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CalTrig: A GUI-Based Machine Learning Platform for Accurate Ca^{2+} Transient Detection and Visualization in Freely Moving Mice

Recent advances in in vivo Ca^{2+} imaging using miniature microscopes have transformed our ability to record single-neuron activity in freely moving animals. However, extracting meaningful information from these large and noisy datasets remains a major analytical challenge. Tools such as MiniAN and CalmAn convert Ca^{2+} imaging videos into numerical signals (CaIV2N), yet post-processing steps—such as synchronizing multimodal data, validating output quality, and reliably detecting transient events—are still time-consuming and technically demanding.

We present CalTrig, an open-source, graphical user interface (GUI)-based software designed to streamline post-CaIV2N analysis. CalTrig integrates multiple data streams, including Ca^{2+} imaging traces, neuronal spatial footprints, and behavioral recordings, enabling synchronized visualization and direct evaluation of signal quality. It incorporates three complementary approaches for Ca^{2+} transient detection: manual labeling, parameter-based identification, and machine learning (ML)-driven classification.

We systematically compared four ML architectures—Gated Recurrent Unit (GRU), Long Short-Term Memory (LSTM), Transformer, and Local Transformer—using ground-truth datasets from C57BL/6J mice. The GRU model demonstrated superior accuracy, computational efficiency, and cross-session stability across animals and brain regions. By combining flexibility, analytical rigor, and an intuitive interface, CalTrig allows users with minimal coding experience to perform robust Ca^{2+} transient detection and visualization.

CalTrig thus represents a scalable, user-friendly tool for decoding neural activity from complex in vivo imaging data. Its integration of behavioral and neuronal signals provides a powerful framework for exploring neural dynamics underlying cognition, behavior, and disease mechanisms.

Keywords

in vivo calcium imaging, miniScope, calcium transients, machine learning, GRU, data visualization

Biography

Dr. Yao-Ying Ma is an Associate Professor in Department of Biochemistry, Molecular Biology, and Pharmacology at the Indiana University School of Medicine. Her research focuses on neural circuit mechanisms underlying addiction, motivation, and neuropsychiatric disorders, combining ex vivo whole cell patch clamp, in vivo calcium imaging, optogenetics, and machine learning–based analysis. Dr. Ma's laboratory develops computational and imaging tools for decoding neuronal activity in freely moving animals. She is committed to integrating neuroscience and artificial intelligence to advance the understanding and treatment of brain disorders.

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