Semi real-time processing and post-hoc quality control of high-density neural recordings

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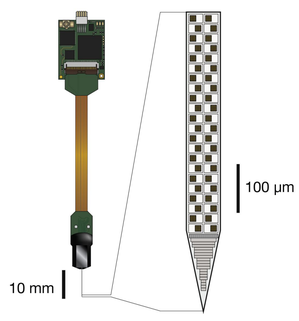
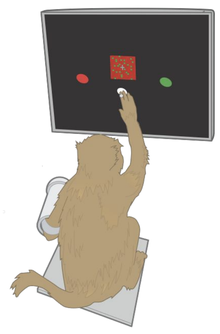
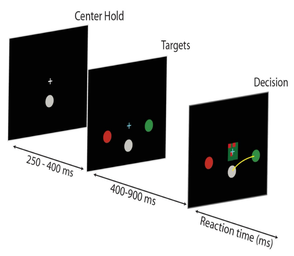
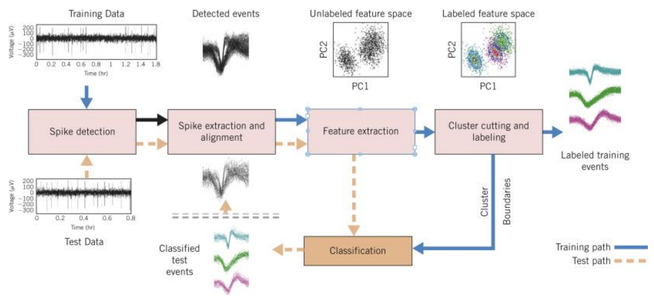
Introduction





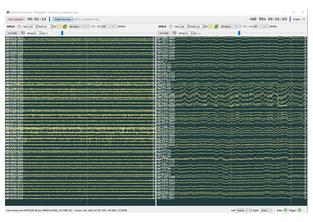


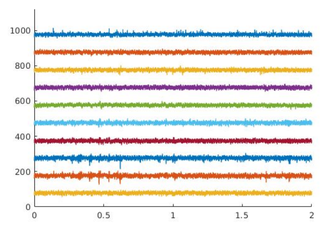


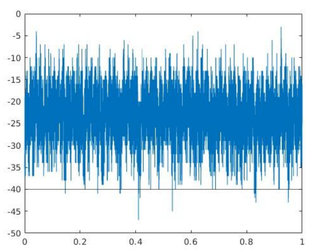
- Processing of neural data is primarily done post-hoc, limiting the ability to interact with the data in real-time or to refine the experimental approach and improve the quality of the collected data.
  - ➢ To address this limitation, we began building a toolbox for semi-real-time high-density electrode data capturing, processing, and analysis to improve the efficacy of electrophysiological experiments.
- While this live analysis has the potential to provide valuable initial insight, further analysis is required to understand the inherent function and location of observed neuronal units.
  - ➢ To address this limitation, we worked towards improving the isolation of 'single-units', action potentials that can confidently be attributed solely to one neuron, through the application of spike quality metrics on spike-sorted data.

Live Implementation

Method:

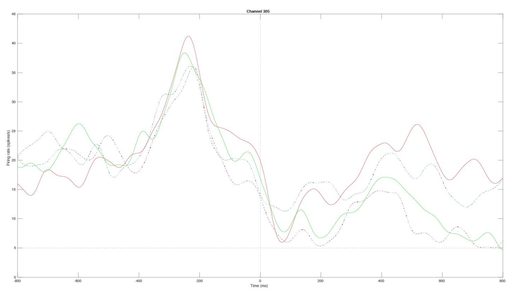




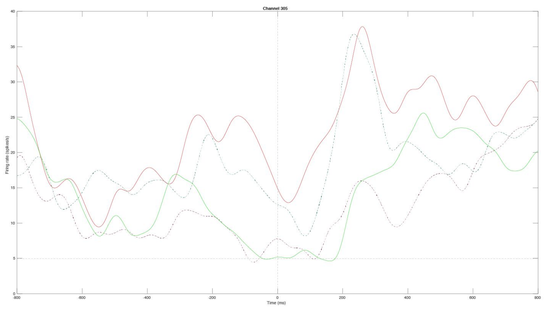


Results:

