38. BIO-CYBERNETIC FUSION

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Key directions of bio-cybernetic symbiosis, including neural interfaces, bionic prosthetics, and human-AI integration are presented in this paper. The potential to enhance human life and work along with emerging threats and ethical concerns is analyzed. Particular attention is paid to the need to consider risks for the successful implementation of these technologies in society.

The rapid advancement of cyber-physical systems (CPS) has led to a convergence of biology and technology. Bio-cybernetic fusion refers to the seamless integration of CPS with the human body and mind, fundamentally altering the way people interact with technology. There are key directions of bio-cybernetic symbiosis:

Neural Interfaces. Neural interfaces that blur the lines between mind and machine have extraordinary potential. They are electronic devices placed on the outside or inside of the brain or nervous system to record or stimulate activity – or both. Interfaces placed inside the brain or body are known as internal, invasive or implanted technologies, as opposed to external, non-invasive or wearable devices – often called brain-computer interfaces [1].

The history of brain-computer interfaces (BCIs) starts with Hans Berger's discovery of the brain's electrical activity and the development of electroencephalography (EEG). Berger was the first to record human brain activity utilizing EEG.

Brain-computer technology has widely found its application in medicine The main goal of BCIs is to replace or restore useful function to people disabled by neuromuscular disorders such as amyotrophic lateral sclerosis, cerebral palsy, stroke, or spinal cord injury [2]. BCIs are used in Neuralink — an American neurotechnology company that has developed implantable BCIs, founded by Elon Musk. In September 2023, Neuralink began its first human trials. In 2024, Neuralink successfully implanted the first chip in a person who was already able to control a computer mouse by thought.

Bionic Prosthetics. Bionics is the field of healthcare concerned with mechanically replacing or enhancing the natural function of body parts [3]. The most understandable example of replaced limbs is the arm. A bionic arm works by picking up signals from a user’s muscles. When a user puts on their bionic arm and flexes muscles in their residual limb just below their elbow, special sensors detect tiny naturally generated electric signals, and convert them into intuitive and proportional bionic hand movement. The bionic hand is controlled by tensing the same muscles which are used to open and close a biological hand.

Human and Artificial Intelligence integration. Artificial Intelligence (AI) performs many tasks with greater efficiency and productivity. However, instead of completely replacing people with AI, the implementation of their joint work can bring much greater results. AI is able to process a huge flow of data and perform repetitive algorithms, while a person brings creativity, empathy, understanding to the work, ensures correctness and accuracy. For example, the way in which humans and AI are capable of interacting is language translation and interpretation. AI can provide quick and automated translation of languages. Humans can refine translations, taking cultural nuances and context into account, ensuring accurate communication.

Serious threats and dangers also arise. First of all, most technologies cost a lot of money. This leads to limited access to cybernetic innovations and to the creation of inequalities between technology-enhanced and ordinary people. However, this transformation might displace jobs. Reliability is also a big issue, especially with devices that connect to the human body, such as BCIs. These applications may extract sensitive information from users without their knowledge. The body reacts to an inserted object, in sometimes unexpected ways. Implants break, and sometimes this causes direct damage, sometimes you just slowly lose functionality, and in both cases there's a good chance you'll need to be opened up again to fix the problem. Moreover, the use of cybernetics also raises ethical issues. In the future corporations may require employees to adopt cybernetic enhancements to increase productivity, blurring the lines between man and machine.

Thus, bio-cybernetic collaboration is a promising development opportunity for medicine, psychology, economics, education and everyday life. Thanks to the interaction of man and technology, it is possible to achieve greater efficiency and speed of execution of many tasks. However, in order to maximize the benefits and improve the usability of technology in society, scientists must consider the potential threats.

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