Russian Academy of Sciences

INSTITUTE
FOR INFORMATION
TRANSMISSION
PROBLEMS

(IITP RAS)

ACTIVITY REPORT 2002
IITP IN BRIEF

Moscow
2003

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GENERAL INFORMATION

The Institute for Information Transmission Problems of the Russian Academy of Sciences (IITP) was founded on the initiative of Professor A. A. Kharkevich (1909-1965), full member of the USSR Academy of Sciences. It was designed to solve problems bearing upon the progress of information theory and its applications, upon the development of principles of integrated systems of information transmission and distribution (the structures of communication networks and switching centers, the problems of control, the teletraffic theory), and upon automatic pattern recognition (reading machines, recognition of images, speech recognition). The formal birthday of the Institute is December 29, 1961, the date when the decision of the Presidium of the USSR Academy of Sciences entitled "On the reorganization of the Laboratory of Information Transmission Systems into the Institute for Information Transmission Problems" was issued. By the same decision, academician A. A. Kharkevitch was nominated director of the Institute.

The first principal fields of research, initiated in the newly founded Institute, were studies in the fundamentals of information and coding theory; formulation and development of the concept of an integrated automated communication network; new approaches in pattern recognition theory; and new approaches in picture processing. 1963 saw the commencement of studies on information processes in living nature after the laboratory of vision biophysics headed by Professor N. D. Nyberg (1899-1967) was transferred to this Institute from the Institute of Biophysics of the USSR Academy of Sciences.

After the decease of academician A. A. Kharkevitch, Professor V. I. Siforov, corresponding member of the USSR Academy of Sciences, became the director of the Institute and held this position since 1966 till 1989. Over these years a number of new laboratories were organized – those of complicated information systems, digital methods of information processing, digital optics, learning systems of behavior organization, computer linguistics, and communication networks.

At present the IITP's basic directions of research are the information theory and applied mathematics, computer and communication sciences in technology, management, language, and living systems. Among the most important topics studied by the Institute are problems of the theory of nonlinear analysis of complex systems, multicomponent homogeneous random systems, information transmission, queuing theory, coding and cryptography, pattern recognition and artificial intelligence, information distribution and computer networks, the theory of linguistic communication and linguistic processes (including machine translation), statistical methods of information processing and control, the theory and methods of image processing (including data compression), intellectual partner computing and information systems, information transmission and processing in living objects, sensory systems, motion control in living systems and robotics.

The Institute is proud to have a stable staff of highly trained specialists and young researchers, including mathematicians, physicists, biologists, linguists, programmers, and engineers. In 2002, the Institute employed 322 staff members. Three of them are full members of the Russian Academy of Sciences and 253 are research officers, including 74 doctors of science (PhD habil.) and 134 candidates of science (PhD). Some of our employees are honorary members of foreign academies, laureates of Russian State Awards and international awards.

In 2002, the Institute included 15 laboratories, 7 sectors, a scientific-organization department, a Committee for Scientific Terminology in the Area of Fundamental Sciences of RAS, and a number of auxiliary departments as well as the administration department.

The financing sources in 2002 were: State budget (through The Russian Academy of Sciences), grants from Russian State Programs (through The Russian Ministry of Industry, Science, and Technology) and other funds (Russian Foundation for Basic Research, International Association for the Promotion of Cooperation with Scientists from the Independent States of the Former Soviet Union, INTAS, etc.), some applied agreements.

The Institute offers post-graduate and post-doctoral courses for Russian and foreign young researchers. A Research and Educational Association "Svyaz' – Informatika (Communication and Informatics)" and V. V. Kalashnikov Educational and Research Center for Controlling Information Processes are affiliated with the Institute. In 2002 nine researchers won PhD and PhD habil. degrees.

The Institute's scientific potential was instrumental in giving rise to its collaboration with the well-known universities and scientific centers of such countries as Australia, Austria, Bulgaria, Canada, Czech Republic, Denmark, Finland, France, Germany, Great Britain, Hungary, Italy, Israel, Korea, The Netherlands, Slovak Republic, Sweden, Switzerland, USA, etc., in all more than 30 Agreements and contracts in 2002.

The Institute has founded and publishes two academic periodicals: "Problems of Information Transmission" and "Automation and Remote Control", which circulate in Russia and abroad. Since October 2000 the Institute was founded the electronic scientific journal "Information Processes".

The Institute hosts nationwide and international conferences and workshops. In 2002 we organized the 8th International Workshop on Algebraic and Combinatorial Coding Theory "ACCT-2002" (8-14 September 2002, Tsarskoe Selo, Russia); the International Seminar on Applied Stochastic Models and Information Processes" (a memorial seminar dedicated to the 60th anniversary of Vladimir V. Kalashnikov, 8-13 September 2002, Petrozavodsk, Russia); and the meeting devoted to the memory of the corresponded member of the Russian Academy of Sciences A. L. Byzov (12 February 2002, Moscow, IITP RAS).

On the basis of the Institute therewere formed The Information Theory Chapter of IEEE in Russia and two scientific departments of The World Laboratory.

It is hoped that this annual report introducing the scientific activities and results of the Institute in 2002 will assist other organizations to better understand the Institute and also promote exchanges between our Institute and research institutions overseas.

IITP'S DIRECTIONS OF ACTIVITY AND RESULTS IN 2002

The directions of activity and results of 2002 (some abstracts and main publications) are presented according to the IITP's basic scientific structure (through laboratories).

AWARDS IN 2002:

1.   IITP RAS was awarded a Diploma of the 2nd Moscow International Salon of Innovations and Investments for constructing a set of ophtnalmological tools, "Ameliya" (Moscow, All Russian Exhibition Center, 6-9 February 2002).

2.   IITP RAS was awarded a Gold Medal of the 2nd Moscow International Salon of Innovation and Investments for the development of the method of dipole electrocardiotopography "DECARTO" (Moscow, All Russian Exhibition Center, 6-9 February 2002).

3.   IITP RAS was awarded a Participant's Diploma at the International Universal Exhibition "Resources, Ideas and Technology – a Look at EXPO-2010" (Moscow, All Russian Exhibition Center, 22-25 October 2002).

4.   IITP RAS was awarded a Diploma for the participation in the 1st annual Exhibition "Medicine, Diagnostics, Prophylaxis, Treatment" (Moscow, 1-5 November 2002).

5.   IITP RAS was awarded a Diploma of the All Russian Exhibition Center for the development and implementation of the devices "KChSM-D" и "Raduga-3" designed for diagnostics and prophylaxis of eye diseases on the basis of the Flicker Fusion principles method (Moscow, All-Russian Exhibition Center, 1 November 2002).

6.   IITP RAS and K.V. Golubtsov was awarded a Diploma and a Gold Medal of the 5th International Salon of Industrial Property, "Archimedes-2002" (Moscow, 27-31 March 2002) for constructing a device for optic nerve diagnostics, "Ameliya".

7.   K. V. Golubtsov was awarded a Diploma and a Prize at the competition "Technology, the chariot of progress" organized by the editorial board of the "Inventor and rationalizer" journal (Moscow, 28 January 2002).

8.   E. A-I. Aidu., K. V. Golubtsov, O. Yu. Orlov, and V. G. Trunov were awarded a Diploma of respect and acknowledgment for their activity in the organization and running of the 5th International Salon of Industrial Property "Archimedes-2002" (Moscow, 27-31 March 2002).

9.   K. V. Golubtsov with co-authors was awarded a Diploma for active participation in forums and a Medal for the device "Raduga-3" in the 1st Russian – Cypriot forum "Inventions and scientific discoveries in the XXI century" (Cyprus, Nicosia, 24 May – 2 June 2002).

10.   K. V. Golubtsov won a prize of the International universal exhibition "Resources, ideas and technology – a look at EXPO-2010" (Moscow, All Russian Exhibition Center, 22-25 October 2002).

11.   K. V. Golubtsov with co-authors were awarded two Gold medals in the 51st World Exhibition of Inventions, Research and New Technology "Brussels-Eureka 2002" (Belgium, Brussels, 3-11 November 2002) for the construction of a device of blood pressure correction "Raduga-3" and an apparatus for diagnosing peritonitis.

12.   K. V. Golubtsov was awarded a Gold medal and a Diploma of the International Festival of Innovation, Knowledge, and Creation "Tesla fest 2002" (Yugoslavia, Novy Sad, October 2002) for the construction of the "Raduga-3" device.

13.   K. V. Golubtsov won a Silver Medal for constructing the "Raduga-3" in the Seoul International Invention Fair 2002 – "SIIF 2002" (Korea, Seoul, 4-8 December 2002).

LABORATORY 1

Laboratory of Information Transmission and Control Theory

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The leading researchers of the laboratory include:

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Dr.Sc. (Math.)	R. Khasminsky	Dr.	E. Asarin
Dr.Sc. (Math.)	A. Krasnosel'skii	Dr.	V. Chepyzhov
Dr.Sc. (Math.)	V. Kozyakin	Dr.	V. Chernorutskii
Dr.Sc. (Math.)	M. Malyutov	Dr.	R. Izmailov
Dr.Sc. (Math.)	M. Pinsker	Dr.	M. Klepzina
Dr.Sc. (Math.)	A. Pokrovskii	Dr.	G. Martynov
Dr.Sc. (Math.)	D. Rachinskii	Dr.	A. Sheverdyaev
Dr.Sc. (Techn.)	Yu. Sagalovich	Dr.	A. Skorobogatov
Dr.Sc. (Techn.)	Yu. Shtarkov	Dr.	A. Vladimirov
Dr.Sc. (Math.)	M. Vishik	Dr.	I. Vladimirov

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.

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-

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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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- **Russian Foundation of Basic Research (No. 01-01-00146):** "Periodic oscillations in control systems".
- **Russian Foundation of Basic Research (№ 02-01-00227): "**Global attractors for systems of equations of mathematical physics, theory of perturbation and averaging".
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<u>Abstracts</u>

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SECTOR 1.1

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DIRECTIONS OF ACTIVITY:

• Construction of algorithms of reasonable complexity (quadratic, cubic) for analysis of regulation on the DNA and RNA levels. Search for regulatory signals and given patterns in genomic sequences, identification of conserved and alternative RNA structures, and, in particular, analysis of attenuation-based regulation. Analysis of complex interacting regulatory systems in a cell.

• Construction of acceptable-complexity (quadratic, qubic) algorithms for reconciliation of protein phylogenetic trees. Application of these algorithms to construction of species trees and analysis of evolutionary events such as horizontal transfer.

• Development of the concept of information interaction and effective description of objects based on combining the theories: model completeness, descriptive set theory, stochastic games with discrete time, modal logic, information transformers categories, algorithmic complexity and randomness.

MAIN RESULTS

A new algorithm for identification of horizontally transferred genes was suggested and implemented. The algorithm computes the dissimilarity between gene and species trees and identifies the most offending gene in the tree. The algorithm was applied to clusters of orthologous genes (COGs).

The previously suggested algorithm for tree reconciliation was improved using normalization of branch lengths and introduction of a weighting scheme for duplications and losses. A new species tree for forty microorganisms represented in COGs was constructed.

The algorithm for identification of conserved RNA structures based on alignment of half-stems was improved by accounting for conservation of sequence boxes. A procedure searching for such boxes by multiple alignment of given sequences was suggested. The new algorithm takes into account energy parameters, pseudoknots and other biological details. The identified structures are merged into a consensus structure using the technique of identification of dense subgraphs. The algorithm was successfully tested on tRNA, RFN, T-box and S-box sequences, as well as simulated sequence fragments.

A new algorithm was developed for identification of weakly conserved signails with the cloverleaf topology.

The algorithms were applied to the number of problems of comparative genomics (joint work with Integrated Genomics, Inc.). This included description of structural properties of protein-DNA recognition, analysis of evolution of regulons in bacterial genomes, as well as studies of regulatory systems such as bacteriocin production, SOS-response, purine biosynthesis, biosynthesis of vitamins such as riboflavin, thiamin, and biotin.

It was shown that biosynthesis of riboflavin and thiamin is regulated by formation of alternative RNA secondary structures, and the same structural mechanism acts on different functional levels, attenuation (premature termination) of transcription and ihibition of translation initiation. This prediction was subsequently confirmed by independent experimental data. The THI-box pattern known to be involved in regulation of thiamin-related genes was extended and applied to identification of new thiamin regulon members such as thiamin transporters in the Bacillus/Clostridium group.

61 RFN elements were described in 49 bacterial genomes (in all taxonomic groups excluding spirochaetes, mycoplasmas and rickettsiae); all of them occur upstream of riboflavin biosynthesis and transport genes. Analysis of the topology and sequence patterns of the RFN elements, together with construction of protein trees, allowed for identification of several horizontal transfer events.

Analysis of the biotin regulon lead to identification of a regulatory signal common to bacteria and archea; this is the first observation of this kind. We demonstrated that conserved base pairs in regulatory signals form more contacts with recognizing proteins and suggested a method for identification of amino acid residues responsible for the specificity of recognition of DNA sites and ligands in large families of transcription factors.

A new recognition rule for identification of T-boxes was constructed based on comparative computer analysis of known examples. The search new T-boxes produced new biological results; this is the first attempt of complete characterization of a global RNA-based regulatory system.

New attenuators in alpha- beta-and gamma-proteobacteria were identified using analysis of RNA structures and other relevant features such as candidate leader peptides, and relative positions of the Shine-Dalgarno boxes and start codons.

Complete analysis of the glycerol-3-phosphate regulons (GlpR repressor from the DeoR family) in the genomes of proteobacteria leaded to identification new regulatory signals that are palindromic in gamma-proteobacteria from the Enterobacteriaceae and Pasteurellaceae families and tandem repeats in alpha- and beta-proteobactera.

A problem of influence of the players' knowledge level and its form on creating the optimal strategies in games connected with stochastic dynamic systems with discrete time (Nesh equilibrium) is studied. It was shown that additional information and favorable external conditions can have a negative impact on the game results. However, for the cooperative behavior of the players in the same situations both increase of the knowledge and improvement of external conditions always lead to the players' payoffs. Developed methods are implemented in computer algorithms.

The general properties of categories of information transformers (IT) were investigated as a monoidal category of special kind. The key concept in construction of such category as Kleisly category is a functor T that takes an object A to an object TA of all "distributions on A", and a natural transformation which assigns an "independent joint distribution" to a pair of "distributions". Necessary and sufficient conditions for a derived Kleisly category to satisfy the axioms for a monoidal category of ITs were obtained.

Institute for Information Transmission Problems

There where studied measurement systems that are described by an integral operator on a plane, which is invariant with respect to the group of motions on a plane. The problem of construction of an optimum measurement-computer system was studied. It was shown that adequate consideration of invariance reduces the problem on a plane to a one-dimensional Fredholm equation on an interval. Developed methods are implemented in computer algorithms.

Well known hypothesis: that fragments of the intuitionistic propositional logic defined by limitation on the number of variables used are decidable by a polynomial algorithm is refuted. This hypothesis was also formulated for standard modal logics with PSPACE-complete problem of decidability. This hypothesis was also refuted for modal logics, namely, it was proved that the condition of PSPACE–completeness for K, K4 logics are ensured by constant formulas, and for S4, Crz, GL logics – by formulas with one variable.

The complexity of decidability for modal logic of statements on consistency in formal arithmetic (GLLin logic) with limitation on the number of variables is studied. It is proved that its constant fragment is polynomial decidable, and one variable formulas fragment have NP-complete problem of satisfability (unprovability).

The problem of reducibility of Borel and countably determined equivalence relations in nonstandard domains is studied. It is proved that reducibility relation between such equivalence is determined by the relative rate of growth of confinal sequences in initial segments which induce the monads. In particular, any two equivalence relations induced by countably confinal monads are comparable by Borel reducibility.

A generalization of Gilbert geometric form theorem on basis was obtained. The sense of this generalization is in the replacement of the notion of "polynom" to more general notion of "quasipolynom" from variables $x_1, x_2, \ldots, x_k$. By quasipolynom we mean a polynom from $x_1, x_2, \ldots, x_k$ and expressions $F(x_1), F(x_2), \ldots, F(x_k)$, and also of derivatives $F'(x_1), \ldots, F'(x_k), \ldots, F^{(i)}(x_1), \ldots, F^{(i)}(x_k)$. It is proved that for any infinite sequence S of quasipolynoms of $x_1, x_2, \ldots, x_k$ there exists such a number c that for almost all polynoms $p=F(x)$ for any point $a=<x_1, x_2, \ldots, x_k>$ either all polynoms in $S(p)$ equal 0 in the point a or some polynom from $S(p)$ having number not greater than c is not equal to 0 in the point a (phrase "for almost all" means that for any polynom it is always possible to change its coefficients as little as possible so)

Well-known universal (for stationary ergodic sources) data compression algorithms (for example Lempel-Ziv algorithms) have a property of asymptotic optimality. In particular, for almost every infinite data sequence generated by a source with unknown statistics the average length of the code sequence on one bit of input sequence tends to entropy of the source when the block-length tends to infinity. Non-robustness property for such algorithms is proved in the case when ergodicity is violated. We used a notion of deficiency of randomness as a measure of dissimilarity between probability distribution and data sequence. The robustness property for more specific sources is proved: Lempel-Ziv algorithm is robust on any sequence generated by Markov chains if the deficiency of randomness of this sequence grows as o(n).

