LABORATORY 7
Laboratory of Bioelectric Information Processing
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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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8.	Titomir L.I., Mikhnev A.A., Trunov V.G., Aidu E.A.I. NEKTAL-16 lead system for noninvasive display of the cardioelectric field on an imaging sphere // Int. J. Bioelec-tromagn. 2002, v. 4, p. 133-134.

9.	Blinova E.V., Sakhnova T.A., Atkov O.Yu., Trunov V.G., Aidu E.A.I., Titomir L.I. Mapping of repolarization duration in normal subjects by DECARTO technique // Int. J. Bioelectromagn. 2002, v. 4, p. 323-324.

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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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12.   Stefanuk V.L. In Search for Hidden Meaning: Pospelov's Work on Applied Semiotics // Submitted to International Conference on Integration of Knowledge Intensive Multi-Agent Systems (KIMAS'03). 2 p. (submitted).

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).