 DOI: 10.3217/978-3-85125-962-9-45

Validation of an Automated EEG Artifact Removal Tool for Eye Movement and Muscle Artifacts

D. Comaduran Marquez[1*], B. Irvine[1,2], A. Kirton[1], E. Kinney-Lang[1]
[1]Cumming School of Medicine, [2]Schulich School of Engineering, University of Calgary. Calgary, AB. Canada.
*Alberta Children's Hospital, 28 Oki Dr NW, Calgary, Canada. e-mail: dcomadur@ucalgary.ca

Introduction: Automated artifact removal is a crucial step for brain-computer interface (BCI) systems. Maddirala & Veluvolu have developed an automated method to eliminate eye-blink artifacts for single-channel applications [1]. The purpose of this work is to extend this method to (a) be suitable for multichannel applications; and (b) test its performance in removing eye movements and muscle artifacts by computing its EEG quality index (EQI) [2].

Materials, Methods and Results: The multichannel artifact removal tool was implemented in Python 3.9.12 and has been made publicly available [3]. Resting-state EEG, eye movement, and muscle artifacts were extracted from the Temple University Hospital EEG Artifact Corpus (v2.0) dataset [4]. EEG traces were filtered with a 4th order band-pass digital Butterworth filter (f_c = 1 and 30 Hz). The filtered traces were then processed with the artifact removal tool (i.e., artifact-free data). The EQI was compared between the artifact-free and filtered traces. Filtered resting-state traces were considered as the reference for the EQI. Statistical analysis of the EQI was performed between the artifact-free and filtered traces by means of a paired one-tailed t-tests.

The artifact removal tool reduces eye movement and muscle artifacts in the EEG compared to just filtering (Fig. 1.A). EQI shows an increase (i.e., cleaner data) in most metrics, except zero crossing rate (ZRC) and kurtosis; the increase is more prominent in frontal channels (Fig. 1.B). Statistical analysis shows a significant increase in EQI ($p < 0.05$) for Fp1, Fp2, and T1 for eye movements, and Fp1, Fp2, F3, F4, P4, O1, T1 for muscle artifacts, respectively.

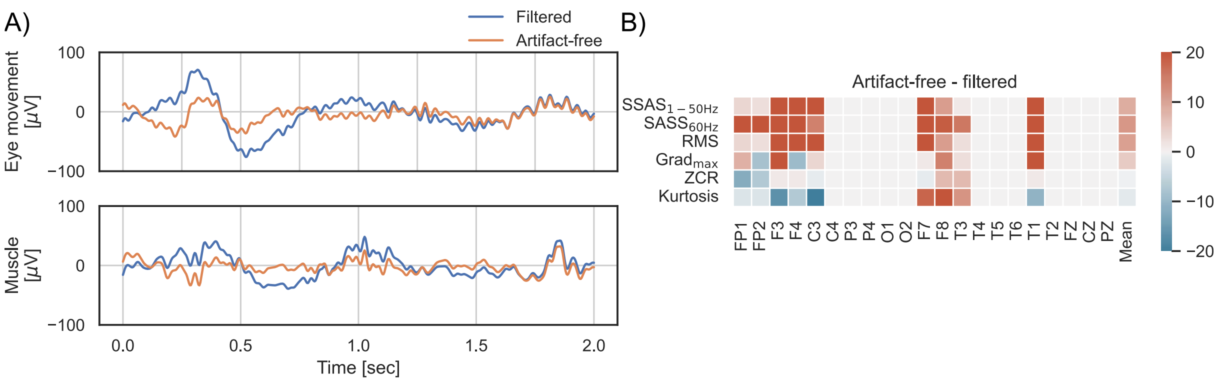

Fig. 1. A) Representative EEG traces showing eye movement (top) and muscle (bottom) artifacts. The filtered (blue) as well as the artifact-free (orange) traces are shown for channel Fp1. B) Representative EEG quality index heatmap showing the increase in quality comparing artifact-free vs filtered data for an eye movement artifact (higher is better).

Discussion: The artifact removal tool reduces eye movement and muscle artifacts but also affects some EQI metrics (e.g., ZRC and kurtosis). Further analysis should evaluate performance of machine learning classification and use of computational resources to test the suitability of the tool for online applications.

Significance: The updated automatic artifact removal tool presented is a viable solution for reducing eye movement and muscle artifacts.

Acknowledgments: We would like to thank ACHRI and NSERC CREATE for the funding of this work.

References

[1] A. K. Maddirala and K. C. Veluvolu, "Eye-blink artifact removal from single channel EEG with k-means and SSA," *Sci Rep*, vol. 11, no. 1, Art. no. 1, May 2021, doi: 10.1038/s41598-021-90437-7.
[2] S. D. Fickling, C. C. Liu, R. C. N. D'Arcy, S. Ghosh Hajra, and X. Song, "Good data? The EEG Quality Index for Automated Assessment of Signal Quality," in *2019 IEEE 10th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON)*, Oct. 2019, pp. 0219–0229. doi: 10.1109/IEMCON.2019.8936246.
[3] D. Comaduran Marquez, B. Irvine, and E. Kinney-Lang, "EEG Artifact Removal Tool." [Online]. Available: https://github.com/danielcomaduran/eeg-artifact-removal-tool
[4] A. Hamid *et al.*, "The Temple University Artifact Corpus: An Annotated Corpus of EEG Artifacts," in *2020 IEEE Signal Processing in Medicine and Biology Symposium (SPMB)*, Dec. 2020, pp. 1–4. doi: 10.1109/SPMB50085.2020.9353647.