ABSTRACT AND REFERENCES

MATHEMATICS AND CYBERNETICS – APPLIED ASPECTS

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ANALYSIS OF CONVERGENCE OF ADAPTIVE SINGLE-STEP ALGORITHMS FOR THE IDENTIFICATION OF NONSTATIONARY OBJECTS (p. 6-14)

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The study deals with the problem of identification of non-stationary parameters of a linear object which can be described by first-order Markovian model, with the help of the simplest in computational terms single-step adaptive identification algorithms – modified algorithms by Kaczmarz and Nagumo-Noda. These algorithms do not require knowledge of information on the degree of non-stationarity of the studied object. When building the model, they use the information only about one step of measurements. Modification involves the use of the regularizing addition in the algorithms to improve their computing properties and avoid division by zero. Using a Markovian model is quite effective because it makes it possible to obtain analytic estimates of the properties of algorithms.

It was shown that the use of regularizing additions in identification algorithms, while improving stability of algorithms, leads to some slowdown of the process of model construction. The conditions for convergence of regularizing algorithms by Kaczmarz and Nagumo-Noda at the evaluation of stationary parameters in mean and root-mean-square and existing measurement interference were determined.

The obtained estimates differ from the existing ones by higher accuracy. Despite this, they are quite general and depend both on the degree of non-stationarity of an object, and on statistical characteristics of interference. In addition, the expressions for the optimal values of the parameters of algorithms, ensuring their maximum rate of convergence under conditions of non-stationarity and the presence of Gaussian interferences, were determined. The obtained analytical expressions contain a series of unknown parameters (estimation error, degree of non-stationarity of an object, statistical characteristics of interferences). For their practical application, it is necessary to use any recurrent procedure for estimation of these unknown parameters and apply the obtained estimates to refine the parameters that are included in the algorithms.

Keywords: Markovian model, adaptive algorithm by Kaczmarz, by Nagumo-Noda, regularization, recurrent procedure optimal parameter.

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ADVANCEMENT OF A LONG ARITHMETIC TECHNOLOGY IN THE CONSTRUCTION OF ALGORITHMS FOR STUDYING LINEAR SYSTEMS (p. 14-22)

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We have advanced the application of algorithms within a method of basic matrices, which are equipped with the technology of long arithmetic to improve the precision of performing the basic operations in the course of studying the ill-conditioned linear systems, specifically, the systems of linear algebraic equations (SLAE). Identification of the fact of ill-conditionality of a system is a rather time-consuming computational procedure. The possibility to control computations entering the state of incorrectness and the impossibility of accumulating calculation errors, which is a desirable property of the methods and algorithms for solving practical problems, were introduced.

Modern computers typically use the standard types of integers whose size does not exceed 64 bytes. This hardware limitation was resolved using software, specifically, by developing a proprietary type of data in the form of a special Longnum library in the C++ language (using the STL (Standard Template Library)). Software implementation was aimed at carrying out computations for methods of basic matrices (MBM) and Gauss matrices, that is, long arithmetic for models with rational elements was used. We have proposed the algorithms and computer realization of the Gauss type methods and methods of artificial basic matrices (a variant of the method of basic matrices) in MatLAB environment and Visual C++ environment using precise computation of the methods' elements, first of all, for the ill-conditioned systems of varying dimensionality. The Longnum library with the types of long integers (longint3) and rational numbers (longrat3) with the numerator and denominator of the longint3 type was developed. Arithmetic operations on long integers were performed based on the modern methods, including the Strassen multiplication method. We give

the results from the computational experiment employing the mentioned methods, in which test models of the systems were generated, specifically, based on the Gilbert matrices of different dimensionality.

Keywords: method of basic matrices, precise calculations, ill-conditioned system of linear equations.

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IDENTIFICATION OF THE STATE OF AN OBJECT UNDER CONDITIONS OF FUZZY INPUT DATA (p. 22-30)

