ABSTRACT AND REFERENCES

MATHEMATICS AND CYBERNETICS — APPLIED ASPECTS

IMPROVEMENT OF THE METHOD FOR SCIENTIFIC PUBLICATIONS CLUSTERING BASED ON n-GRAM ANALYSIS AND FUZZY METHOD FOR SELECTING RESEARCH PARTNERS (p. 6–14)

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For the problem of formation of project teams, in particular, scientific research project groups, there was proposed the comprehensive method, which consists of the two-stage method for clustering the graph of citation of scientists» publications and the method of fuzzy inference for coordination of experts» opinions on the selection of potential partners and their inclusion in the project group.

The essence of the two-stage method for clustering publications of scientists is clustering the citation graph based on the proximity of abstracts of publications. The distance between publications is calculated based on the determined metrics and approaches of the n-gram analysis. The described method allows identifying the areas research of scientists, which is a necessary component of the rational choice of a partner for the formation of a project team and is the input information for experts who form this group. The next step is the application of the method of fuzzy inference, which is constructed to coordinate opinions of experts on the creation of project teams. This method consists of three stages. At the first stage, fuzzification is performed through the introduction of function of scientist»s belonging to the area of scientific research. The second phase of fuzzy inference is the statement of experts» requirements to candidates for a place in a project group. At the final stage, defuzzification with the use of the method of the weight center takes place. To verify the fuzzy method for identification of research project groups, the organizations-executors for a fundamental scientific research were determined.

Described methods can be used for the problem of formation of scientific research groups and identification the similarities between the fragments of text information based on the n-gram analysis, which is used in the problem of identification of incomplete duplicates between fragments of text information.

Keywords: clustering, n-gram analysis, scientific research area, citation graph, project group.

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A STUDY OF APPROXIMATION OF FUNCTIONS OF BOUNDED VARIATION BY FABER-SCHAUDER PARTIAL SUMS (p. 14–20)

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The Faber-Schauder system of functions was introduced in 1910 and became the first example of a basis in the space of continuous on [0, 1] functions. A number of results are known about the properties of the Faber-Schauder system, including estimations of errors of approximation of functions by polynomials and partial sums of series in the Faber-Schauder system.

It is known that obtaining new estimates of errors of approximation of an arbitrary function by some given class of functions is one of the important tasks in the theory of approximation. Therefore, investigation of the approximation properties of polynomials and partial sums in the Faber-Schauder system is of considerable interest for the modern approximation theory.

The problems of approximation of functions of bounded variation by partial sums of series in the Faber-Schauder system of functions are studied. The estimate of the error of approximation of functions from classes of functions of bounded variation C_p ($1 \leq p < \infty$) in the space metric L_p using the values of the modulus of continuity of fractional order $\varpi_{2-1/p}(f, t)$ is obtained. From the obtained inequality, the estimate of the error of approximation of continuous functions in terms of the second-order modulus of continuity follows.

Also, in the class of functions C_p ($1 < p < \infty$), the estimate of the error of approximation of functions in the space metric L_p using the modulus of continuity of fractional order $\varpi_{1-1/p}(f, t)$ is obtained.

For classes of functions of bounded variation $KCV_{(2,p)}$ ($1 \leq p < \infty$), the estimate of the error of approximation of functions in the space metric L_p by Faber-Schauder partial sums is obtained.

Thus, several estimates of the errors of approximation of functions of bounded variation by their partial sums of series in the Faber-Schauder system are obtained. The obtained results are new in the theory of approximation. They generalize in a certain way the previously known results and can be used for further practical applications.

Keywords: functions of bounded variation, integral metric, modulus of continuity, Faber-Schauder system.

