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PROJECT NAFAS: ANNOUNCEMENT AND BRIEF OVERVIEW

Laurens R. Krol[1], Thorsten O. Zander[1,2]

[1] Zander Laboratories GmbH, Germany

[2] Brandenburg University of Technology Cottbus–Senftenberg, Germany

E-mail: laurens@zanderlabs.com

ABSTRACT

Funded by the German federal agency *Agentur für Innovation in der Cybersicherheit - "Innovation for Cybersecurity"* (Cyberagentur) with a record €30 million, we announce Zander Labs' Project NAFAS, which aims to integrate Brain-Computer Interface (BCI) technology with Artificial Intelligence (AI). By first addressing the traditional constraints of EEG-based neurotechnology and developing mobile, secure hardware capable of decoding multiple mental states in real time, this project paves the way for a new era of Neuroadaptive Human-Computer Interaction (HCI)—and, ultimately, Neuroadaptive AI. Beyond the project's scientific aims which we briefly introduce, Project NAFAS itself represents confidence in the ability of the scientific community to solve the critical challenge of transitioning BCIs from theoretical constructs to practical real-world applications, and in the positive impact the resulting BCI technology can have in our daily lives.

INTRODUCTION

Already in the 1960s, when initial thought came to paper concerning what was termed man-computer symbiosis, it was said to be "likely that the contributions of [humans] and [computers] will blend together so completely […] that it will be difficult to separate them" [1]. This was more than a decade before Vidal introduced BCI as a unique human-computer communication method [2], and even a few years before Weizenbaum's ELIZA inspired a large movement in AI research to focus on yet a different kind of "blend" [3]. In many ways it has been this idea of blending, or merging, human cognitive processes with digital computation in various forms that has guided HCI, BCI and AI advancements ever since. Project NAFAS (*Neuroadaptivity for Autonomous Systems*) sees itself in this same tradition, and targets these same technologies. By further developing passive BCI [4] technology, we enable HCI and AI to become neuroadaptive [5], and introduce a more intuitive, more natural, and indeed, more symbiotic form of human-computer or human-AI interaction.

Project NAFAS is Zander Labs' winning proposal to a tender published by the Cyberagentur in 2022. The project will be executed together with a number of subcontractors, which we cannot yet exhaustively list at the time of submission. With its states goal "to harness key technologies and breakthrough innovations that help to enable and improve internal and external security" ([6], translation from German by the authors), the Cyberagentur called for "secure neural human-machine interaction" to be developed, with which they thus identified (passive) BCI as a key technology of strategic interest. With € 30 million, to the best of our knowledge, this is the largest single-entity funding ever granted within the European Union. The tender in general, and Project NAFAS' win in particular, highlights the importance of passive BCI and its related fields, and underscores their public recognition as such. We are happy to announce this project to the community and are looking forward to sharing our results.

OBJECTIVES

In an era where technology increasingly mediates our interactions with the world and with other human beings, the importance of intuitive and natural forms of human-computer communication has never been more acute. Current BCI and AI technologies, while groundbreaking, often remain confined within the realms of academia and specialized applications, largely detached from the daily experiences of the broader public.

Project NAFAS is a four-year effort that was formulated to address these and other current limitations of neurotechnology in general and (passive) BCI in particular. Project NAFAS will develop safe, practical neurotechnology that allows a new generation of technologies to adapt in real-time to the cognitive and emotional states of users. We believe such a development will make digital interaction, be it with AI or more traditional HCI applications, more fluid, instinctive, and human-centered—or, will even remove the explicit need to 'act' altogether.

The safety and practicality of the technology are all elements that are explicitly addressed in this project, starting with new hardware that will be developed. Also the "new generation of technologies" is addressed, by developing Neuroadaptive HCI as a core technology, Neuroadaptive AI as an AI-focused extension, and a series of demonstrators to showcase all of these results.

Safe and Practical: The Mobile EEG Suite

Central to Project NAFAS is the development of a *Mobile EEG Suite*, which combines mobile, self-applicable electrodes and amplifiers with dedicated BCI

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hardware.

