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SUBIECTE MEDICO-BIOLOGICE, ECOLOGICE ȘI ANTROPOLOGICE ALE SĂNĂTĂȚII CREIERULUI

THE DEVELOPMENT OF THE INTEGRATIVE AND CREATIVE ACTIVITY OF THE HUMAN BRAIN THROUGH THE INVOLVEMENT OF HUMAN RESOURCES IN NEUROTECHNOLOGY AND NEUROENGINEERING

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DEZVOLTAREA ACTIVITĂȚII INTEGRATIVE ȘI CREATIVE A CREIERULUI UMAN PRIN IMPLICAREA RESURSEI UMANE ÎN NEUROTEHNOLOGII ȘI NEUROINGINERIE

O sinteză bazată pe o revizuirea bibliografiei are ca scop o soluție conceptuală la problema îmbunătățirii activităților educaționale și a formării profesionale a resursei umane prin implicarea directă a acesteia în implementarea proiectelor din domeniul neurotehnologiilor. Se propune o integrare mai strânsă a realizărilor din științe ale naturii, medico-biologice și tehnologiile aferente în științele tehnice și inginerie, care, pe lângă importanța sa socio-economică semnificativă, oferă și o motivație puternică pentru activitatea intelectuală și inovatoare.

Introduction

In the 21st Century, amid the ongoing scientific and technological revolution, education and professional training in a broad sense may

become useless. The declining interest in the sciences of the living and non-living world, and the displacement of such professions from the labor market, is a significant social issue, as science education plays an important formative role in shaping future socially active citizens. Moreover, the implementation of various flawed approaches in educational institutions may compromise social security and harm the mental health of both learners and educators.

A strategy of preventive actions aimed at avoiding the adverse consequences of implementing educational programs should be based on the achievements of Neuroscience, Neuroengineering, and Neurotechnologies. Today's schoolchildren and students studying in the fields of Natural Sciences and, in particular, Medical-Biological Sciences are tomorrow's doctors, nurses and paramedics, pharmacists and pharmaceutical chemists, clinical diagnostic laboratory staff, biotechnologists and bioinformaticians, veterinarians, agronomists and agrochemists, ecologists, bioengineers, and food industry technologists. Professionals in the aforementioned fields face pressing socio-economic challenges related to ensuring the sustainable development of public governance and human society, based on the preservation of biodiversity in ecosystems and the systematic development of strategies to maintain a balance between economic growth, environmental protection, and public health preservation. To ensure the sustainable development of any modern society, it is necessary to redirect investments into people – that is, into "Human resources" or "Human capital", which generates the Gross Domestic Product (GDP). As is well known, "Human capital" accounts for two-thirds of "Physical capital". To effectively address such challenges and bring all plans to life, a comprehensive, interdisciplinary team effort is required – one that involves researchers and developers, designers, technologists, and engineers working at the intersection of Natural Sciences, Technology, and Engineering. Conceptually, such teamwork can emulate the integrative activity of the brain's regulatory centers, characterized by the abilities of self-regulation, self-assembly, and self-learning, based on sensory monitoring, associative processing, and the generation of optimal solutions transmitted to effectors.

Updating and modernizing Natural and Medical-Biological Sciences and Technologies through the implementation of Neuroengineering

The evolution of the brain's abilities for learning, creative, and constructive activity can be realized through the updating and modernization of the professional activities of human resources in the fields of Natural and Medical-Biological Sciences and Technologies, based on their integration into Technical Sciences and Engineering. Among the main branches of Engineering, for example, Chemical Engineering is based on the implementation of achievements in Chemical, Physical, and Biological Sciences into the technology of converting raw materials and various chemical compounds into more useful or valuable forms. Notably, Biomolecular Engineering; Materials Engineering, including biomaterials; Molecular Engineering; and Process Engineering (Technological Design) are constituent sub-disciplines of Chemical Engineering. In Civil Engineering, Environmental Engineering is identified as a sub-discipline. The retraining of biologists, technicians, and engineers into bioengineers, neuroengineers, or biotechnologists and neurotechnologists is critically necessary in the 21st Century. At present, the Mathematical and Computer Modeling, as well as engineering simulation of the mechanisms of functioning of living systems – their self-organization, self-assembly, and reproduction – are becoming feasible. For the development of bioinspired technologies, the mechanisms operating in the nervous system are particularly attractive, as they ensure highly accurate perception and monitoring of the environment, processing and storage of all information in memory, generation of the most appropriate decisions, and adequate coordination of movements and behavior as a whole. A new stage of industrial development involves Neuroengineering and the Neurotechnologies for creating neural networks and artificial intelligence (AI). For example, the Human Brain Project (HBP) attracted $1.6 billion and is still under development. In modern engineering models of the brain and various smart systems, the receptive component – responsible for perception and monitoring – is necessarily included as a primary element, along with integrative processing of multimodal ascending influx of sensory information (visual, auditory, tactile, gravitational, proprioceptive, etc.) [1]. Mechanisms of self-or-

ganization, systematization, self-diagnosis, and self-repair are coordinated by these sensory influx and the system responsible for their detailed processing. Modern supercomputers are being built based on the architecture of neural networks of the brain or spinal cord. One such model, SPAUN (Semantic Pointer Architecture Unified Network), is indeed an artificial brain composed of 2.5 million virtual neurons divided into populations that simulate subsystems of the brain. In such a smart system, all subsystems engage in close communication with each other, simulating a real human brain. The engineering model "Blue Brain", developed at the École Polytechnique Fédérale de Lausanne in France, includes 1 million artificial neurons. IBM's SyNAPSE model (Systems of Neuromorphic Adaptive Plastic Scalable Electronics, SyNAPSE) operates based on close communication within neural networks consisting of 1 billion neurons [2].

Motivation for research and development through the effective implementation of advances in Neuroscience and Neurotechnologies into practice

The rapid advancement of electroencephalography (EEG) techniques through a significant increase in its resolution, the robotization of microelectrode implantation onto neuron membranes, and subsequent software-based spectral analysis provides the foundation for creating a Brain-Computer Interface (BCI) [1]. BCI enables neuroengineers to decode EEG and electromyography (EMG) signal streams and use them as a means to initiate and control motor actions. The improvement of the Brain-Computer Interface brings Neurorehabilitation Technology and bionic motorized limb prosthetics to a new level of development. Neuron activity simulation technology has the capability to model cellular structures and the neurotransmitters used, generate nerve impulses, and induce inter-neuronal interactions within neural networks [2, 3, 4]. Such models can be used not only to perform specific tasks but also to gain a deeper understanding of the physiological mechanisms of normal human brain function and the pathophysiology of various nervous disorders. Their application in the educational process can enhance the productivity of cognitive and creative activities. IBM researchers continue to work on creating a cutting-edge computer chip design that will be more powerful and

efficient than anything currently known worldwide for information processing [2]. In our laboratory, for many years we have successfully recorded the bioelectrical activity of neural and muscular formations (electrocorticography, electrohippocampography, electrooculography, and electromyography) in laboratory animals with chronically implanted electrodes. We have unique experience studying unihemispheric slow-wave (non-REM) sleep and REM sleep, evaluating of vigilance, attention concentration, eating and exploratory behaviors in laboratory and wild marine animals. Such methodological approaches open new opportunities for uncovering subtle mechanisms of optimization and improvement in the coordination and integration of sensory and motor functions in living beings in specific extreme habitats.

Thus, the implementation of projects based on involving human resources in knowledge-intensive activities in the fields of Neurotechnologies and Neuroengineering has the potential not only to create a competitive product but also to develop the integrative and creative abilities of the brain in researchers and developers.

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