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 economic 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 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;
- model estimation of accuracy of the method proposed for spatial location of electrogenic zones in the heart, taking into account anthropometrics parameters, and experimental-clinical approbation of an approach to anthropometric correction of the electrocardiographic mapping data;
- developing efficient methods of intelligible-pictorial representation of the cardiac electrophysiological states and functions for noninvasive electrocardiographic measurements in patients with ischemia and infarction;
- comparatively investigating model-structural methods of statistical data analysis on examples of electrocardiographic records;
- working out a criterion of scientific rationality as a basis for methodology of analysis and organization of complicated objects and systems, and means to control them.

MAIN RESULTS

Methods of filtration of unipolar electrocardiographic lead signals are developed for separation of the signal components at a given high-frequency band, which are generated by pathologic electrogenic regions of the myocardium.

A physical-physiological substantiation is given for the processes of occurrence of the bioelectric generators at the focuses of moderate and acute ischemia of the ventricular myocardium. Generalized mathematical models are proposed for the local cardioelectric generator at the ischemic regions of the myocardium with unstable depolarization process which is described by dipole microgenerators with random variation of the dipole moment magnitude and orientation. There is established interrelation between these models and parameters describing the ventricular late potentials used in the methods of high resolution electrocardiography.

For noninvasive determination of localization of the ventricular arrhythmogenic regions, the concept of fictitious point generator is proposed. This generator gives rise to electric field with spherical symmetry, which varies with the distance from the generator similarly to the field of a point dipole. On the basis of such a model, two versions of the method for location of the arrhythmogenic zones are developed, in particular, for the optimal multiple-lead systems NEKTAL-48 and NEKTAL-16 proposed previously and for the economic few-lead system Frank-M. The program-algorithmic units for solving the aforementioned problems of location of the arrhythmogenic regions are tested on verified cases of difficultly diagnosed states with a high probability of cardiac arrhythmia and are included into the whole package of the computer programs for diagnosis of ischemia and infarct. This package provides determination of the stage of development and localization of the ischemic lesion, as well as hypertrophied parts of the heart ventricles.

To substantiate the methods of locating the myocardium regions with more pronounced alterations causing not only generation of the high-frequency late potentials, but also significant replacement of the electrocardiographic ST segment, there was used a modified concept of the cardiogenerator midplane proposed previously. For comparative estimation of the possibilities to locate the acute ischemic lesions with the use of multiple-lead and economic lead systems, studies were carried out on a realistic mathematical model which takes into consideration anatomic structures of the human heart and chest, as well as electrophysiological processes occurring at the excitable myocardium. This model developed in the Institute of Normal and Pathological Physiology, Slovak Academy of Sciences, and the Institute of Measurement Science, Slovak Academy of Science, was used in the framework of agreements on scientific cooperation concluded by the Russian Academy of Sciences and the Slovak Academy of Sciences.

The efficiency of the proposed economic lead system is demonstrated when solving the aforementioned diagnostic problems under complicated conditions of examination of the patients. The experimental-laboratory approbation of the methods proposed is carried out with dynamical observation of myocardial infarction, using intelligible-pictorial representation of the data for increasing the efficiency of empiric-heuristic analysis of the electrocardiographic measurements.

The scientific workers of the Laboratory actively participated in the USA-Russian Technical Seminar "Technologies for Psychological and Physiological Screening" organized by All-Russian Research Institute of Automatics and Los Alamos National Laboratory (USA), Moscow, Nov. 17-20, 2003. At this Seminar, the scientists of IITP RAS presented a paper on new electrocardiographic methods with intelligible-pictorial visualization of the data and described the prospects for application of these methods in estimating psychophysiologocal state of the workers involved in dangerous production, in particular, in atomic industry.

A scientific paper devoted to the problem of electrocardiographic location of the ischemic injuries in the heart, was presented by PhD E. A.-I. Aidu on the XXX International Congress on Electrocardiology, Helsinki, Finland, June 11-14, 2003.

