100TH ANNIVERSARY OF ACADEMICIAN NIKOLAI MIKHAILOVICH AMOSOV'S BIRTH

In honor of the 100th anniversary of Nikolai Amosov's birth United Nations Educational, Scientific and Cultural Organization (UNESCO) declared 2013 The Year of Amosov in the medical field.

December 3, 2013 a jubilee session of the Academic Council of the International Research and Training Center of Information Technologies and Systems NAS and MES of Ukraine was held. The research team of this Center develops and implements Amosov's ideas in the Biocybernetics Department and other departments with biomedical orientation.

In this issue "Cybernetics and Computer Engineering" presents a series of articles about formation and modern state of researches in biological and medical cybernetics which have been carried out at the International Research and Training Center of Information Technologies and Systems, NAS and MES of Ukraine for fifty years.

V.I. Gritsenko

ACADEMICIAN NIKOLAI AMOSOV IS AN OUTSTANDING SCIENTIST AND SURGEON

Introduction: In the report milestones of the life and scientific activity of an outstanding scientist are presented. Cybernetics, its methods and tools have caused the great interest of Nikolai Mikhailovich. With cybernetics he connected qualitatively new research of biological and medical systems.

Results: In Ukraine, a new scientific field of cybernetics — biological and medical cybernetics arose. In the 60s meetings of Nikolai Mikhailovich AMOSOV with Director of the Institute of Cybernetics Academician Victor Glushkov played a huge role in the development of this scientific direction. The department of biocybernetics that Nikolai Mikhailovich led more than forty years was created at the Institute of Cybernetics.

Nikolai Mikhailovich set forth principles of information processing in complex living systems. This approach allowed to develop robot control systems based on the ideology of the ensemble of stochastic neural networks. Family of specialized layouts autonomous mobile robots (TAIR, MALYSH, MAVR, STAR and other) was created. In his scientific works Academician N.M. Amosov gave a powerful impetus to the development of biological and medical cyberhetics, in which such scientific areas as neural network technology, medical informatics, physiological cybernetics, information technology of motion control, mathematical modeling of biological systems stood out.

Conclution: Modern School of Biological and Medical Cybernetics develops successfully. The problem of intelligent information technology (IIT) occupies the central place of it. Achieved fundamental results allowed the Centre to develop and realize a world-class original intellectual information technologies and high-tech products, instruments, devices with developed intellect. Digital medicine devices FAZAGRAF, TRENAR, DIABET PLUS aimed at early diagnosis of cardiovascular diseases, rehabilitation of patients with movement disorders and diabetes care.

Keywords: Academician N.M. Amosov, cardiac surgery, biological and medical cybernetics, intellectual information technology, digital medicine.

L.M. Kasatkina, A.M. Kasatkin, A.D. Goltsev, D.A. Rachkovskij

THE IMPLEMENTATION OF THE IDEAS OF ACADEMICIAN N.M. AMOSOV IN NEURAL INFORMATION TECHNOLOGIES

Introduction: The hypothesis of Academician Nikolai Mikhailovich Amosov on the mechanisms of information processing by the human brain allowed us to determine the main aspects of the brain work that should be implemented in the models capable of generating intelligent behavior. The specifics of the hypothesis consists in understanding the processes of information processing by the brain as a continuous interaction of multiple hierarchies of data models that map the elements of the external and the internal world of the subject. At the structural level, a plurality of information models form a network of interconnected elements where the characteristics of connections reflect mutual relationship and influence of different information items corresponding to the plurality of imageries and concepts involved in the formation of integrative mental functions implemented by the brain. Computer modeling of the main provisions of the hypothesis allowed us to create two original neural network paradigms — an active semantic network and associative-projective neural network — and to develop a set of non-trivial behavior models, promising applications, and information technologies.

The purpose is to analyze the specificity and demonstrate the possibilities of neural network models and information technologies that address the diverse phenomena of human mental activity.

Results: We provide the description of the structure and functional characteristics of the active semantic network that uses the value characteristics of information in the course of its processing and displays the interaction of conscious and unconscious levels of thinking. The main results of the study of neural network computer models are given showing the psychological aspects of goal-directed behavior, as well as the results of the application of neural network systems to control the movement of autonomous robotic vehicles. The paradigm of associative-projective neural networks is described, as well as the results of applying this paradigm to create a hardware neurocomputer, neural network classifiers, and information technologies. The directions of the development of associative-projective neural networks in the context of the distributed representations is given, and the results of the application of the developed methods for the classification and retrieval of texts, as well as for modeling of analogical reasoning.

