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
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DIRECTIONS OF ACTIVITY:

• investigating the few-lead electrocardiographic system Frank-M which provides obtaining new electrophysiological characteristics of the heart and increasing diagnostical accuracy without using more complex measuring procedures as compared to the standard electrocardiography;

• working out, modeling, and experimental-clinical approbation of optimal methods for location of pathological electrogenic zones in the heart for topical diagnosis with the use of economic lead systems;

• theoretical and experimental investigation of possibilities to determine the anatomic position of the ventricular myocardium region generating the high-frequency components of the cardioelectric signals, which could be used for prediction of dangerous cardiac arrhythmias;

• developing efficient methods of intelligible-pictorial representation of the cardiac electrophysiological states and functions for noninvasive electrocardiographic measurements in patients with ischemia and infarction;

• theoretical and experimental investigation of a method for pictorial visualization of the atrial characteristics on the basis of dipole electrocardiotopography method (DECARTO) worked out previously only for the heart ventricles;

• using the methodology of scientific analysis applied to the analysis of biomedical information, for investigation of the historical development of social relations (ideological doctrines) and projects of adequate social structures.

MAIN RESULTS

Efficient methods for separation of high-frequency components of the unipolar signals measured by the modified Frank-M lead system are developed. There are realized standard algorithms and worked out new algorithms for filtration, averaging, and parameterization of cardiocycles to detect low-amplitude late potentials of the heart ventricles. The new algorithms take into account the variations of the unipolar signals caused by the breath and hemodynamical changes during prolonged recording of the cardiosignals. These methods are based on an unconventional technique to superpose the curves of spatial-temporal variation of the heart dipole moment vector for consecutive cardiocycles, where there is achieved the most efficient filtration of the noise, which could insert distortions into the measured high-frequency components of the signals. Application of these algorithms to actual electrocardiographic measure-

ments leads to increased accuracy of estimation of the averaged cardiocycle and parameters of the ventricular late potentials.

To improve the method of locating arrhythmogenic zones in the heart, the study of the generalized cardiogenerator model in the form of point generator with spherically symmetric field is continued (the potential of this field is inversely proportional to the squared distance from the generator position). The situation of the arrhythmogenic region center is defined with sufficient accuracy by the position of such fictitious generator, when the potential of its field approximates with minimum error the mean square values of the high-frequency components of the body surface unipolar lead signals. On the basis of this approach, mathematical relations are obtained for determining the coordinates of the arrhythmogenic region center from the measured power of the high-frequency cardiosignal components (late potentials) and coordinates of the measuring electrodes. The method is investigated on the simplified parallelepipedal model of the chest worked out previously and the correction parameters of the basic mathematical relations are obtained. It is shown that with the use of the economic lead-system Frank-M recommended for practical diagnosis, the proposed method can provide location of the arrhythmogenic region center in the ventricular myocardium with an error not exceeding 1 cm.

For futher development of the method of locating the myocardial regions with explicit ischemic changes, which lead to significant shift of the ST segment of electrocardiogram, investigations are carried out on the simplified parallelepipedal model and on a realistic mathematical model taking into account anatomical structure of the heart and chest, as well as the electrophysiological processes in the excitable heart tissue. This study is accomplished in cooperation with the Institute of Normal and Pathological Physiology, Slovak Academy of Sciences, and Institute of Measurement Sciences, Slovak Academy of Sciences.

In the investigations on the realistic model of the heart and chest, it is found that the initial version of the method for determination of the ischemic lesion midplane, which takes into account the distance between the generator and measuring point but does not take into account the impact of the boundedness of the conducting medium, provides insufficient accuracy for some directions of the ischemic heart vector. In this connection, the method was improved with the use of a simplified model of the body as volume conductor in the form of parallelepiped. Thus the accuracy of determination of the ischemic lesion midplane using the economic lead system Frank-M was raised.

