*Manuscript in preparation.*

# Convolutional neural networks for detecting memory-related neurophysiological events

Andrea Navas-Olive[1]*, Rodrigo Amaducci[2]*, Teresa Jurado-Parras[1], Enrique R Sebastian[1] and Liset M de la Prida[1]✉

[1]Instituto Cajal. CSIC. Madrid 28002, Spain.

[2] Grupo de Neurocomputación Biológica (GNB). Universidad Autónoma de Madrid. Madrid 28049. Spain

*These authors contributed similar

✉ Corresponding author: lmprida@cajal.csic.es

Understanding the function of the hippocampus in memory requires detection and manipulation of sharp wave ripples (SWRs), a type of short-lived oscillation underlying memory consolidation. While spectral filter methods are widely used, they suffer from issues especially when dealing with poor signal-to-noise ratios and experimental artefacts. To address this challenge, we used Convolutional Neural Networks (CNN) to detect SWRs in the hippocampal local field potentials (LFP) recorded from laboratory mice. The architecture included seven convolutional layers, which process LFP inputs to provide an output probability of SWR occurrence. We trained the network with two recording sessions annotated by an expert electrophysiologist. Using supercomputer resources, we tested several hyper-parameter combinations that provided stable operation.

Next, we used 15 additional annotated recording sessions to evaluate the CNN performance. We found the CNN overcame traditional spectral methods in detecting SWRs. When implemented online, our method anticipated the emergence of events several milliseconds in advance. In the offline context, the CNN exhibited a much higher stability, less threshold-dependant sensitivity and overall higher performance as compared with the spectral filter. Moreover, detailed examination of CNN False Positives by an expert revealed that at least 15% of them could be reclassified intro biologically relevant categories.

To understand this point further, we applied a standard procedure from image recognition to visualize the CNN kernel features that had better explained performance. We found that the CNN operation relied in identifying specific LFP features which can be interpreted through the lenses of hippocampal physiology. Therefore, using CNN to examine neurophysiological signals may be exploited for the detection of known events and the discovery of underlying biological processes.