DOI: 10.32347/2412-9933.2022.50.39-43
UDC 004.5-77-91/007.5:008

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BRAIN-COMPUTER INTERFACING PROSPECTS IN E-SOCIETY

Abstract. *One of the achievements of modern society is the brain-computer interface (BCI) as a way to organize an intelligent environment. Such systems have already been successfully implemented and contribute to integrating people with disabilities into society, overcoming disorders, diagnosis, and monitoring well-being. Studying mental activity in business interaction, training, consumer activity, and entertainment is becoming increasingly popular. The study of the peculiarities of the functioning of human consciousness contributes to the successful integration of brain-computer interfaces into modern technologies of information systems such as invisible computing. The article highlights the latest trends in the development and implementation of neuro-computer interfaces with the principles of the organization of e-society and the problems and prospects that arise in the conditions of its evolution. The analysis was carried out based on the research of real successfully implemented projects, and the experience of participation in conferences was applied. Possible actual implementations are described, and examples have already been implemented. Particular attention is paid to the issue of neuro-computer inequality and its solution, which is one of the main detachable issues that have been updated in recent years. The implementation of neuro-computer interfaces in combination with popular trends and technologies such as post-quantum programming, consciousness uploading, cloud and fog computing, and enter civilization communication are investigated. The nearest electronic society stage (2035-2050) based on Z and α generations will acquire critical skills in mental management of intelligent environments, increasing the efficiency of information systems of any complexity and purpose. The first steps to this point of development that have already been done are the legalization of BCI technology and mass user implementation, which continue to be investigated along with the rapid growth of generation and the performance of new ideas in accordance with the latest opportunities and conditions.*

Keywords: brain-computer interfacing; e-society; connectivity; individual mental image; intellectual environments

Introduction

Brain-computer became more popular and developed their comprehensive improvement for different spheres of human activity in various technological decisions and specialization. Today we have a range of successfully used projects such as assistive and for typical users. The technology field includes consumer, education, business, navigation, fashion, health monitoring, emotion control, etc. Shared experience and the number of equipment realize the opportunity to raise a BCI community at the nearest time. The 2015 BNCI society report showed the significant growth of customer activity in 2011, when in comparison with the previous year, 4 million devices were sold. Also, this report presented an essential and large volume of prognosis for the nearest paths of BCI development as increasing hybrid functional use in 2025 and the rising number of devices for non-medical use by 2035, and increasing BCI society by 2045. The technology overcame a range of problems by 1980-1990, and the main achievement of implementation in 2008-2011 is a trend of wireless devices available for everyday use for mood monitoring, health care, input and administration, business, etc. [1]. Mental commands are accessible for interfacing for any task, and an open software development policy improves the efficiency of the exchange of ideas and practices of its implementation.

The purpose of the article

The comprehensive development of BCI at the intersection of many trends in information technology forces us to evaluate the next steps in technology development and outline the likely directions and solutions for wide implementations. It is also worth noting the new challenges and problems of using such technologies in the predicted conditions. The most significant interest lies in the fascination of the next 20-30 years, and the conditions are influenced by the progress of development technologies and approaches to system design. No less critical factors will be the co-alignment in the labor market of different generations and the difference in the ability to use such tools.

Main material

Brain-computer interfaces have become a standard technology for organizing intelligent environments for user and business activity of modern society. Various methodologies for organizing networks based on neuro-computer systems for many specific tasks today and their successful implementation indicate the beginning of the formation of a BCI society. The tendency to develop mental management skills in complex systems is observed in generations Z and α, which are gradually entering the labor market. The last will have 11% of the workforce in 2030.

One of the most significant achievements of BCI in modern society is the successful suppression of several age-related health disorders (dementia, Alzheimer's disease), disability, schizophrenia, Asperger's syndrome, increased activity syndrome, and attention deficit disorder in children. BCI's achievements in this direction, combined with particular practices, are already improving lives, providing opportunities for millions of people's full functioning and socialization.