The electrodes will be designed with a focus on ease of use and comfort, such that they can be applied by individuals without technical expertise, making the technology accessible to a broad audience. We recognize self-applicability and comfort as a requirement to reduce the current barriers to BCI adoption, and to enable widespread use across various environments. We do not limit ourselves to specific use cases, but rather target usability in the widest possible range, be it personal computing environments, outdoor settings, or sophisticated research laboratories.

Complementing the electrodes, the project will develop lightweight, miniaturized amplifiers that further increase the system's mobility and practicality. These amplifiers will be designed to be compact and efficient, with extended battery life suitable for prolonged use. Together with the electrodes, this will enable the continuous and comfortable monitoring of brain activity in everyday settings.

The monitored brain activity will also be decoded in hardware. A core target of Project NAFAS is to develop *universal classifiers*, allowing for the real-time interpretation of brain activity across different individuals without the need for dedicated calibration sessions. This addresses one of the most significant challenges in BCI technology today. A large-scale data collection project will be set up to provide the basis of these classifiers.

When EEG hardware can be worn anywhere, and calibration is no longer necessary, a person's naturally-occurring brain activity can be recorded and decoded at any time. To address the clear privacy issues arising from such a technology, the universal classifiers will be implemented directly in hardware. This hardware will give the user maximum authority over their data: they will have full, physical control over the decoding process, while the hardware ensures that no unauthorized brain activity can leak out. This follows, among other guidelines, the privacy- and (cyber)security-preserving BCI framework that was previously funded by the Cyberagentur [7].

In short, Project NAFAS will address a number of fundamental issues of present-day neurotechnology by providing mobile, comfortable, and safe hardware capable of decoding brain activity in real time without explicit calibration periods. This will serve as the basis for further developments within the project; specifically: Neuroadaptive HCI and Neuroadaptive AI.

Neuroadaptive Human-Computer Interaction: Passive BCI in the Wild

On the basis of the above neurotechnological hard- and software solutions, universal passive BCI classifiers can be made available in almost any and all HCI context, enabling *Neuroadaptive HCI*. A Neuroadaptive HCI software framework, which will be developed in this project, will enable systems to implicitly obtain, use, and even learn to anticipate, a person's needs and preferences, and to adjust their functionality accordingly. Neuroadaptive HCI will thus allow for unprecedented personalization of existing HCI systems, and for the development of novel systems following neuroadaptive principles. For instance, educational software could modify its approach based on the learner's current mental state, enhancing both engagement and comprehension. By also integrating context assessment, the Neuroadaptive HCI framework will help ensure that interactions are not just personalized but also relevant to the user's immediate environment and situation.

The Neuroadaptive HCI framework will provide a core technology to make future interactive applications more intuitive, more natural, and more human-centric on the basis of brain activity.

Neuroadaptive Artificial Intelligence: Empowering AI with Human-Like Understanding

One of the main innovations of Project NAFAS will be to use all of the above technologies to ultimately expand the capabilities of AI. Project NAFAS' above-mentioned results will enable us to provide AI with real-time insights into human cognitive and emotional intricacies. We believe that this combination can cultivate AI systems that are not only more human-like, but ultimately even empathetic, capable of engaging in interactions that resonate on a human level.

With access to the kinds of subjective human nuances that are not present in any amount of raw data, but can only be obtained directly from implicit mental states, these neuroadaptive AI entities can adjust their responses and actions in real time, effectively anticipating user needs and preferences. Furthermore, we believe that these kinds of insights into the inner workings of human cognition, mental strategies, and decision making, can be used to teach future AIs uniquely human skills that are currently beyond their reach.

The concept of Neuroadaptive AI, then, represents a type of technology that is both uniquely human itself, and genuinely tuned to human idiosyncrasies, bridging the gap between cold computational processes and the dynamic spectrum of human emotion and cognition.

CONCLUSION

The aims of Project NAFAS are bold: to stride toward the seamless integration of technology with the essence of human experience. But what the project represents, beyond the data, results, developments, and solutions that it targets, may be even bolder: it's a call to action for the global BCI, HCI, and AI research communities to envision and create a future where technology doesn't just serve us—it understands us, adapts to us, and becomes an empathetic extension of our own, human intellect. We see this as our collective chance to not only advance our scientific and technological frontiers, but to also make a profound impact on how we interact with the digital world.

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