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MEAN QUANTITIES: A MULTICRITERIA APPROACH

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Abstract. A new approach to defining the concept of the mean quantity for a fixed finite set X of numbers x_1, x_2, ..., x_n is proposed: the distance of an arbitrary point x from each individual point x_i is estimated by the distance $f_i(x)$ between them, and the distance of a point x from the entire set X is characterized by a vector criterion $(f_1(x), f_2(x), ..., f_n(x))$; using this criterion, the preference relation in distance is introduced; the mean value is the point x^*, non-dominated with regard to this relation. Properties and structure of such averages for several preference relations, including the Pareto relation and the relation generated by information about the equal importance of criteria, are investigated. The relationship between the introduced mean quantities and the main statistical averages (arithmetic mean and median) is clarified. The issues of constructing sets of such averages are considered and an effective method of construction is proposed for the case when equally important criteria have the first ordinal metric scale. The directions of possible generalizations of the introduced concept for the multidimensional case are discussed.

Keywords: mean quantities, multi-criterial choice problems, preference relations, non-dominated points, criteria importance theory, criteria of equal importance, theory of majorization.

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ROBUST STABILITY CONDITIONS FOR A FAMILY OF LINEAR DISCRETE-TIME SYSTEMS SUBJECTED TO UNCERTAINTIES

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Abstract. Robust stability conditions are established for a family of linear discrete-time systems subjected to uncertainties. The traditional approach, which involves the construction of a common quadratic Lyapunov function for the entire family of systems with uncertainty, often leads to the problem of conservatism. In this connection, constructing the parametric quadratic Lyapunov functions seems promising. The main tools of the proposed approach are the apparatus of linear matrix inequalities and presented modification of the well-known Petersen's lemma. A simple approach to finding the radius of robust quadratic stability of the considered family is proposed in the paper as well. The corresponding optimization problems have the form of semi-definite programming and one-dimensional minimization, which could be easily solved numerically. The effectiveness of the proposed approach is demonstrated via numerical example. The results obtained can be generalized to the design problems for linear discrete-time systems subjected to uncertainties, to other robust statements, and to the case of exogenous disturbances.

Keywords: linear discrete-time system, parametric Lyapunov function, structured matrix uncertainty, robustness, linear matrix inequalities.

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DURATION OF FILTRATION PROCESS DURING FINITE-FREQUENCY IDENTIFICATION

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Abstract. A linear control plant subjected to an external disturbance is considered. The disturbance is assumed to be an unknown bounded function. The finite-frequency identification allows us to find estimates of this control plant's parameters. It uses special integral filters (Fourier filters), that find estimates of the plant frequency response at a specific set of frequencies. A system of linear equations is formed from the set of the plant frequency response points. The solution of this system provides desired estimates of the plant parameters. Error dynamics of filtration process is studied. The research is based on known results that describe asymptotic characteristic of the Fourier filters errors in presence of unknown-but-bounded external disturbances. A new approach to determine the filtration duration is proposed, estimation of the filtration accuracy is described. The proposed approach is based on a special linear programming problem, the solution of which gives us an estimate of the filter value and a value of parameter that describes the rate of the filter error convergence. The last one is used for duration determination. The appropriate filtration algorithm is developed. Numerical experiments that prove efficiency of the proposed approach were carried out.

Keywords: finite-frequency identification, Fourier filter, linear programming, identification duration, estimation accuracy.

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SYNTHESIS OF THE OPTIMAL MECHANISM OF ACTIVE EXPERTISE: REALIZATION VIA COMPUTER MODELING SYSTEMS

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Abstract. The paper considers a model of active expertise as expertise that takes into account the experts' possible interest in its results. We study its one-dimensional formulation – the problem of one-criterion collective choice or, in other terminology, active planning. There is a goal procedure for expertise that is optimal when experts are not active. The problem of synthesis of the optimal mechanism of active expertise is given. The article presents proof of solution existence to the problem of synthesis of the optimal mechanism of one-dimensional active expertise. Earlier, only an algorithm for its obtaining by solving a system of equations was proposed. We show that, within the framework of generally accepted assumptions on the class of goal procedures, a solution to the problem of active planning always exists and is so-called generalized median voter schemes, described by Herve Moulin in 1980 as a class of strategy-proof collective choice rules (or mechanisms in the terminology of the theory of active systems), which are Pareto efficient. A model for analyzing mechanisms of active expertise based on a GMVS and a model for synthesizing an optimal strategy-proof mechanism have been developed in the simulation environment. A search for the parameters of the equivalent direct mechanism is also implemented.

Keywords: control science, organizational-technical system, systems analysis, strategy-proofness.

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EVALUATION OF EFFICIENCY OF ECO-INNOVATION MANAGEMENT BASED ON DEA MODELS WITH LAGS AND NEGATIVE OUTPUTS

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Abstract. The article develops a new approach to assessing the effectiveness of environmental management systems in Russian regions based on the use of DEA models. The current and capital expenditures on environmental protection measures are considered as inputs of the model, and the changes in the load of the regional economy on the environment in a wide range of environmental indicators are considered as outputs. A distinctive feature of the proposed approach is the accounting for delayed effects of capital expenditures on environmental protection measures. The possibility of applying the scale shift procedure to eliminate the problem of the presence of negative outputs is shown. Based on a combination of econometric modeling methods and DEA methodology, dynamic models were constructed and the level of eco-innovation development in Russian regions was assessed. It has been revealed that the proposed combination of models and approaches allows better taking into account the economic logic of regional environmental management processes in comparison to the traditional method of selecting inputs and outputs of the environmental DEA model and, as a result, setting the incentives system of the state environmental policy more precisely.

