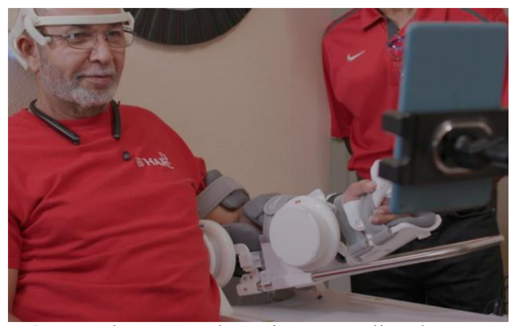
DOI: 10.3217/978-3-85125-962-9-208

NeuroExo: A Low cost Non Invasive Brain Computer Interface for upper-limb stroke neurorehabilitation at home

Jose Gonzalez-Espana*, Alexander Craik, Ayman Alamir, Jeff Feng, and Jose L Contreras-Vidal
Departments of Electrical and Computer, and Biomedical Engineering, Department of Industrial Design, University of Houston, Houston, USA
jgonzalezespana@uh.edu

Introduction: The use of scalp electroencephalography (EEG) signals for brain-computer interface (BCI) to control end effectors in real time, while providing mobile capabilities for use at home neurorehabilitation, requires of software and hardware robust solutions. Moreover, to ensure democratized access to these systems, low cost, interoperability, and ease of use are essential. These challenges were addressed in the design, development and validation of the NeuroExo BCI System. As a proof of concept, the system was tested with an exoskeleton system for upper-limb stroke rehabilitation as the end effector.

Material, Methods and Results:



- Headset Design and Development**:** a one size-fits-most five dry comb electrodes EEG headset was developed based on the initial pilot study of [1, 2], where a BCI-exoskeleton system for upper-limb stroke rehabilitation was demonstrated in stroke survivors.

- BCI Design**:** BeagleBone Black – Wireless (BBB) was selected as the processing unit, while ADS1299 and ICM-20948 were the amplification-filtering-ADC and IMU (3-axis accelerometer and gyroscope) devices, respectively. LabVIEW (National Instruments Inc.) was chosen as the primary coding language.

- At-home validation of the BCI system in individuals with chronic stroke**:** In closed loop BCI operation, a WiFi-enabled robotic arm for upper-limb rehabilitation was used as the end effector. In this test, the system interacts with the participant in real time using a user-specific trained machine learning model for intent detection. The system will be demonstrated at this BCI meeting.

Discussion: The development of the proposed system went through a concurrent evolving of its parts to achieve interoperability, usability, and reliability. Similar endeavors would need to have this in mind to avoid expensive redesigning in late stages of the project.

Significance: This system fosters the democratization of BCI systems for applications beyond clinical rehabilitation including, but are not limited to, robust BMI control, IoT, video games, more engaging learning environments, and attention tracking to name a few application domains.

Acknowledgements: This work was supported in part by NSF PFI Award # 1827769.

References.

[1] Craik, A., Kilicarslan A., and Contreras-Vidal J.L. "A translational roadmap for a brain-machine-interface (BMI) system for rehabilitation." 2019 IEEE International SMC. IEEE, 2019.

[2] Nikunj A. Bhagat, Nuray Yozbatiran, Jennifer L. Sullivan, Ruta Paranjape, Colin Losey, Zachary Hernandez, Zafer Keser, Robert Grossman, Gerard E. Francisco, Marcia K. O'Malley, Jose L. Contreras-Vidal, "Neural activity modulations and motor recovery following brain-exoskeleton interface mediated stroke rehabilitation", NeuroImage: Clinical, Volume 28, 2020,