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DEVELOPMENT OF A METHOD FOR TRIANGULATION OF INHOMOGENEOUS REGIONS REPRESENTED BY FUNCTIONS (p. 21–27)

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In the process of designing structures from inhomogeneous materials, there is the need to build discrete models that consider the peculiarities of the geometrical shape of subdomains from different materials. The first stage in the modeling of such structures is the construction of a geometric model. In order to describe the shapes of inhomogeneous structures, we have proposed a functional approach, based on the use of systems of implicit functions and R-functions. The first implicit function defines the shape of a structure. The implicit functions starting from a second one determine the shapes of the subdomains whose boundaries must be considered when building a discrete model. Each implicit function within the system exceeds zero at inner points of the respective domain or subdomain, is equal to zero at the border, and is less than zero at outer points. The result is a possibility to describe the shapes of domains and subdomains of arbitrary complexity.

We have constructed a method for the triangulation of structures from inhomogeneous materials, whose shape is assigned functionally. The devised method makes it possible to consider the shape of subdomains from different materials used in the structure. The basic idea of the method implies consistent correction of coordinates for the nodes from the primary triangulation of the domain. Primary triangulation can be arbitrary, but it must fully capture the structure. At each step, the boundary of the structure or a subdomain from a particular material is approached by the node closest to the respective boundary. Following the displacement of each node, the coordinates of neighboring nodes are computed by minimizing the functional of exponents in the planes of incident elements. At the same time, for the elements that are incident at nodes and whose coordinates were changed, meeting the Delaunay condition is checked; if necessary, the operation «flip» is performed to change the diagonal. Upon removing the outer nodes, one would obtain a discrete model in which the boundaries of the structure and subdomains from different materials are approximated by nodes and edges of elements.

Keywords: triangulation, discrete model, functional representation, implicit function, triangle, heterogeneous domain.

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DEVELOPMENT OF A FORMAL ALGORITHM FOR THE FORMULATION OF A DUAL LINEAR OPTIMIZATION PROBLEM (p. 28–36)

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The rigorous formal algorithm for formulating a dual problem for different forms (general, basic, standard, and canonical) of a primal linear programming problem is proposed. First, definitions of a pair of dual problems for standard form of primal linear programming are given. This approach is based on the fact that such a pair was noted first, since it had substantial interpretation.

The economic interpretation of the standard problem is profit maximization in the production and sale of some types of products. Such an approach substantially indicates the existence of the primal problem (I) and the strictly corresponding dual (conjugate) (II). The problem of cost minimization is accompanying to the primal problem.

The basic concept of the duality theory in linear programming problems is the fact that a pair of problems are mutually conjugate — obtaining dual of dual leads to a primal problem.

The rigorous approach to obtaining an algorithm for formulating a dual problem is based on the statement that the dual problem of dual is a primal (original) problem. This approach is used in the paper. For different pairs of dual problems, this statement is rigorously proved.

The existing schemes of primal to dual conversion are substantial. Given this, the algorithm of the general approach to formulating pairs of conjugate problems is proposed and rigorously proved.

Formalization of the developed scheme makes it easy to get pairs of known dual problems. This allowed for the first time to propose and validate the algorithm for constructing a dual problem for an arbitrary form of the primal problem.

Keywords: linear optimization, primal problem, dual problem, duality, objective function, constraint system, pairs of conjugate problems.

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CONSTRUCTION OF THE FRACTIONAL-NONLINEAR OPTIMIZATION METHOD (p. 37–43)

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A method for solving the fractional nonlinear optimization problem has been proposed. It is shown that numerous inventory management tasks, on the rational allocation of limited resources, on finding the optimal paths in a graph, on the rational organization of transportation, on control over dynamical systems, as well as other tasks, are reduced exactly to such a problem in cases when the source data of a problem are described in terms of a probability theory or fuzzy math. We have analyzed known methods for solving the fractional nonlinear optimization problems. The most efficient among them is based on the iterative procedure that sequentially improves the original solution to a problem. In this case, every step involves solving the problem of mathematical programming. The method converges if the region of permissible solutions is compact. The obvious disadvantage of the method is the uncontrolled rate of convergence. The current paper has proposed a method to solve the problem, whose concept echoes the known method of fractional-linear optimization. The proposed technique transforms an original problem with a fractional-rational criterion to the typical problem of mathematical programming. The main advantage of the method, as well its difference from known ones, is the fact that the method is implemented using a single-step procedure for obtaining a solution. In this case, the dimensionality of a problem is not a limiting factor. The requirements to a mathematical model of the problem, which narrow the region of possible applications of the devised procedure, imply:

