

ABSTRACT AND REFERENCES

MATHEMATICS AND CYBERNETICS – APPLIED ASPECTS

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SYNTHESIS OF FAST-OPERATING DEVICES FOR DIGITAL SIGNAL PROCESSING BASED ON THE NUMBER-THEORETIC TRANSFORMS (p. 6–10)**Andrey Ivashko**National Technical University
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The selection of special-form moduli and their corresponding primitive roots have been proposed, which provide for a simplified structure of arithmetic devices using number-theoretic transforms. A method for determining moduli has been developed that ensures a minimum number of arithmetic operations when performing the modulo addition and multiplication operations. The structures of special-form modulo adders have been developed and modeled, which make it possible to perform the addition operation as quickly as possible. The modulo adders for the Fermat, Mersenne, and Golomb numbers have been synthesized and tested, which could be used in the arithmetic units of high-speed correlators and filters.

Real-time correlation and convolution calculation become a rather time-consuming task in the case of long input sequences. To solve this task, it is advisable to apply the so-called fast algorithms. However, this requires the high-performance calculators of convolution and correlation, which often exceed the capabilities of modern computer equipment. Therefore, the proposed procedure for determining the modulus, as well as the designed structural circuits for special-form modulo adders, make it possible to accelerate the computation of correlations and convolutions using number-theoretic transforms.

Since the operation of modulo multiplication is performed using the addition and shift operations, the complexity of calculating the number-theoretic transformations largely depends on the number of unities in the binary representation of the degrees of the primitive root. The operation of multiplication is typically reduced to the multiple addition of numbers, which is why the complexity and speed performance of arithmetic devices for numeric-theoretic transformations is determined by the characteristics of the modulo adders.

The proposed method for designing computing moduli for the digital devices that calculate correlation and convolu-

tion, based on rapid theoretical-numerical transformations, provides the simplified hardware and software implementation of these structures, resulting in high-speed processing of signals and images.

Keywords: autocorrelation function, correlation, convolution, programmable logical integrated circuits, discrete Fourier transform.

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CONSTRUCTION OF A METHOD FOR THE STRUCTURAL FUNCTIONAL-COST MODELING OF A COMPLEX HIERARCHIC SYSTEM
(p. 11–22)

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A method has been proposed for the structural functional-cost modeling of a complex hierarchical system. The initial data for carrying out calculations directly based on the functional-cost model have been determined. We have proposed and substantiated the cost description of a complex system and its components by using analytical approximating dependences. An example of the functional-cost algorithm has been given that employs a Lagrange multiplier method for complex systems with a serial combination of its separate parts. The solution to the example is the distribution among the desired probabilities of the effective operation of individual parts in terms of the minimum cost. Deriving such distribution does not require absolute values of the cost of both parts and the entire system. The issues addressed in the cost rationalization include the following: ensuring the

predefined level of the functional perfection of a system at its minimum cost; determining the minimum required level of functional excellence in a single link at the known levels of functional excellence of the system and all other links except the one under investigation; determining the required number of parallel operating links for the same purpose; clarification of the required level of the functional perfection of links (information sensors, information processing links, communication channels) that have parallel communication; the structural improvement of a complex system by selecting a link within the system for which the improvement of functional perfection can be realized at minimum cost. We have proposed rules for the structural rationalization of a complex system. The first of them is the rule of the rational structural structure of a complex system. That makes it possible to receive a sufficient benefit from the complex system at minimum cost. The second rule is the expediency of complicating a complex system. According to it, complicating a complex system is advisable only if it improves the functional perfection of the entire complex system. The third rule, a rule of the proper structure, shows that there are no unnecessary links in the complex system, that is, those links that do not perform any activities that are not functionally required by a given system.

Keywords: structural functional-cost models, complex hierarchical systems, functional-cost calculations, approximating functions.

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STRUCTURAL ANALYSIS OF TERRITORIAL
TRANSPORT SYSTEMS BASED ON
CLASSIFICATION METHODS (p. 23–32)

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Development of industrial zones, districts and entire regions largely depends on the solution to the problem of the formation of the rational structure of territorial transport systems and their effective development. Peculiarities of the functioning of territorial transport systems are closely related

to their structure which is characterized by some combination of pair proximity indexes. The functioning of such systems is closely linked with their structure. The structure of any transport system is multilevel. To clarify the number of structural levels of the system and their constituent elements, criteria and algorithms have been developed to determine the relative position of the sets in a plane taking into account their possible overlap. A generalized index of the proximity of several non-overlapping sets was developed based on the account of pair indexes of the proximity of individual sets and equal to their mean square value. The procedure of structural analysis of the transport system is connected with the necessity of preliminary determination of its structural index according to the results of calculations of values of pair proximity indexes. A method of establishing the number of structural levels of an interregional transport system was developed based on preliminary determination of the structural index of the system with subsequent decision-making on joining the overlapping sets if any. Practical problems related to the refinement of the structure, composition and modes of operation of transport systems should be solved on the basis of the predefined structural index. The study results make it possible to structure transport systems with singling out individual levels and differentiate costs for the development and operation of systems in order to optimize their properties.