A theoretical ground for Minimum Description Length principle (MDL) was given. Assume that we are given some data x (we may assume that x is a finite binary sequence). We want to find a best hypothesis explaining x. By definition a hypothesis is a probability distributions on the set of all binary strings. Assume that the description complexity of any explanation must not increase a given number a. MDL principle suggests to define the best hypothesis as that minimizing the difference K(P)-log_2(P(x)). It is proved (with P. Vytanyi) that this hypothesis is the best, i.e. it also

minimizes the randomness deficiency of x with respect to P (among all hypothesis of complexity at most a).

The a priori measure of any set is at least 2 to the power of minus complexity of its implicit description. It is proved that an inverse inequality holds: the square of the measure of any set is at most the same value. This was already known with the cube in place of the square (Solovay's theorem).

The members took part as invited speakers at the conferences and schools:

– International Summer School in Functional Genomics "From Genome To Life. Structural, Functional and Evolutionary Approaches", Cargese, Corsica, July, 2002.

– Modern Logik: theory, hystory and applications, Sankt-Petersburg, 2002.

– Fourth conference Advances in Modal Logic, Toulouse, 2002.

– Nonstandard methods and applications in mathematics. Pisa, Italy, 10-16 June 2002.

– Logic Colloquium 2002, ASL European Summer meeting. Munster, Germany, 2002, August 3-10.

– Workshop on Descriptive Set Theory, Analysis, and Dynamical Systems. Fields Institute, Toronto, Canada, 2002, Oktober 6-12.

– Fourth International Conference «Problems of control amd modelling in the compex systems», Samara, 2002, June 17-23.

– The third international conference on bioinformatics of genome regulation and structure, BGRS'2002, Novosibirsk, Russia, 2002, July 14-20.

– Computational Learning Theory, Australia, Sydney, 2002, January.

International cooperation: Vuppertal (Germany), Bonn (Germany), Royal Holloway College (London university), CWI (Amsterdam, The Netherlands), Provance university (Marselle), Dagshtul (Germany), Vienna university (Austria), AstraZeneca (Boston), NCBI (Bethesda, USA), Int. Summer School (Cargese, France), MIT (Boston), Lawrence Berkeley National Laboratory (Беркли), Stanford University (США).

GRANTS FROM:

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LABORATORY 2
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DIRECTIONS OF ACTIVITY:

- mathematical modeling of images and sequences of images;
- investigation of discrete-continuous and hybrid systems;
- control of stochastic and deterministic discrete-continuous systems;
- application of the theory of generalized optimization to problems of observation control and signal processing;
- methods of regularization for inverse problems;
- image processing, filtering, enhancement, and compression;
- interpretation and scene analysis;
- recognition and identification of video data;
- investigations of man-machine interaction systems for finite object area.

MAIN RESULTS

The theoretical investigation in optimal stochastic control and filtering for discrete-continuous stochastic systems described by differential equations with measures was continued. The problem of the optimal singular control existence was solved for systems with linear dependence on control. It was shown the relation between singular controls and generalized solutions obtained with the aid of approximation of generalized control actions by the ordinary ones. The new statement of the singular control problem with unbounded coefficients in dynamical equations was suggested. The method of this problem reduction to the equivalent problem with bounded controls and controlled stopping time was developed. It allows to prove the global existence theorem and to prove the theorem concerning the approximation of the generalized solution and the generalized control by ordinary (continuous) paths and by bounded controls, respectively. This result is the essential generalization of the optimal singular control existence theory and gives a way to the development of the optimality conditions.

The program of the investigation of discrete-continuous systems with phase constraints is performing. The main area of the applications of such systems is the mechanical systems with unilateral constraints. The new approach was suggested to the description of the constraint interaction dynamics. This allows developing the contansive theory for new class of dynamic systems with active constraints.

It was shown that the impulsive action arising during the contact with elastic constraint could be represented in terms of some controlled shift-operator along the paths of some auxiliary system of differential equations. This representation can be a basis for the new optimal control problems statements where some additional control possibilities arise during the interaction with the constraint. (B. Miller)

In the framework of the agreement between IITP and MicroSpec Technologies Ltd., Carl Zeiss Group, Israel "Investigation of the defect detection algorithms" the investigation of the defect detection algorithms on images captured by CCD camera was performed. The problem of joint defect and color variation detection was investigated. The correlation type algorithms modified on the basis of quasi-regular properties of the images were suggested. Modeling programs were developed and tested on the series of the images of quasi-regular objects. MicroSpec approved the results. (P. Chochia)

The reconstruction problem in optic-acoustic tomography (OAT) was studied. It was obtained the parametrix for the OAT problem in the case the odd dimension of the image space. The corresponding algorithm for OAT reconstruction in 3D space was developed. This algorithm is based on the using of the parametrix as the reconstruction operator. The mathematical model of 3D optical-acoustic tomography was developed and the series of numerical experiments was performed. The results obtained lead to a general conclusion: the effectiveness of the OAT reconstruction algorithm is only a little less than of the standard Radon restoration algorithms. So this algorithm can be used in practice. (D. Sushko)

In the framework of RFBR Project No. 00-07-90032, development was continued of text-graphic database on the history of Russian science. A relational database along with bank of images was populated to represent some personal funds of the RAS Archive in digital form. Specifically, we processed the following funds:

− Fund no. 1916 of the academician A. P. Aleksandrov, RAS President in 1975-1986 (inventory no. 1). The fund comprises 322 storage units regarding years 1932-1986, included in the Archive in 1987. 87 storage units were inserted into the database thus making up 600 entries.

− Fund no. 1729 of the academician M. V. Keldysh, RAS President in 1961-1975 (inventory no. 1 and 2). The fund comprises 272 storage units regarding years 1937-1986. 184 storage units were inserted into the database thus making up 555 entries.

− Portrait gallery of Russian scientists of past time selected from Musin-Pushkin collection, which is a part of personal fund no. 543 of the academician N. A. Morozov (inventory no.8). The whole collection consists of 2651 storage units. 468 storage units were inserted into the database thus making up 763 entries.

Participation in the work of Sector 1.1 on problems of computational genomic. Effective parallel algorithm was developed to search regulatory signals in bacterial genome sequences. The algorithm suits for a wide range of supercomputers supporting MPI protocol.

− Some experiments with real data were carried out on TKS9 18-CPU cluster at NICEVT and MBC-1000M supercomputer at the Joint Supercomputer Center of RAS, MSU et al. That task involved up to 380 CPU's simultaneously and has proved anticipated estimations of performance including its linear dependency on the number of processors in effect.

Performing a database administrator functions for the State registered database of the RAS history and membership since 1724 (RAS2000) and mastering/support functions for Web site http://hp.iitp.ru (L. Rubanov)

Institute for Information Transmission Problems

The investigation of the image recognition on the basis of the parametric identification of blurring operators was performed. The new approach based on the neural networks methodology was suggested. (O. Milukova)

The observation control problems in stochastic dynamical systems with noises in observation, depending on the state and the estimate were investigated in details. The local optimality conditions of the observation controls were obtained in program and feedback forms. It was shown that optimal observation control has a complicated switching structure even within the unique observation act. The thesis "Estimation and control in systems with noises depending on the state and estimation" was successfully defended. (K. Stepanyan)

On the basis of stochastic model of uneven surface with using the Kirhgoff approximation in near (and far)-field region and with taking into account the radio-wave shading by the surface elements it was performed the investigation of functions, coefficients and correlation radius of scattered radio-signals, spased in the space, angle and polarization coordinates. Time-correlation functions and Doppler's spectra of the signals received by uniformly moving receiver were investigated. It was determined the class of statistical features of the irregular surfaces that can be detected by direct remote sensing methods. (A. Prosin)

Conferences:

− IS&T/SPIE's 14th Annual Symposium "Electronic Imaging 2002: Science and Technology" (EI'2002), January 20-25, 2002, St-Jose, USA.

− 3rd International Conference on Bioinformatics of Genome Regulation and Structure (BGRS'2002), July 14-20, 2002, Novosibirsk, Russia.

− 4th All-Russian Scientific Conference. "Digital libraries: advanced methods and technologies, digital collections" (RCDL'2002), 15-17 October 2002, Dubna.

− Annual Mediterranean Conference on Automatic Control MED2002, July 2002, Portugal.

− International Conference "Image Processing and Related Mathematics," Moscow State University, The Lyapunov Institute – INRIA (France), July 1-3, 2002, Moscow, Russia.

GRANTS FROM:

- **Russian Foundation of Basic Research (No. 00-07-90032):** "Development and creation of text-graphical database on Russian fundamental sciences on the basis of the RAS archives" (jointly with Sector of Digital Optics).
- **Russian Foundation of Basic Research (No. 00-07-90361):** "Robust methods of estimation and control for stochastic processes in hybrid functional dynamic systems".
- **US National Science Foundation Grant No. (CMS-0000458):** "Active Singularity Approach to Control of Nonsmooth Mechanical and Electromechanical Systems Using Wavelet-based and Impulsive Contol Methods".
- **Cooperation program CNRS (France) – RAS (Russia). Project CNRS/RAS cooperation № PECO/NET 9570:** "Theory of singular control in stochastic systems".

International Project:
Collaboration agreement between IITP and MicroSpec Technologies Ltd., Carl Zeiss Group (Israel): "Investigation of algorithms for the image defect detection".

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SECTOR 2
Sector for Digital Optics
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The leading researchers of the laboratory include:

Dr.Sc. (Math.)	L. Yaroslavsky	Dr.	V. Kober
Dr.	T. Belikova	Dr.	V. Lashin
Dr.	I. Bockstein	Dr.	M. Mozerov
Dr.	V. Karnaukhov		

DIRECTIONS OF ACTIVITY:

- development of relative databases and DBMS;
- optical-digital methods of image processing and pattern recognition;
- synthesis of two-dimensional digital filters;
- digital image enhancement;
- medical image analysis and classification;
- motion estimation;
- dynamic image analysis;
- multimedia;
- three-dimensional scene reconstruction;
- digital holography.

MAIN RESULTS

An original approach for construction of watermark databases and application software with multilanguage support was developed. Databases and application software created in accordance with the developed approach, working under the control of a modern DBMS (Database Management System) and supporting telecommunication data access, guarantee the possibility of simultaneous use of information in all supported languages. The registration in a database of an object in one of the supported languages is organized in such a manner that the given object will be registered and in all remaining (supported) languages and, therefore, will be accessible for the users working in any of the supported languages. All data, which are independent from the language, are shared by all languages. Methods of data population and usage of data, dependent on language, are determined by concrete realization of the database and application software. Auxiliary data fields are generated, supported, and used by the developed software in order to maintain the relations between objects independently from the used language.

Given the second order statistical properties of a wide sense stationary process, the optimal series expansion for data representation and data analysis is the well known Karhunen-Loeve expansion which is defined as the solution of the Karhunen-Loeve eigenvalue integral equation. An analytical solution of the Karhunen-Loeve expansion for a practical case when the covariance function of a stationary process is exponentially oscillating was proposed. Extensive testing using test and real images was provided.

Simple element-wise transformations based on circular centering operation performed over multi-component image before channel correlations were proposed to improve pattern recognition of multi-component objects. The transformations reduce a strong correlation among channel components of real-life images. Subsequent channel correlations are performed independently in the decorrelated channels. We investigated multichannel pattern recognition with the element-wise transformations in terms of noise robustness and discrimination capability. Computer simulation results for noisy test four-component images and various correlation filters were provided and discussed.

Methods of digital processing of a set of fragmented watermark images aimed to data binding and de-fragmentation of watermark images is proposed and developed.

In cooperation with the manuscript department of the State Historical Museum a new approach for generation of databases of manuscripts and incunabula is developed. A basic structure of data fields and triggers of such databases is defined. The relational database for chronological identification of medieval manuscripts and early printed books is generated.

A new method for computing precise motion vector field estimates of moving objects in a sequence of images is proposed and theoretically proved. Correspondence vectors field computation is formulated as a matching optimization problem of multiple dynamic images. The proposed method is a heuristic modification of dynamic programming applied to 2-D optimization problem. The motion vector field estimates using real movie images demonstrate a good performance of the algorithm in terms of dynamic motion analysis.

The research aimed to development of the text-graphic database on the history of the Russian science was continued. A relational database along with bank of images were populated to represent some personal funds of the RAS Archive in the digital form. Specifically, we processed the following funds:

− Fund no.1916 of the academician A. P. Aleksandrov, RAS President in 1975-1986 (inventory no. 1). The fund comprises 322 storage units regarding years 1932-1986, included in the Archive in 1987. 87 storage units were inserted into the database thus making up 600 entries.

− Fund no.1729 of the academician M. V. Keldysh, RAS President in 1961-1975 (inventory no. 1 and 2). The fund comprises 272 storage units regarding years 1937-1986. 184 storage units were inserted into the database thus making up 555 entries.

− Portrait gallery of Russian scientists of past time selected from Musin-Pushkin collection, which is a part of personal fund no.543 of the academician N. A. Morozov (inventory no. 8). The whole collection consists of 2651 storage units. 468 storage units were inserted into the database thus making up 763 entries.

The complex of methods is developed, which allows to reveal informative diagnostically important features (specific attributes) of a half-tone picture and to reduce a task of complex scene analysis to an estimation of values of these attributes. The complex of methods includes: 1) creation of the initial dictionary of attributes with use of expert domain knowledge; 2) preprocessing of images by optimum linear filtering for improvement of diagnostic feature imaging; 3) the description of the preprocessed images by the expert in the terms of collected attributes, and creation of a database of image descriptions; 4) the statistical analysis of the data in the database and revealing of significant attributes and their values specific to each class of images, submitted in the database; 5) construction of decision rules for image classification. Developed decision rules were used for the control of influence of each attribute and

their combinations on accuracy of classification and allowed to specify the list of significant attributes and the threshold values of each attribute necessary for the effective decision of the task of the complex scene analysis (and classifications); 6) replacement of the expert-made estimations of some attributes on the automated estimation and measurement of the attribute values on the image. The developed complex of methods was used for the analysis of complex scene on lung tomograms. It has allowed revealing significant attributes and helped to automate the analysis of some attributes at the analysis of complex scenes.

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1.   Aizenberg I., Bregin T., Butakoff C., Karnaukhov V., Merzlyakov N., Milukova O. Type of Blur and Blur Parameters Identification Using Neural Network and Its Application to Image Restoration // Lecture Notes in Computer Sciences. Springer, 2002. V. 2415. P. 1231-1236.

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LABORATORY 3
Laboratory of Data Analysis, Error Correction Codes and Cryptology

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Dr.Sci. (Math.)	V. Sorokin	Dr.	V. Sidorenko
Dr.	V. Aphanasiev	Dr.	I. Stenina
Dr.	A. Barg	Dr.	A. Trushkin
Dr.	S. Bezrucov	Dr.	A. Weinstock
Dr.	A. Davydov	Dr.	D. Zigangirov
Dr.	E. Jurkov		E. Vashenko
Dr.	V. Pereverzev-Orlov		M. Vitushko
Dr.	E. Petrova		

DIRECTIONS OF ACTIVITY:

- error control codes and information transmission;
- geoinformation technologies and systems;
- partner system design;
- theory of the speech signal.

MAIN RESULTS

ERROR CONTROL CODES AND INFORMATION TRANSMISSION

The following problems are under consideration:
- constructions, decoding and bounds for convolutional and block codes;
- combinatorial problems in vector spaces, covering codes;
- arcs, caps, and saturating sets in projective geometries over finite fields;
- graph theory.

In 2002 year as a continuation and an extension of many years works the following researches and developments are carried out.

Researches and development of rearrangements in turbo codes and woven convolutional codes maximizing code distance and optimizing weight distribution are performed. Nonrandom rearrangements based on linear and cubic transformations modulo code length are proposed. A program system permissive to research and to choose rearrangements for turbo and woven convolutional codes efficiently is created. An analysis of concatenated schemes based on convolutional codes is executed.

A basic version of a program system for simulating and researches of concatenated code constructions based on convolutional codes is developed. This system permits to create distinct constructions from built-in sets of convolutional codes and interleaving types, to research distance characteristics of constructions, to create distinct variants of concatenated and iterative decoders, to perform a statistical simulating for estimates probability characteristics of code constructions and decoders.

Jointly with Lund University, Sweden, a construction of woven convolutional codes with one tailbiting component code is developed. This construction has better parameters than a woven convolutional code with the same convolutional codes-components but without tailbiting. Estimates of correcting properties of convolutional and tailbiting convolutional codes based on their active distances are obtained. A suboptimal decoding algorithm of tailbiting convolutional codes is proposed. This algorithm has the same probabilistic characteristics as the optimal decoder but its implementation complexity is essentially smaller. Metric characteristics of an estimate of correcting properties for window decoding of convolutional codes are obtained.

Jointly with Ulm University, Germany, researches of woven codes based on bipartite graphs and hypergraphs-extenders with block codes as components are executed. Random methods constructing codes based on bipartite graphs and hypergraphs-extenders with Read-Muller codes as components are developed. Program systems for simulating are created. Simulation results show big availability of the considered class of woven codes.

Estimates of probabilistic characteristics for decoding binary codes into a list defined by code words in a sphere of a given radius are investigated. Relations between probabilities of error and rejection of decoding are obtained. For a small radius this relations are better than known those.