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The modernization of the methods for identification of the state of objects under conditions of fuzzy input data, described by their membership functions, was performed. The selected direction of improvement of traditional methods is associated with the fundamental features of solving this problem under actual conditions of a small source data sample. Under these conditions, to solve the problem of state identification, it is advisable to transfer to the technology of description of source data, based on the mathematical apparatus of fuzzy mathematics and less demanding in terms of information. This transition required the development of new formal methods for solving specific tasks. In this case, the procedure for solution of the fuzzy system of linear algebraic equations was developed for multidimensional discriminant analysis. To solve the clustering problem, a special procedure of comparison of fuzzy distances between objects of clustering and centers of grouping was proposed. The selected direction of improvement of the traditional method for regression analysis was determined by impossibility of using the classical least squares method under conditions when all variables are described fuzzily. This fact led to the need to construct a special two-step procedure for solving the problem. In this case, the linear combination of the measure of distance of the sought-for solution from the modal one and the measures of compactness of membership function of the explained variable are minimized. The technology of fuzzy regressive analysis was implemented in the important practical case when the source fuzzy data are described by general membership functions of the (L–R) type. In addition, the analytic solution to the problem in the form of calculation formulas was obtained. The discussion showed that the modernization of the classical methods for solving the problem of the state identification, considering the fuzzy nature of representation of source data, made it possible to identify objects under actual conditions of a small sample of fuzzy source data.

Keywords: fuzzy, multidimensional discriminate, cluster, regression analyses, technologies for reducing fuzzy problems to well-posed problems.

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ON THE ERRORCORRECTING CAPABILITIES OF ITERATIVE ERROR CORRECTION CODES (p. 31-39)

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The influence of the theory of information on development of the error correcting coding theory has been studied. Main differences

between the probabilistic approach and the deterministic approach in the analysis of error-correcting capabilities of different classes of linear codes have been demonstrated.

The automaton hierarchical models for analysis of permutation decoding of cyclic codes have been developed and a cyclic permutation generator based on two Moore automata has been proposed.

A study has been carried out into the regular and irregular states of linear finite-state machines (LFSM) based on the automaton representation of cyclic codes. A possibility of significant simplification of decoding of cyclic codes based on conversion of irregular LFSM syndromes into regular ones using permutations has been shown.

The formalized methods for determination of error-correcting capabilities of iteratively decoded cyclic codes (IDCC) have been devised. They imply the replacementof traditional complete checking of all possible options for comparison of code words to directional search for the solution of the assigned problem, which leads to a significant time saving for calculations. The algorithm for determination of error-correcting capabilities of IDCC with respect to double errors is given.

It has been shown that all iterative codes increase their error-correcting capabilities with an increase in the number of iterations and one can set it as a percentage for errors of various multiplicities. A distribution of error syndromes to separate iterations has been performed, which makes it possible to reduce the length of a check word in a code. As a result, this leads to an increase in a rate of iterative codes in comparison with the traditional correction codes.

A comparative analysis of IDCC and LDPC codes has been carried out to determine a scope of their optimal use.

Keywords: cyclic codes, low-density parity-check codes, error-correcting capabilities, iterative decoding, linear finite-state machine, permutations.

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REDUCTION AND OPTIMAL PERFORMANCE OF ACYCLIC ADDERS OF BINARY CODES

(p. 40-54)

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The conducted studies have established the prospect of increasing productivity of computing components, in particular, combinational adders, based on applying principles of computation of digital signals of the acyclic model.

Application of the acyclic model is designed for:

– the process of series (for low-order digits of the adder circuit) and parallel (for the rest of the digits) computation of sum and carry signals. Due to this approach, it is possible, in the end, to reduce complexity of the hardware part of the device and not increase the circuit depth;

– setting the optimal number of computational steps.

The assumption that the number of computational steps of the directed acyclic graph with two logical operations (AND and XOR) determines optimal number of carry operations in the circuit of the n-bit parallel adder of binary codes was experimentally proved. In particular, this is confirmed by presence of the 8-bit parallel acyclic adder with the circuit depth of 8 standard 2-input logic elements. Connection between the number of computational steps of the acyclic graph and the number of operations of a unit carry to the high-order digit causes the process of comparison of the adder structure with the corresponding acyclic graph. The purpose of this comparison is to set the minimum sufficient number of carry operations for adding binary codes in the circuit of a parallel adder using the parallel carry method.

Use of the acyclic model is more advantageous in comparison with counterparts due to the following factors:

– less development costs since the acyclic model requires a simpler adder structure;

– presence of an optimization criterion, i.e. the number of computational steps of the acyclic graph indicates the minimum sufficient number of operations of a unit carry to the high-order digit.

This provides the possibility of obtaining optimum indicators of the adder structure complexity and circuit depth. Compared to counterparts of known 8-bit prefix adder structures, this provides a 14–31 % increase in the 8-bit acyclic adder operation quality, e.g. power consumption or chip area depending on the chosen structure.

There are grounds to assert possibility of increasing productivity of computing components, in particular, binary code adders applying the principles of computation of digital signals of the acyclic model.

Keywords: acyclic model of addition of binary codes, prefix model, Ling Adder, Kogge-Stone Adder, Han-Carlson Adder.

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