

MNE-RT: A Unified Python Framework for Real-Time M/EEG Signal Processing

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Building a closed-loop neurofeedback system that is both scientifically rigorous and practically robust turns out to be a much harder engineering problem than it first appears. Beyond simply acquiring brain signals and presenting feedback, a complete pipeline must handle streaming data acquisition across diverse hardware, online artifact rejection without accumulating latency, neural feature computation fast enough to close the loop within the needs of in-time neuromodulation, adaptive normalization of raw features into meaningful derivative signals, flexible feedback delivery, and reliable session logging for downstream analysis. Most research groups address this piecemeal, stitching together tools from different ecosystems with fragile in-house scripts that rarely survive a hardware change or a move to a new site.

Existing dedicated platforms each cover part of this landscape but leave gaps. BCI2000 [1] offers mature, high-throughput infrastructure and broad hardware support, yet it may simply be quite outdated and its sensor-space focus and limited Python integration make it difficult to implement source-resolved or connectivity-based protocols. OpenViBE [2] provides accessible graphical prototyping but lacks real-time inverse modeling. MNE-Python [3] is the community standard for offline M/EEG analysis and now supports streaming via MNE-LSL [4], but it does not (yet) provide an integrative suite for general real-time purposes in M/EEG. Timeflux [5] is a lightweight and extensible Python streaming framework but offers no source modeling or artifact rejection depth.

MNE-RT ([link](#)) fills this gap by building the full real-time processing and neurofeedback loop directly on top of MNE-Python's offline analysis infrastructure, extending it to the streaming domain without reimplementing a single existing algorithm. Every inverse operator, connectivity estimator, and spectral method already validated by the offline neuroscience community is immediately available in real time. The package provides twenty neural feature modalities spanning sensor space, source space, and the graph domain; five online artifact correction strategies; ten adaptive reward protocol classes; a multi-modality feature composition module; nine synchronized visualization windows for both continuous monitoring and epoch-triggered analysis; and OSC and LSL feedback output — all through a single, coherent class-based API.

References

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