LABORATORY 1

Laboratory of Information Transmission and Control Theory

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DIRECTIONS OF ACTIVITY:

- the development of the mathematical models, methods and algorithms for the protection of the information networks;
- the development methods of the algebra and information theory for the construction of the diagnostic built-in system;
- the study of limit behavior of solutions of non-autonomous non-linear evolution equations, investigations of trajectory;
- attractors of partial differential equations, their structure and dependence on parameters, constructions of integral manifolds with exponential tracing;
- source coding and data compression;
- the problem of asymptotically optimal universal coding to relative redundancy creation;
- nonparametric estimation: adaptive estimation in partial linear models, statistical approach to some inverse boundary problems for partial differential equations, applications of wavelets in nonparametric estimation;
- algorithmic information theory;
- codes with iterative decoding, code division multiple access (CDMA) systems;
- the development of asymptotic theory nonparametric statistic;
- analysis of systems with complex non-linearities (hysteresis, delays, round-off and discretization effects);
- asynchronous systems;
- hybrid systems;
- oscillation theory, Hopf bifurcations, stability;
- network optimization.

Institute for Information Transmission Problems

MAIN RESULTS

Combinatorial properties of block codes. The binary extended nonlinear perfect codes of length 16, which can be obtained by generalized concatenated construction, were considered and classified. All together there are exactly 285 non-equivalent such codes. In particular, there is one such linear code with rank 11. There are 12 such Vasiliev's codes with rank 12, and there are 272 such codes with rank 13.

The coset weight distribution of arbitrary Goethals-like codes are considered. The coset weight distribution is Found for cosets of weight 1, 2, 3, 5, and 6. The case of cosets of the weight 4 is open. The weight distribution of such cosets is uniquely defined by the number of words of weight 4.

The exact expressions for the number of code words of weight four of cosets of weight four for Z_4-linear Goethals codes are obtained in terms of Kloosterman sums. This gives some new results for Kloosterman sums over finite fields of characteristic 2. In particular, several new identities for Kloosterman sums are obtained.

The Z_4-linear Preparata-like and Kerdock-like are investigated. The ranks and the kernels of all these codes are found.

New classes of polynomials over finite fields are found for which the Module of the trigonometric sum has maximal possible value. In particular, Some new classes of polynomials are found for which the classical Weyl bounmd is exact.

The purpose of this work is to compute a character of a specific representation of PGL(4) over a p-adic field. We relate it to the character of a representation of the twisted endoscopic group GL(2)×GL(2) of PGL(4). This verifies a new and non-trivial case of the Langlands program.

Global and trajectory attractors for non-autonomous evolution equations of mathematical physics with rapidly oscillating terms were studied. Explicit estimates were found for the deviation of the global attractor of equations with rapidly oscillating terms from the global attractors of the corresponding averaged equations. Great ettantion was given to the cases when the averaged equation has the global attractor of a simple structure, for example, it is a finite dimensional torus in the infinite dimensional phase space. The obtained technique were applied to the study of global attractors of 2D Navier-Stokes system with rapidly oscillating external force and to dissipative hyperbolic wave equations.

The asymptotics of the epsilon-entropy of ellipsoids in the Hamming space is obtained as the dimension of the space grows and some optimization problem connected with such a problem is solved.

Necessary and sufficient conditions for the linear detector to be asymptotically optimal are given. In particular, it is shown that finding the asymptotically best linear detector and the largest asymptotic efficiency represents a standard problem of convex analysis in Euclidean space – finding the distance from a point to a convex set.

An effect of a very slow convergence rate in parameter estimation problems was discovered (when Fisher information matrix degenerates).

The experimental results demonstrate that the probability of appearance of new symbol (during the process of sequential encoding) depend on file to be encoded and on the context. Therefore the implementation of the "fixed" expression for this probability can not be very successful. It means that it is reasonable to use the adaptive estimation of the probability of appearance of new symbol. The adaptive approach is well matched with the proposed matrix coding. It was noted that the joint matrix and multialphabet coding with binary decomposition is the most promising.

Exact analytical expression for decoding error probability of memory m=2 convolutional (7, 5) code was derived. The result will be used for calculation of iterative limits for turbo codes using as component codes convolutional (7, 5) codes.

Low rate superorthogonal turbo codes were studied. The iterative limits of these codes was calculated and decoding simulation was done. It was shown that these codes are effective in code division multiple access systems.

New method of downlink transmission from base station to mobile in CDMA system is suggested. The method, called user coordination, increases number of users two times.