Conclusions: The use and development of N.M. Amosov's ideas contribute to higher intelligence level of information technologies, expand the scope and scale of their applications. It is promising to create a basic model of thinking that takes into account the recent results of cognitive psychologists about human thinking and the principles of neural organization of the brain, and allow its natural development through modeling different aspects of thinking.

Keywords: artificial intelligence, information technology, neural network, neural classifier, neurocomputer, robots, distributed representations, analogical reasoning.

V.I. Gritsenko, L.M. Kozak, A.S. Kovalenko, A.A. Pezentsali, N.S. Rogozinskaya, V.G. Ostashko

MEDICAL INFORMATION SYSTEMS AS ELEMENTS OF A GENERAL MEDICAL INFORMATION SPACE

Introduction: In his scientific works academician Nikolai Amosov gave the tasks for the development of biological and medical informatics and cybernetics. The increasing complexity of computer technology, the development of methodological foundations of analysis, modeling and controlling of complex biological systems led to the development of new information technologies as a scientific basis for the

implementation of the achievements of cybernetics and informatics in healthcare practice.

The purpose is to analyze the way of developing and modern scientific results in the field of health system informatization in Ukraine.

Results: The first steps of the development of medical information systems (MIS) are discussed. In line with the objectives set by N. Amosov, analysis of past and current developments to support the process of the health system informatization in Ukraine was done.

The results of the development of theoretical and practical fundamentals of medical informatics were given: the methods of pre-project research of the complex information system, formalization and modeling of different stages of the diagnostic and treatment process, the development of information tools to analyze medical data about the health of the population of Ukraine, principles of the creating and functioning of telemedicine networks and ways for implementation of the medical digital technologies.

Conclusions: The results of the medical and biological cybernetics development showed the correctness of Amosov's theoretical predictions, his scientific insight. The creation of electronic medical records, methods and means of digital medicine, health information standards and, finally, telemedicine technologies have led to the emergence of a general medical information space. The telemedicine technologies give to physician the possibility: to carry out the consultation for patient, being far from him, to analyze the research data that are made in other medical facility, to conduct electronic consultation, to solve large-scale problems by use of GRID systems and "cloud" space.

The application of the principles of evaluation, the proposed indices and information technology for the analysis of medical and demographic status of regions of Ukraine provides science-based information support to the formation of the priorities of the regional health systems policies.

Keywords: medical information systems, information technology, evaluation of population health, telemedicine.

A.B. Kotova, S.I. Kiforenko, V.M. Belov

MATHEMATICAL MODELING IN BIOLOGY AND MEDICINE: THE FORMATION AND DEVELOPMENT

Introduction: The prehistory and development of a biocybernetics are discussed concisely in this article. Attention is focused on the role of mathematical modeling and information technology as means of creating "virtual reality".

The purpose is to consider the theoretical and applied orientation of mathematical modeling as necessary condition for the study and solution of problems in biology and medicine, supplementing traditional methods and allows to acquire new knowledge.

Results: In three chapters of the article there are presented:

— The mathematical modeling as an instrument for theoretical investigation of regularities function of physiological systems.

— The mathematical model as an object for solution practical applications of biologycal problems: diagnosis, prognosis and control.

— The mathematical modeling as a basis of information technology of science investigation.

Conclusions: Evolutionary development of the technological base of research in the biomedical area allowed to cognize on new theoretical and algorithmic levels processes of biomedical orientation and to solve practical problems of medicine.

Keywords: mathematical modeling, information technology, biologycal system, diagnostics, prognosis, control.

M.I. Vovk

BIOINFORMATICS TECHNOLOGY OF MOTOR CONTROL AS AN AREA OF BIOLOGICAL AND MEDICAL CYBERNETICS

Introduction: Motion control of an individual utilising electronic systems as external control circuits is an important area of biological and medical cybernetics. Researches in this direction are determined not only by scientific interest, but also by necessity of new effective methods and means for restoration of motor functions broken by a pathology.

The purpose of this article is to show evolution of synthesis of biotechnical systems for motor control and reveal theoretical and technical grounding of synthesis.

Method: The technology of synthesis of motor control systems is based on programmed electrical muscle stimulation, threshold stimulation and EMG-biofeedback methods.