Researches and program implementation of algorithms of Sudan, Sudan and Guruswami for list decoding of Reed-Solomon codes over arbitrary finite fields of characteristic two are performed. A soft decoding for these approaches is investigated also. A basic version of a program system for simulating and researches of list decoding of Reed-Solomon codes is developed. This system includes whole and stage-by-stage implementation of the list decoding algorithm of Sudan and Guruswami with assignment of input lists with the most probable values of symbols and forming a list of the most probable output code words. The system permits to analyze work and complexity of all stages of the algorithm. It can be used in the educational programs of high Schools on professions of telecommunication and information protection.

The problem of symbol by symbol a posteriori probability decoding for information symbols of nonsystematic encoded block codes is considered. An extended trellis representation for block codes is introduced that enables the application of the known BCJR algorithm as well as trellis based decoding in the dual code space. Complexity properties of the extended trellis are investigated.

OFDM transmission over time varying mobile radio channels is considered. A class of (L, R) channels is introduced. For the (L, R) channel, the duration of the impulse response is upper bounded by L and the spectrum of the impulse response is zero except for the first R components. An algorithm for maximum likelihood estimation of the transfer function of the (L, R) channel is suggested.

By simulations in AWGN and fading channels it is shown that for certain conditions suboptimal iterative multistage decoding is very close to optimal maximum likelihood decoding and even improves it if interleaving is used.

Bounds on the covering radius of linear codes with a known dual distance, bounds on packings of spheres in the Grassmann manifolds, a low-rate bound on the reliability of a quantum discrete memoryless channel, some polynomials related to weight enumerators of linear codes, and random codes are investigated. A number of researches connected with error exponents are performed.

In graph theory the following problems are considered: edge isoperimetric problems for regular graphs, a new approach to Macaulay posets, a local-global principle for vertex-isoperimetric problems.

Institute for Information Transmission Problems

Jointly with Perugia University, Italy, relations and close properties of saturating sets in projective geometry PG(n,q) and covering codes in coding theory are investigated. With using these relations upper and lower bounds, constructions, and infinite families of codes and sets are obtained. With the help of computer many new relatively small 1-saturating sets in PG(2,q) and 2-saturating sets in PG(3,q) are constructed. New constructions of "small" complete caps in binary projective spaces are proposed.

During 2002 laboratory was cooperated with universities of Germany, Sweden and Italy. The main topics of the cooperation were continuation of many years investigations in communication problems and combinatorial problems in vector spaces. With Ulm University (Germany) woven convolutional codes based on bipartite graphs and hypergraphs-extenders with block codes as components was investigated. With University of Lund (Sweden) woven convolutional codes using cyclic closed convolutional codes as one of components was created and analyzed. Royal Academy of Sweden supports these investigations. With Perugia University (Italy) arcs, caps, and saturating sets in projective geometry over finite fields are studied.

GRANTS FROM:

GEOINFORMATION TECHNOLOGIES AND SYSTEMS

Geoinformation technology of new generation is under developing. Fundamental principles of the technology are remote access to geographical information (GI), high interactivity of GI analysis, intuitive understandable interface and spatio-temporal data mining tools.

The fundamental principles of geoinformation technology are realized in the network analytical GIS GeoProcessotof and COMPASS, problem domains of which are analysis and forecasting of natural and social processes and phenomena. The GISs are designed in Java 1.1 in client-server architecture (http://www.iitp.ru/projects/geo, http://borneo.gmd.de/and/geoprocessor).

GIS GeoProcessor is intended for publication and complex analysis of spatio-temporal characteristics of geological environment and for solving of forecasting and zonation problems in Earth sciences (natural hazard assessment, mineral and oil/gas deposits exploration). The system supports remote access to geographical information, interactive cartographic analysis of grid-based, vector and point data, spatial data mining. The system helps to evaluate the environment properties on the base of principle of analogy using the methods of multidimensional plausible reasoning: method of similarity on a precedent set, method of similarity on expert fuzzy logic knowledge, method of membership function for two classes, method of non-parametric regression.

GIS COMPASS II (Cartography Online Modeling, Presentation and Analysis System) supports analysis of vector GI. Friendly and interactive interface for multilayer vector GI cartographic representation and intuitive understandable tools for spatio-temporal data mining based on interactive analysis of complex properties of geographical objects make the system available for a wide range of the Internet users (non-professionals and specialists). Problem domains of GIS COMPASS are economy, sociology, demography, ecology, policy, marketing research, and management control.

Demonstration databases, which contain geological, geophysical, seismo-tectonic, social, economic and demographic information, have been created. The total volume of the data is about 35MБ. The databases are accessible on site http://www.iitp.ru/projects/geo for interactive cartographical exploration and analysis with the help of GISs GeoProcessor and COMPASS. The database for GIS GeoProcessor contains the digital models of topography, geophysical fields, geological faults, catalogues of earthquakes and topographical elements. The database for GIS COMPASS contains examples of social and economic information on Russian Federation and World Countries, as well as an example of census data on region of Manchester.

Exploration of the databases by the tools of GISs GeoProcessor and COMPASS confirms their efficiency. It allows to offer free of charge dissemination of GISs GeoProcessor and COMPASS to publish and analyse geographical information for scientific and educational centres of Russia, including the sites of the appropriate RFBR grants.

International cooperation.

Cooperation within the framework of the 5FP IST program under the project "Spatial mining for Data of Public Interest" (acronym SPIN!, contract IST-1999-10536) was continued. The following countries participate in the Project: Germany, Italy, Great Britain and Netherlands. Very close problems are investigated in scope of the Agreement on scientific and technical cooperation "Spatial-Temporary Data Mining Information Technology for Environmental and Human Dimension Applications" with Fraunhofer AIS.SPADE institute (former name GMD, Germany)**.** New methods of the spatio-temporal analysis of grid-based and vector data were developed and some methods of GIS GeoProcessor and GIS Descartes (AIS) were integrated.

The agreement on scientific and technical cooperation with Institute of seismology of the Ministry of education and sciences of the Republic Kazakhstan "Development and application of geoinformation technology for complex seismic hazard assessment of Kazakhstan territory" was concluded.

The work with Institute of the Earthquake Prediction and Analysis of Chinese State Seismolo-gical Bureau (CSB) was continued within the framework of the agreement on scientific and technical cooperation between RAS and CSB (together with UIPE RAS) "Study and physical interpretation of spatio-temporal variations of earthquake precursors in the North-East China".

The research results were reported on the international conferences and workshops. The systems GeoProcessor and COMPASS were presented with the support of RF Ministry of industry, science and technology at international exhibition Ce-Bit'2002 (Germany).

GRANTS FROM:

- **Russian Foundation of Basic Research (No. 00-07-90100):** "Network geoinformation systems for presentation and analysis of spatio-temporal information referring to Earth Sciences and human dimension".

- **Ministry of Industry, Science and Technology of Russian Federation:** "Development of an information technology for spatio-temporal data mining for analysis and forecasting of natural and social processes and phenomena".

- **IST Program (EU IST – 10536):** "Spatial Mining for Data of Public Interest (SPIN!)".

Institute for Information Transmission Problems

PARTNER SYSTEM GROUP

Investigated the problem of knowledge and data integration with the goal of creation encyclopedic knowledge systems for decision support systems, and knowledge production and propagation.

Developed technologies get further evolution. They will be used to creation of applied intellectual systems on the base of generating them by means of projecting integral base onto particular problem area.

Windows prototype of software environment kernel for support of knowledge and data unification process on the base of conceptual network models matching is developed. Created kernel allows us to realize previously developed method for clinical information structuring with the goal of fullness providing of registered data in computer systems for physician's professional decisions supporting. This provides us by possibility for developing of software environment for supporting of physician's professional decisions in real multiple profile medical clinic when needed to process data and knowledge in multidimensional spaces of initial descriptions, users interaction, knowledge receiving from different sources, and creation of new knowledge.

Developed kernel provides us also by possibilities of multiphase learning process realization in the frame of Partner Systems concept. These processes first of all are oriented onto medicine, and allow to user to learn the professional language and knowledge in the active regime. All of this can spread the learning process up to creation of absolutely new knowledge.

GRANTS FROM:

- **Russian Foundation of Basic Research (No. 01-01-01020):** "The development of knowledge management methods for large clinical knowledge-based system".
- **Program of Presidium of Russian Academy of Sciences "Intellectual Computer Systems" (№ 3.4):** "Intelligent decision support within the framework of the project "Partner System".

THEORY OF THE SPEECH SIGNAL

There were studied criteria of optimality for inverse problems "acoustic parameters – vocal tract shape", "vocal tract shape – controls", "articulatory displacements – controls" using X-ray microbeam measurements and electromyograms of internal and external muscles. Instantaneous and integral criteria of work, elastic force, kinetic energy and total force were considered. In non-speech mode and for the task "from vocal tract shape to controls", instantaneous criteria provided sufficiently accurate solutions while for the task "from articulatory displacements to controls" only integral criteria on the time interval about 100 ms were appropriate. Inverse problem solutions reproduced the effect of bite-block compensation and the reorganization of control scores for different rates of articulation.

A 3-dimensional vocal tract model was developed taking into account *sinuses piriformis*, alternative width of the pharynx and yielding walls, which considerably increased the accuracy of resonance frequencies computation.

The first version of digits recognition was tested in the speaker-independent mode, different type of microphones and channels for signal-to-noise ratio 10-20 dB. Word error rate was about 12%.

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<u>Articles</u>

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LABORATORY 4
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Dr.Sc. (Math.)	L. Bassalygo	Dr.	M. Boguslavskii
Dr.Sc. (Math.)	M. Blank	Dr.	S. Gelfand
Dr.Sc. (Math.)	V. Blinovsky	Dr.	G. Kabatyanskii
Dr.Sc. (Math.)	A. Kirillov	Dr.	A. Kuznetsov
Dr.Sc. (Math.)	M. Kontsevich	Dr.	V. Lebedev
Dr.Sc. (Math.)	G. Margulis	Dr.	D. Nogin
Dr.Sc. (Math.)	M. Men'shikov	Dr.	G. Okun'kov
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Dr.Sc. (Math.)	G. Olshanski	Dr.	S. Popov
Dr.Sc. (Math.)	D. Panyushev	Dr.	A. Rybko
Dr.Sc. (Math.)	V. Prelov	Dr.	A. Vishik
Dr.Sc. (Math.)	S. Shlosman	Dr.	S. Vladuts
Dr.Sc. (Math.)	V. Shehtman	Dr.	E. Zhizhina
Dr.Sc. (Math.)	Yu. Suhov	Dr.	Yu. Zhukov
Dr.Sc. (Math.)	M. Tsfasman		

DIRECTIONS OF ACTIVITY:
- the Gibbs random fields and Markov chains with local interactions;
- mean-field models of queuing systems;
- fluid models of queuing networks;
- large deviations and its applications;
- queuing systems;
- systems of information transmission, information channels and coding theory;
- algebraic geometry and number theory;
- combinatorial and probabilistic aspects of representation theory;
- modal logics.

MAIN RESULTS

An one-boson space for the polaron system is constructed. This space describes scattering states of one boson on a polaron.

We considered the ferromagnetic Ising model with Glauber spin flip dynamics in one dimension. The external field vanishes, and the couplings are independent identically distributed bounded or unbounded random variables. The long-time behavior of the time auto-correlation function averaged over the disorder was under consideration.

Using the spectral analysis of the transfer matrix for classical lattice spin systems under high temperatures we found invariant subspaces for quasi-particles of various species. The corresponding branches of the transfer matrix spectrum ("the energy of the quasi-particles") have different orders with respect to a small parameter (inverse temperature).

The central limit theorem in the region of small stochasticity for directed polimer in a random environment.

A number of results from one dimensional dynamics based on spectral properties of the Ruelle-Perron-Frobenius transfer operator has been extended to Anosov diffeomorphisms and general expanding or contracting on average random maps on compact manifolds.

Analysis of statistical properties of a family of maps acting in the space of integer valued sequences, which model dynamics of simple deterministic traffic flows has been done. Asymptotic (as time goes to infinity) properties of trajectories of those maps corresponding to arbitrary initial configurations in terms of statistics of densities of various patterns (in the space of sequences) are obtained and weak attractors of these systems and the rate of convergence to them are described.

A class of ferromagnetic bynary models with manyparticle interactions is studied. The classification of these models from the point of view of the drop form of one phase in another one.

Condition on Hamiltonian under which there exists a unique state of non-ideal gas are given.

An asymptotic behavior of an epsilon-entropy of a ellipsoid in a Hamming space (as his dimension increases) is invesigated. Sufficient conditions for the asymptotic exactness of the generalized Hamming bound are obtained. An exact solution of an optimization problem is found. This problem is related to the investigation of asymptotic of the epsilon-entropy of an ellipsoid.

Harmonic functions on certain fractals have benn considered. In particular, for the case of the Sierpinski carpet, an explicit expression involving fractional derivatives has been obtained.

A detailed study of the Gromov-Witten theory for curves has been undertaken. This study is connected with the classical Hurwitz theory of enumeration of maps between curves by their ramification data, which, in turn, is closely connected with symmetric group characters. The results include a proof of the known conjecture concerning a link between the Gromov-Witten theory for the projective line and the Toda hierarchy of nonlinear equations.

The dimer model on periodic bipartite planar graphs has been studied. It is shown that the scaled limit behavior of the model can be described in terms of the so-called amoeba of a suitable plane real algebraic curve, which turns out to be a Harnack curve. This is a generalization of the previous results on the limit behavior of random 3-dimensional partitions.

It has been shown that the distribution function of the first particle in a discrete polynomial ensemble can be obtained through a certain recurrence procedure provided that the difference (or the q-difference) log-derivative of the weight function is rational. In a number of cases the recurrence procedure is equivalent to certain difference or q-difference analogs of Painleve equations. Our approach is based on the formalism of discrete analogs of integrable operators and Riemann-Hilbert problems as developed in our previous works.

An analog of isomonodromy deformations for matrix difference equations has been introduced and studied. It has been shown that both the classical Schlesinger equations and Schlesinger transformations can be obtained from our construction through appropriate limit procedures.

A new relation between Ulam's problem on longest increasing subsequences in random permutations and random matrix ensembles has been studied. New proofs of the Baik-Deift-Johansson theorem and its generalizations due to Baik-Rains has been obtained.

Institute for Information Transmission Problems

A family of probability measures on partitions of naturals has been studied. These measures originated in representation theory, and we demonstrate their connections with random matrix theory and multivariate hypergeometric functions. Our measures depend on three parameters including an analog of the beta parameter in random matrix models. Under an appropriate limit transition our measures converge to certain limit measures, which are of the same nature as one-dimensional log-gas with arbitrary value of the parameter beta. It is proved that averages of products of "characteristic polynomials" with respect to the limit measures are given by the multivariate hypergeometric functions of type (2,0).

Codes in real and complex Grassmannians were studied. For such codes the Varshamov-Gilbert and Hamming type bounds on the size were obtained.

The theory of infinite number fields and function fields was constructed. In particular, an analogue of a zeta-function was introduced. The Odlyzko-Serre bounds on discriminants and the Brauer-Siegel theorem on the product of the class number and the regulator are generalized.

Realizations of the category of mixed motives were studied. Analogues of Hilbert theorem proven. Various faithfullness results for realization functors obtained. Conjectures introduced which together with Beilinson conjuctures would imply that the realization functor constructed is actually an equivalence of categories.

Deformations of Picard-Fuchs differential equations were studied. A family of the 3-rd order ordinary differential equations related to 3-dimensional Fano varieties was introduced. The mirror-symmetry predicts the geometricity of this family. For the case of a complete intersection the stronger modularity property is proven.

The connection is established between the growth of multiplicities in branching rules and the complexity of homogeneous spaces. It is shown that the irreducible representation of a reductive group restricted to it's reductive subgroup gives multiplicities growing no faster than the polynomial on the norm of a highest weight, whose degree can be computed as a complexity of an explicitely constructed auxiliary homogeneous space.

The problem of optimal choice of the sequence of isometries of a homogeneous space of a compact Lie group was studied. The estimate on the norm of an averaging operator in the space of functions with zero integral was obtained for arbitrary homogeneous space.

The asymptotic behavior of the eigenvalues and the spectral measures corresponding to a selfadjoint operator assigned to any symmetric sequence of points on a compact Lie group was studied. The convergence of the sequence of spectral measures is proven.

The contribution was made to the Vinberg's theory of θ-groups. The link between that theory and recent results of Springer and Lehrer concerning regular elements of reflection groups was established.

The commuting variety related to an involutory automorphism of a simple Lie algebra was studied. In particular, a sufficient condition for the irreducibility of such variety was obtained. Also, the complete description of the commuting varieties for the symmetric pairs of rank one was given.

Equations satisfied by Cantor derivative operation together with boolean operations were studied for various topological spaces ($\Bbb R^n$; subspaces of $\Bbb R$). These equations are described in terms of modal logic. For the corresponging modal logics the finite model property and the decidability was proven.

The problem posed more than 20 years ago by R.Goldblatt is solved: the finite axiom set was constructed and the finite model property was proved for the modal logic of chronological future time in the Minkowski space was studied.

The research on products of modal logics was continued. The finite model property for the products of minimal modal and minimal temporal logic was established. This allows to identify new decidable fragments of classical first-order logic as well as of the equational theory of relational algebras.