Keywords: analysis of the functioning environment, negative inputs, delayed effects, optimization, eco-innovations, regional environmental management system.

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INVESTIGATION OF THE STOCHASTIC POLLING SYSTEM AND ITS APPLICATIONS IN BROADBAND WIRELESS NETWORKS

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Abstract. A polling system with adaptive dynamic polling order for modeling a broadband wireless network with a centralized control mechanism is considered. A new algorithm for calculating the stationary state probability distribution of the number of packets in subscriber stations has been developed, which makes it possible to calculate the average waiting time and other characteristics of the network performance. A queuing system with several queues is investigated, in which the server serves queues in a dynamic polling order. This order of queuing involves skipping queues that were empty in the previous polling cycle. The queues that were skipped in this cycle the server can poll only in the next cycle. The specified queue servicing algorithm allows to reduce the duration of the queue polling time and thus increase the system performance. A comparative numerical analysis of various options for constructing and evaluating the performance characteristics of broadband wireless IEEE 802.11 networks with a centralized control mechanism is presented. Numerical studies were carried out using a software package for evaluating the stochastic polling systems.

Keywords: broadband wireless network, polling systems, adaptive polling order, exhaustive service, generating function method.

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OPTIMUM MULTIDIMENSIONAL TORI BASED ON LOW-PORT ROUTERS AND HUBS

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Abstract. A method for constructing optimal system networks with the topology of multidimensional tori is considered. The optimization was performed according to such important functional characteristics of the network as the number of its subscribers (processors) and transmission delays between them, set by the network diameter. Optimization was carried out in the element base of low-port routers and splitters of duplex channels (hubs) by using networks with the topology of quasi-complete graphs. Optimization is realized due to the invariant expansion of the multidimensional torus and the duplex channel with preservation of their route properties such as the routing method and maximum transmission delays (network diameter). It is shown that optimization leads to an increase in the number of subscribers with constant delays and to a reduction in delays with a constant number of subscribers. Optimization is accompanied by some complication of the network in terms of circuit and cable costs. In this case, the measure of complication (expressed in the number of times) is less than the measure of joint improvement of both characteristics. The comparative characteristics of the optimal tori and tori of the Angara domestic system network are given. A substantial increase in the number of subscribers and a decrease in the diameters of optimal tori in comparison with the Angara network have been proven.

Keywords: system-area networks of supercomputers, networks with the topology of multidimensional tori, networks with the topology of quasi-complete graphs, invariant expansion of networks, number of network subscribers and network diameter, optimization of network characteristics, Angara network.

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THE SOLUTION OF THE PROBLEM OF MULTICRITERIA OPTIMIZATION UNDER PARAMETRIC UNCERTAINTY DURING PRE-CALCULATION OF JET AIRCRAFT PARAMETERS

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Abstract. A model of a multi-criteria optimization problem under parametric expert uncertainty is considered. This model is useful when the expert cannot set an exact value for a parameter with expert uncertainty. To describe such parameters, the uncertainty theory is applied. It provides analytical expressions for calculating deterministic duplicates of objective functions and constraints, which allows us to effectively solve optimization problems with expert uncertainty, reducing undefined optimization models to deterministic models of mathematical programming. The problem of preliminary calculation of supersonic jet aircraft parameters at the preliminary design stage is formalized and solved using the considered model. The relevance of applying the uncertainty theory to this problem relates to the increased role of the preliminary design stage in the development of advanced aircrafts. A numerical optimization algorithm has been developed and implemented that takes into account expert estimates of uncertain parameters and allows us to obtain the values of the technical characteristics of the developed aircraft with different levels of degree of belief in their implementation.

Keywords: expert uncertainty, epistemic uncertainty, model of an optimization problem, preliminary design, Pareto solutions, deterministic equivalent, maneuverable aircraft, uncertainty programming.

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SCHEDULES FOR PERFORMING TASKS IN INTERCONNECTED SEQUENTIAL PRODUCTION SYSTEMS

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Abstract. The problem, which is classical in scheduling theory, of constructing a sequence of tasks execution on one machine under conditions of restrictions on the start and end times of tasks execution and which takes into account not only the time spent on equipment operation, but also the losses for post-processing, is considered for multistage production systems consisting of an interconnected chain of sections and workshops of an industrial enterprise. The criterion for the optimality of the task is the implementation of the multistage schedule in the shortest possible time. The problems considered in this paper belong to the class of NP-complete problems of exponential complexity. The properties of admissible and optimal task execution sequences are investigated. Methods for calculating the lower bound for the length of the optimal schedule and the rules for rejecting inadmissible and non-optimal extensions are proposed. Algorithms for the exact and approximate solution of the problem by modified branch and bound methods have been developed. The proposed algorithms are illustrated with numerical examples. The computational experiments performed by the author have shown that the presence of a system of strict restrictions on the timing of tasks when implementing the algorithms proposed in the paper in a number of cases significantly reduces the number of options under consideration.

Keywords: sequence of task execution, multistage schedule, minimum time, heuristic algorithm, lower bound of the optimality criterion, screening out unpromising continuations, branch and bound method.