Linking neural activity to mouse perception using closed loop approaches

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ABSTRACT

Invariant object recognition is the ability of animals to rapidly recognize objects irrespective of variations in their appearance. In primates, this remarkable ability is mediated by the ventral visual stream, a set of hierarchically organized interconnected visual areas. Due to the hierarchical organization of deep neural networks, they have been routinely used to both model and predict the stimuli that optimally activate the neurons along the ventral visual stream. In mice, anatomical and physiological studies have revealed a network of lateral higher-order cortical visual areas which are believed to form the mouse ventral visual stream. While deep learning approaches have explored optimal stimuli in mouse visual areas, similar to primate studies, they have mostly been restricted to functional imaging data from the primary visual cortex. Here, we aim for a detailed characterization of the optimal excitable stimuli across the mouse visual hierarchy and their role for invariant object representation.

Therefore, we use large-scale electrophysiological data from multiple visual cortical areas to generate a digital twin of the mouse visual cortex. Specifically, we record *in-vivo* the activity of hundreds of neurons simultaneously across the mouse visual areas in response to natural images. We then train a convolutional neural network to predict the responses of each neuron recorded across the different areas and generate synthesized stimuli to optimally excite the recorded neurons. Subsequently, we show the optimized stimuli back to the mice and record the activity of the same neurons.

This closed loop approach enables us to probe neural activity without directly manipulating neurons, but rather by modifying the visual stimuli shown to the mice. Importantly, the digital twin of the mouse visual cortex is a powerful tool for studying visual information processing as it allows for multiple in-silico experiments, that would otherwise require considerable amount of time and animals to be performed *in-vivo.* Additional investigations are ongoing to uncover neural invariances across the visual hierarchy. Identifying the neural invariances across the visual hierarchy will allow us to dissect the role of hierarchical processing in complex cortical computations such as invariant object recognition.