Keywords: transport system, structural analysis, structural index, structural level, structuring algorithm.

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MODELING OF TRAFFIC FLOWS IN THE JUSTIFICATION OF PROJECTS OF ROAD CONSTRUCTION IN CONDITIONS OF CONCESSION (p. 33–42)

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A method for studying the expected traffic flow distribution between toll and alternative roads based on user behavior principles is proposed. It is assumed that the user's behavior is rational: he always chooses the most suitable option. The proposed model takes into account the cost of fuel and lubricants, the time and toll of toll and alternative routes. This means that if the cost of toll and alternative roads is the same, the user will not care which route to choose. By changing the toll for 1 km, it is possible to affect the cost of the “expenses for the toll route” component and the corresponding traffic flow. Saturation of the road with vehicles will occur until, due to the complication of traffic on it, the total costs exceed those when driving another road.

Analytical models are developed and proposed for:

- 1) toll determination;
- 2) traffic flow distribution between toll and alternative roads.

The models provided information on the expected traffic flow distribution between toll and alternative routes. It is necessary for:

1) economic justification of project attractiveness for private investors and project feasibility under concession;

2) determination of traffic intensity, below which it is impractical for the authorities to set concession payments under the concession agreement.

The use of the models proposed by the authors is presented on the materials of the project of the construction phase of the Great Kyiv Ring Road (Ukraine).

Keywords: toll, road construction concessions, traffic flow, toll road, road construction.

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CALCULATION OF THE GREEN'S FUNCTION OF BOUNDARY VALUE PROBLEMS FOR LINEAR ORDINARY DIFFERENTIAL EQUATIONS (p. 43–52)

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The Green's function is widely used in solving boundary value problems for differential equations, to which many mathematical and physical problems are reduced. In particular, solutions of partial differential equations by the Fourier method are reduced to boundary value problems for ordinary differential equations. Using the Green's function for a homogeneous problem, one can calculate the solution of an inhomogeneous differential equation. Knowing the Green's function makes it possible to solve a whole class of problems of finding eigenvalues in quantum field theory.

The developed method for constructing the Green's function of boundary value problems for ordinary linear differential equations is described. An algorithm and program for calculating the Green's function of boundary value problems for differential equations of the second and third orders in an explicit analytical form are presented. Examples of computing the Green's function for specific boundary value problems are given. The fundamental system of solutions of ordinary differential equations with singular points needed to construct the Green's function is calculated in the form of generalized power series with the help of the developed programs in the Maple environment. An algorithm is developed for constructing the Green's function in the form of power series for second-order and third-order differential equations

with given boundary conditions. Compiled work programs in the Maple environment for calculating the Green functions of arbitrary boundary value problems for differential equations of the second and third orders. Calculations of the Green's function for specific third-order boundary value problems using the developed program are presented. The obtained approximate Green's function is compared with the known expressions of the exact Green's function and very good agreement is found.

Keywords: Green's function, ordinary differential equations, power series, generalized power series, boundary value problems.

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CONSTRUCTION OF A GENETIC METHOD TO FORECAST THE POPULATION HEALTH INDICATORS BASED ON NEURAL NETWORK MODELS (p. 52–63)

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A genetic method has been proposed to forecast the health indicators of population based on neural-network models. The fundamental difference of the proposed genetic method from existing analogs is the use of the diploid set of chromosomes in individuals in a population that is evolving. Such modification makes the dependence of the phenotype of the individual on the genotype less deterministic and, ultimately, helps preserve the diversity of the gene pool of the population and the variability of features of the phenotype during the execution of the algorithm. In addition, a modification of the genetic operator of mutations has been proposed. In addition, a modification genetic operator of mutations is proposed. In contrast to the classical method, those individuals that are exposed to the operator of mutations are selected not randomly but according to their mutation resistance corresponding to the value of the function of an individual adaptability. Thus, individuals with worse values of the target function are mutated, and the genome of the strong individuals remains unchanged. In this case, the likelihood of loss of the function reached during the evolution of the extremum due to the action of the mutation operator decreases, and the transition to the new extremum occurs if enough specific weight of the best attributes in the population is accumulated.

A comparative analysis of the models synthesized with the help of the developed genetic method has shown that the best results were achieved in the model based on a neural network of long short-term memory. While creating and training the model based on a long short-term network, the ability to use the particle swarm method to optimize the network settings was investigated. The results of our experimental study have shown that the developed model yields the smallest error in predicting the number of new cases of tuberculosis – the average absolute error is 6.139, which is less compared with models that were built by using other methods).

The practical application of the developed methods would make it possible to timely adjust the planned treatment and diagnostic, preventive measures, to determine in advance the necessary resources for localization and elimination of diseases in order to maintain people's health.

Keywords: neural networks, genetic algorithm, phenotype, modified genetic mutation operator, forecasting of public health indicators.

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