Brain–DNN homology and its applications

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Abstract—Deep neural networks (DNNs) are computational models inspired by the functions of neurons and synapses of the brain. They have been studied as general-purpose machine learning models apart from neuroscience research. However, recent studies have recast the understanding of the relationship between the brain and DNNs. In image recognition using a DNN, for instance, by optimizing the hierarchical network composed of convolutional and nonlinear computation using large scale image data, features having different levels of complexity are automatically extracted at each DNN layer. Recent work has revealed that these features can be quantitatively correlated with characteristic representations found in monkey and human visual cortex (1). Our group focuses on the homology between the brain and DNNs from the viewpoint of decoding, and aims to elucidate neural representations of visual and internal imagery. In this presentation, I give a general overview of how DNNs are “inspired” by the brain and neurons in computational terms, and then explains methods for analyzing information representations at each DNN unit learned via the training with large scale natural image data. Based on these, I show how to convert human brain activity into a DNN signal pattern and then into an image, which is a reconstruction of a stimulus or an internal imagery.

References

Bio—Yukiyasu Kamitani Ph.D.
Professor at Graduate School of Informatics, Kyoto University & Head of Department of Neuroinformatics at ATR Computational Neuroscience Laboratories, Kyoto, Japan. He received B.A. in Cognitive Science from University of Tokyo in 1993, and Ph.D. in Computation and Neural Systems from California Institute of Technology in 2001. He continued his research in cognitive and computational neuroscience at Beth Israel Deaconess Medical Center (Harvard Medical School), and Princeton University. In 2004 he joined ATR and since 2015 he is Professor at Kyoto University. He is a pioneer in the field of brain decoding, which combines neuroimaging and machine learning to translate brain signals to mental contents. He was named Research Leader in Neural Imaging on the 2005 “Scientific American 50”, and received awards including Tsukahara Memorial Award (2013), JSPS Prize (2014), and Osaka Science Prize (2015).