Results: Theoretical basis, the evolution of synthesis and development prospects of bioinformatics technology of motor control as an area of biological and medical cybernetics were considered. It was shown that the technology is based on biotechnical cybernetics systems which utilise various programmes (models) and methods for motor control. Such systems collect and process electromyographic signals characterising muscle activity of an individual, and then transform them into informative programme signals to impact the muscular system and brain structures with the goal of activating one's body's reserves to restore and correct motor and other functions.

The technology evolution is presented by several classes of the control systems, such as open, (without feedback), adaptive with several loops of feedback, and biologically adequate built on the variety methods, including biofeedback method, and programmes.

Wide spectrum of applications of such systems in clinical practice and for solving special tasks of motor control was demonstrated.

Utilising an example of controlling functions closely related to motor ones, and speech in particular, prospects of this technology development were considered.

Conclusion: Electronic systems for motor control "embedding" in a person's own motion control system play there (in a person's own system) the role of a missing and/or an additional circuit in motion regulation. Such cybernetic approach promotes activation of reserves to restore motor functions (in pathology cases), learn motor skills, as well as recover other functions related to motor ones.

Keywords: motor control, adaptive systems, biologically adequate systems, programmed stimulation, threshold stimulation, EMG-biofeedback, restoration, motor functions.

R.D. Grygoryan, K.G. Lyabakh, P.N. Lissov, I.I. Deriev, T.V. Aksenova

MODELING OF HUMAN ENERGY MEGASYSTEM

Introduction: Under adaptation organism keeps track of cell's energy balance. The maintenance of this balance requires special regulators that will provide inflow of expendable substances into a cell at the required tempo. Necessary servicing arrangements form a functional energy megasystem EMS, in which mitochondria play a fundamental role.

The aim of this article is to formulate the basic concepts of EMS and to outline the problems of its simulation.

Results: Under the lack of ATP in a cell, its autonomous mechanisms (AM) try to increase the rate of ATP synthesis for overcoming the energy lack. If AM cannot do it, cells produce molecular chemicals. Some of these chemicals cause local vasodilatation and angiogenesis. Others intensify lung ventilation, erythropoiesis, as well as increase of blood pressure. These mechanisms represent extracellular organism-scale mechanisms of EMS. All these systems of EMS promote a proliferation/hypertrophy of

mitochondria. So, the fight of AM against energy deficit is accelerated. A mathematical model describing the main intracellular alterations under local hypoxia is proposed.

Conclusions: A new approach to study adaptation of an organism as a physiological multi-scale system is proposed. It is shown that prolonged processes, derived from brain control are provided by cell autonomous adaptation mechanisms. Namely they establish long-term balance between the average rates of production and consumption of ATP molecules. Two necessary conditions of functioning of EMS are identified: a) the existence of negative feedbacks between the cells with the energy deficiency and cell regulators of material supply, b) the existence of certain chemical low molecular weight agents diffusing from the cells with the energy deficiency into the blood.

Keywords: individual adaptation, mitochondria, cell energetics, integrative physiology.

I.I. Yermakova

INFORMATION PLATFORM FOR MULTICOMPARTMENTAL MODELS OF HUMAN TEMPERATURE REGULATION

Introduction: The development of human temperature regulation model was initiated by academician Nikolai Mikhailovich Amosov. Temperature homeostasis is referred to main processes of human organism. As the result of metabolism the heat is produced so that it should be transferred to environment immediately. Body temperature is maintained at the same level due to intensive work of all physiological systems.

The purpose of this article is to show the possibilities of the information platform and the results of its applications.

Method: Class of the multicompartmental dynamic models for heat transfer and temperature regulation describes heat production in human organs and tissues, heat transfer by blood flows, conduction, convection, radiation, evaporation from the skin and upper respiratory ways, afferent and efferent thermoregulatory processes. Models are based on the single compartment. Compartment has a source of energy, the ability to get and transfer heat to neighboring compartments, and to exchange energy with environment. A set of compartments and links between them determine the nature and degree of approximation for human body and physiological processes occurring in it.

Results: Use of information platform for human temperature regulation allowed predicting dynamics of thermo physiological processes impact the environment, adaptation, heat strain, exercise of different intensity and duration, clothing, protective equipment of firefighters and effect of EMF.

Conclusions: The analysis of modeling results allows to identify and evaluate the possible risk factors that threaten human health in definite conditions. Use of the information platform results into assessment of backup human capabilities and prevents the danger of exhaustion.

Preliminary prediction that runs through the platform shows the safe time for human taking into consideration power and duration of exercise, environmental characteristics, properties of clothing and protective equipment.

Keywords: modeling, termal regulation, imizonmental stress.