

SECTOR 1.1

Sector of Computer Logic in Information Processes

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DIRECTIONS OF ACTIVITY:

- Construction of algorithms of reasonable complexity (low degree polynomial) for analysis of regulation on the levels of transcription and translation: search for regulatory signals (protein-DNA and secondary RNA structure) in genomic sequences. Construction of algorithms of reasonable complexity (low degree polynomial) for reconciliation and analysis of protein phylogenetic trees: construction of species trees, estimation of the quality of complexes of orthologous groups of genes and reconstruction of evolutionary events on molecular level (in particular, search of genes involved in the process of horizontal transfer). Analysis of complex interacting systems in a cell on this basis.
- Investigation of the influence of information quality on the accuracy of decision: construction of dependence for the result of complex dynamical interaction of partners, processes, "prayers" (in stochastic dynamical discrete time games) on the structure and the amount of the information available prayers (at each step of a game).
- Development of the concept of information interaction and effective description of objects based on combining the theories: descriptive set theory, model completeness, modal logic, categories of information transformers, algorithmic complexity and randomness.

MAIN RESULTS

Enhancements of algorithms for mass identification of: attenuators, conserved RNA secondary structures, identification of genes subject to horizontal transfer; as for construction of species phylogenetic trees.

Identification of candidate attenuators of branched amino acids, histidine, threonin, tryptophan, phenylalanine operons in diverse taxonomic groups of bacteria.

Description of evolutionary dynamics of regulation by transcriptional attenuation.

New functional assignment, in particular, branched chain amino acid racemase, histidine transporters.

Analysis of evolution of riboswitches. Identification of an activating riboswitch (regulating lysine catabolism).

Analysis of alternative splicing in human and mouse genomes demonstrated that at least 50% of alternatively spliced genes (25% of all genes) have genome-specific isoforms. Alternative splicing tends to shuffle protein domains and to target functional sites in proteins.

Complete metabolic reconstruction of cobalamin, lysine, aromatic amino acids pathways. Reconstruction of the zinc utilization pathway. Identification of new enzymes (lysine and cobalamin pathways), transporters (tryptophan, lysine, zinc, cobalt, cobalamin and its precursors), and zinc-dependent pathogenicity factors (in streptococci).

Model of regulation of tryptophan biosynthesis by transcriptional repression and attenuation.

Identification of regulatory B12-element (a riboswitch) in various bacteria, and new members of the cobalamin regulon: cobalt transporters, cobalamin reductases, methionine synthases, ribonucleotide reductases.

Analysis of the LYS-element riboswitch and the lysine regulon. Identification of new lysine transporters and biosynthetic pathways,

Analysis of regulatory systems of aromatic amino acids pathways in Gram-positive bacteria, identification of binding signals for a new potential transcription factor, new tryptophan transporters. Study of evolutionary dynamics of the regulation demonstrating the presence of at least four regulatory systems: RNA-level (TRAP and T-boxes) and DNA-level (unknown transcription factors).

Investigation optimal strategies (i.e. strategies that form Nash Equilibrium point) for games in stochastic dynamical discrete time systems has been continued. Special attention was given to the influence of the players' knowledge level and to the influence of external (e.g., economic) conditions on the outcome of a game. In particular the cases of incomplete or even, asymmetric information about the system were investigated. It was shown that additional information and favorable external conditions can have a negative impact on the game results. Developed methods are implemented in computer algorithms. The problems of existence and uniqueness of Nash Equilibrium strategies have been studied by means of computer experiments.

The general properties of categories of information transformers (ITs) were investigated as a monoidal category of a special kind. Special attention was paid to the categories of ITs that can be constructed as monoidal Kleisly categories. The key concept in construction of such categories is a functor T that takes an object A to an object TA of "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.

Formalization of a game with incomplete information in terms of categories of information transformers was proposed. The concepts of informativeness and semantical informativeness were extended from the class of information transformers to the class of games. It was shown, that in game theoretic context the correspondence between informativeness and semantical informativeness has much more complicated nature than in the context of information transformers in decision making problems. In particular the use of more informative ITs in a game can lead to the decrease of players' payoffs, i.e., to the lower semantical informativeness.