The discrete invariants of quadrics were studied. New results on the structure of the Chow groups of the Grassmanians of r-planes on a quadric were obtained. The action of the Steenrod algebra on those groups was described. As an application, the possible dimensions of anisotropic quadratic forms from the given power of the fundamental ideal of even-dimensional forms were computed.

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LABORATORY 5

Laboratory of Teletraffic Theory

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Dr.Sc. (Math.)	I. Tsitovich	Dr.	V. Naumov

DIRECTIONS OF ACTIVITY

The laboratory deals with the development of teletraffic theory and its applications in telecommunications and computer systems. The following problem areas and models are studied at the laboratory in 2002:

- the construction of numerically optimized algorithms of calculation the performance measures of queueing models described by multi-dimensional Markovian processes;

- the development and analysis of teletraffic models for performance evaluation of new cost-effective telecommunication systems;

- the development of the software tools based on the efficient algorithms to support the performance modelling of the teletraffic models;

- the construction of the asymptotically optimal procedures for the sequential design of experiments for statistical problems related to telecommunication networks;

- the analysis of switching systems and interconnection networks for telecommunication and multiprocessing systems.

MAIN RESULTS

Optimized algorithm of estimation the performance measures of ideal gradings is constructed. Optimization is achieved by removing out of calculation the states with small probabilities of existence. Ideal gradings are widely used in construction and planning of telephone networks. It is shown that usage of such approach can decrease the time of calculation up to 10 times and more for cases of large loads and number of trunks. Also it allows to skip problems related to calculation of probabilities with very small numerical values. (S. N. Stepanov)

It is shown how to use the methodology derived for estimating the performance measures of multirate connection-oriented networks for solving the similar problems appeared in telecommunication networks based on MPLS technology and considered on connection level. The corresponding model that can be used for MPLS network dimensioning is described. Constructed model can be used for study the performance measures of networks with differentiated services. Examples of such models having one or two nodes with several traffic flows are studied with help of constructing corresponding Markov processes. (S. N. Stepanov, E. O. Naumova, E. I. Melik-Gaikazova)

Models of subscriber's access system are constructed which are compatible with other parts of multiservice communication network. They take into account a traffic flours dividing, a level of mixing the channels cluster and can be used for analyzing a network's structure. (A. D. Kharkevich, E. I. Melik-Gaikazova)

An asymptotic extension for the risk function of asymptotically optimal sequential strategy for hypothesizes testing for markov chain's distributions was analyzed when the maximal probability of error tends to zero and a small parameter exists. An accuracy of a model for possible distributions as the small parameter was considered. A bound for likelihood ratio deviations of discreet distributions under an regularity condition validated for distributions in telecommunication networks was found. (I. I. Tsitovich)

The interconnection switching systems with many different groups of points are considered. Optimal crosspoints for different types of connections are received. (V. A. Garmash)

Properties and applications of *z*-transformations for elementary discrete signals with multiple poles of their Laplace transforms have been discussed. It has been deduced that in such cases *z*-transformations are represented by compound structure fractions, denominated *V*-fractions. *V*-fractions structure in case any poles multiplicity have been also discussed. The new computed methods for direct and inverse *z*-transformations have been developed by using *V*-fractions. (A. A. Vitkova)

It was proposed the Media Switch, which is able to combine different switching disciplines into a compact fabric and provides a platform for multimedia services. Long-term and short-term QoS effects of traffic aggregation and multipath routing in the Internet was investigated. An object/oriented model of multi-layer transport network described with Unified Modelling Language (UML) was proposed. (V. A. Naumov)

A statistical analysis of quality of internet -service for different types telephone stations modem users: step-by-step, crosspoint and electronic were carried out (jointly with "MTU-Inform" (Russia)). Arrival traffic characteristics were investigated : an incoming Internet-calls number, mean number of internet-calls per busy hour, mean duration of internet-session and also dependences of some parameters on time period. The estimates of statistical parameters on grade of service of different types telephone stations Internet-users were obtained. The method to calculate the capacity of corporative network with Internet-service modem pool have been developed; this method takes into account the arrival traffic screening effect. (V. A. Ershov, O. F. Sergeeva)

For Jackson network the necessary and sufficient conditions of presentation of its stationary distribution of state probabilities in analytical form have been obtained. For cases, when parameters of open Jackson network do not depend on and depend on time, its exact nonstationary distribution of state probabilities in analytical form have been obtained in partial case of infinite number of servers in every node and initial conditions (Poisson distribution of queue length in every node). In general case of initial conditions and finite number of servers in every node determination of nonstationary distribution has been obtained by method of iterations. (V. A. Ivnitski)

The necessary and sufficient conditions of product form distribution of queue lengths for network of nodes with generalized processor sharing discipline and network state dependence of nodes parameters and with account the time for customers transmission are suggested. An effective recurrence algorithm of calculation the coefficients of the asymptotic expansion for an arbitrary number of expansion terms is constructed. (O. V. Ivnitski)

GRANTS FROM:

PUBLICATIONS IN 2002

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LABORATORY 7
Laboratory of Bioelectric Information Processing
Head of Laboratory – Dr.Sc. (Biology), Prof. Leonid Titomir
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The leading researchers of the laboratory include:

Dr.Sc. (Techn.)	L. Malinovskii	Dr.	A. Zhozhikashvili
Dr.Sc. (Techn.)	V. Stefanuk		E. Aidu
Dr.	V. Trunov		

DIRECTIONS OF ACTIVITY:

- investigating characteristics of practical lead systems for electrocardiographic mapping under experimental-clinical conditions;
- working out, model and experimental-clinical approbation of optimal methods for location of pathological electrogenic zones in the heart for topical diagnosis with the use of "economical" lead system;
- choosing the most informative parameters of the vectorcardiogram for estimation of the cardiac state in pilots and astronauts under various levels of overload:
- developing efficient methods of intelligible-pictorial representation of the cardiac electrophysiological states and functions for noninvasive electrocardiographic measurements;
- comparatively investigating model-structural methods of statistical data analysis by examples of electrocardiographic records.

MAIN RESULTS

With the use of mathematical models, a new modification of the Frank vectorcardiographic lead system is proposed and investigated. The modified lead system Frank-M consists of the same number of electrodes as the standard 12-lead system, however it provides a simpler measuring procedure and much higher informativity as compared to the standard electrocardiography.

A new method for location of the anatomical position of the acute ischemic lesions in the heart using noninvasive measurements with the Frank-M lead system is developed on the basis of mathematical modeling; the optimal parameters of the method are defined.

A new approach to extracting informative parameters of vectorcardiogram with the use of linear transformation of the vectorcardiographic loop is proposed. This approach is used in the analysis of vectorcardiograms recorded under various levels of overload in pilots and astronauts during training flights. There are proposed vectorcardiographic parameters providing sufficiently reliable prediction of dangerous states of the heart when the organism is subjected to great degree of overload or weightlessness.

The developed new methods of statistical analysis of electrocardiograms are of universal value and allow significantly extending capabilities of such computer software packages as BMDP and SAS.

A preliminary experimental-laboratory approbation of the proposed method for diagnosis and dynamical observation of the cardiac state when the heart is subject to the ischemic disease was carried out in Russian Cardiology Research Complex, Ministry of Health of Russian Federation with the use of the Frank-M lead system and original modification of the dipole electrocardiotopography method (DECARTO); the approbation confirmed the efficiency of this method and revealed the perspective directions of its improvement.

Some studies were performed in collaboration with scientists of Slovak Republic in the framework of agreements on scientific cooperation concluded by Institute for Information Transmission Problems, Russian Academy of Sciences, with the following scientific institutions: Institute of Measurement Science, Slovak Academy of Sciences; Institute of Normal and Pathological Physiology, Slovak Academy of Sciences; and International Laser Center in Bratislava.

The computer algorithms and programs are prepared for implementation of the modified DECARTO technique on the unique mathematical model of the cardioelectric generator situated within the electrically conducting medium of the human chest (this model was worked out by slovak scientists).

The DECARTO method was rewarded with Gold Medal at the II International Salon of Innovations and Investments (Moscow, 6.2.2002 – 9.2.2002) and with Diploma of Honour at the V International Salon of Inventions "Archimed-2002" (Moscow, 27.3.2002 – 31.3.2002).

The scientific workers of the Laboratory V. G. Trunov and E. A. I. Aidu took part in the international seminars on the project ASTROCARD – INTAS No. 99-01319 (Paris, France, 21.2.2002 – 28.2.2002).

Prof. L. I. Titomir participated in the international cooperation on scientific-organizational problems as a Member of Council of the International Society of Electrocardiology, Editorial Consultant of "Journal of Electrocardiology" (USA), and Member of Editorial Board of "Bratislava Medical Journal" (Slovak Republic).

GRANTS FROM:

- **Russian Foundation of Basic Research (No. 01-01-00104):** "Mathematical modeling of the bioelectric processes in the heart and development of methods for diagnosis, dynamical observation, and prediction of the ischemic heart disease on the basis of computer and information technologies".

- **INTAS (№ 99/01319):** "Monitoring of the cardiovascular system of astronauts by means of noninvasive methods based on comprehensive computerized analysis of orthogonal electrocardiogram (ASTROCARD)".

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Artificial Intelligence Group

DIRECTION OF ACTIVITY:

- behavior of locally organized artificial intelligence systems in theory and applications;
- research on the use of theory of category for description of learning and knowledge processing in artificial intelligence;
- semiotic methods of artificial intelligence;
- development intellectual tutoring systems.

MAIN RESULTS

The problem of tutoring is shown to consist from two subtasks: the transmission of knowledge from teacher to learner, and that of assimilation of knowledge by the learner. It is shown in this project that these two close subtasks are drastically different with respect to their scientific development, the latter explaining the slow progress in the modern computer based education.

For the area of learning systems some new mathematical results have been obtained concerning criteria of asymptotic optimality of finite devices.

For the area of teaching systems on the base of an original scheme of cognitive levels, involved in education process, a model of cognitive transactions has been built which shows itself in the process of education.

It is this model which is taken as the base of the personal tutoring system, which is the central topic of the given project. Such a system allows to dynamically control the personal properties of the student exhibited in the process of education. It has been shown that this system is in a good agreement with the arrangement of intelligent man-machine interface previously developed by the authors.

A special issue of the journal "AI News" #5 was compiled by V. Stefanuk. This issue includes both the materials by V. Stefanuk and the translations of some important Eastern and Western papers in this area.

A theoretical study of the production base design by learning from examples was performed. The individual, tree and net arrangements of productions have been considered. The results obtained were reported at the Joint Conference on Knowledge Based Software Engineering, Maribor (Slovenia) and at the 8th National conference on Artificial Intelligence (CAI-2002), Kolomna (Russia).

The new definition for productions was proposed to encompass many concrete cases of production used in Artificial Intelligence. In this definition some important elements of productions were considered which for some reasons were out of view of many researches. Independent from the content and the formats this definition remains rigorous and hence admits the mathematical analyses. The results obtained create a sound base for the studies which were led in our group for many years concerning the use of a categorical approach in Artificial Intelligence.

We started a discussion of mobile communication for the public sector of the society as a supplement to the existing commercial approaches. The proposed methods for solving of arising problems return us back to our original model of Collective of Radiostations, which was aimed to provide a nomadic mobile communication in public domain.

A book devoted to the locally organized systems which is the main direction of our activity was prepared in 2002. Another text book on intellectual tutoring systems has been published.

In 2002 Vadim Stefanuk served as an organizer and the member of Programming Committees of several conferences:

− Joint Conference on Knowledge Based Software Engineering (JCKBSE), Maribor (Slovenia) (with two papers).
− International conference IEEE "AI Systems" (AIS-2002), Gelendzhik, (Russia).
− Intellectual data processing, Kiev (Ukraine).
− National conference on AI with international participation (CAI-2002), Kolomna (Russia), Conference chair, with two papers.

In 2002 Vadim Stefanuk has been reelected to be the Vice-President of Russian Association for Artificial Intelligence (RAAI) for the next term.

Elected in 2001 to be a fellow of European Coordinating Council for Artificial Intelligence (ECCAI) in 2002 Vadim Stefanuk was appointed to be the member of Programming Committee of IJCAI-2003 which will be held in Mexico, August, 2003.

In 2002 V. Stefanuk was also appointed to be a PC member of the 3rd International, Central and Eastern European Conference on Multi-Agent Systems (CEE-MAS), June 16-18, 2003, Prague, Czech Republic.

GRANTS FROM:

• **Program of Russian Academy of Sciences "Mathematical modeling and intellectual systems" (award № 2.2.4):** "Problems of category theory formalization of intellectual knowledge-based computer systems". Project leader V. L. Stefanuk.

• **Russian Foundation of Basic Research (No. 02-01-00955):** "Problems of design of personal tutoring systems based on intellectual man-machine interfaces". Project leader V. L. Stefanuk.

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13.   Stefanuk V.L. Problems of Performance Measurement in Locally-Organized Systems. Submitted to International Conference on Integration of Knowledge Intensive Multi-Agent Systems (KIMAS'03). 2 p. (submitted).

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The leading researchers of the laboratory include:

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Dr.Sc. (Techn.)	D. S. Lebedev	Dr.	O. Orlov
Dr.Sc. (Math.)	D. G. Lebedev	Dr.	T. Podugolnikova
Dr.Sc. (Biol.)	I. Pigarev	Dr.	E. Rodionova
Dr.Sc. (Biol.)	G. Rozhkova	Dr.	M. Smirnov
Dr.	K. Golubtsov	Dr.	V. Vedenina
Dr.	E. Maksimova		P. Maximov

FIELD OF RESEARCH

The main research area of the laboratory is investigation of information processing in sensory systems and in nervous system of man and animals in general. These researches are aimed onto:

- elaboration of adequate models which show how the studied principles of information processing in the nervous system are realized in the formation of complex behaviour;
- elaboration of mathematical models simulating significant functions of distinct divisions of sensory systems, including peripheral, central and sensorimotor levels of information processing;
- comparison of principles and solutions of similar problems in live and technical information systems intended to improve the later;
- designing and implementing diagnostic methods and devices for ophthalmology.

To cope with the problems mentioned, different approaches and methods are used by the laboratory researchers, including neurophysiological, psychophysical and morphological methods, as well as animal behaviour field studies and computer simulations of sensory processing. Among the most important problems is description and classification of numerous functional types of neural units which are involved in the sensory information processing at several levels of integral nervous system. Thus, in vision the peripheral level of information processing is represented by the retina, while the brain visual centres (cortex and caudate nucleus in cats and monkeys, diencephalon and mesencephalon in fish and in frogs) represent the central level. Investigation of neurons' functional types is performed by means of both neurophysiological and morphological methods. Microelectrode experiments are aimed on recordings of responses from separate single units (neurons) at different levels of the retina, which itself is composed of several distinct layered nerve structures, each of them being a complex ordered network built of different neuron classes. These experiments are performed on immobilized live animals using their visual stimulation. Morphological studies specify those neural structures and morphology of the nerve cells which are subject of neurophysiological investigation. Functional features of neural components are the matter of comparison to some distinct forms of sensory-guided integral behaviour of the same experimental animals (fish, amphibia cats),

this way providing the background for modeling of corresponding neural circuits in terms of computer simulations. Such, computer simulations include modeling of neural event underlying of information processing at the level of cone receptor population (in primate retina), as well as interaction of receptor and horizontal cells in the retina (in fish). General principles of sensimotor information processing (such as colour and size constancy in visual perception, binocular vision mechanisms, spatial orientation, echolocation in moths, bioacoustics in locusts during the breeding period) are the matter of psychophysical experiments on both healthy subjects and medical patients having different sensory disturbances; as well as in behavioural experiments on animals. Basic researches provide the background for applied outcomes in the form of diagnostic methods and devices for medical ophthalmology, which are as well being designed and implemented by the laboratory staff.