New waves and spheres of interest of BCI have applied studies of consciousness (consumerism, elections, neuroesthetics), training (success, pleasure), and health surveillance (fitness, yoga, sleep, well-being). The study of the nature of choice and free will in applying to the testing of applied systems increases the efficiency of business and training strategies. It develops the functionality of social research and methods of organizing network work and enterprises, improving the quality of products.

Most BCI technologies and visions were described in the late XIX to 20ies of the XX century. These researches and thoughts have a form of futuristic analysis connected closely with social evolution prognosis and design. Hanz Berge realized the first successfully used BCI in 1924. Such technology is used for mind imagining through mental activity visualization with brain potential differences dynamics research. Most technologies were used for diagnostics, but from 1930 to 1940, its also used for prosthesis (peripheral neural activity), truth detection, and management of intellectual environments. In 1965 Alvin Lucier performed famous Music for Solo Performer, which began the state-of-the-art stage in BCI evolution. With this event, the notion of neuroesthetics connected successfully developed through neuroesthetics in the reception of films researches. Such experiments were essential in individuality identification research and design through brainwaves and creative mental models.

In 1973 Jaque Vidal formulated a special term and described the features of modern brain-computer interfaces. By 1980 he realized conception for artifact (harmful noise) overcoming, which successfully integrated into BCI illiteracy research at the beginning of 2000 when the number of technologies and areas of implementation arose.

In 1997 brain-computer interfacing was legislated by European Commission as prospective technology and, to this day, saves actuality for most of the agendas in prior technological studies and activities. One of the most famous initiatives in the European Union is the International Map of Brain, successfully realized according to the modern tendencies in the EBRAINS projects [1–7, 15, 17].

The typical brain-computer systems today can be implemented on devices or just sensor systems for electroencephalography (EEG) production and computer or gadget. For networks with several users and different environments, such additional equipment as a router will be used successfully with connection to the Internet for cloud/fog technologies or cooperation through the global network. We can build an interface on essential functions in such a system according to environment regulation conditions. All types of interfaces are based on EEG images of the user and their mental efforts for needed action through imagined algorithms [4, 5]. For quality assurance, we can save and work with databases of samples to train the system's patterns and models (Fig. 1).

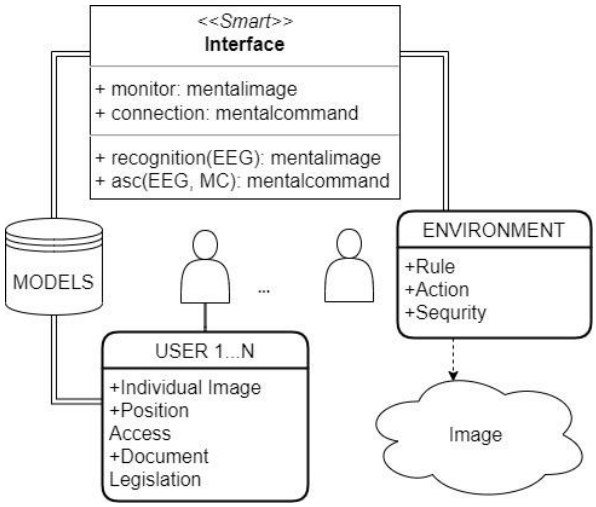

Fig. 1. Basic sample for BCI System

The next generation of BCI will reduce such dependencies as keyboard and cursor mandatory input. In new systems, we will combine different input modes (voice, touch, visual and mental) depending on need and possibilities. Suppose that the standard interface also will change from graphical to complex with mental or virtual mode and use cloud or fog databases. Users will not wander through graphical labyrinths but immediately and exactly find needed information or activate operations with typical mental effort. Developers or administrators will not use consoles or enterprise for their work, but invisible systems with distantly independent access because sensors on their devices like smartphones and

right in clothes or environments will also allow it. Such a path and massive use of this technology will provoke an increasing range of management actions like mental torrents efficiently used simultaneously.

