論文の内容の要旨

論文題目　Visualisation and analysis of nonlinear receptive fields of visual neurons by convolutional neural network (畳み込みニューラルネットワークによる視覚野神経細胞の非線形受容野の可視化と解析)

氏名　浮田　純平

A comprehensive understanding of the stimulus-response properties of individual neurons is necessary to crack the neural code of sensory cortices. However, a barrier to achieving this goal is the difficulty of analysing the nonlinearity of neuronal responses. Here, by incorporating convolutional neural network (CNN) for encoding models of neurons in the visual cortex, we developed a new method of nonlinear response characterisation, especially nonlinear estimation of receptive fields (RFs), without assumptions regarding the type of nonlinearity. Briefly, after training CNN to predict the visual responses to natural images, we synthesised the RF image such that the image would predictively evoke a maximum response. We first demonstrated the proof-of-principle using a dataset of simulated cells with various types of nonlinearity. We could visualise RFs with various types of nonlinearity, such as shift-invariant RFs or rotation-invariant RFs, suggesting that the method may be applicable to neurons with complex nonlinearities in higher visual areas. Next, we applied the method to a dataset of neurons in mouse primary visual cortex (V1). We could visualise simple-cell-like or complex-cell-like (shift-invariant) RFs and quantify the degree of shift-invariance. Finally, we applied the method to a dataset of neurons in mouse secondary visual cortex (V2), revealing that RFs of some V2 neurons were a mixture of Gabor kernels. These results suggest that the RF estimation method is useful in nonlinear response analyses of visual neurons and potentially of any sensory neurons.