A method of recognition and intelligible-pictorial visualization of the atrial enlargement with the use of the Frank-M lead system is developed.

The DECARTO technique, used previously only for the heart ventricles, was supplemented with algorithms for analysis and pictorial visualization of the atrial part of cardiocycle. The proposed method for visualization of the atrial state allows displaying in a map-like form a parameter of the atrial size, thus providing recognition of enlargement of both atria or one atrium and indication of the atrium with changed size. The most reliable diagnosis is achieved with the availability of the atrial late potentials, as soon as in this case the decartographic criteria of the atrial enlargement are applied together with the criteria of location of the electrogenic region for the high-frequency component of the cardioelectric signals.

Now the DECARTO method can serve as a general-purpose means for comprehensive analysis of the orthogonal vectorcardiographic signals, thus providing increased accuracy of diagnosis, as compared to the commonly used electrocardiographic techniques, especially at the dynamical observation of the heart state.

The proposed methods for pictorial representation of the electrocardiographic data significantly increase the efficiency of their interpretation, owing to the combination of quantitative and heuristic approaches.

The results of the investigations were presented at the 31st International Congress on Electrocardiology (Kyoto, Japan, June 27 – July 1, 2004) and the 9th Congress of the Slovak Cardiological Society with International Participation (Bratislava, Slovakia, Oct. 7 – 9, 2004).

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

On the basis of the cognition scheme of model-constructive thinking and concrete definition of scientific rationality introduced on the previous stages of investigation, there is formulated an approach to social sciences (to the ideology in the first place) as to the applied, in the first place technical sciences, but not as to social sciences. Such approach is the most adequate for the life reality. In this approach to thinking and ideology, the most part of which is formulated in the frame of religious and philosophical archaics, a project of social structure is explicitly set off and gnosiological subject, cognizing and constructing the social relations, is introduced.

The results of the investigations were presented in the scientific papers at the 2nd International Conference "Parallel Calculations and Control Problems RASO'2004" (Moscow, Oct. 4 – 6, 2004) and the 4th all-Russia conference ''Building of Humane (Moral) Society" (Moscow, June 1 – 2, 2004).

GRANTS FROM:

PUBLICATIONS IN 2004

Published papers

1. Иванов Г.Г., Трегубов Б.А., Титомир Л.И., Кудашева И.А. Анализ показателей ЭКГ высокого разрешения зубца Р в униполярных прекордиальных отведениях Франка у больных с пароксизмальной формой мерцательной аритмии. *Функциональная диагностика*, 2004, № 3, стр. 33-41.

2. Малиновский Л.Г. Диалектика национальных доктрин и перспективы развития России и человечества. В кн.: *Наука и ее методы накануне XXI столетия.* Под ред. В.И. Метлова. М.: РХТУ, 2004, стр. 213-229.

3. Малиновский Л.Г. Конкурентоспособность и бедность в России и их связь с системной организацией мировой и российской политики и экономики. *Национальная безопасность и геополитика России*, 2004, № 3-4, стр. 106-116.

4. Малиновский Л.Г. Конкретизация научной рациональности – ключевой элемент системной методологии. *2-я Международная конференция «Параллельные вычисления и задачи управления», Москва, 4-6 октября 2004 г., PACO'2004*. М.: ИПУ РАН, 2004, стр. 1228-1243.

5. Малиновский Л.Г. Научная рациональность как идентификация знаний об организации и управлении в обществе. *4-я Всероссийская конференция «Построение человечного (нравственного) общества», Москва, 1-2 июня 2004 г.* М.: МГУ, 2004, стр. 140-143.

6. Deutsch T, Gergely T., Trunov V. A Computer System for Interpreting Blood Qlucose Data. *Computer Methods and Programs in Biomedicine,* 2004, vol. 76, pp. 41-51.

