

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Abstract. In the framework of frequency analysis various methods of stability analysis of airplane with MIMO control system are considered. They assume that control system is open for selected signal with other loops closed, or that system is open for all signals of selected loops and allow solving stability equation and calculating transfer functions matrix eigenvalues. It is shown that all methods deal with different forms of the same equation, and thus the equivalence of methods considered for calculating closed loop stability domains is proved. The application of methods is demonstrated for calculation of stability domains for airplane equipped with MIMO stability and control augmentation system in lateral motion that uses ailerons and rudder as control surfaces. It is shown that in case of MIMO system open loop transfer function that defines closed loop stability is nonlinear function of control system gains. It introduces uncertainty to concept of amplitude and phase margins.

Keywords: MIMO system, open loop transfer function, transfer functions matrix, stability margins, airliner, stability and control augmentation system.

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DATA ACCUMULATION AND SORTING METHOD FOR SOLVING PARAMETRIC OPTIMIZATION PROBLEM

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Abstract. It is noted that optimization problem is highly relevant for complex system development. However, such optimization is difficult since there are no reliable methods that give efficient solutions regardless of the features of a specific mathematical model. Developing a method for solving arbitrary parametric optimization problems is a complicated but highly relevant task. The new approach is considered, which is based on heuristics and experiments. It uses special truncation and sorting procedures, Pareto methods, and random process theory methods. The software implementation and multiple modifications of the method proposed are developed and tested with a number of highly complex test functions covering the entire range of parametric optimization problems. It is shown experimentally that the approach proposed is highly efficient. The method can be applied for solving complex research problems and its software can become a part of large integrated systems such as CADs, smart systems, etc. where multivariate analysis is used for decision making.

Keywords: random search, multi-extremality, discrete optimization, continuous optimization, integer values, uncertainty.

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INCENTIVE-COMPATIBLE CONTROL IN DYNAMIC MULTI-AGENT SYSTEMS. Part 2. Contracts in dynamic hierarchical multi-agent system

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Abstract. The results obtained in the Part 1 of the paper are extended to a multi-level dynamic multi-agent system, as well as to the case of uncertain agent costs. It has been proved that for any admissible trajectory of results, a coordinated compensatory incentive system can be constructed that implements (as an equilibrium in dominant strategies) the trajectory of the agents leading to the desired trajectory of results; decomposes the control task by agents and by time periods; provides guaranteed (for all possible far-sighted agents) minimum costs of the governing body of the principal for the implementation of this trajectory of results. It is shown that in such incentive systems, the values of payments depend only on the corresponding values of the cost functions, which, in turn, indirectly take into account the technological functions, network structure and active system structure as a whole. The problem of optimal planning is posed and an algorithm for solving it is indicated.

Keywords: contract theory, incentive problem, dynamic hierarchical multi-agent system.

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EXPANDING THE CAPABILITIES OF THE ANGARA SYSTEM AREA NETWORK

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Abstract. A method for expanding the capabilities of the Angara system area network through the sharing of its own 24-port routers and market hubs 1×3 and 1×4 is considered. The method is based on the use of networks with the topology of quasi-complete graphs constructed in an extended elemental basis consisting of switches (routers) and hubs of duplex channels. These networks are the basis of the method of invariant expansion of arbitrary networks, which preserves transmission delays and increases the number of subscribers. Using this method, a distributed extended router is constructed from Angara network routers, and networks based on it are constructed with the structure of 1, 2, 3, 4-dimensional tori, either containing a significantly larger number of subscribers with the same network diameter, or having a smaller diameter with the same number of subscribers compared to the Angara network. In fact, the method under consideration made it possible to increase the number of processors, reduce the diameter and increase the channel fault tolerance of the network.

Keywords: system networks of supercomputers, Angara network, networks with topology of quasi-complete graphs, invariant expansion of networks, number of network subscribers and network diameter, scaling and performance.

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ALGORITHM OF OPTIMAL CONTROL OF MIMO TECHNOLOGICAL SYSTEMS WHEN CHANGING THEIR PERFORMANCE INDICATORS OVER A LONG TIME INTERVAL

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Abstract. The issues of managing complex energy- and resource-intensive technological objects that operate in variable performance modes for the products produced over a long period of time using algorithms of destabilization optimization are discussed. The linear problem of destabilization optimization of the regimes of a multidimensional technological object, which operates over a time interval when its productivity changes twice, is considered with redundant control actions affecting the coordinates of the state of the object that appear as a result of destabilization. The problem is decomposed into a set of linear one-dimensional problems of destabilization optimization with redundancy of control actions, which are based on the formulated theorem and an algorithm developed on its basis. The operation of this algorithm is illustrated geometrically indicating the effect obtained. The possibility of using destabilization control of a real production facility, a large low-pressure air separation unit, is demonstrated. The necessity of developing an algorithm for solving the linear problem of destabilization optimization of the regimes of a multidimensional technological object with redundancy of control actions, which functions with repeated changes in its performance over a time interval, is noted.

Keywords: destabilization, time interval, integral criterion, MIMO system, optimization, performance, optimal control, additional effect.

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FROM NON-CLASSICAL TO POST-NON-CLASSICAL SCIENCE: AN EXAMPLE OF INDUSTRIAL OPERATORS' COMPUTER-BASED TRAINING SYSTEMS

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Abstract. A review of constructing and using of industrial operators' simulators in the framework of the periodization of scientific rationality from classical and non-classical to post-non-classical phase is given. The key post-non-classical characteristics of modern simulators are presented: self-development, interdisciplinarity, anthropocentric factor, orientation to practice. Special attention is paid to the simulation technique as a fundamentally new way to determine the response of a big technical system to user's arbitrary interventions, as well as to immersive tools for reproducing the trainees working environment. The post-non-classical role of the instructor was studied, combining the functions of a training organizer, a development agent, who initiates the reconfiguring of simulator's components and improving teaching methods, as well as a key link in the best professionals' knowledge capitalization. The fundamental changes in the simulator project organization and implementation are shown, covering now not only research and development, but also the maintenance and improvement of simulator systems. The transfer of skills acquired in the training and modern approaches to the automated assessment of the operators' work on the simulator are considered. The basic trends in the simulator constructing are analyzed: a change in the motives of training (the prevalence of workers' professional growth and self-realization), a generational shift against a revolutionary renewal of the means of labor (virtual and mixed reality, advisors based on artificial intelligence), the development and assessment of employees' professional competencies. Given the high synthetics of training technologies, the presentation is based on a wide conceptual context, including scientific, technical, cognitive-psychological, pedagogical, socio-economic and literary phenomena.

Keywords: classical, non-classical and post-non-classical scientific rationality, industrial processes, operators' computer-based training systems, self-developing systems, human-sizedness of complex technical systems, interdisciplinary approach.

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XXVII INTERNATIONAL CONFERENCE «THE PROBLEMS OF COMPLEX SYSTEMS SECURITY CONTROL»

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Abstract. Scientific results of participants of the conference that took place in December of 2019 are presented. The thematic directions (sections) of the conference were theoretical and methodological questions of security support, problems of economic and sociopolitical security support, problems of information security support, ecological and technogenic security, methods of modeling and decision making of complex systems security control, automatic systems and instruments of complex systems security support, legal aspects of complex systems security support. More than a hundred authors from 40 organizations of Russian Federation and some foreign countries presented 80 papers.

Keywords: conference, complex systems, security control.