In our "paper colourimetry" experiments with manual or mechanical movement of papers painted in different colours on backgrounds of other colours, directionally selective ganglion cells of the fish retina projecting to the tectum opticum was shown to be practically colour blind, for it was always possible to match stimuli with backgrounds varying only their intensities. Sensitivity of these units was placed in the long-wave end of the spectrum. We are able to refine the situation presenting on colour monitor screen stimuli of high contrast, specified for the visual system of goldfish. The spectral sensitivity of directionally selective units had been found to determine not only by the red-sensitive cones but green-sensitive ones also. Green-sensitive cones participate weekly with opponent manner. So the sensitivity of directional-selective units is reduced in the blue-green end of the spectrum, its maximum shifted even further to the red end. This shift of spectral sensitivity may be considered an adaptation to the underwater condition, where acute vision is possible only in long wavelength because of the substantial light scattering in blue-green region of the spectrum. (V. V. Maximov, E. M. Maximova)

A hypothetical post-retinal mechanism for separating the red-green opponent signals from the outputs of the midget ganglion cells, which are a mixture of red-green and brightness signals, is presented. The mechanism consists of an inverter and a low space frequency filter, which are series connected. The inverter forms two groups of signals: the first one is a set of the outputs of the on-ganglion cells with L-center and off-ganglion cells with M-center; the second group consists of the outputs of the on-ganglion cells with M-center and off-ganglion cells with L-center. The filter suppresses the false color opponent signals caused by stimulus brightness changes. As a rule such filtration provides forming the "pure" color opponent signal. But the computer experiments show that some special stimuli create the false color opponent signals, which are so powerful that the filter cannot completely suppress them. Probably these results explain the origin of the illusory colors caused by some achromatic stimuli in psychophysics experiments. (D. S. Lebedev)

Possible mechanisms of the colour opponency (CO) in the outer retina were considered. A mechanism of the CO by means of Byzov's ephaptic feedback from horizontal cells to cones is investigated in detail by use of computer simulation. Cone output signal – glutamate release – is controlled by potentials of horizontal cells which are synaptically connected with cones. However, unlike feedforward versions, such scheme of the CO meets with some logical difficulties. Physiological functions usually attributed to CO require the opponent signal to be independent of brightness ("pure" CO). For that the transmitter release must not depend on intensity of the stimulus. A paradox is that in this case HCs apparently do not receive any information about the intensity too and so cannot provide necessary feedback. Unfortunately,

the fact, clear to any radio-engineer, was not fully realized by neurophysiologists. The paradox can be settled by assuming that the feedback loop possesses practically "infinite" gain. Then the output cone signal proves to be rather stabilized, while the HC potential does reflect variations of intensity and supply necessary signal for feedback. A substantial amplification of graded potentials in HCs is possible due to voltage-dependent properties of their nonsynaptic membrane. Appropriate "negative" resistance of the HC membrane was described by A. L. Byzov et al. in fish retinas (A. L. Byzov et al. Vision Research. 1977. No. 17. P. 265-273), but its function remained unclear since 1977. The first, analog model made on the basis of operational amplifiers (op amp) confirmed that responses independent of the intensity of input stimuli can be achieved by use of the op amp with "infinite" gain in the feedback loop. The second, detailed computer model of the retinal network in the framework of Byzov's hypothesis of the ephaptic feedback in triade synapses shows that a feedback via HCs possessing membrane with negative slope resistance indeed simulates necessary "pure" CO (V. V. Maximov, P. V. Maximov).

A new explanation for the orientation-contingent colour after-effect also known as the McCollough effect (ME) is proposed. Like other illusions the ME is supposed to be a result of activity of some visual mechanism (presumably, the novelty filter) that is useful in natural conditions but gives wrong visual perception under special experimental stimulation. As to ME there were no clear view on possible role of the novelty filter in the visual system. It is usually considered that this filter stores frequently appeared image in distributed synaptic weights and subtracts it from the current input image. However the novelty filter can be represented as a special device that eliminates cross-correlation between the input signals. In this case it may be used as a tool for correcting of a priori unknown optical distortion (such as defocusing, astigmatism, chromatic aberration and so on). Pilot experiments with a computer model show that the novelty filter can remove the redundancy of input visual information. In particular, this redundancy may appear due to a significant overlapping of spectral sensitivities of red and green cones. In this case after a long adaptation to such correlated signals the novelty filter would perform a colour-opponent transformation (P. V. Maximov, V. V. Maximov).

Until recently, in most studies of binocular vision, the attention was focussed almost exclusively on the mechanisms of stereopsis based on looking for the matched elements in the left and right images and comparing their positions. At the same time, the human binocular system also include principally different mechanisms capable to produce a single binocular percept from unpaired left and right fragments in the absence of corresponding elements. These integrative mechanisms seem to be of particular interest in view of the finding that, in the cases of binocular disorders, they usually become disturbed later and restore earlier than others. Comparative studies of the integrative mechanisms in adults and in children of various ages with normal binocular vision and with binocular anomalies have shown that the rate of binocular integration reachs the adult level at about 9 years of age. The data obtained could be used for differential diagnostics, optimization of treatment and prediction of the expected progression in the course of binocular vision abilitation and training (G. I. Rozhkova, T. A. Podugolnikova).

In our previous study ("Neuroscience", 1993) it was demonstrated that neurons in the primary visual cortex of cats responded to the intraperitoneal electrical stimulation during slow wave sleep. This observation opened the new direction for the investigation of sleep function. However, it was often argued that electrical stimulation was artificial for the visceral organs and the recorded responses were nonspecific in nature.

The goal of our study during this year was to check our observation using only natural activity of the gastro-intestinal system. Three cats were operated for chronic recordings of neuronal activity in the cortical visual area V4A. Electrodes for chronic recording of myoelectrical activity were also implanted into the smooth muscles in the walls of stomach. Electrodes in stomach recorded typical migrating myoelectrical complexes – high amplitude bursts of the periodic activity. This activity take place in a stomach with intervals 10 – 20 seconds and reflect strong muscle constructions. It was found that during slow wave sleep appearance of these complexes coincided in time with strong increase of neuronal firing in cortical area V4A. Eye movements, which can be recorded during slow wave sleep also demonstrated correlation with stomach activity. These observations confirmed the involvement of cortical areas in the processing of visceral information during seep and have directly demonstrated that slow wave cortical activity during sleep reflect activity of the gastro-intestinal system (I. N. Pigarev).

In prey–catching behavior of monocular frog under experimental control during slow approach to stable prey, for the first time the features of the visual stimulus (namely, its lateral shift without distance change, and the change of its visible angular size), have been revealed, the change of which lead to illusion of distance change between animal and stimulus, although this distance did not change indeed. In psychophysical experiments on human subjects likewise situation had been tested. In the case when one eye had been occluded, subjects perceived distinct illusion of lateral (outward of visual field) stimulus displacement when the stimulus approached, and an opposite (inward) if the stimulus moved away (V. A. Bastakov).

Two points of interrelation between vision and language are discussed, (i) one regarding resemblance of processing of these two so much unlike sensory flows, and (ii) the second, abundance of words and lexemes describing thinking and mental events in the "cognitive" area, and such concerning communication and interpersonal contacts, which appeal to associations from visual experience. "Vision-related" words and idioms belonging to these topics may be of interest for comparative–lexicological study in non–relative languages, because they may reveal some conservative mental tendencies common to people in general (O. Yu. Orlov).

We have investigated the effects of peppermint and lavender odors, presented during a class-work, on the students' performance in math and spelling at elementary and middle school. Peppermint presented in the air in a very low concentration (0,03 mg/m^3) significantly improved the students' performance in the word-dictation spelling test. The effect manifested itself as a decrease of the mean number of errors and a respective increase of the mean school-mark. Peppermint, however, did not affect the performance in the text-copying test, which depended more on attention than on memory. A similar selectivity of peppermint towards the math tests was revealed. The performance in the arithmetic dictation was improved by peppermint, but the results in the written math test were not affected. It seems that in both dictation tests the performance depends on a common mental process, that probably employs operative memory, which was facilitated by peppermint. Lavender demonstrated a dual effect: like peppermint, it improved the performance in word dictation but adversely affected the students' performance in both math tests (E. I. Rodionova).

The shape of the threshold-frequency characteristics of the echolocating moths was studied with varying delay of the tonal stimuli in relation to the own signals of the insects. It was shown that the zone of the optimal acoustic reception was moving along the frequency axis in a cyclic manner. Immediately after the emission of the echolocation click, the acoustic system was "tuned" to the main spectral peak of the

expected echo signal (40-50 kHz) but, in 15 mc, the optimal zone was already shifted to 24 kHz. The tuning frequency of the acoustic system was determined by the tension of the tympanal membrane by methatoracic muscles. The particular attention of the insects to the low-frequency part of the ultrasonic range could be accounted for by their need to control the surrounding space in order to detect echolocation signals of the approaching predators (D. N. Lapshin).

In the behavioral experiments, intact females of the two closely related species *Chorthippus albomarginatus* and *C. oschei* selectively (in 80-90% of cases) responded to the intact conspecific males in choosy conditions. Elimination of the chemical or visual components of the complex courtship signal did not change a female selectivity, whereas elimination of the acoustic component decreased both the female selectivity and the whole number of the positive responses. Thus, acoustic component of the courtship is not only a reproductive barrier between closely related species but also a component of sexual selection. A rate of hybridisation between closely related species *C. albomarginatus* and *C. oschei* was evaluated on the base of associations between different characters (acoustic signals and morphological characters). In 15 populations of the hybrid zone, a correlation between courtship songs and the number of stridulatory pegs was revealed for all males studied (V. Yu. Vedenina).

SCIENTIFIC EVENTS

The meeting devoted to the memory of the corresponded member Russian Academy of Sciences A. L. Byzov was held 2002, February 12. The organizers L. M. Chailahjan and V. A. Bastakov.

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Patents and inventions

1.   Golubtsov K.V., Kuman I.G., Khailo T.S., Bogdanova L.V., Sophronov P.D. Diagnostic method of visual function destruction and arrangement for its practical use. Patent on invention No. 2189168 // Bulletin of inventor No. 26 from 20.09.2002.

2.   Golubtsov K.V., Sophronov P.D. Device for diagnostics optic nerve pathology at children, which determinate with critical flicker fusion frequency // Application for invention. Positive decision from 10.08.2002.

3.   Golubtsov K.V., Orlov O.U., Shigina N.A. Device for diagnostics optic nerve pathology // Application for invention.

4.   Golubtsov K.V., Sophronov P.D., Khuman I.G. Device for computer diagnostics in one side optic nerve atrophy // Application for invention.

5.   Jiavelov I.S., Golubtsov K.B., Milekhin U.M. etc. Device for control of parameters of the cardio-vascular systems // Application with invention.

6.   Golubtov K.V., Bubra V.I., Shamshinova A.M. etc. Device for registration a local electroretinogram // Application for invention.

7.   Golubtsov K.V., Trunov V.G., Aidu E.A-I. Method of topical diagnostic of visual pole and arrangement for its practical use // Application with invention.

Diplomas and medals

1.   Golubtsov K V. was awarded with Diploma and Medal of a prize-winner competition "Technique – a wheel-carriage of progress" which was lead by redaction of magazine "Inventor and rationalizer" (Moscow, 28 January 2002).

2.   Golubtsov K.V. was awarded with Diploma and Medal of 5th International Salon of Industrial Property "Archimedes-2002" (Moscow, 27-31 March 2002) for construction instruments for optic nerve diagnostic, named "Ameliya".

3.   Golubtsov K.V., Orlov O.Yu. were awarded with Diploma of consideration and acknowledgment for activity in organization and leading to 5th International Salon of Industrial Property "Archimedes-2002" (Moscow, 27-31 March 2002).

4.   Golubtsov K.V. was a prizewinner of Gold medal and Diploma of International Festival of Innovation, Knowledge, and Creation "Tesla fest 2002" (Yugoslavia, Novy Sad, October 2002) for construction apparatus "Raduga-3".

5.   Golubtsov K.V. was a prizewinner of International universal exhibition "Resources, ideas and technology-sight into EXPO-2010" (Moscow, VVC, 22-25 October 2002).

6.   Golubtsov K.V. with co-authors were awarded with two Gold medal in 51st World Exhibition of Inventions, Research and New Technology "Brussels-Eureka 2002" (Belgium, Brussels, 3-11 November 2002) for construction the apparatus for blood pressure correction "Raduga-3" and apparatus for diagnostic a peritoneum.

7.   Golubtsov K.V. with co-authors were awarded a Diploma for active participation in forums and a Medal for apparatus "Raduga-3" in 1st Russian – Cyprus forum "Inventions and scientific discoveries in the XXI century" (Cyprus, Nicosia, 24 May – 2 June 2002).

8.   Golubtsov K.V. was a prizewinner of Silver Medal for construction apparatus "Raduga-3" in Seoul International Invention Fair 2002 – "SIIF 2002" (Korea, Seoul, 4-8 December 2002).

LABORATORY 9
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The leading researchers of the laboratory include:

Dr.Sc. (Biol.)	M. Lipshits	Dr.	Yu. Levik
Dr.	A. Grishin	Dr.	K. Popov
Dr.	Yu. Ivanenko	Dr.	V. Selionov
Dr.	O. Kazennikov	Dr.	V. Shlykov
Dr.	G. Kozhina	Dr.	B. Smetanin

DIRECTIONS OF ACTIVITY

Laboratory of neurobiology of motor control investigates the mechanisms of control of posture and movements for more then 25 years. At present time the efforts are focused at study of system of internal representation and its role in motor control and at the investigations of reference systems used by brain for organization of motor behavior. During last years it was shown that in situations with discrepancy between real and perceived position of body segments many motor reactions such as vestibulo-motor and neck influences on leg muscles or oculomotor reactions are determined not by real body configuration but by its description in the system of the internal representation.

In the activity of laboratory the studies of neural mechanisms of locomotion in cat traditionally took an important place. Now we begin to study stepping automatisms in humans. These studies successfully advance.

Manned spacefights open a possibility for studying how the human central nervous system adapts to the microgravity, to what extent the gravitation is essential for processing of proprioceptive information and for motor control. A series of joint research projects with France and other countries was accomplished in this direction during 1982-2002 under conditions of real spaceflights.

MAIN RESULTS

Studies of a role of proprioceptive feedbacks in control of voluntary movements permitted to formulate theoretically important conclusion that the models of motor coordination can not be constructed only on the basis of analysis of one-joint (laboratory) movements, as in this case only a direct control, one feedback and one copy of a motor command are used. In an example of natural movement (rising when laying on a back without the help of hands) it is shown, that alongside with muscles realizing the basic pattern of movement, many more other muscles participate in movement. Their activity can have auxiliary character or to be useless. In realization of natural movements the different physiological mechanisms are used simultaneously

and consistently: a direct control, synergies, automatisms and reflexes. Feedbacks also are of complex character. The coordination provides the compromise of mobility and stability. It was shown, that the muscles of the trunk actively participate in dynamic stabilization of a pose. This dynamic stabilization is combined with fixating activity of muscles of a back.

The hypothesis is confirmed that the anticipatory eye movements in response to axial torsion of a spine are determined by changes in internal representation of body configuration, instead of direct proprioceptive inputs. Such anticipatory orientation probably helps in elaboration of stable reference system necessary for programming and realization of movements. It is interesting also, that these experiments clearly demonstrate the connection between higher (level of a spatial field) and lower (level of synergies) levels of motor control system (according N.A. Bernstein classification).

It was shown, that CNS can elaborate the system of coordinates connected to external space and used for perception of body movements, not only on the basis of visual and vestibular information, but also on the basis of proprioceptive signals. In this situation the domination of sensation of reciprocating movements or turns is directly connected to prevalence of signals from receptors of certain muscles.

Within the framework of cooperation with laboratory of motor systems of neurological of clinic of the Bern university headed by prof. M. Wiesendanger, and laboratory of neurophysiology of hearing and motor control of Institute of physiology of Frieburg university the analysis of the data on coordination of movements of hands during playing on a violin was carried out. With the help of ELITE system movements of fingers of the left hand and movements of a bow held in the right hand were recorded. The preliminary analysis shows, that the pressing of a string by fingers of the left hand occurs at the moment of change of a direction of movement of a bow. It was shown, that the interval between a point of turn of a bow and pressing of a string did not differ in different subjects, though techniques of execution of a musical phrase differed considerably.

With the purpose of finding-out, how the accuracy of internal representation of lengths of body parts varies during maturing of motor system, we measured the accuracy of the indication of characteristic points of a forelimb without the visual control in adults and children (4-11 years). It was shown that in children, as well as in adults, the apparent shortening of a limb occur, and the hand is shortened stronger, than forearm. In children of 4-6 years the length of a limb as a whole also decreased by 40%. It is connected with more expressed underestimation of forearm length in children. The dispersion of the data in the children is more pronounced than in adults. This, apparently, is connected with unequal speed of maturing of the appropriate brain structures.

The method of transcranial magnetic stimulation permitted to demonstrate the increase of a role of motor cortex in postural regulation after increase of complexity of the motor task. For study of supraspinal influences we applied transcranial magnetic stimulation to human motor cortex during standing on a steady or unstable support. After transition from standing on a firm floor to standing on an rocking platform absolute EMG – response on transcranial magnetic stimulation grew by 2,7 times. The amplitude of H-response reflecting the reflex excitability of spinal motoneurons, did not change. Thus, the increase of EMG – responses on transcranial magnetic stimulation is connected not to the increase of reflex excitability of spinal motoneurons, but with the increased involvement of cortical structures. The postural control on an unstable support represents a more complex task and consequently requires involving

of high-level supraspinal structures in process of sensory-motor integration for maintenance of balance.

The studies of vestubular tonus of the man by a method galvanic stimulation of labyrinth were commenced. The experiments confirm theoretical predictions, according to which the level of tonic activity in vestibular nerves determines a difference in magnitude of postural reactions on unilateral galvanic stimulation of a labyrinth. The data obtained demonstrate high inter-individual distinctions in the level of vestibular tonus.

In 2002 two dissertations were defended:

– M. I. Lipshits – for degree of the doctor of biological sciences in biomechanics "Sensory-motor interaction and system of internal representation of the man (research in ground conditions and in weightlessness)".

– I. A. Solopova – for degree of the candidate of biological sciences in biomechanics "Structurally functional features of the system of maintenance of human vertical posture".

GRANTS FROM:

- **Russian Foundation of Basic Research (No. 00-04-48156):** "The investigation of supraspinal control and adaptive mechanisms mechanisms of equilibrium maintenance on unstable support" (head Yu. Ivanenko).
- **Russian Foundation of Basic Research (No. 02-04-48234):** "Proprioceptive perception and calibration of internal model of a body" (head Yu. S. Levik).
- **Russian Foundation of Basic Research (No. 02-04-48302):** "The study of vestibular tonus in man by a method of galvanic stimulation of labyrinth" (head K. E. Popov).

