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Paper Title: Identification of the spatiotemporal activity patterns of cultured neural networks using deep convolutional neural networks (CNNs)

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Abstract

To understand the basis of information processing in the brain, it is important to analyze the dynamics of neural activity patterns using an electrophysiological approach. In this study, we attempted to extract units of neural activity that represent certain information and to distinguish between activity patterns induced by electrical stimulation and spontaneous activity patterns. X-means clustering was applied to a triplet of "two-dimensional spatial coordinates and timestamps" of neuronal electrical spike bursts to transform the single extracted spatiotemporal neural activity patterns into a standardized 8×8 2D-spatial pattern map. The pattern maps were then collected in the order of time of occurrence of the neural activity patterns, and a VGG16 deep convolutional neural network (deep CNN) was used to classify stimulus-responsive activity and spontaneous activity. For this purpose, we transformed the 2D spatial pattern map and prepared two types of 224×224 images: Spatial Information-Prioritized Neural Activity Pattern images (SIP-NAP images) and Temporal Information-Prioritized Neural Activity Pattern images (TIP-NAP images). As a result, we achieved high discrimination accuracy of over 85% for both types of VGG16 input images, especially with TIP-NAP imagesachieving a discrimination accuracy of 99.5%. This suggests that the 3D clustering extracted spatiotemporal features that contribute to the discrimination between spontaneous and evoked response activities. In addition, the combination of transfer learning and the SIP-NAP/TIP-NAP image transformation method was shown to accurately discriminate spatial patterns of neuroelectric activity even with a small amount of training data.