The Neuroergonomic Vision of Project NAFAS

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Synopsis

Project NAFAS represents a four-year, pioneering endeavor to "revolutionize human-computer interaction" by integrating passive brain-computer interfaces (passive BCIs) and artificial intelligence (AI). The German federal agency *Agentur für Innovation in der Cybersicherheit – "Innovation for Cybersecurity"* funded this project at Zander Labs with a record budget of €30 million, to overcome existing barriers in EEG-based neurotechnology by developing mobile, secure hardware capable of decoding and contextualizing multiple mental processes in real time. This will enable unprecedented access to context-associated, multi-dimensional mental states for user adaptation and technological evolution. By narrowing the gap between BCI concepts and their application, and by embedding these concepts in everyday and occupational environments, Project NAFAS enhances the symbiosis between humans and technology, in line with the foundational principles of Neuroergonomics as expounded by Raja Parasuraman.

Background

The pursuit of an optimal synergy between humans and machines dates back to at least the 1960s, when, for example, J. C. R. "Lick" Licklider described a future where technology is seamlessly integrated with human cognitive processes to augment both performance and experience [1]. This vision thus long predates the emergence of BCIs [2] and AI (e.g., [3]), but it is exactly these two technologies that we believe will finally enable its embodiment. By integrating passive BCI [4,5] and AI, we at Zander Labs will create novel forms of neuroadaptive technology [6] to create exactly such "optimal synergy" between humans and autonomous systems in Project NAFAS (*Neuroadaptivity for Autonomous Systems*). The neuroergonomic principle of adapting to the user's cognitive state and environmental context [7] is the perfect guide to integrate all of the relevant technologies—BCI, AI, and HCI—and enable the safe and secure use of context-associated passive BCI-based implicit input to a variety of systems. The goal of all these disciplines combined—and, indeed, of Project NAFAS—is ultimately is to redefine both human-computer interaction and human-AI interaction in a manner that is human-centric, human-compatible and conducive to enhancing human performance and well-being.

Methods

Project NAFAS started in December, 2023, and is centered around the two concepts of Neuroadaptive Human-Computer Interaction and Neuroadaptive Artificial Intelligence, with a number of other developments laying the groundwork for these innovations. Neuroadaptive HCI employs real-time monitoring of brain activity to create interfaces that are more intuitive and personalized, for example to enhance productivity, reduce cognitive load, or increase mental wellbeing. Neuroadaptive AI extends this concept by enabling AI systems to comprehend and adapt to human mental states in real time, fostering empathetic interactions and intelligent, context-aware automation.

For such solutions to be accepted by future users and to perform as planned in real-world environments, for one, they will ultimately have to work with mobile, user-friendly EEG hardware. As such, as one of the prerequisite building blocks, Project NAFAS includes the development of a *Mobile EEG Suite*, an EEG hardware solution emphasizing ease of use, comfort, and privacy. Notably, it will combine both EEG acquisition and its analysis, outputting not raw EEG but rather decoded activity ready for consumption by neuroadaptive technology—without requiring individual calibration. Among other use cases, this Suite can be deployed across various professional settings and will enable users to optimize cognitive engagement and efficiently manage workload. With such information readily available, the planned work towards neuroadaptive HCI and AI is set to transform workplace technologies, making them more intuitive and responsive to human mental states. By capturing the subtle nuances of human mental processing, these technologies can create environments where machines comprehend and adapt to their human counterparts, leading the way for capable yet empathetic AI systems that can truly function as professional "team players" [8].

While specific methodological details cannot be announced at this time, the various research and development efforts of Project NAFAS clearly support existing visions of neuroergonomic workplaces, underscoring the project's commitment to advancing human-centered technology while aligning with broader objectives of enhancing occupational health, productivity, and the overall human-technology partnership.

Results

Among the main results of Project NAFAS will be the above-mentioned Mobile EEG Suite providing a general tool to obtain implicit brain-based information in a user-friendly and safe manner, as well as the two concepts of Neuroadaptive HCI and Neuroadaptive AI, making use of this information in novel ways.

The Mobile EEG Suite in particular will enable the real-time, simultaneous decoding of multiple, contextualised mental processes. This produces an abstract representation of the human mind as it operates within a similarly known environment. The concept of Neuroadaptive HCI and Neuroadaptive AI will make different uses of this information. Neuroadaptive HCI will enable technology to dynamically adjust to the goals and needs of their operators, in an iterative interaction and learning process. Taken beyond the immediate goals of adaptation, this iterative learning process will facilitate a deeper situational understanding and the acquisition of human-like capabilities by autonomous systems, which will be further explored and demonstrated by the concept of Neuroadaptive AI.

Discussion

Parasuraman's first published work stems from the 1970s, the same decade Vidal first demonstrated BCI to the world [2]. Throughout the decades, the principles and ideals of both neuroergonomics and brain-computer interfacing in general have evolved and been further detailed, in preparation for real-world applications, of which many have been envisioned. As of 2024, Project NAFAS represents the largest-ever funding of its kind to realize these principles and ideals, addressing the necessary building blocks and means in general, as well as additional, novel solutions.

We are aware that, as an ambitious research and development project that explicitly aims beyond well-controlled academic settings, the potential impact of the planned results is significant, both within scientific circles and for society at large. We are committed to the development of safe and beneficial technology, to work towards that one vision shared across the fields of BCI, AI, HCI, and

neuroergonomics: a future where interactions with technology are not only more intuitive and even empathetic, but are also deeply aligned with all the nuances of the human mind.

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