The completeness problem of extensions of Visser's basic and formal logics is studied. It has been shown that, for some natural definition of the notion "extension" (for example, by the request of closure under the rule modus ponens), all the extensions of Visser's formal (but not basic) logic are of infinite slice, and there exists a continuum of such logics which are of width 2, and are axiomatized by one-variable axioms. These facts contrast with the well-known situation in modal and superintuitionistic logics.

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It has been proved that the problem of finitary semantic consequence (that is, "is it true that the formula ψ is valid in all finite semantical structures from the class C in which the formula φ is valid") is decidable for the class of frames with functional (deterministic) relation of accessibility.

It has been proved that the problem of finitary semantic consequence is undecidable for the class of frames of Visser's formal logic and for the class of generalized frames of Visser's formal logic, moreover these relations are different.

It has been proved for any natural number n , that the set of first-order formulas which are modally definable by formulas of n variables, but are not modally definable by formulas of $n-1$ variables, is undecidable.

It has been proved some modification of Kripke semantics of predicate variant of Visser's basic and formal logics by the introducing of so called "exploded" worlds i.e. worlds in which all formulas are true, including "false".

In the area of descriptive set theory the theorem on perfect subsets of invariant CA -sets was obtained. This theorem generalizes results previously known for a more narrow class of sets. The results for hyperfinite and hypersmooth equivalence relations in the Solovay's model have been proved. The positive solution for the problem of existence of definable nonstandard models has been obtained.

Results on non-robustness of the universal compressing schemes were obtained: non-robustness property was considered under small violations of source ergodicity.

Extreme relations between Kolmogorov complexity and additive loss functions were studied. A new notion of algorithmic random object with respect to a finite partition of the given set of finite objects is introduced.

It is proved that any finite set A of pairs can be divided into $poly(\log |A|)$ parts, so that, all horizontal sections of each part differ from each other at most by $poly(\log |A|)$ times; and the same statement is true for vertical sections (also for any dimension). This statement is used in combinatorial interpretation of inequalities for Shannon entropy.

There were continued investigations in the field, connected with the reduction of arbitrary test for randomness to frequency test. It is proved that for all sufficiently large L and for any set S of $(0/1)$ -sequences of length L with non-null specific defect δ there exists a set R consisting of $poly(1/\delta)$ monotone rules of choice with the following property. For any element from the set S there is a rule from R choosing from this element a subsequence of length at most $cL\delta$ (c is a constant) with deviation of fraction of 1s from $1/2$ not more than square root of $c\delta$. Specific defect of these rules is at most $c\delta^{4/3}$.

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

- 1st Int. Con. "Functional Genomics and Disease, Prague, May 2003.
- Int. Moscow Conference on Computational Molecular Biology MCCMB'03, Moscow, Russia, July 22-25, 2003.
- 4th Int. Georgia Tech. Conf. on Bioinformatics, Atlanta, USA, November 2003
- International Conference: Kolmogorov and modern mathematics, Moscow, June 16-21, 2003.
- Logic Colloquium 2003, Helsinki, Finland, August 14-20.
- Fourth International Conference «Smirnov Lecturings», May 28-30, 2003.
- Dagstuhl centennial Seminar on Kolmogorov Complexity and Applications (at the occasion of the 100th anniversary of Andrei N. Kolmogorov's birthday), Dagstuhl, June 28 – May 2, 2003.
- International Conference «Algorithmic Learning Theory», Sapporo, Japan 2003.

- 11th Annual IEEE Conference on Computational Complexity, Danish, Orhus, July 7-10, 2003.
- Fifth International Conference «Problems of control and modelling in the complex systems», Samara, June 17-22, 2003.

International cooperation: Technische Universitaet Muenchen (Germany), Ludwig Institute of Cancer Research (New York, USA), AstraZeneca (New York, USA), Burnham Institute (San Diego, USA), University of California (San Diego, USA), Harvard Med. School (Boston, USA), Boston University (USA), ICGEB (The International Centre for Genetic Engineering and Biotechnology (Triest, Italy), Institute National De Recherche en Informatique et En Automatique (France), Institute de recherche en informatique de Toulouse, (France), The University of Vuppertal (Germany), CWI (Amsterdam, Netherlands), The Provance University (Marseille, France), The University Paris-7 (France).

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PUBLICATIONS IN 2003

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