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LABORATORY 10
Laboratory of Communications Network Theory
Head of Laboratory – Dr.Sc. (Mathematics) Valerii Polesskii
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The leading researchers of the laboratory include:

Dr.Sc. (Math.)	N. Vvedenskaya	Dr.	V. Mikhailov
Dr.Sc. (Techn.)	A. Kuznetsov	Dr.	I. Orlov
Dr.Sc. (Techn.)	I. Levshin	Dr.	V. Polyakov
Dr.Sc. (Techn.)	B. Tsybakov	Dr.	A. Rubinov
Dr.	N. Likhanov	Dr.	S. Fedortsov

DIRECTIONS OF ACTIVITY:

- network reliability theory;
- self-similar traffic in ATM networks;
- multiple access packet communications networks;
- asymptotical investigation of large queueing systems;;
- coding and signal processing for storage systems;
- imitational processes for hydroacustic information transmission systems.

MAIN RESULTS

In Lab.10 there are three scientific groups: 1) Polesskii V. P., Rubinov A. R., Kuznetsov A. V.; 2) Likhanov N. B., Vvedenskaya N. D., Tsybakov B. S., Fedortsov S. P., Mikhailov V. A.; 3) Levshin I. P., Orlov I. A. Polyakov V. G. is an independent individual.

The groups develop the contemporary communication network theory. The first group uses and elaborates discrete mathematics methods, the second group and third one uses elaborates probabilistic methods.

V. P. Polesskii continued his investigations in the theory of system and network reliability bounds. His approach to the theory is motivated from revealing the reliability combinatorics. It was described in electronic journal "Information Processes", 2001, v. 1, no. 2. The contemporary state of the monotone systems reliability bounds theory was described by V. P. Polesskii in [1]. The theory is the first level of the network reliability bounds theory. V. P. Polesskii constructed [2] new record efficiently computabled two-sided bounds for monotone systems reliability. The bounds use groups of minimal paths or groups minimal cuts (for example, the shortest minimal paths or the smallest minimal cuts). The results were announced on the Third International Conference "Mathematical Methods in Reliability" held in the June of 2002, Norway. A program to compute the two-sided bounds for the monotone system reliability was done by the Institute of Information Science of RAS. The program can allow to find the best practical method to choice minimal path groups and minimal cut groups in order to obtain good bounds.

The ability to transport information at very high data rates has come the realization that traditional assumptions on the stochastic nature of network traffic flows are inadequate. Recent studies have demonstrated that long-range-dependence is an important characteristic of traffic flows in current networking infrastructures. Numerous studies have shown that in the presence of such traffic the tail of the buffer overflow

probability has an asymptotic power-law decay compare with conventional traffic models where the tail of the buffer overflow probability is exponential. For this reason, it is interesting to know what classes of inputs define the transition between the two types of behavior. Subexponential models are considered as one approach. For these models N. Likhanov get [3] the exact asymptotic decay rate for the buffer overflow probability.

N. D. Vvedenskaya continued [4-7] the investigation of large queueing systems. The topic is a traditional one for our institute, members of different laboratories are involved in consideration of large systems. This theme is closely connected with investigation of the modern telecommunication systems. The mathematical models of systems with dynamic routing are considered, that is the routing that depends on the current state of the system. The tool of the work is the estimation of the network performance parameters, in particular the conditions under which the network is not overloaded. Thus the load-balance routing protocols are proposed and estimated. The open Jackson-type network is the main model. That is the system where new tasks approach upon the system and each task after being served by a server leaves the system with some probability or is resent to some server to be served again. The asymptotical methods are used, the limit systems that appear when the number of servers is growing to infinity are considered. The work uses the methods of theory of probability (for the systems with finite number of servers) and the methods of differential (by new terminology functional) equations (for the limit system model with infinite number of servers). In both cases nontrivial mathematical problems have to be solved. In particular we met a new type of differential (functional) equations with nonlocal coefficient that depend on solution values at fixed points. Interesting boundary value problems for differential equations appear also in TCP-type queuing systems. These systems are very popular nowadays because of use of TCP-type protocols in modern telecommunication networks.

The wide spread of digital wireless telephony and the growing request for support of real-time applications have led to an increasing demand for wireless data and file transmission. The third generation (3G) of CDMA mobile communication networks is beginning to meet the demand. Fundamental problems need to be solved for such mobile communication networks to operate efficiently. One of the problems is finding optimal scheduling algorithms for the transmission over the fading downlink channel from a base station to mobile users. The problem was not considered in the classical queuing and scheduling theories. The problem is solved by B. S. Tsybakov for a specific system. It is assumed that the base station is involved in a transmission of a finite number N of files. There are no new file arrivals before completion of transmission of these N files, or if there are new arrivals, they do not intervene in the ongoing transmission of N files. In general case, at any time, the transmission algorithm knows the lengths of remaining files and knows the transmission rates in all N downlink channels. For the system, the three specific algorithms are considered. One algorithm chooses the channel having the maximum rate in slot, the next algorithm transmits the file having the minimal ratio (remaining file length/channel rate), and the last is the time-sharing algorithm. Using the additive property, the work gives the equations for finding the average delay and average transmission time for the algorithms. It is show how the equations can be solved recursively. Then it is presented a general algorithm or a class of algorithms that includes the three considered algorithms as special cases. After definition of the class, it is possible to state a problem of finding of optimal algorithm. The optimal algorithm is found. The importance of optimal algorithm is in both the possibilities of its implementation and it's using as a ref-

erence for comparison with other algorithms. Examples of numerical comparison of considered algorithms are given. The examples show that the dynamic time-sharing algorithm is almost as good as the optimal algorithm, and that sometimes, it is even better than the algorithm that transmits over the best channel in slot. The results are published in [8, 9].

In paper [10] of B. Tsybakov and A. Rubinov the conflict-avoiding codes are presented. They can be used as protocol sequences for successful packet transmission over the collision channel without feedback. We give a relation between conflict-avoiding codes and known codes are discussed. The upper bounds to maximum code size and three particular code constructions are given.

A. V. Kuznetsov completed (see [11-17]) the study of the BER characteristics of the structured LDPC codes under different conditions for perpendicular and longitudinal channels. Designed simplified encoders and decoders for the structured LDPC codes. Encoders and decoders for some rll-codes were designed.

The information technology of the automatic prognosis of the quality of the information transmission channels, like communications, search and discovery of the marine and submarine ships, navigation, telemetry and others, of the moving marine objects is considered. The technology, based on the methods and means of the simulation modelling, in the Institute for Information Transmission Problems is developed by I. P. Levshin. The technology includes the elaboration and investigation of the mathematical and simulation models of the complicated physical media of the information transmission signals. The methodic of the separate and joint elements of the information transmission channels construction is developed. The data banks of the geophysical and geological parameters, used in the model, are considered [18, 19].

I. A. Orlov developed the method of the analysis of the noiseproof for the underwater acoustics communications system on the base of the algorithm of the computer simulation model of the underwater acoustics communications system and of the generation algorithm of the stochastic transfer function of the hydroacoustic medium. Examples of results of the analysis are presented [18, 20].

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LABORATORY 12
Laboratory of Bioinformatics of Cell Processes and Motocontrol

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The leading researchers of the laboratory include:

Corresponding member of Russian Academy of Science L. Chailakhian

Dr.Sc. (Biology)	M. Berkinblit	Dr.Sc. (Biology)	S. Minina
Dr.Sc. (Biology)	V. Bozhkova	Dr.Sc. (Biology)	N. Samosudova
Dr.Sc. (Math.)	V. Dunin-Barkowsky, President of the RNNS	Dr.Sc. (Biology)	Yu. Panchin
Dr.Sc. (Biology)	Z. Khashaev	Dr.	J. Burmistrov
Dr.Sc. (Biology)	E. Liberman	Dr.	L. Kudina
Dr.Sc. (Math.)	I. Lukashevich	Dr.	D. Voronov

DIRECTIONS OF ACTIVITY

The general theme of the scientific work in the laboratory is: analysis of the information processes in cellular systems and in motor control. The main directions of theoretical researches in this realm: developmental biology (analysis of principles for the realization of genetic information in the developmental systems), neurobiology (neural communication and biochemical modulation in neural centers), motor control (study of geometry of manipulative space and of control goal-directed moving). Also some new bioinformatical principles are worked out including the building of computerized system for the analysis of expert knowledge.

MAIN RESULTS

Developmental biology. In the framework of the theme "Analysis of principles of the genetic information realization in developmental systems" d-r V. P. Bozhkova continued the investigation of the signal mechanisms in early development which depend on the physical as well as molecular regulators. In particular the significance of G-proteins for fish embryogenesis was studied. Earlier using the activators and inhibitors of G-proteins it was shown that they have important role in control of the morphogenetic movements during epiboly. The main point of the recent work was the analysis of the G-protein influence on the cytoskeleton organization. The work was held together with the Institute of Theoretical and Experimental Biophysics, RAS on the Danio rerio embryos, the model which is recognized all over the world as the best one for the molecular-genetic studies. Injection of G-protein activator GTP-gamma-S in the yolk cell, which directs the epiboly in fish, has two phases in its action. At the first (fast) stage pushing the cell surface and appearance of the surface protrusions near the injection site took place. The second phase (10-25 min after the first one) was pointed by the local contraction of cell surface. The data suggest that the protrusive response was related with the activation of the actin filaments polymerization under GTP-gamma-S action and that there are several different sites in the cytoskeleton of embryonic cells regulated by G-proteins. The second tested question was which signal systems were involved in G-proteins control of cytoskeleton. It was

found that the components of the phosphatidylinositol cycle didn't influence on the first phase of the GTP-gamma-S action. But the contraction phase strengthened markedly with inositol-1,4,5-trisphosphate and calcium. According to a new hypothesis for the epiboly mechanism G-proteins act as regulation factors for the actin cytoskeleton polymerization and contraction.

Neurons can communicate with each other via exchange of specific molecules at synapses or by direct electrical connections (EC) between the cytoplasm of either cell. Although electrical connections are abundant in nervous systems, little is known about the mechanisms that govern specificity of their formation. Dr Y. V. Panchin and his collaborators have recently defined a new group of transmembrane molecules (pannexins) which incorporates invertebrate gap junction proteins (innexins, OPUS) and their vertebrate homologous proteins. They also developed a reliable model system to study how the neurons choose the correct counterparts for electrical coupling in vitro. It was hypothesized, that specificity of electrical coupling in the nervous system may be determined by combinations of different gap junction proteins expressed in distinct cell types. This hypothesis is supported by recent data on differential expression of pannexins in the mollusc neurons and in the experiments where the specificity of gap junctions was drastically altered by intracellular injection of mRNA encoding the mollusc innexin Panx1. As a main model system for these studies pteropod mollusc Clione limacin well studied by Y. V. Panchin and his associates was using. Although the homology of the vertebrate pannexins with gap junction molecules of invertebrates is apparent, the question of the actual function of mammalian pannexins in human and animal cells remains unclear and its study is in progress.

D-r D. A. Voronov studied the mechanics of cardiac looping in the invertebrate heart in collaboration with Prof. Larry A. Taber (Washington University in St. Louis, USA). The work was carried out with the chicken embryo, a standard object in biomechanics of heart development. D. A. Voronov found that in previous experiments in this field of embryology the influence of surface tension was not taken into account. He developed a new method of chicken embryo cultivation in the liquid medium enriched by oxygen that allows excluding completely surface tension. Using this new technique, surface tension was found to distort the results of some classic experiments in mechanics of heart development. The development of heart asymmetry was shown as a very redundant process. It depends mostly not on the mechanical properties of primitive heart tube, as it follows from standard models and experiments in this field of science, but on asymmetry of the left and right rudiments that are forming the heart tube by fusion on its rear end. Spatial restrictions imposed to the heart by surrounding tissues are also very important in cardiac looping. On the basis of experiments that were made by D. A. Voronov, in the laboratory of Prof. L. A. Taber a computer 3-D model of cardiac looping was developed.

D-r N. V. Rozanova is working on the MARCKS protein project in the Laboratory of Signal Transduction (National Institute of Environmental Health Sciences, USA) under the supervision of Dr. Perry J. Blackshear. MARCKS is a protein kinase C substrate that is distributed widely in early embryogenesis. However, its precise developmental role is yet to be established convincingly. Rozanova studies MARCKS protein using the Xenopus embryo as a model, using an antisense approach that allows her to deplete specific proteins from the early embryonic stages well before zygotic gene transcription is activated. Rozanova's data show that depletion of MARCKS protein during cleavage stages leads to abnormal cell division and adhesion, resulting in delayed development of the blastula and delayed morphological movement at gastrula. As a result, the experimental embryos are arrested at the end of gastrula-

tion. Depletion of MARCKS protein significantly reduces expression of several mesoderm genes such as MyoD, Xbra, Goosecoid, and FGF8. In contrast, expression of endoderm genes Mix1 and Mix2 was increased. These significant changes in expression pattern may be the underlying cause of arrested development at gastrulation. The data imply an important role for MARCKS protein in determination of mesoderm and endoderm fates in the Xenopus embryo.

Dr. I. M. Plonsky explores the structure and function of persistent and temporary intercellular contacts.

Gap junctions between liver cells (hepatocytes) were studied using the double whole-cell recording (DWCR) technique that yields the conductance of the junctional area between cells (G_j) while perfusing cells contents with experimental solutions. G_j is ensured by intercellular channels (gap junctions). Previous studies show that external solution enriched with CO_2 decreases intracellular pH, rises the concentration of free Ca^{2+} in the cytoplasm, and decreases G_j (uncouples cells). Using a combination of extra as well as intracellular treatments Dr. Plonsky has shown that uncoupling effect of CO_2 is mediated by the acidification of the cytoplasm. It has been concluded that intercellular communications through gap junctions are highly sensitive to intracellular pH and can be regulated upon changes of liver cells metabolic status.

The structure of tight junctions was explored by a combination of DWCR and admittance measurements (AM). This approach allowed measurements of cell capacitance while the trans-contact electric field is applied. It has been found that exogenic charged hydrophobic compound can move from one cell membrane to a neighboring cell upon application of the trans-contact potential. Such translocation was detected as a characteristic change in the membrane capacitance. The effect has been attributed to the existence of the persistent hydrophobic pathway in the region of tight junctions. Trans-contact potential-dependent traffic was observed even in the absence of the exogenic compound, signifying that cells can exchange endogenous hydrophobic charged molecules.

The fusion of biological membranes is known to be driven by specific proteins. The temporary contact, a narrow fusion pore, is formed at early stages of this process. The pore yields information on characteristics of the initial fusion site. It is not known if merging membranes or fusion proteins determine features of the pore, such as initial conductance and kinetics of formation. The fusion pore induced by the viral protein was studied using DWCR as well as AM. New algorithms that allow more reliable restoration of the fusion pore conductance from AM data have been introduced. Data on fusion pore conductance and kinetics of pore formation were used for modeling the initial fusion site. Dr. Plonsky has found that at the early stage of the initial pore formation its features are rather determined by fusion proteins. The fusion site has been visualized as a structure comprised by about 6 protein trimers.

Currently Dr. Plonsky works in the field of taste reception and chemotransduction

Neurobiology The neural system, a base of informational interaction of multi-cell animals, was studying in the laboratory at different levels.

The cerebellum studies present the traditional topic in the laboratory. D-r W. L. Dunin-Barkowski working in the Health Centre of Texas Tech University, USA, continued analysis of the experimental data on the neuron activity in the medullary respiratory center of cats in the cycle waking-sleep. A new computer model of the respiratory rhythm generator was worked out. It unites the so called pacemaker and network models taking in account the intraneuron processes. In particular one uses the mechanism of calcium releasing through plasmatic membrane in the excitation process. It is shown that the neurons can use this mechanism to generate the batch fir-

ing. Neuron network from two model neuron groups which mutually inhibit one another presents a behavior spectrum seen in experiment. Raising the connection force between neuron groups from zero to large values one remarks firstly asynchrony of pacemaker neuron activity, then synchronize bursts (synphase for neurons of inspiration and expiration) of pacemaker activity, and at last counter-phase bursts of inspiration and expiration neurons.

D-r N. V. Samosudova, d-r N. P. Larionova and corr. member of RAS L. M. Chailakhian together with d-r V. P. Reutov (Inst. High Neural Activity RAS) showed using electron microscopic methods a possibility of NO participation in microtubules (MT) activity during signal conducting from one neural cell (granular cell) to another (Purkinje cell). Electron-dense precipitation seen at longitudinal sections of MT was localized with period approximately 24-25 run that is characteristic for dynein which possesses the ATP-ase activity and may interaction with the tubulin in presence of Ca^{2+}. The electron-dense precipitation (forming in NO presence during stimulation) was found to be a polymerized protein containing calcium ions, what was revealed by Petrunyaka's method (EGTA, 20 mM, 20 min, 37°C). It is known that both ATP-ase activity and NO-synthase activity need calcium. Thus the Ca-containing precipitation in MT formed by exogenous NO may mark "work" sites of endogenous nitric oxide during transmission of neural signal that possibly mediates a release of the intracellular calcium.

