 DOI: 10.3217/978-3-85125-467-9-151

M3BA: New Technology for Mobile Hybrid BCIs

Alexander von Lühmann[1*], Klaus-Robert Müller[1,2]

[1]*Machine Learning Department, Computer Science, Berlin Institute of Technology, Berlin, Germany*

[2]*Department of Brain and Cognitive Engineering, Korea University, Seoul, Korea*

*Marchstr. 23, 10587 Berlin, Germany. E-mail: vonluehmann@bimos.tu-berlin.de

Introduction: Over the last decade, the range of Brain-Computer Interface applications has substantially been enlarged by combining BCI with other physiological or technical signals [1]. Also, comparatively new technologies like functional Near-Infrared Spectroscopy (fNIRS) joined the modality set used for multi-modal BCI or for the enhancement of EEG based BCI [2]. To contribute to the progress in this new generation of hybrid approaches, we designed modular hardware specialized for new approaches of hybrid BCI in and outside the lab.

Material, Methods and Results: Based on our previous work on modular mobile open source fNIRS technology [3], we designed a highly miniaturized next-generation device for Mobile (Bluetooth) Modular Multimodal Biosignal Acquisition (M³BA = "MEBA"). The M3BAs are fully stand-alone battery powered modules, each providing 4-6 EEG/EMG/ECG channels (@500Hz/24Bit), 4-6 fNIRS channels (@16,66Hz/24Bit, 750/850nm LED) and a 3-axis accelerometer. In a novel approach, the Texas Instruments ADS1299 integrated EEG circuit with its outstanding electrical characteristics (e.g. 1µVpp input noise) was used for combined EEG- and NIRS acquisition hardware design. Figure 1 depicts a M3BA module and raw EEG, ECG, fNIRS and accelerometer data simultaneously recorded with one device in a session including open/closed eyes (alpha) and deep breathing.

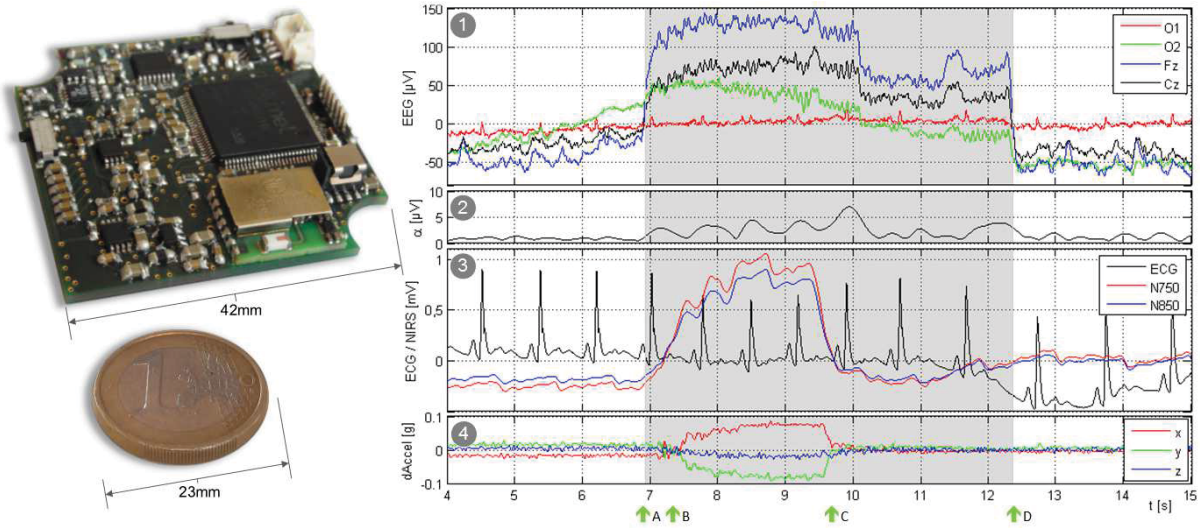

Figure 1. *M3BA Device (left) and multiple signal modalities [(1): EEG, (3): ECG and NIRS, (4): Acceleration] acquired during simple relaxation (white) and trial (grey) period. Distinctive points in trial: close eyes (A), deep breath in (B), breath out (C), open eyes (D). Signals (1,3,4) are raw signals without any filtering/ pre-/post processing except mean offset removals. (2) shows the average envelope of bandpass filtered (4th o. butterw., 10-13Hz) EEG channels O2, Fz, Cz for mean alpha visualization.*

The raw data in the figure exemplifies some advantages of using multiple modalities for further signal analysis, as several obvious interrelations are easily observable: ECG artifacts in EEG (esp. O1, an electrode with bad skin contact), ECG and pulse wave artifacts in the optical NIRS signal, EOG induced EEG voltage offsets and optical artifacts /slow NIRS signals during breathing (movement/accelerometer signal), amongst others.

Discussion: M3BA is a new customizable research tool designed for the use in multimodal mobile BCI in and outside the lab and is aimed to facilitate a better identification and use of common and complementary information in multiple (bio-)signals. By this, we hope to improve the robustness against non-stationarities and artifacts in our signal analysis and machine learning based BCI approaches. Currently, in collaboration with the Physikalisch-Technische Bundesanstalt Berlin, the EEG- and NIRS hardware characteristics of the device are extensively evaluated and first BCI studies are on the way.

Significance: The use of multiple modalities measured by miniaturized mobile hardware could contribute to bringing (hybrid) BCI technology further out of the lab and into real-world scenarios – clinical or non-clinical, where potential users can benefit from it the most.

References

[1] Müller-Putz G, et al. „Towards Noninvasive Hybrid Brain-Computer Interfaces: Framework, Practice, Clinical Application, and Beyond." *Proceedings of the IEEE*, vol.103, no.6, pp.926-943, 2015

[2] Fazli S, et al. "Enhanced performance by a hybrid nirs-eeg brain computer interface" *NeuroImage*, vol.59, no.1, pp.519-529, 2012

[3] Von Lühmann A, et al. "Towards a wireless open source instrument: functional Near-Infrared Spectroscopy in mobile neuroergonomics and BCI applications." *Frontiers in Human Neuroscience*, vol. 9, no. 617, 2015