In such interfaces, users can, and there are no differences and dependencies between structural levels of complexity or hierarchy as elements of the system as operation, even for a few such manipulations simultaneously. Also, users will refuse to work with GUI and get a chance to work with mental environments with an exchange of information and request for data to own memory and imagine. Invisible computing, which was successfully widespread last years, is especially suitable for brain-computer interfacing [8].

A user's BCI typically realizes a wireless headset connected with a device or tablet through specialized software. The leaders of such enterprises are Emotiv, g.tec, and Neurosky. Hardware and software solutions for BCI are a prime field of activity for these companies. Neurosky's decision for "mindball" (2008) become very popular. This game's main concept is training mental activity to manage objects in a preset environment. Also, the company was the first successfully presented gaming and office management system. Today there are even Championship and Ligue for mindball. Such skill as the ability to manage any environment through own mental efforts is a significant and influential factor and indicator for the consciousness of e-society. Emotiv has advanced in the study of consumer choice factors based on the study of buyers' mental activity in making decisions on the choice of goods. The company also offers joint participation in the development of BCI with an open-source policy.

Technologies are used in monitoring well-being, well-established sleep, and educational projects (Table 1). In particular, the methods of overcoming attention deficit disorder and excessive activity are worth noting. The most valuable projects are the navigation system for the car with participation in Formula 1 2017 based on its own headset and the creative project of Enoia 2011. The company recently announced it was launching a collaboration with L'Oréal to explore the emotional responses of smell sensation. Emotiv hardware and software are recommended for use in developing the Internet of Things [18]. In 2016 g.tec laboratory presented its research on plane navigation systems with hyper scanning mode [11]. The first modern research concept for brain-to-brain interaction through non-invasive BCI. Also, this year a new Pangolin solution (universal mosaic sensors) was proposed by this company. Neuroestetic technology allows you to fold the shell for your style independently. The company also cooperates with researchers of models of consciousness.

The intractable problem of BCI in modern society should be considered a possible BCI inequality, the essence of which is the presence of individual characteristics of the neurofeedback, which makes it impossible to unify modern EEG standards and mental commands. Having a certain number of people who cannot use mass technology will lead to inequality [7; 10; 15].

Table 1 – ***Leaders of EEG BCI and availability***

Headset	***Techn.***	***Using***	***Available***
Emotiv Unicorn Neurosky	EEG	Consumer Fashion Assisting Entertain. Navigation Immersive IoT	Raspberry GitHub C#/++, Python, Java MS, Mac TensorFlow, RedHat

The solution lies in the field of individual biosensory and bio identification. When the technology of creating systems sensitive to individual mental inquiry is developed, it will be possible to freely create any large spaces of information activity available to each person [11]. This stage of development will coincide with the introduction of post-quantum computing and new intelligent substances such as graphene for supercomputers. Such issues have already been raised in many previous discussions and conferences. The large volume of data and models is a purpose for postquantum programming used in BCI [13; 14]. This question was briefly discussed in BCI Neurotechnology Spring School g.tec 2022 and found the interest of participants.

Table 2 – ***The main paths for the BCI society***

Year	**Technology**
1924	Diagnostical BCI BCI for research Noninvasive BCI
1999	Wireless BCI
1997	Legislation
1996	Comercial using
2017	Navigation models
2019	Fashion
2028	Invisible computing
2035	Map of brain
2045	Consciousness upload
2050	NMRI-BCI paradigm

The expected effect of the introduction of BCI and the transition of society to mental ways of organizing work will be the acceleration and informatization of processes of almost any complexity and level. One of the signs of this development stage will be replacing keyboard input and cursor manipulation with mental identification and input methods, mental spaces, and interfaces [12; 16].