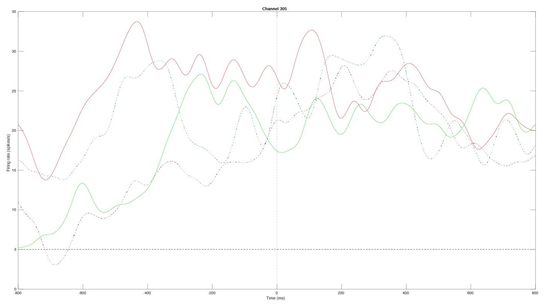
Target Aligned



Checkerboard Aligned



Movement Aligned

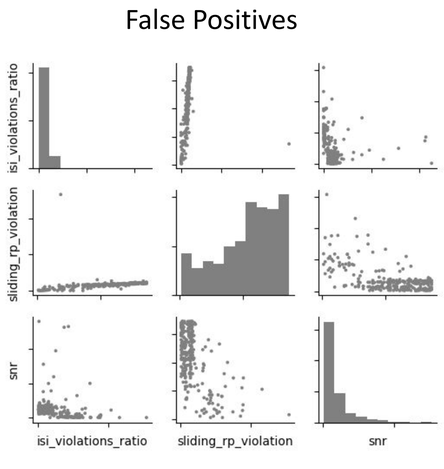


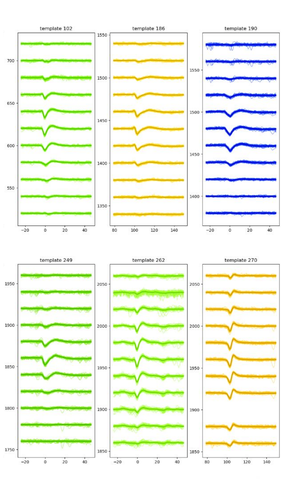
Quality Metrics

Method:

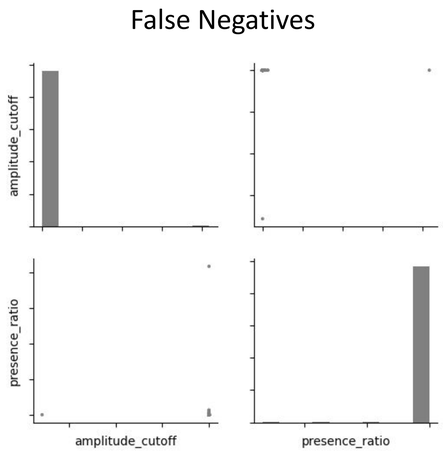
Results:

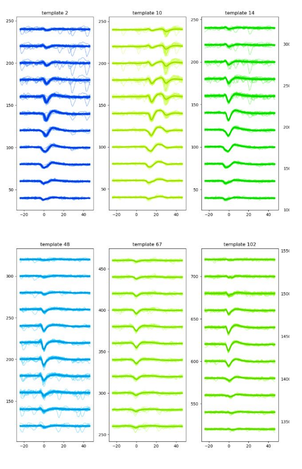
False Positives

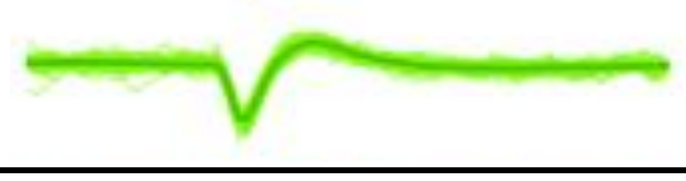


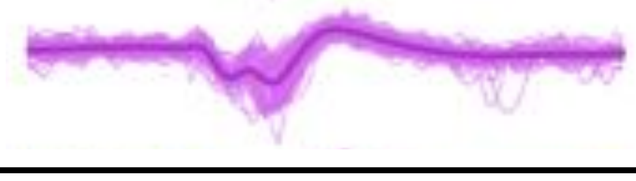


False Negatives









Discussions

- Currently, the toolbox immediately detects units via threshold crossings, aligns the data with the stimulus, and displays how these units respond to the stimulus and other experimental variables using peri-stimulus time histograms (PSTHs).
- Stringent control for false positives (signal-to-noise ratio, inter-spike-interval violations, and sliding-refractory-period violations) yielded the highest quality of isolated single units based on their waveforms.
- Controlling for false negatives (amplitude median cutoff and presence ratio) yielded weak waveform results.
- The isolation of these single units gives further intuition into the activity of putative single neurons, allowing for the understanding of the role of distinct neurons in function and behavior.
- Integration of real-time processing with robust quality control has the potential to significantly contribute to the understanding of neural dynamics and facilitate more informed experiments.

Future Work

- Improvements in the data collection and analysis pipeline to make the system completely live.
- Automating the thresholding of spike quality metrics.
- More extensive testing to determine proper metrics for individual experiments.
- Comparison between sorting algorithms (i.e., DREDge).
- Development of brain computer interfacing through shorter, more concise data collection and processing for predictions of behaviors.

Acknowledgments

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References