Papers accepted for publication

1. Блинова Е.В., Сахнова Т.А., Ощепкова Е.В., Лазарева Н.В., Айду Э.А.И., Трунов В.Г., Титомир Л.И. Новые подходы к диагностике гипертрофии левого желудочка методом дипольной электрокардиотопографии (ДЭКАРТО). *Функциональная диагностика* (принято в печать).

2. Трунов В.Г., Титомир Л.И., Айду Э.А.И., Сахнова Т.А, Блинова Е.В. Картографическое представление предсердной деполяризации на основе дипольной электрокардиотопографии (ДЭКАРТО) для диагностики увеличения предсердий. *Функциональная диагностика* (принято в печать).

Paper abstracts

1. Blinova E.V., Sakhnova T.A., Sergakova L.M., Trunov V.G., Aidu E.A.I., Titomir L.I. Electrocardiographic assessment of left ventricular hypertrophy in hypertensive patients. *J. Hypertension*, 2004, vol. 22, Suppl. 2, p. S308.

2. Titomir L.I., Trunov V. G., Aidu E.A.I., Sakhnova T.A., Blinova E.V. Pictorial representation of atrial depolarization on the basis of dipole electrocardiotopography (DECARTO) for diagnosis of atrial enlargement. In: *31-th Int. Congr. On Electrocardiology (Abstracts)*, 2004, p. 121.

3. Tysler M., Turzova M., Szathmary V., Aidu E.A.I., Trunov V.G., Titomir L.I. Model substantiation of a method to determine the lesion midplane indicating the position of acute ischemia in the heart ventricles. *Cardiology*, 2004, vol. 13, Suppl., p. 32S.

Artificial Intelligence Group

DIRECTION OF ACTIVITY:

- behavior of locally organized artificial intelligence systems (theory and applications);
- development of intellectual tutoring systems;
- development of semiotic methods of Artificial Intelligence;
- the use of category theory for description of learning and knowledge processing in artificial intelligence;
- development of intellectual methods to struggle with viruses and spam.

MAIN RESULTS

In the area of locally organized systems main results of our AI group are obtained along the following lines:

1. A survey was made of basic approaches to mathematical modeling of large systems which showed the place occupied by the models with local organization among the known versions of models for large-scale systems. The notion of local-organized systems was strictly defined as well as the methods to analyze such systems.

2. The methods have been studied for the case when the subsystems are stochastic or deterministic automata with finite number of possible actions. Besides it was assumed that the inner states of automata may change in discrete time upon the effects caused by activity of other subsystems.

3. The systems were considered with the subsystems having continuous action sets provided that they are interacting in continuous time. The main application for such systems is the problem of stability of Power Control in collectives of mobile radios.

4. It was shown that some fundamental problems of AI, such as establishing good representation for tasks, knowledge and learning, also may be considered as performance of locally-organized systems.

5. Finally a number of new applications were demonstrated using some programming packages based on the local principles.

Category Theory based algebraic approach to describe production systems is being developed in our group for a number of years. This universal language allows to describe various types of production and rules from AI, mathematical logic and adjacent areas.

New results were obtained for so-called production nets, the latter presents a recursive alternative to the production systems used in AI and Expert Systems, where normally productions applied in somewhat sequential manner. Correspondingly, some algorithms of automatic learning in such production systems developed earlier were extended to include the production nets.

In the computer tutoring traditionally it is assumed that the student model is a collection of student's knowledge. However practice proved that this model is not sufficient, that is why we proposed some intellectual student model which takes into account his/her cognitive level.

A scheme of transactions was proposed in our group to provide for a personalized computer tutoring by allowing detailed and dynamic control of personal features of the student. This approach is in a good agreement with the notion of intellectual interface previously developed in our collective. The main difficulty here is the problem of cognitive level determination which we began to study. Special attention was paid to the level of analogy and generalization, or learning by examples. The ability of student to make a generalization is crucial for the level.

Moreover, it was shown that the cognitive level of the tutor also plays an important role and the momentary play between cognitive levels of the tutor and the student is especially important. For this reason the role of multistep transactions built in an analogy with psychological transactions has been deeply studied.