The method of diagnosis of tree-like processor net is constructed with assumption the probability of error extension is not equal to one.

Two simple constants for the mentioned constants are obtained with the properties: wan probability transfer the constants, then the truth of diagnosis is changed jump-like.

The new proof of some lemma in coding theory is obtained.

Library of subroutines is implemented in DSP ADSP-21160 assembly language to support front-end (signal level) of OFDM modems.

The syntax of Harvard architecture support is revised in the maintained since 1999 cross-development system (based on Oberon-2 translators to C) for 32 bit CPU and for 16/32 bit DSP by the Analog Devices. The libraries were redeveloped accordingly and library modules of OOC project were adopted.

Package of subroutines is developed for identification of the linear, time-quasiinvariant models of the systems with pregnant woman electromiogramm as input/output and foetus hart-rate as output/input. An analysis technique is described that allows to detect and time localize feedback in those systems. A preliminary (for the lack of sufficient statistical data) research allows one to count on the reliable recognition of certain birth throes types.

The study of various problems on bifurcations of cycles was continued. Theorems on the existence of global continuous branches of cycles (from zero to infinity) based on the information about the linear part and sector estimates of nonlinearities were suggested for Andronov–Hopf bifurcations. We suggested methods to study bifurcations in systems without smoothness, systems with approximately known nonlinearities and with nonlinearities satisfying sector estimates. Algorithms for the analysis of resonance situations with multiply degenerate linear part (with arbitrary multiplicity) and for the study of delayed loss of stability in systems with constant linear part in case of slowly changing parameters were developed. Theorems on degree of mapping in finite dimensional spaces with weak algebraic structure were obtained.

Problems on periodic oscillations in systems with complex hysteresis nonlinearities were analyzed. New results were obtained about natural for such systems continual sets of periodic regimes.

The new possibilities of applicability of split-hyperbolicity techniques and topological degree theory, with applications to qualitative and numerical analysis of systems with strong nonlinearities were studied. The following objectives were pursued and accomplished: adaptation of hyperbolicity theory to study systems with non-smooth nonlinearities; analysis of relationships between properties of hyperbolicity and split-hyperbolicity; rigorous, computer aided, studies of chaotic behavior of dynamical systems playing fundamental roles in physics and economics such as: Lang–Kobayachi type equations of semiconductor lasers with feedback, Korteweg-de-Vries type equations in fluid dynamics, and Kaldor type models of business cycle with hysteresis; de-

signing low-cost control algorithms, based on split-hyperbolicity properties of the model, for stabilizing chaotic systems on prescribed periodic regimes.

Plenty of non-trivial properties of homeomorphisms of the circle are known. Sometimes, continuity of a mapping of the circle may be restrictive in applications. Therefore, it is necessary to solve the problem on distinguishing a class of mappings of the circle retaining as many properties of homeomorphisms as possible while being rather broad and containing not only continuous mappings. It was shown that discontinuous order preserving mappings of the circle retain the majority of symbolical properties of homeomorphisms of the circle and the corresponding symbolical sequences are Sturmian. New proofs of undefinability in o-minimal structures of the problem on convergence, divergence or boundedness of infinite products of matrices from a finite variety are obtained.

The research of infinite products of matrices drawn from a finite set in an arbitrary order was continued, as well as of closely related problems of one-dimensional dynamics of systems with a discontinuous transition map. Another direction of research was concerned with the dynamics of fluid models of queueing systems; the main attention was paid to the uniqueness of solutions. To this end, new methods were developed involving chemical kinetics models and mathematical hysteresis operators with variable characteristics.

Theoretical concepts of entropy were being applied to problems of robust control in linear stochastic systems. In the domain of hybrid systems, a new acceleration-based approach was explored. A new formalism for description of timed formal languages has been developed.

The homogenization problem for the random non-stationary parabolic operator has been studied. It is shown that a solution of Cauchy problem converges in law. We solve the basic fractional analogue of the classical finite time horizon linear-quadratic Gaussian regulator problem. We have investigated the optimal filtering problem in the linear system driven by fractional Brownian motions. The asymptotic stability of the filter is analyzed. The statistical problem of estimation of the drift and variance parameters the fractional analogue of the Ornstein-Uhlenbeck process has been investigated.

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Abstracts

1. Зиновьев В.А., Зиновьев Д.В Двоичные расширенные совершенные коды длины 16, построенные обобщенной каскадной конструкцией // Труды Восьмого международного симпозиума по агебраической и комбинаторной теории кодирования. Россия, Царское Село, 8-14 сентября 2002 г.
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