 DOI: 10.3217/978-3-99161-050-2-223

ezmsg: An Enhanced Open-Source Framework for High-Performance Brain-Computer Interface Development

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We present significant updates to *ezmsg* ("easy message") – a high-performance execution engine and multiprocessing backend implemented in pure Python – to enhance its capability as a robust, flexible software framework for real-time signal processing in BCI development. Originally created at Johns Hopkins' Applied Physics Lab, and introduced publicly at Society for Neuroscience 2024 [1], *ezmsg* has been successfully deployed in multiple clinical BCI studies [2, 3], and in ongoing efforts at Blackrock Neurotech and the Wyss Center's INTRECOM and W-ICONS studies utilizing ABILITY implant technology.

This work introduces major enhancements to the *ezmsg* ecosystem that expand its utility for BCI research and development. Core improvements include state persistence and rehydration in *ezmsg-sigproc*, enabling module reuse on scalable cloud platforms. New modules provide essential functionality: *ezmsg-tools* for graph introspection and profiling, *ezmsg-learn* for machine learning inference and online adaptation, and *ezmsg-event* for processing sparse neural events such as action potentials and physiological signals. All components are available as open-source software under permissive licensing [4].

To demonstrate real-world performance, we implemented a representative BCI pipeline that processes 256-channel ECoG data for speech decoding, approximating the methodology described in Metzger et al., 2023 [5]. This implementation achieves processing latencies of 2.75 ms per data chunk on consumer hardware, extracting both high-gamma and low-frequency features and performing phoneme classification via PyTorch.

ezmsg's combination of flexibility, modularity, and performance makes it well-suited for both rapid prototyping of online BCI systems and offline analysis for medical device validation. With continued industrial support, we are committed to expanding the *ezmsg*'s capabilities and optimizing its performance for the evolving needs of the BCI community.

References:

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 Published by Verlag der Technischen Universität Graz