Rather complex interactions were observed in the electronic message systems of Internet for the case of Spam and viruses. It was shown that the filtering technique is not adequate as a means against these harmful phenomena, the latter reducing advantages of WWW considerably. It was shown that the problems reminds very much the problems of Easop language in literature studied by L. Savinitch.

As a result of our research an original approach was proposed in the area of straggling with e-mail spam, which differs drastically from widely spread use of syntactic filters. The approach is based on anticipatory actions and hence it is called the active filtering.

Vice-president of Russian Association for AI (RAAI) and the Fellow of European Coordinating Council for AI (ECCAI) was involved in organization of a number of international and national conferences in 2004:

• 6th Joint Conference on Knowledge Based Software Engineering (JCKBSE2004), Protvino (Russia), August 2004, Conference co-Chairman.

• International conference IEEE "Artificial Intelligence Systems" (AIS'04), Divnomorskoe, 3-10 September, 2004 (Russia), Conference PC member.

• Russian-Ukrainian seminar "Intellectual information analyses", Kiev (Ukraine), May 19-21, 2004, Seminar PC member.

• National conference on AI with international participation (CAI-2004), Tver' (Russia), October 2004, Conference PC member.

Artificial Intelligence Group is involved in the practical education. V.L.Stefanuk is the Professor in Russian University of People Friendship, Moscow, regularily reads lectures, supervises a number of students and supervises two post graduate students. In September 2004 V.L.Stefanuk was invited to read a collection of lectures for the students of Computer Department of Tartu University, Estonia.

GRANTS FROM:

• **Program of Russian Academy of Sciences "Mathematical modeling and intellectual systems" (award No. 10002-251/П-16/097-096/310303-068):** "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.

PUBLICATIONS IN 2004

Books

1. Стефанюк В.Л. Локальная организация интеллектуальных систем. Модели и приложения. М.: Физматлит, 2004. 328 с.

2. Stefanuk V., Kaijiri K. (editors). Knowledge-Based Software Engineering. Proceedings of the Sixth Joint Conference on Knowledge-Based Software Engineering, V. 108 в серии "Frontiers in Artificial Intelligence and Applications", IOS Press, Amsterdam: 2004, 319 p.

Published papers

 1. Жожикашвили А.В., Стефанюк В. Л. Продукционные сети: развитие теории ТК-продукций // Вестник Российского университета дружбы народов; серия "Прикладная и компьютерная математика". 2004. Т. 2. № 1. С. 118-126.

 2. Жожикашвили А.В., Стефанюк В.Л. Сети обобщенных продукций для представления знаний. Труды национальной конференции по искусственному интеллекту (КИИ-04), Т. 1, М.: Физматлит, 2004, С. 63-69

 3. Стефанюк В. Л. Чему нас научили спаммеры? Научная сессия МИФИ-2004. Сборник научных трудов. Т. 3: "Интеллектуальные системы и технологии". Министерство образования Российской Федерации. М: Московский инженерно-физический институт, 2004, С. 33-35.

 4. Стефанюк В.Л. Активный фильтр для вирусов и спама. Материалы семинара V международного научного семинара "Информационные сети, системы и технологии". Материалы семинара. М.: 2004. С. 43-49.

 5. Stefanuk V. Cognnitive Transactions in Individualized Education // Knowledge-Based Software Engineering. Proceedings of the Sixth Joint Conference on Knowledge-Based Software Engineering, V. 108 in the Series "Frontiers in Artificial Intelligence and Applications", IOS Press, Amsterdam: 2004, P. 139-146.

Papers accepted for publication

 1. Стефанюк В. Л. Союз щита и меча в диполиях свободного рынка. – Научная сессия МИФИ-2005. Сборник научных трудов. Т. 3: "Интеллектуальные системы и технологии". Министерство образования Российской федерации. М: Московский инженерно-физический институт.