In the framework of a scientific tour of Russian scientists, the scientific lectures "DECARTO Technique in Cardiology" was delivered in several cities of China.

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).

GRANTS FROM:

PUBLICATIONS IN 2003

1. Малиновский Л.Г. Идеология – системная наука об основах управления в обществе. – В кн.: Вторая международная конференция по проблемам управления (Москва, 17-19 июня 2003 г.). Т. 1. М.: ИПУ РАН, 2003. С. 102-103.
2. Малиновский Л.Г. Модельно-конструктивное мышление. М.: Наука, 2003. 656 с.
3. Титомир Л.И., Грачев С.В., Кушкова Н.М., Хасан С.Х. Исследование электрофизиологических свойств миокарда у больных различными формами ИБС с использованием методов ЭКГ ВР и поверхностного картирования при проведении стресс-теста. – В кн.: Электрокардиография высокого разрешения. М.: Триада-Х, 2003. С. 207-224.
4. Титомир Л.И., Трунов В.Г., Айду Э.А.-И. Неинвазивная электрокардиотопография. М.: Наука, 2003, 200 с.
5. Титомир Л.И., Трунов В.Г., Айду Э.А.-И., Сахнова Т.А., Блинова Е.В. Динамическое наблюдение за состоянием сердца при инфаркте миокарда методом дипольной электрокардиотопографии (ДЭКАРТО) // Функциональная диагностика. 2003. № 2. С. 46-51.
6. Титомир Л.И., Хасан С.Х., Бабаахмади С., Кузнецов А.Б. Оценка электрофизиологических свойств миокарда с использованием ЭКГ высокого разрешения и дипольной электрокардиотопографии. – В кн.: Электрокардиография высокого разрешения. М.: Триада-Х, 2003. С. 225-232.
7. Aidu E.A.I., Trunov V.G., Titomir L.I., Capderou A., Vaïda P. Transformation of vectorcardiogram due to gravitation alteration. – In: Measurement 2003. Bratislava: Inst. Meas. Sci. SAS – VEDA, 2003/ P. 169-172.
8. Aidu E.A.I., Trunov V.G., Titomir L.I., Szathmary V., Tysler M. Noninvasive location of acute ischemic lesion in the heart ventricles using a few-lead system: Study on a realistic mathematical model. – In: Measurement 2003. Bratislava: Inst. Meas. Sci. SAS – VEDA, 2003. P. 173-176.
9. Titomir L.I., Trunov V.G., Aidu E.A.I., Sakhnova T.A., Mikhnev A.A. Recognition of myocardial ischemic lesion on the basis of ECG-mapping data // Int. J. Bioelectromagn. 2003. V. 5. No 1. P. 246-247.

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. Finnaly 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.

Last year 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 a crucial for the level.

More 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 philology studied by L. Savinitch.

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 conferences in 2003 :

- 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.
- IJCAI-2003 held in Mexico, 2003, Conference PC member.
- International Conference on Integration of Knowledge Intensive Multi-Agent Systems (KIMAS'03: Modeling, Exploration, and Engineering), 2003, Boston, USA, Plenary Speaker, Session Chairman.

GRANTS FROM:

PUBLICATIONS IN 2003

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. Stefanuk V.L. – In: International Conference on Integration of Knowledge Intensive Multi-Agent Systems (KIMAS'03: Modeling, Exploration, and Engineering). Institute of Electrical and Electronics Engineers. 2003. P. 432-437.
3. Stefanuk V.L. In Search for Hidden Meaning: Pospelov's Work on Applied Semiotics // International Conference on Integration of Knowledge Intensive Multi-Agent Systems (KIMAS'03: Modeling, Exploration, and Engineering). Institute of Electrical and Electronics Engineers. 2003. P. 575-578.
4. 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.
5. Стефанюк В.Л. Локальная организация интеллектуальных систем: Модели и приложения.– М.: Наука. Физматлит, 2004. 349 с. (in print).