1) the components of the objective function must be separable functions;

2) the indicators for the power of all nonlinear terms of component functions should be the same.

Another important advantage of the method is the possibility of using it to solve the problem on unconditional and conditional optimization. The examples have been considered.

Keywords: fractional nonlinear function optimization, linear constraints, single-step procedure, exact solution.

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CHAOS-BASED SIGNAL DETECTION WITH DISCRETE-TIME PROCESSING OF THE DUFFING ATTRACTOR (p. 44–51)

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The results of detection of periodic signals using the chaos theory based on discrete processing of the Duffing attractor in the Poincare section were considered.

A chaotic Duffing system characterized by high sensitivity to periodic signals and a possibility of implementation by means of a relatively simple circuit was chosen for the study.

Response of the Duffing system to the periodic influence was analyzed. It was shown that when amplitude of periodic components of the input signal grows at a frequency of driving oscillations, there is a shift of the phase trajectory along the Poincare section which is characterized by fractal geometry. Types of the Duffing attractor changes that result from the influence of a periodic input signal were determined. Control regions for recording types of the

phase trajectory dynamics were identified in the phase plane formed by the output signal and its derivative. In accordance with the characteristics of the obtained phase trajectories, a truth table was constructed. It enables estimation of influence of the periodic component with a sufficiently large time sampling increment which is important for ensuring speed of the signal processing devices. Transforms were obtained that describe the process of detecting periodic signals by discrete processing of the Duffing attractor in the Poincare section.

Based on the formulated transforms and the truth table, a block diagram of a device for detecting periodic signals in noise was proposed. The proposed device can be used as an input unit to implement the Duffing system based on an analog electric circuit.

Values of discrete estimates of amplitude of the periodic component of the input signal according to the shift of the phase trajectory of the Duffing system with respect to the attractor in the Poincare section were obtained. According to the modeling results, the proposed circuit makes it possible to detect periodic signals at low values of the signal-to-noise ratio.

Keywords: signal detection, chaotic system, harmonic signal, attractor, digital signal processing.

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METHODS FOR MULTICRITERIAL SELECTION OF OPTIMAL ROUTES IN COMMUNICATION NETWORKS (p. 52–57)

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Traditionally, the problems of routing in communication networks are solved based on the scalar approach, which takes into consideration only one quality indicator. However, information transmission in communication networks is characterized by a totality of quality indicators. That is why to obtain the optimal solution to the problems of routing in a communication network, it is necessary to use the multicriterial approach. This determines the relevance of solving the problem of routing in communication networks considering the totality of quality indicators, which characterize the quality of information transmission. To solve this problem, this study used the methods of multicriterial optimization. The methods for discrete selection of a subset of Pareto-optimal variants of routing taking into consideration the totality of quality indicators were proposed. In this case, unconditionally worse options for routing are excluded and potentially possible values of the totality of quality indicators are ensured. It also suggests a possibility of multipath routing organization, which provides uniform loading of all communication lines. The practical features of application of the selected methods of multicriterial optimization for choosing optimal routes in communication networks taking into consideration the totality of quality indicators were explored. The advantages and constraints of the multicriterial approach to solving the problem of routing in communication networks were shown.

The research results are useful for professionals who are engaged in planning and designing optimal communication networks.

Keywords: information transmission, communication network, designing, optimal routing, totality of quality indicators, multicriterial optimization.

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