In the work of d-r Ju. Burmistrov it was established that electrical potentials that may be recorded near the specialized ventilatory appendage (scaphognathite) represent the cumulative potentials of the scaphognathite-moving muscles. Sequence of these potentials was investigated in free-moving crayfish Procambarus cubensis. In long-term experiments correlation between the ventilatory activity and functional state of the animal was shown, and a ventilatory component of behavioral reactions to sudden changes of the environment was described.

D-r. Z. Kh.-M. Khashaev studies the influence of the varied pharmacological media, especially the supertoxicants of the dioxin series, on the biomembrane penetrability . The study goes in collaboration with the Institute of experimental and theoretical biophysics RAS (Poushchino), and Institute of biochemical physics RAS.

Motor control. D-r M. B. Berkinblit and d-r S. V. Adamovich (together with Ratgers Univ., USA) continued studying of the sensorimotor integration mechanisms in human with their changing under normal ageing and caused by Parkinson disease. They used two main methods. It was, firstly, the cinematic analysis of the pointing movements in a virtual space to the visual aim without seeing arm and with distortions visual feedback. The examinee resumes the visual information about his mistake when the movement plays after end of movement. It was shown that parkinsonics learn to compensate such a distortion so quick as healthy aged men do, but they cannot do it after the visual distortion changes its sign into inverse one. (When e.g. after learning to show below target they must learn to show higher of it). Secondly, they studied the coordination of trunk and arm movements in pointing with the same groups of examinee, and confirmed the hypothesis that humans may plan arm movements in both coordinate systems, relative to the out space or relative to the body, depending on where the description of the aim is simpler (in particular, where the aim reposes). As it was shown that parkinsonics relearn illy under distortion of the visual field as well as under changing of the force field, one can say that a principally new result is obtained about role of the basal ganglia in motor learning. It is shown that their injuring precludes relearning. It would be important to know what time lasts the difficulty for relearning.

In order to clarify the role of motoneuron recurrent inhibition in motor control, which remains obscure, especially in humans, its distribution and efficacy in motoneurones supplying hand muscles in healthy humans were analyzed. In contrast to previous suggestions from the literature, in some hand muscles the inhibition was revealed whose characteristics (stimulation conditions, the latency and duration) suggest strong evidence for Renshow inhibition. In contrast to recurrent inhibition in soleus motoneurones which has been investigated earlier, recurrent inhibition in motoneurones of hand muscles frequently followed by short excitatory effect as well as long-latency and long-lasting inhibitory one (d-rs L. P.Kudina, R. E. Andreeva and N. M. Zhoukovskya in collaboration with d-rs M. Piotrkiewicz, Inst. Biocybernetics and Biomedical Engineering, Polish Acad. Sci., and I. Hausmanova-Petrusewicz, Medical Research Center, Polish Acad. Sci.).

Bioinformatical principles. D-r I. P. Lukashevich developed a method of the structural organization for the mildly formalized information and professional knowledge, which served as foundation to building knowledge bases in neurology, neuropsychology and electroencephalography. The main principle consists in singling out different levels of knowledge, their structuring and picking out essential bonds inside levels and between them. This principle was used in building several learning systems and in particular a computer system for encephalography studying. In the last case the computer system exists as the computerized automatic system for diagnostics "EEG-EXPERT". One uses this system in practice at neurological hospitals and polyclinics for learning and raise of qualification, and also for investigations.

In the framework of his studies in foundations of science d-r E. A. Liberman has carried out the first series of experiments eliciting mechanisms of cytoskeleton functioning, which decide inside neuron the brain tasks. Problems of the new science are formulated, the solution of which is within the rich to direct experiments.

D-r A. V. Chernavsky (together with the sector 1.1) prepared for printing in the electronic journal "Informational Processes" an article about principles of the informational interactions in framework of bioinformatics.

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- **Russian Foundation of Basic Research (No. 00-04-49344):** "Изучение механизмов взаимодействия различных мозжечковых входов".
- **Russian Foundation of Basic Research (No. 00-04-48822):** "Сигнальная функция фосфатидилинозитольной системы в морфогенезе".
- **Russian Foundation of Basic Research (No. 01-50-70102):** "Изучение высоко специфических нейронных ансамблей".
- **Russian Foundation of Basic Research (No. 02-04-48775-а р):** "Новое семейство трансмембранных белков паннексинов и их роль в избирательном формировании электрических связей".
- **Russian Foundation of Basic Research (No. 02-04-48352-а и):** "Исследование нового семейства генов, кодирующих трансмембранные белки-паннексины у позвоночных животных".
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LABORATORY 13

Laboratory of Systems for Behavior Organizing

Head of Laboratory – Dr. Modest Vaintsvaig
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The leading researchers of the laboratory include:

Dr.Sc. (Techn.)	V. Neiman	Dr.	A. Romashchenko
Dr.Sc. (Math.)	P. Nickolayev	Dr.	A. Shen
Dr.	A. Cherkasov	Dr.	A. Tsybakov
Dr.	A. Khovahskii		

DIRECTIONS OF ACTIVITY:

- associative memory;
- behavior planning;
- computer vision;
- images recognition;
- asimptotic estimates;
- Kolmogorov complexity;
- parallel computations and networks.

MAIN RESULTS

The organization of the purposeful behavioral reactions conceptual model was defined more precisely. The model is intended for the work in real time and for the using of the associative memory based on neural networks architecture. At the frame of this model the algorithms of preliminary vision information processing were constructed together with the programs that implement it such as de) compressing algorithms, structural representation algorithms of 2-D patterns and also the correspondence algorithm between two 2-D patterns for using in the stereo synthesis problems and calculations of the optical stream.

The uniform scheme of automatic binocular correspondence between the contrast elements of 3D-object observed in two central projections based on affine and projective invariants is developed so as numerical model of its 3D reconstruction. The scheme and the model admit parallel implementation and can be generalized for using at the correspondence problem in conditions of monocular dynamics to restore the form of solid nontransparent 3-D object by motion parallax.

The relations between Shannon and kolmogorof complexity and entropy were investigated:

– Kolmogorof variant of "conditional independencitivity" method is developed. Early it used only for Shannon entropy;

– Generalization of the information Jang–Young inequality for the Shannon and kolmogorof complexity and entropy is obtained.

The problem of sufficient statistics searching for kolmogorof complexity of words was studied (by two given words A and B find a word B' with little complexity relative

B for which information I(A,B') not strongly less than mutual information between A and B). It was shown that at the general case the sufficient conditions of this problem solution are also necessary.

Also it was shown that the problem of interpolation by random choice of the interpolation points belongs to class pac-learning. Numerical experiments that affirm the efficiency of Rissanen heuristics for this problem solution were carried out.

The signal estimations at the strongly ill posed inverse problems with adaptive property in the asymptotically exact sense (i.e. achieving the optimal constants at the risks expression) were constructed.

The nonparametric procedure of the independent components problem solution was suggested (the generalization of the main components method at the case when basic directions may be non orthogonal). The procedure is based on evaluation of the matrix density functionals and allows enhance the order of convergence rate for the final density valuation.

A survey of neural network applications in telecommunications is made up further research the problem of neural networks application cellular network control systems substantiated. An example of control system based on fuzzy logic and neural networks for the two-level cellular network presented.

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LABORATORY 14

Laboratory of Problems of Consciousness and Communication

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The leading researchers of the laboratory include: Dr. A. Kiselev

DIRECTIONS OF ACTIVITY

Direction of research is concerned with specific characteristics of communications connected with the alterations of human consciousness states. This activity is based on the metapsychological approach proposed by leading scientists of Laboratory for describing the phenomena of consciousness and indirect communications.

MAIN RESULTS

Given the crucial role of indirect communication in the processes of knowledge transmission in cultural and scientific traditions it is important to understand its psychological and semiotic mechanisms. The systems theory approach to the analysis of various forms of indirect communication allows to identify their similarities and to draw parallels with the methods of modern psychotherapy. In particular, we have been able to demonstrate with this approach the presence of various consciousness modification mechanisms in the texts of Old and New Testaments as well as to identify the roles of fascination and recipients' belief systems reprogramming functions in these texts. The need for the introduction of new symmetrical semiotics for the analyses of such texts also have been shown, that is based on juxtaposition not of a sign and a meaning, but of two or more mutually replacing and mutually complimenting seminal images. Each of these renders the same meaning but does not express it quite clear, while all of them in concert are able to express in completely and unambiguously.

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LABORATORY 15

Laboratory of Computational Linguistics

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The leading researchers of the laboratory include:

Full member of the Russian Academy of Sciences, Dr.Sc. (Linguistics) Jury D. Apresjan

Dr. Sc. (Linguistics).	Vladimir Z. Sannikov	Nikolay V. Grigoriev
Dr.	Leonid L. Iomdin	Alexander V. Lazursky
Dr.	Leonid G. Mitjushin	Irina E. Kayali
Dr.	Leonid L. Tsinman	Leonid G. Kreidlin
Dr.	Svetlana A. Grigorieva	Nadezhda E. Frid

DOMAINS OF RESEARCH

The Laboratory is concerned with the study of language as a means of information transmission. Fundamental research carried on in the Laboratory aims at the elaboration of a full operative "Meaning ⇔ Text" type of linguistic model. The model is intended to simulate the language behaviour of humans, that is, their ability to produce and understand texts in a natural language. The computerized version of the model developed by the Laboratory is shaped as a poly-functional multilingual processor known under the name of ETAP. ETAP consists of morphological and combinatorial dictionaries of the working languages and various sets of rules. Ideally, the rules in combination with the dictionaries should simulate the language behaviour of humans in text production and interpretation. Integrated into certain modules, they acquire an applied function. Namely, they make possible the operation of a number of NLP systems designed in the Laboratory, such as English-to-Russian and Russian-to-English machine translation, generation of Russian texts from the semantic representation of an utterance in UNL, paraphrasing sentences in the given natural language, and some others. Apart from solving a number of practical problems in NLP, such systems, on the other hand, serve as an experimental testing ground, which allows the researchers to rectify certain details of linguistic descriptions and sometimes even derive totally new linguistic knowledge from the experimental data. In 2002 the Laboratory was concerned with the extension and improvement of the functional potential of ETAP. The demo version of the system is accessible at the following address: http://proling.iitp.ru.

BASIC RESULTS

1) Much effort was devoted to the development and replenishment of the combinatorial dictionaries of Russian and English.

− The number of entries has grown to 65,000 items in each dictionary, which corresponds to the average size of large traditional all-purpose bilingual dictionaries.

− Lexicographic information in various zones of the dictionaries was expanded and updated. Fundamental changes were introduced into a) the entries of polysemic words, b) government patterns, c) lexical functions zones. The expansion and up-

dates were motivated, in particular, by the experimental data drawn from the functioning of applied systems constructed by the Laboratory.

– A module for semi-automatic introduction of phraseological units into the combinatorial dictionaries was developed.

2) Work on the replenishment and improvement of morphological dictionaries of Russian and English was carried on.

– The dictionaries were replenished with geographical and proper names.

– Introduction of composites (of the type *quasi*) and the components of compound words was continued.

3) Studies on the topic "Elaboration of the theory and dictionary of verbal government for the purpose of parsing and automatic synthesis of Russian texts" were commenced. The following results were obtained:

– A new lexico-semantic theory of verbal government was elaborated. It can be summed up in the following points: a) verbal government is partly motivated semantically and partly unmotivated; b) those governing properties of verbs which can be accounted for by semantic considerations are determined by two factors – the systemic senses of the type 'action', 'process', 'state', 'property', 'actionality', 'purpose' etc., making part of the lexicographic definitions of the respective predicate lexemes, and by those definitions themselves; c) unmotivated governing properties of lexemes are rooted in the "personal" lexical properties of the verbs.

– A list of verbs to be included in the dictionary was compiled counting some 6000 items.

4) A special module for paraphrasing Russian sentences on the basis of the lexical functions apparatus was developed; the following results were obtained in the course of this work:

– A new apparatus of lexical functions was constructed consisting of the new system of definitions, the zone of lexical functions in the combinatorial dictionaries and three sets of rules: rules of identification of lexical functions in the processed sentence, rules of reducing sentences to their canonical forms and rules of paraphrasing proper. This apparatus was integrated into ETAP as a separate module.

– The system of paraphrasing was debugged, and a large series of computer experiments were conducted.

– The examination of the experimental data was commenced which allowed not only to introduce a number of local improvements in the linguistic knowledge base, but also to make considerable headway in the understanding of the fundamental properties of language.

5) Much work was done on constructing the Russian subsystem for the programme of multi-language communication on the basis of the Universal Networking Language (UNL). This programme, which is being developed by a large international consortium under the aegis of the UN, is aimed at providing the Internet users with the facilities for receiving and disseminating information in their mother tongues. The system is accessible at the site www.undl.org. The following results were obtained.

– The first version of Russian-to-UNL translation module was developed.

– The module for UNL-to-Russian translation was considerably improved. This module is accessible at the address www.unl.ru.

– The existing specifications of UNL were analyzed and a number of improvements were proposed.

6) Work on creating an annotated corpus of Russian texts was carried on.

– 4 000 sentences in the corpus were annotated.

– The software of the complex "The working bench of the annotator" was perfected: a program was written which either corrects itself certain mistakes found in the text or detects formal inconsistencies in the morpho-syntactic structures and supplies the operator with a list of mistakes.

– A fragment of the corpus was handed over to the YANDEX company for joint effort at developing an information retrieval system and creating an open telecommunication access to the corpus via Internet.

7) An original combined parser was constructed and integrated into the ETAP linguistic processor. It allows parsing rules to dynamically interact in the process of ambiguity resolution with the specially designed statistical module which assigns certain weights to the hypothetical syntactic relations on the basis of the syntactically annotated corpus.

8) The first version of an innovative interactive system of lexical ambiguity resolution for machine translation and other NLP applications was constructed. The system is based on a dynamic interaction of the algorithm with the intuitions of the human user who has no linguistic expertise. On receiving the user's answers to some simple questions posed to him (choose a synonym of the given word, or its paraphrase, or its simplified definition and the like) the system ensures a hundred percent resolution of lexical ambiguity. With the help of this system some 20,000 entries in the combinatorial dictionary were processed for which the structure of their polysemy was established and diagnostic descriptions for various meanings were introduced.

9) Linguistic means of lexico-grammatic ambiguity resolution were worked out.

10) A program for identifying and tagging nominal groups in the text which designate persons was written.

11) Support for accessing symbols of various code tables by ETAP was ensured.

12) A new version of the HELP system for ETAP was elaborated.

GRANTS FROM:

- **Russian Foundation of Basic Research (No. 01-06-80453):** "Development of a Compound Parsing Algorithm for the Linguistic Processor ETAP-3".
- **Russian Foundation of Basic Research (No. 01-07-90405):** "Creation of an Annotated Corpus of Russian Texts (second release)".
- **Russian Foundation of Basic Research (No. 02-06-80085):** "Development of an Interactive System of Lexical Ambiguity Resolution for Machine Translation and other Applications".
- **Russian Foundation of Basic Research (No. 02-06-80106):** "Development of the Theory and the Dictionary of Verbal Valencies for the Purposes of Automatic Analysis and Synthesis of Russian Texts".

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2. Апресян Ю.Д. Взаимодействие лексики и грамматики: лексикографический аспект // Русский язык в научном освещении. 2002. № 3. С. 10-29.

3.   Апресян Ю.Д. Новый объяснительный словарь синонимов русского языка: ход работы и результаты // Вестник Российского гуманитарного научного фонда. 2002. № 3. С. 87-99.

4.   Апресян Ю.Д., Цинман Л.Л. Формальная модель перифразирования предложений для систем переработки текстов на естественных языках // Русский язык в научном освещении. 2003. № 4.

5.   Богуславский И.М. «Сандхи» в синтаксисе: загадка *уже не* // ВЯ. 2002. № 5. С. 19-37.

6.   Богуславский И.М., Григорьев Н.В., Григорьева С.А., Иомдин Л.Л. Разработка синтаксически размеченного корпуса русского языка // Доклады научной конференции "Корпусная лингвистика и лингвистические базы данных". С.-Пб.: изд-во С.Петербургского университета, 2002. С. 40-50.

7.   Иомдин Л.Л. Уроки русско-английского (из опыта работы системы машинного перевода) // Труды Международного семинара Диалог'2002 по компьютерной лингвистике и ее приложениям. М.: Наука, 2002. Т. 2. С. 234-244.

8.   Иомдин Л.Л., Сизов В.Г., Цинман Л.Л. Использование эмпирических весов при синтаксическом анализе // Обработка текста и когнитивные технологии. Казань: Отечество, 2002. № 6. С. 64-72.

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10.   Apresjan Ju.D. Principles of Systematic Lexicography // Lexicography and Natural Language Processing. A Festschrift in Honour of B.T.S. Atkins. Marie-Hélène Corréard (ed), Euralex 2002. P. 91-104.

11.   Apresjan Ju.D., Boguslavsky I.M., Iomdin L.L., Tsinman L. L. Lexical Functions in NLP: Possible Uses. – In: Computational Linguistics for the New Millenium: Divergence or Synergy? Proceedings of the International Symposium held at the Ruprecht-Karls-Universität Heidelberg, 21-22 July 2000. Manfred Klenner / Henriëtte Visser (eds.) Frankfurt am Main, 2002. P. 55-72.

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16.   Апресян Ю.Д. Системность лексики: семантические парадигмы и семантические альтернации // В сборник в честь С. Кароляка (в печати).