The next stage of the development of BCI-society will be entering civilization communication through the implementation of the technology of new receptive consciousness based on a combination of spectroscopy methods for different types of living matter, and the implementation of its achievements will be implemented in space colonization. The foreseeable prospects are joint nuclear magnet resonance spectroscopy (NMRS) and EEG solutions for entering civilization communication networks and cognitive perception models. Such trends are observed in methodologies and databases obtained during experiments with representatives of various taxonomic groups of living matter. For example, the Xenotext Christian Book project allows live programming to transmit stylized messages. Something like combining BCI with DNA programming and material research.

Conclusion

Neuro-computer interfaces are becoming a standard technology in modern society. Careful regulation of implementation standards and different quality of developer products, availability, and ease of use indicate readiness for widespread implementation.

The use of BNCS in adjustment with the latest immersive technologies (VR, voice input, game learning) expands the possibilities of mastering the skills of neurocomputer management.

– The availability of methods for improving neurocomputer literacy, regulation of this concept, and active research to improve the quality of BCI implementation means a fundamental stage in developing technology in modern intellectual environments and the world of IoT.

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The article was received by the editorial board 15.06.2022

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ПЕРСПЕКТИВИ РОЗВИТКУ НЕЙРОКОМП'ЮТЕРНИХ ІНТЕРФЕЙСІВ У ЕЛЕКТРОННОМУ СУСПІЛЬСТВІ

Анотація. *Одним із досягнень сучасного суспільства є нейрокомп'ютерні інтерфейси (НКІ) як спосіб організації розумного середовища. Такі системи вже успішно впроваджені й успішно сприяють інтеграції людей з обмеженнями до соціуму, подоланню розладів, діагностиці, моніторингу самопочуття. Дедалі більшої популярності набувають практики вивчення ментальної активності у бізнес-взаємодії, навчанні, споживанні. Дослідження особливостей функціонування людської свідомості сприяє успішній інтеграції нейрокомп'ютерних інтерфейсів до сучасних технологій інформаційних систем, таких як невидимий комп'ютинг. У статті висвітлено новітні тенденції розвитку та впровадження нейрокомп'ютерних інтерфейсів відповідно до принципів організації електронного суспільства та проблем і перспектив, які постають в умовах його еволюції. Аналіз здійснено на основі дослідження реальних успішно втілених проєктів, застосовано досвід участі в конференціях. Описано можливі реальні реалізації та наведено вже реалізовані приклади. Окрему увагу присвячено питанню нейрокомп'ютерної нерівності та її вирішенню, що є одним із основних дискутивних питань, актуалізованих у останні роки. Досліджено втілення нейрокмоп'ютерних інтерфейсів у поєднанні з популярними тенденціями та технологіями такими як постквантове програмування, завантаження свідомості, хмарні та туманні обчислення, міжцивілізаційна комунікація. Електронне суспільство, що постане невдовзі (2035–2050) на базі Z та α-поколінь набуде ключових навичок ментального управління розумними середовищами, що підвищить ефективність інформаційних систем будь-якої складності та призначення. Першими кроками до цього вже стали легалізація технології НКІ та масове користувацьке впровадження, що продовжують досліджуватися поряд із нестримним зростанням генерування та втілення нових ідей відповідно до новітніх можливостей та умов.*

Ключові слова: нейрокомп'ютерний інтерфейс; електронне суспільство; індивідуальний ментальний образ; розумні середовища

Link to the publication

APA Mykhalchuk, V. (2022). Brain-computer interfacing prospects in E-society. *Management of Development of Complex Systems*, 50, 39–43, dx.doi.org\10.32347/2412-9933.2022.50.39-43.

ДСТУ Михальчук В. В. Перспективи розвитку нейрокомп'ютерних інтерфейсів у електронному суспільстві. *Управління розвитком складних систем.* Київ, 2022. № 50. С. 39 – 43, dx.doi.org\10.32347/2412-9933.2022.50.39-43.