17.   Апресян Ю.Д. Акциональность и стативность как сокровенные смыслы (охота на *оказывать*) // Сборник статей к 70-летию Н.Д. Арутюновой. М.: Языки русской культуры, 2003 (в печати).

18.   Апресян Ю.Д. Трактовка вида в словаре: правила, тенденции, лексикализация // Сборник в честь проф. Лемана, Гамбург (в печати).

19.   Апресян Ю.Д. Об одной закономерности устройства семантических систем // Пятые Шмелевские чтения (в печати).

20.   Апресян Ю.Д. Принципы организации центра и периферии в лексике и грамматике // Сборник в честь В.С. Храковского (в печати).

21.   Богуславский И.М. Замечания об актантной структуре адвербиальных дериватов (в печати).

22.   Богуславский И.М. Часть – Целое – Признак: заметки о сфере действия кванторных слов (в печати).

23.   Иомдин Л.Л. Идея и цель: об одном типе русских связочных предложений // Сборник статей к 70-летию Н.Д. Арутюновой. М.: Языки русской культуры, 2003 (в печати).

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LABORATORY 16
Laboratory of Stochastic Dynamical Systems
Head of Laboratory – Dr.Sc. (Mathematics), Prof. Aleksandr Veretennikov
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The leading researchers of the laboratory include:

Dr.Sc. (Techn.)	R. Liptser	Dr.	P. Kitsul
Dr.	F. Grigoriev	Dr.	A. Puhalskii
Dr.	O. Gulinsky	Dr.	A. Serebrovskii
Dr.	V. Kistlerov	Dr.	S. Lototsky

Currently R. Liptser, P. Kitsul, A. Puhalskii and S. Lototsky are working abroad remaining the staff members of Laboratory.

MAIN RESULTS

The main direction of activity in 2002 was stochastic analysis and its applications. The important results in this area have been obtained during last years in laboratory. The series of Puhalskii's publications received recognition as 2002 INFORMS Applied Probability Society Best Publications:

– Polling Systems in Heavy Traffic: A Bessel Process Limit // Mathematics of Operations Research. 1998. V. 23. No. 2. P. 257-304 (with E.G. Coffman, Jr., and M.I. Reiman).

– Polling Systems with Zero Switchover Times: a Heavy-Traffic Averaging Principle. // The Annals of Applied Probability. 1995. V. 5. No. 3. P. 681-719 (with E.G. Coffman, Jr., and M.I. Reiman).

Special attention was given to studying non-standard problems of the large deviation theory.

A. Puhalskii obtained new results on the connection between large deviation principles for trajectories of stochastic processes and the associated invariant measures. The large deviation accumulation point of a sequence of invariant measures is identified as invariant measure of the limit idempotent processes. Application to diffusion and queueing processes are provided.

– Puhalskii A. On large deviation convergence of invariant measures // J. Theoret. Prob. (to appear).

O. Gulinsky proposed an approach to large deviation for asymptotic problems without evident probabilistic representation behind. The motivation of this method is coming from some problems of quantum mechanics. These tools make it possible to handle non-commutative asymptotic problems as one would handle classical large deviations. The approach is applied to an example of non-commutative large deviations which is based on an analysis of mean-field quantum crystal model.

– Gulinsky O. The Principle of the Largest Terms and Quantum Large Deviations // Kybernetika. 2003. V. 38. No. 2 (in print).

R. Liptser and A. Veretennikov studied moderate deviations for smooth processes.

Large deviation results for stochastic differential equations driven by Brownian motions are known. However in some problems of mathematical physics it is more natural to consider equations with smooth random perturbations. A large deviation princi-

ple are established for a family of vector-valued smooth random processes defined by a system of ordinary differential equations with perturbations defined by smooth vector function of vector-valued ergodic diffusion.

− Liptser R., Veretennikov A. Freidlin-Wentzell type moderate deviations for smooth processes // Markov Processes and Related Fields (to appear).

Large deviations for approximations of stochastic differential equation is a new direction of activity.

A. Veretennikov proved the large deviation principle for Euler approximation of SDE.

− Veretennikov A. On large deviations for approximations of SDEs // Probability Theory and Related Fields (to appear).

− Veretennikov A. On large deviations for approximations of SDEs on the torus // Theory of Probability and their Applications – TViP (to appear).

A. Veretennikov continued studying diffusion approximation of Poisson processes.

− Veretennikov A., Pardoux E. On Poisson equation and diffusion approximation 2 // Annals of Probability (to appear).

Some new results are obtained on parameter estimation for ergodic Marcov chains with polynomial growth lost function.

− Veretennikov A., Varakin A. On parameter estimation for polynomial ergodic Markov chains with polynomial growth lost function // Markov Processes and Related Fields. 2002. No. 8(1). P. 127-144.

P. I. Kitsul, R. Sh. Liptser, A.P.Serebrovski studied properties of observable components of a Markov process. Necessary and sufficient conditions of markovianity are obtained.

− Kitsul P.I., Liptser R.Sh., Serebrovski A.P. Markovianity of a subset of components of a Markov process // J. Systems & Control Letters. 2002. V. 46/4. P. 237-242.

Teaching:

− Moscow Institute of Physics and Technology: O.Gulinsky, A.Serebrovskii and F. Grigoriev;

− Universities abroad: A.Veretennikov, R. Liptser, A. Puhalskii, P. Kitsul, S. Lototski.

International collaboration. Fruitful collaboration is established with the probability group of the LATP CMI Universite de Provence, Marseille, France, and, in particular, with Professor Etienne Pardoux as its leader.

We also have close contacts with Universite Paris 6 (Professors Jean Jacod and Pierre Priouret); Universite du Main in France (Professor Yuri Kutoyants); Weierstrass Institute for Applied Analysis and Stochastics – WIAS, Berlin, Germany; the Univerity of Warwick, UK (Professor David Elworthy); Mathematical Institute of the University of Copenhagen; University of Trier (Professor Dieter Baum); University of Wuerzburg (Professor Elart von Collani), and some others.

GRANTS FROM:

LABORATORY 17
Laboratory of Information Transmission Networks
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The leading researchers of the laboratory include:

Dr. Sc. (Techn.)	V. Lazarev	Dr.	N. Bakanova
Dr. Sc. (Techn.)	A. Lyakhov	Dr.	D. Mironov
Dr. Sc. (Techn.)	I. Ovseevich	Dr.	E. Pijl
Dr.	I. Astafjeva	Dr.	V. Vorobiev

DIRECTIONS OF ACTIVITY

Basic directions of the laboratory activity are development of theoretical foundation for analysis and synthesis of distributed information transmission networks, and practical implementation of large-scale projects concerning with distributed computer communication networks.

The theoretical researches are carried in the following directions:

– Development of methods and algorithms for dynamic routing in ATM networks.

– Extension of product-form stochastic network theory in part of methods and algorithms for G-networks study.

– Development of methods for analysis and synthesis of wireless local and distributed information transmission networks controlled by the IEEE 802.11 protocol.

– Development of methods and algorithms for topology synthesis and optimal routing choice in information transmission networks.

– Research and development of wireless networks on the base of infrared and laser modems.

– Development and study of methods based on extended Petri network for analysis of intellectual telecommunication networks.

MAIN RESULTS

In 2002, the Laboratory continued the fundamental researches related to extreme graph theory, queuing networks theory, and reliability theory. Moreover, the field experiments with various physical media (fiber-optical, radio, satellite communications), operational environments and various network architecture were carried on simultaneously.

The Laboratory has obtained the following fundamental results:

– Routing methods and algorithms in packet switching networks have been systematized and studied, in particular, dynamic routing algorithms for ATM networks have been surveyed.

– Models of G-networks with negative requests have been developed to describe adequately computer network operation in the presence of noises and viruses.

– Mathematical models have been developed for analysis and synthesis of topological structure of regional wireless computer networks (specifically, for optimal allocation of base stations and connection of radio subscribers in this class networks).

– Verification model based on extended Petri network has been developed for a protocol of intellectual telecommunication networks.

Theoretical results related to analysis and synthesis of distributed information transmission networks have been adopted as a foundation for practical implementation of large-scale projects concerning with this class of networks. *Results of scientific researches have been implemented with the following projects:*

–Topological development of the cellular radio-modem network Radionet to provide Moscow scientific, cultural and educational institutions with access to Internet.

–Development of an atmospheric optical line prototype adopting infra-red modems and its passing to the Plant of Zverev's name for pilot batch production.

–Development of a typical project for scientific city computer network (using Obninsk scientific city as an example).

–Development of a unified terminal for air and railway ticket reservation on domestic and international trips.

–Development of protocols for interaction of wireless 802.11 networks and cellular GPRS networks, which has provided an opportunity to implement corporate wireless networks in almost any region of Russian Federation and to extend the geography of access to Internet for state and commercial subscribers.

–Development and extension of information transmission networks of Russian Ministry of Transport, Presidium of RAS, and Russian Road Agency.

–Development of automated docflow system for large managerial institutions.

GRANTS FROM:

- **Purpose Programme of RAS:** "Telecommunications and Integration Systems".

- **Ministry of Industry, Science and Technologies of RF (State contract No. 37.053.11.0063):** "Methods for Design of Computer Networks".

- **International Russian-Italian project. Ministry of Industry, Science and Technologies of RF:** "Optimal Design of Mobile Wireless Information Transmission Networks, Using Stochastic Models" ("Wireless Communication Networks" project).

- **NATO Science Programme in the Collaborative Linkage Grant PST.CLG.977405 (program "Partnership with NATO"):** "Wireless access in INTERNET on base technology IEEE 802.11".

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3. Vishnevsky V.M., Lyakhov A.I. Estimation of Maximal TCP/IP Traffic Rate over 802.11 Network with Hidden Stations // Proc. of Int. Seminar "Applied stochastic models and information processes" (Petrozavodsk, September 8-13, 2002). P. 156-158. (See also: Information Processes. 2002. V. 2. No. 2. P. 270-272 (http://www.jip.ru/2002/46.pdf).

4. Vishnevsky V.M., Lyakhov A.I. Maximal Throughput Estimation for a Regional Network exploited for access to Internet // Proc. of 8th Int. Conf. on information networks, systems and technologies ICINSAT-2002 (St.-Petersburg, September 16-19, 2002). P. 34-42.

5. Lyakhov A.I., Matsnev D.N., Lakontsev D.V., Shelihov O.N. Collecting and Analysis of Operation Characteristics of Real-Life Wireless Network Basing on IEEE 802.11 Protocol // Proc. of 8th Int. Conf. on information networks, systems and technologies ICINSAT–2002 (St.-Petersburg, September 16-19, 2002). P. 225-235.

6. Lazarev V.G., Folomeev A.K. Adaptive Control in an ATM network // Proc. of 57th scientific session dedicated to Radio Day. Moscow, 2002. P. 7-9.

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8. Kiseliov E.M., Lazarev V.G. Distribution of digital flows in a transport SDI Network // Proc. of 57th scientific session dedicated to Radio Day. Moscow, 2002. P. 14-16.

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10. Lazarev V.G. Management of Telecommunication Network Services // Proc. of 8th Int. Conf. on information networks, systems and technologies ICINSAT–2002 (St.-Petersburg, September 16-19, 2002). P. 9-10.

11. Vekselman M.I., Lazarev V.G. Intellectual Platform Application in Data Transmission Networks // Proc. of Int. scientific and technical conference "Supercomputers and Multiprocessor Computer Systems MCS-2002" (Taganrog, 2002). P. 91-94.

12. Vishnevsky V.M. Theoretical Foundations for Computer Network Design. Moscow: Technosphera, 2003. 512 p. (to be published).

13. Bocharov P.P., Vishnevsky V.M. G-networks: Extension of Product-Form Network Theory // Automation and Remote Control (to be published).

14. Vishnevsky V.M., Porotsky S.M. Dynamic Routing in ATM Networks: Problems and Solutions // Automation and Remote Control (to be published).

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MAIN RESULTS

Researches were continued for a problem of the state and municipal property management and the following results were achieved:

– analysis and systematisation of valuation activity problems in the global process for investment and property markets, providing mutual professional recognition in dual and multisided business,

– analysis of ways and modes for protection and efficient using the state and municipal property (real estates) in the contemporary conditions of land and property legislation, including mechanisms of property market professionals accreditation, regulations for landlord and tenant interacting, modes for auctions,

– comparative analysis for land rights and tenure in the different conditions of transitional economies and developing markets of Eastern Europe, Russia, Asia and others.

The joint distance teaching laboratory (IPPI – Oxford Brookes University) continued its work. During the period there was elaborated a basis for a business game "Auction". The game simulate multilevel interacting at the system "state (municipal) proprietor – auctioneers – bidders (investors)". The game is intended for teaching every side of the mentioned system to make decisions in different competitive situations and altered states of the market.

GRANTS FROM:

- **DFID** (Department for International Development), UN-HABITAT – participation in the international project run by Geoffrey Payne examining alternative tenures for the urban innovations (with Richard Grover and Dr Paul Munro-Faure).

PUBLICATIONS IN 2002

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2. Соловьев М.М., Айзенцон С.Е, Полянский А.И. Регулирование имущественных отношений и защита государственной собственности // Сб. тезисов Международной конференции «Проблемы управления безопасностью сложных систем», М.: ИПУ РАН, 2002.

3.	Grover R., Munro-Faure P., Soloviev M. Housing tenure change in the transitional economies // Land Rights and Innovation / Edited by G. Payne, ITDG-Publishing, UK, 2002, Part II, Chapter 3. P. 41-56.

4.	Управление государственной собственностью: Учебник / Под ред. д.э.н., проф. В.И. Кошкина. – М.: ЭКМОС, 2002. 664 с. (в составе авторского коллектива).

5.	Гровер Р., Соловьев М. Сравнительный зарубежный опыт регулирования профессиональной оценочной деятельности // Организация и методы оценки предприятия (бизнеса): Учебник / Под ред. В.И. Кошкина. – М.: ИКФ «Экмос», 2002. Глава 18. С. 671-744.

IPPI'S PERIODICALS

The Institute has founded and publishes two academic periodicals: "Problems of Information Transmission" and "Automation and Remote Control" which circulate in Russia and abroad.

Since October 2000 the Institute has founded the electronic scientific journal "Information Processes".

Problems of Information Transmission

Editor-in-Chief: L. A. Bassalygo.
Associate Editor: N. A. Kuznetsov.
Secretary: D. Yu. Nogin.
Editorial Board: A. M. Barg, I. A. Ibragimov, V. D. Kolesnik, R. Sh. Liptser, V. A. Malyshev, I. A. Ovseevich, M. S. Pinsker, V. M. Tikhomirov, B. S. Tsybakov, Yu. N. Tyurin, V. A. Uspenskii, V. A. Zinov'ev, V. V. Zyablov.

"Problems of Information Transmission" is a quarterly journal published in English by Plenum Publishing Corporation (233 Spring St., New York, NY 10013, USA).

"Problems of Information Transmission" contains research and survey articles in the following and related areas:
- Information Theory;
- Coding Theory;
- Methods of Signal Processing;
- Automata Theory;
- Large Systems;
- Information in Living Systems;
- Communication Network Theory.

"Problems of Information Transmission" is abstracted or indexed in Mathematical Reviews, Language and Language Behavior Abstracts, Engineering Index, Computer and Information Systems Abstracts Journal, INSPEC – Electrical and Electronics Abstracts and Electronics Abstracts, Zentralblatt für Mathematik, and Information Science Abstracts.

In April 1936, the first journal in the world devoted especially to the issues in control theory, "**Avtomatika i Telemekhanika,**" come off press. The frequency of publication was six issues per year.

Since 1956 the journal has been a monthly publication and it has been translated into English and published in the United States under the title "**Automation and Remote Control**" by Plenum Publishing Corporation (233 Spring St., New York, NY 10013, USA).

During its existence, the scope of the journal substantially evolved and expanded to reflect virtually all subjects concerned in one way or another with the current science of control.

Now "**Automation and Remote Control**" contains research and survey articles in the following and related areas:

- Deterministic Systems;
- Stochastic Systems;
- Queuing Systems;
- Discrete Systems;
- Adaptive and Robust Systems;
- Evolving Systems;
- Developing Systems;
- Simulation of Behavior and Intellect;
- Control Hardware;
- Computer-Aided Production Control Systems;
- Computers in Control;
- Automation of Design and Programming;
- Control in Biological Systems and Medicine;
- Automata;
- Technical Diagnostics;
- Reliability;
- Computing Techniques in Automatic Control;
- Technical Tools in Control.

Automation and Remote Control is abstracted or indexed in Mathematical Reviews, Chemical Abstracts, Electronics and Communications Abstracts Journals, Current Contents, Engineering Index, Applied Mechanics Reviews, Computer and Information Systems Abstracts Journal, Zentralblatt für Mathematik, and Information Science Abstracts.

Information Processes

The journal "**Informational Processes"** was founded in 2000 as electronic scientific journal.

"Information Processes" contains research and survey articles in the following and related areas:

- Information Theory and methods of Signal Processing;
- Information Transmissions in Computer Networks;
- Control in Data Bases and Knowledge Bases;
- Informational Security;
- Computer Linguistics;
- Informational Technologies in Technical and Social-Economic Systems;
- Programming;
- Analysis and Syntheses of Control Systems;
- Mathematical Models, Computational Methods;
- Informational Interaction.

Electronic address of the Journal – http://www.ijp.ru

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